Journal of Special Operations Medicine

A Peer Reviewed Journal for SOF Medical Professionals

UNCONVENTIONAL WARFARE
UNCONVENTIONAL MEDICINE

IN THIS EDITION: UPDATED TACTICAL COMBAT CASUALTY CARE GUIDELINES

THIS EDITION'S FEATURE ARTICLES:

● Thoughts on Aid Bags: Part One
● Canine Tactical Field Care: Part One – Physical Examination and Medical Assessment
● Intermittent Hypoxic Exposure Protocols to Rapidly Induce Altitude Acclimatization in the SOF Operator
● A Series of Special Operations Forces Patients with Sexual Dysfunction in Association with a Mental Health Condition
● CME - Mild Traumatic Brain Injury: Situational Awareness for Special Operations Medical Providers
● Spontaneous Pneumopericardium, Pneumomediastinum and Subcutaneous Emphysema in a 22-year old Active Duty Soldier

Dedicated to the Indomitable Spirit & Sacrifices of the SOF Medic

Journal of Special Operations Medicine

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COVER
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The battle for Iwo Jima resulted in over 28,000 U.S. casualties before the island was finally secured in March 1945. "A Warrior Homeward Bound," painted by William F. Draper, is from the Navy Art Collection, Washington, DC. This painting was on the cover of Navy Medicine Jan / Feb 2007.

From the Editor

The Journal of Special Operations Medicine (JSOM) is an authorized official military quarterly publication of the United States Special Operations Command (USSOCOM), MacDill Air Force Base, Florida. The JSOM is not a publication of the Special Operations Medical Association (SOMA). Our mission is to promote the professional development of Special Operations medical personnel by providing a forum for the examination of the latest advancements in medicine and the history of unconventional warfare medicine.

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Distribution: This publication is targeted to SOF medical personnel. There are several ways for you to obtain the Journal of Special Operations Medicine (JSOM). 1) USSOCOM-SG distributes the JSOM to all our SOF units and our active editorial consultants. **2) SOMA members receive the JSOM as part of membership. Please note, if you are a SOMA member and are not receiving the subscription, you can contact SOMA through http://www.trueresearch.org/soma/ or contact Jean Bordas at j.bordas@trueresearch.org. SOMA provides a very valuable means of obtaining SOF related CME, as well as an annual gathering of SOF medical folks to share current issues.** 3) For JSOM readers who do not fall into either of the above mentioned categories, the JSOM is available through paid subscription from the Superintendent of Documents, U.S. Government Printing Office (GPO), for only $30 a year. Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. GPO order desk -- telephone (202) 512-1800; fax (202) 512-2250; or visit http://bookstore.gpo.gov/subscriptions/alphabet.html. You may also use this link to send a email message to the GPO Order Desk — orders@gpo.gov. 4) The JSOM is on-line through the Joint Special Operations University's new SOF Medical Gateway; it is available to all DoD employees at https://jsoupublic.socom.mil/publications/index.php. On the left you will have several tabs; you must first "log-in" using your SS#, DOB, and name; then go to "publications." Scroll down until you get to the JSOM and click on the picture. From this site, you can link straight to the Government Printing Office to subscribe to the JSOM. We are working with the JSOU to have a SOCOM-SG medical site; we will keep you posted as that progresses. 5) The JSOM can also be emailed in PDF format; if you would like to be added to the PDF list please send your request to JSOM@socom.mil.

We need Continuing Medical Education (CME) articles!!!! In coordination with the Uniformed Services University of Health Sciences (USUHS), we offer CME/CNE to physicians, PAs, and nurses. SOCOM/SG Education and Training office offers continuing education credits for all SF Medics, PJs, and SEAL Corpsmen.

JSOM CME consists of an educational article which serves to maintain, develop, or increase the knowledge, skills, and professional performance and relationships that a physician uses to provide services for patients, the public, or the profession. The content of CME is that body of knowledge and skills generally recognized and accepted by the profession as within the basic medical sciences, the discipline of clinical medicine, and the provision of healthcare to the public. A formally planned Category 1 educational activity is one that meets all accreditation standards, covers a specific subject area that is scientifically valid, and is appropriate in depth and scope for the intended physician audience. More specifically, the activity must:

- Be based on a perceived or demonstrated educational need which is documented
- Be intended to meet the continuing education needs of an individual physician or specific group of physicians
- Have stated educational objectives for the activity
- Have content which is appropriate for the specified objectives
- Use teaching/learning methodologies and techniques which are suitable for the objectives and format of the activity
- Use evaluation mechanisms defined to assess the quality of the activity and its relevance to the stated needs and objectives

To qualify for 1 CME, it must take 60 min to both read the article and take the accompanying test. To accomplish this, your articles need to be approximately 12 - 15 pages long with a 10 - 15 question test. The JSOM continues to survive because of the generous and time-consuming contributions sent in by physicians and SOF medics, both current and retired, as well as researchers. We need your help! Get published in a peer-review journal NOW! See General Rules of Submission in the back of this journal. We are always looking for SOF-related articles from current and/or former SOF medical veterans. We need you to submit articles that deal with trauma, orthopedic injuries, infectious disease processes, and/or environment and wilderness medicine. More than anything, we need you to write CME articles. Help keep each other current in your re-licensure requirements. Don't forget to send photos to accompany the articles or alone to be included in the photo gallery associated with medical guys and/or training. If you have contributions great or small… send them our way. Our e-mail is: JSOM@socom.mil.

Lt Col Michelle DuGuay Landers

Dedication

**Sergeant First Class
Michael J. Tully**

Sergeant First Class Michael J. Tully, 33, a Special Forces Medic assigned to the Company C, 2nd Battalion, 1st Special Forces Group (Airborne) Fort Lewis, Washington, died Aug. 23, 2007 from fatal wounds sustained when his vehicle was struck by an improvised explosive device near Al Aziziyah, southeast of Baghdad, Iraq. He was deployed to Iraq in support of Operation Iraqi Freedom as a member of the Combined Joint Special Operations Task Force – Arabian Peninsula.

After initially entering military service in the U.S. Marine Corps, Sergeant Tully transferred to the U.S. Army in 1997 and was assigned as an infantryman in Company E, 313th Military Intelligence Battalion, 82nd Airborne Division at Fort Bragg. He then served as a Long Range Surveillance Detachment assistant team leader in the same unit one year later. In 2004, Sergeant Tully was selected to attend the Special Forces Qualification Course at Fort Bragg to become a Special Forces Medical Specialist. He earned the coveted "Green Beret" and was assigned to the 1st Special Forces Group (A) at Fort Lewis, Washington, in Dec 2006.

Sergeant Tully was posthumously awarded the Bronze Star, Purple Heart, Meritorious Service Medal, Iraqi Campaign Medal, and the Combat Infantryman Badge.

Sergeant Tully's military education includes the Warrior Leaders Course, Basic Noncommissioned Officer Course, Basic Airborne Course, Military Free Fall Parachutist Course, Ranger Course, Survival, Evasion, Resistance, Escape Course, Total Army Instructor Training Course, Long Range Surveillance Leaders Course, and Special Forces Diving Supervisors Course.

His awards and decorations include: Army Commendation Medal Second Oak Leaf Cluster, Meritorious Unit Citation, Good Conduct Medal Second Award, National Defense Service Medal Second Award, Global War on Terrorism Service Medal, Korean Defense Service Medal, Noncommissioned Officer Professional Development Ribbon, Army Service Ribbon, Overseas Service Ribbon, U.S. Navy and U.S. Marine Corps Overseas Service Ribbon, Expert Infantryman Badge, Parachutist Badge, Military Free Fall Parachutist Badge, Scuba Diver Badge, Ranger Tab, and the Special Forces Tab.

He is survived by his wife and son, parents, brother (currently serving in Iraq), and his sister.

From the Command Surgeon

WARNER D. "Rocky" FARR
COLONEL, U.S. ARMY
Command Surgeon
HQ USSOCOM

We have been going through the usual summer PCS season here in Tampa. I would like to thank all those departing, such as COL Bob Vogelsang, LTC Mike Salamy, Lt Col Kevin Franke, and two of our interns, MAJ Anthony King and Maj Dave Phillips, for a job well done. I am eagerly looking forward to their replacements arriving and getting to work. LCDR Joe Patterson is now Chief of Medical Operations and Training and LTC Kimm has moved over from CENTCOM to become the Intel Chief.

The office continues to support all of our components. Please don't hesitate to let me know of any issues that we need to take on. We are slowly winning both the Theater Special Operations Command (TSOC) Surgeon sections and the Level II medical support issues. We talk to the newly emplaced TSOC Surgeons on a regular basis, as well as the component surgeons and their senior enlisted medical advisors. In fact, I just met with all the component surgeons and senior enlisted medical advisors last week.

On the research, acquisition, and logistics side, we just had a Biomedical Initiatives Steering Committee (BISC) meeting and finalized the Fiscal Year FY09 medical research monies. Chris Murphy, who is moving on from his current assignment at Fort Bragg, made many medical ideas successfully transition into the hands of SOF Operators.

The Tactical Combat Casualty Care Committee (TCCC) also met recently and switched their recommendations from Hemcon (Chitosan) dressings to combat gauze and Woundstat. Our TCCC Acquisitions Program, led by COL Jose Baez, was well supported in the United States Special Operations Command (USSOCOM) FY 10-15 POM funding, so we will be able to continue to field SOF Operator kits, Medic/Corpsman

kits, two casualty litter capability and CASEVAC kits, and various other items. Additionally, the Command Medic Certification Program (the ATP test) was fully funded in the FY 10-15 POM. The Warfighter Rehabilitation and Performance Center was funded under "Soldier Support" by the Commander, USSOCOM, to preserve and sustain Operators as the GWOT continues.

The Journal of Special Operations Medicine just published a new 2008 Training Supplement containing the updated Tactical Medical Emergency Protocols (TMEPS) and Drug List. The Curriculum Evaluation Board, chaired by Dr. Rick Hammesfahr, has been busy updating and expanding the TMEPS while continuing to write questions and improve the testing database for the Advanced Tactical Provider (ATP) examination. The JSOM will also be publishing its second annual Lessons Learned Supplement produced by the Center for Army Lessons Learned this fall. Before the Special Operations Medical Association (SOMA) meeting to be held here in Tampa, FL this December, we plan to have the second edition of the SOF Medical Handbook published and on the street. See the cover illustration on page three. I have seen the galley proofs and it should be at the publishers for final editing and publishing very soon. This will mark our shortest turnaround from one edition to the next; a mere seven or so years. That speaks to how fast medicine is changing and how important the handbook has become to our Medics, physician assistants, and physicians. As you have heard from me before, I have the red one published in 1968, the green one from 1981, and the black one from 2001; quite an evolution. A big "thank you" to all the authors, proofreaders, and editors! We continue to pitch it at the "GMO country doctor" level and are eager for feedback once it gets into your hands. The last edition, the 2001 one, had some subjects

missing and I have tried to make sure everything gets into this edition. As before, we will put out a more comprehensive CD within a year of the publishing of the hard copy edition this fall. Mr. Bob Clayton, Mrs. Gay Thompson, and CDR (Ret) Les Fenton have been spearheading this initiative; as Bob and Gay did the last one, and deserve a big thank you from all of us.

Last year, SOMA membership reached an all time high of 1,300 members. It's not too early to start trying to make plans to go unless you have something better to do, like a trip to the war. Otherwise, see you there!

I attended COL John Holcomb's Change of Command and retirement ceremony last month. ADM Olson attended to award him the US-SOCOM Commander's Medal for all his merits. See the article in the Current Events section.

John not only served with us as a surgeon in Somalia, but as the commander of the "burn unit" at the U.S. Army Institute of Surgical Research, Fort Sam Houston, TX. John led the advances we have seen in combat and surgical care in this war.

We have an interesting time ahead of us with the upcoming change of administration and the growth of the Special Forces fourth battalion, Ranger, and SEAL units.
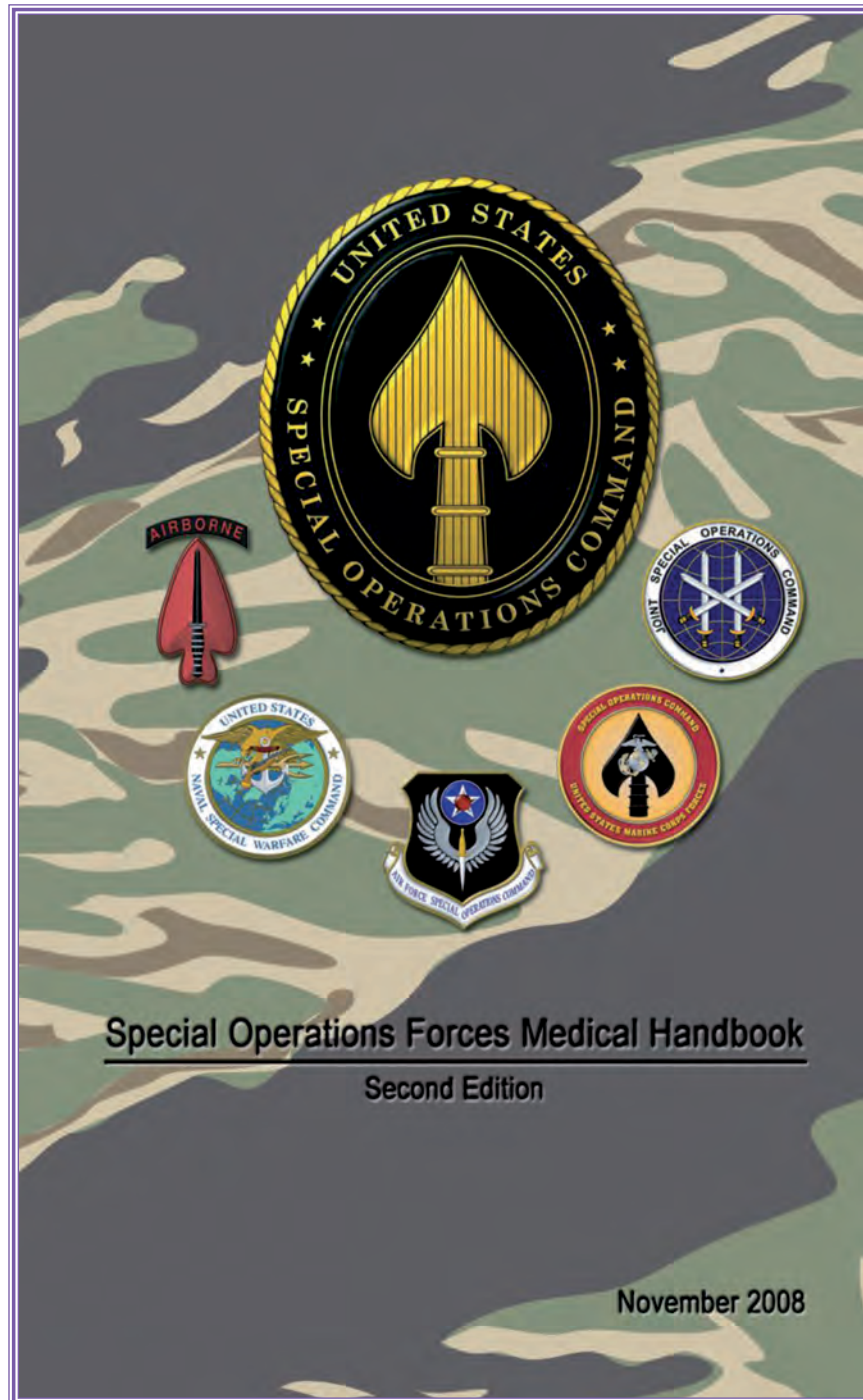
ENLISTED CORNER

SENIOR ENLISTED MEDICAL ADVISOR (SEMA)
SOCM GLENN MERCER

This quarter the Surgeon's section realized several efforts on our strategic planning docket. Of specific interest was the recognition and future funding of the Warfighter Rehabilitation and Performance Center (WPRC) under "Soldier Support." This initially vague concept of the human weapon system has been cultivated and refined over several years. Ultimately, NAVSPECWARCOM believed this should be classified as a critical requirement and acted as the proponent in the Board of Director's (BOD) strategic asset allocation process. The WPRC was received favorably by the Directors and assessed as a capital planning point for the entire Special Operations Force.

As of this edition, my section has the task to serve as the office of primary responsibility (OPR) for three tracks. They are implementation, institutionalizing, and oversight. As these editorials are drafted months in advance, by the time our constituents are reading this, we will be several layers deep into the planning and improvisation of best practices for roll out of this concept in advance of FY 2010. While this may seem to be relatively distant, in USSOCOM time we perceive this as occurring within the next two quarters. As word of the BOD decisions distill down into the force, we are experiencing a 200% increase in normal call and mail volume for a month. A consistent query that merits space in the column is specifically, what are we staffing as the OPR?

There are two concepts that have become the cornerstones for planning. First would be a generalized response to the question of what the WRPC is. It is the specific product (line item) that was approved by the BOD and directly equates to a five-year funding line that allows procurement of human resources to staff the rehabilitation and performance requirements inside the wire at designated geographic areas of concentration. The genesis point of the WRPC is the civilian professional sports model. It would be assessed as an operational concept in the arena of human capital preservation, a high interest item in the Command Groups.

The second planning concept is the institutionalizing of a doctrinal human performance program (HPP). From a width and breadth perspective this is a layered strategic concept that will fully mature after the standup of the WRPC. It has seven areas of professional expertise and is best appreciated using a weapons system analogy. For example, strength and conditioning, combat applications, technology integration, performance accelerators, applied research, and nutrition are all areas of practice and support within the nascent HPP model. Several of these are already staffed with ad hoc project teams.

Title 10 directs that USSOCOM functions as the higher headquarters that provides solutions and facilitates the process to train, organize, and equip. Many parts of that process require an inordinate amount of patience to wait for a good idea to actually yield. While we are not there yet, the essential elements of creating a global preservation strategy for the human system are now tangible. In conclusion, I would like to recognize a great sound bite I recently heard regarding HP. Paraphrased: Human performance directly impacts a commander's combat power, whether you're describing a Seal Team, ODA, MSOC, or SOS; the success or failure of HP efforts directly impacts a commanding officer's force list. It is imperative that we not only sustain the force but provide the commanders a fighting force that is peaking on the first day of operations.

COMPONENT SURGEON

USASOC

Virgil Deal, MD
COL, USA
Command Surgeon

First of all, please join me in saluting the outgoing USASOC Surgeon, COL Dalton Diamond, who is the living embodiment of selfless service; he is now in his seventh year of life as an activated Reservist in the conflicts at hand. There isn't any aspect of our support to combat operations from lessons learned, to personnel management, to getting the right stuff into the right hands, that has not benefited from his leadership. Fortunately for us, he has even elected to put off starting to collect his BG retirement pay to stay on the rolls for a while longer. Please don't let him buy a beer at the SOMA however; that oughta be on us. Many thanks, Boss.

The universe of USASOC concerns continues to evolve around the core of what our SOF medical folks do, and do very well, every day in harm's way. One of our missions is to continue to look for lessons learned on the battlefield and translate those into better practices and equipment. Please keep the lines of commo open on that one.

The cumulative effect of stress on the force is a concern to all. How we measure that on a collective and individual basis continues to change as the AMEDD gives us more tools, but it still comes down to a SOF Medic or first line leader knowing how the individuals in our smallest units of maneuver are doing. I'm convinced that nobody does that better than the Medics employed by USSOCOM. In the area of mild traumatic brain injury (mTBI), we've been invited to sit in on a task force outbrief at the end of this month discussing how clinical practice guidelines are shaping up. Whatever wisdom we garner there, we'll promptly pass on.

The USSOCOM Care Coalition is now following close to 1,900 of our sick or wounded. When it comes to expert advice on the disability process or getting the right care to the right SOF Soldier, nobody knows the disability battlefield better than they do. Don't hesitate to give 'em a call.

COMPONENT SURGEON

AFSOC

Timothy Jex, MD
Col, USAF
Command Surgeon

It is with great sadness that I announce that this will be my last submission to JSOM. After just two years at HQ AFSOC, the fun is over and I will be moving to another assignment in the next couple of months. The AFSOC medical community has had some world-changing successes while I've been here, and I expect even more in the future. Although my successor hasn't been announced yet, I have no doubt that AFSOC will continue to accomplish extraordinary things regardless of who happens to be in my position.

This is a great time to be in AFSOC. Special Ops Forces in general, and AFSOC Medics in particular, are increasingly being recognized for the unique and essential role they play in the GWOT. The rapidly growing AFSOC mission and the almost as rapidly increasing re-sources guarantee that we will be in high demand and very busy for the foreseeable future. Stay ready and focused, and let the importance of what you do brush aside the daily challenges and frustrations you face taking care of business. You will be in the history books that will be written about this crucial time in our nation's history. Thank you for your tremendous service and sacrifices. It has been a rare honor and privilege to serve with you and I envy all of you who will continue to wear the AFSOC patch. Although they may be able to drag me out of AFSOC, they'll never get the AFSOC out of me! I'll be flying top cover for you in DC.

Please take care of yourselves and each other. God bless you and protect you in this war.

Jex out.

Jay Sourbeer, MD
CAPT, USN
Command Surgeon

Like the human skeletal system which grows according to the stresses imposed upon it, Naval Special Warfare (NSW) is constantly developing new form and strength under the stresses of war. The Warrior must be able to selectively adapt; it is inherent in our duty. Driven by the human costs of war, military medicine has made many adaptations in recent years, improving standards of Warrior care from accession through retirement.

The unprecedented peak in survival rates from severe combat wounds is well known, partially attributed to body and vehicle armor, but also due to improved first responder care, forward resuscitative surgery, and improved evacuation. Advances in salvage of functioning tissue and prosthetics give wounded Warriors more options than ever before. Warriors unable to return to active duty can often move on to a productive second career and successful mentors are helping many of our Warriors set high sights for the future. Organizations such as the Care Coalition provide lifelong support from injury through the healing and transition processes.

Besides expanding casualty care for life, the medical support for the Warrior has broadened as well, reflecting the important role of family care as part of Warrior resilience. Resilience, the ability to function and even to grow under stress, develops as a learned response to specific stressors. Warriors and families can develop resilience to better recognize and cope with stress, preventing mental health problems or secondary problems such as alcohol abuse, domestic violence, or suicide. Naval Special Warfare has partnered with the Bureau of Medicine and Surgery (BUMED) to develop evidence-based methods to improve resilience of our community.

To date, the funded BUMED initiatives include a community needs assessment, Project Focus to provide individualized training for families under stress. An initiative to baseline neuropsychiatric function and help to manage traumatic brain injury, and the NSW Resilience Enterprise to better understand and develop resilience factors in our community. Future BUMED initiatives will (hopefully) include programs to pilot improved access to care, since barriers to expedient family medical care have been cited as a significant stressor for Warriors. To employ a time-proven military technique, NSW Warriors will soon start Third Location Decompression (TLD) with their fellow Warriors to get mental health training and rest before coming home to the sometimes stressful process of reunifying with their families. Although initially met with suspicion, TLD is now gaining traction with experienced spouses who have heard how it works and who want a spouse who is mentally home and ready to go when he physically arrives home.

Whether addressing the physical, the mental, or the spiritual needs of the Warrior community, many changes are afoot. This captures only a fleeting glimpse of many initiatives that bear great promise for the future. To be sure, some of our "new" advances are relearned lessons from a previous war, but as we adapt scientifically proven means to deal with both old and new problems, we have steadily "raised the bar" to improved standards of care.

No elevation of our medical care standards will ever remove the cruelties of war or compensate the sacrifices that must come with it. Our duty is to ever adapt and improve our care as we honor what others have given.

Stephen F. McCartney, MD
CAPT, USN
Command Surgeon

The U.S. Marine Forces Special Operations Command (MARSOC) has undergone changes in a major way since my last submission in the Spring 08 edition. Our plank owner, Commanding General, Major General Dennis J. Hejlik, USMC, turned over command to Major General Mastin M. Robeson, USMC. By publishing time, the former MARSOC Commander will have put on his third star and will be Commanding General, II Marine Expeditionary Force. Thankfully, not only will his profound accomplishments and leadership lessons live on, but he will be physically only one floor above MARSOC HQ here at the historic former Navy Hospital building known as "H-1". Major General Robeson reported aboard 24 July 2008 from previous assignments as Commanding General, 3rd Marine Division in Okinawa and most recently, as Chief of Staff, Multinational Forces, Iraq. Welcome aboard Major General Robeson and family!

Throughout MARSOC there are challenges of command changes, reorganization, active engagement in OEF-P, OEF-A, and OEF-TS while still growing as the newest component command in USSOCOM. We recently have been able to begin a long desired luxury of sending some of our medical specialists down range to gain much needed experience. Our medical officer personnel and junior enlisted mostly come from a non-SOF background. When we stood up it was impossible to get them on missions in the correct capacity; now we can

do that when feasible. My vision has been to "*grow tomorrow's MARSOC medical leadership ... today*". Recently we sent one of our own physicians to support another component's requirements and gain much needed experience on a SOF deployment.

Whilst speaking to personnel issues in MARSOC we welcome our new Marine Special Operations Support Group Surgeon, Lieutenant Mark Burger, MC, USN. He just completed his Internal Medicine residency and, not uncommon to MARSOC Medical, is a former Marine officer. He replaced CDR Dave Krulak, MC, who now is Senior Medical Officer on the carrier *USS Stennis* (CVN 74). Welcome aboard LCDR (sel) Burger. We also welcome LCDR Eugene Garland, MSC, USN, who is MARSOC's second Environmental Health Officer. He reports aboard from the Naval Hospital, replacing LCDR Shelton Lyons who is now EHO for Marine Forces Pacific.

When reporting to MARSOC as Senior Navy Officer, I wondered what potential impact being OPCON to USSOCOM and SOF may have on our Navy officers regarding promotion. My concerns were relieved as all MARSOC Navy officers in zone have made promotion on first pass, (in one case promoted two years under zone). Congratulations to CAPT (sel) Andrew Davidson, MSC; CAPT (sel) Dale White, CC; CDR (sel) Steven Kriss, MC; and CDR (sel) Mike Lappi, MC.

May God Bless America and its heroes.

CAPT McCartney doing surgery at a FST in OEF-A Oct 2007.
The patient was 10 y/o with severe intestinal injuries from IED at end of
Ramadan celebration in Spin Boldak.

Patient on the mend several days later(ISO surgical support of COIN).
CAPT McCartney was there to gain SA on USSOCOM Level II conops, etc.

TSOC SURGEON

SOCCENT

Ricardo Ong, MD
LTC USA
SOCCENT Surgeon

Our SOF in Iraq and Afghanistan continue to do great things. Every day our Medics, PAs, and Docs in theater show our leadership how medical operations can be used to build goodwill, to open the doors to village tribal leadership, and to simultaneously build partner capacity by enabling our local national counterparts. In Iraq, our physicians and PAs are actively engaged in training Iraqi physicians at local teaching hospitals. Our Medics welcome the opportunity to access specialized care for local children in need. Our forces in Afghanistan have taken full advantage of the female treatment teams, as they continue to be in high demand. Coalition medical personnel, together with local medical personnel, provide medical care for thousands of local nationals on a regular basis.

Ethiopia represents an excellent example of how SOF medical operations can be used to open doors and establish relationships. In general, it has been very difficult to establish a working relationship with the Ethiopians. Despite these difficulties, our SOCCE-HOA Surgeon, COL Mouri, was very successful in setting up medical training. Physicians from both SOCCE-HOA and JTF-HOA participated in a physician exchange training program with their Ethiopian counterparts. Additionally, they were able to train-the-trainer in TC3. These Ethiopian TC3 trainers have subsequently taken their skills and knowledge to train their Ethiopian troops. We're hoping that this relationship we have established may serve as a foundation for future SOF cooperation.

In our current operations, we continue to push for SOF specific level II surgical capability. We have turned-

over a team (the new team appears to be more amenable to the flexibility of SOF operations), and are preparing to request another team as our requirement in the OEF theater expands. Additionally, we are actively looking at this requirement in the OIF theater as the prospect of conventional force draw-down looms, although it is far from definite.

Everyone is aware that we continue to take casualties. Fortunately, our troops entering theater remain well trained in basic field medicine. This should not be limited to Operators, as our support personnel engage in high-risk activity on a daily basis. My 10th Group brothers were hit hard on day number one of the transition of authority, losing one Soldier, and two others with life-threatening injuries. These two wounded Soldiers managed to survive a very harsh situation due in large part to the strong medical training they had. I implore all to maintain a relentless vigilance in ensuring our men and women are trained appropriately.

I'll close with a note on a recent, small victory. I have finally managed to consolidate the entire SOCCENT medical staff under the Surgeon. The three medical operations and plans officers have formally moved from J4 to the Surgeon's section. I've been accused of "empire building," and there may be a little truth in that; in reality, this allows me to build a staff that can more effectively engage and support the guys down-range that we are responsible for supporting. I actively try to remember (and instill this in my new staff) that our job at the TSOC level is to support the guys on the ground. Feel free to remind me of this should I stray from this mission.

SOCPAC

Frank J. Newton, MD
COL USA
Command Surgeon

Greetings, or as they say in Hawaii, aloha, from the newest Theater Special Operations Command (TSOC) Surgeon at Special Operations Command, Pacific. This Command, overlooking Pearl Harbor at Camp Smith, Hawaii, just celebrated its 25th anniversary. Like the other TSOCs, we are turning over (lava) rocks and creating our operational plan from the Commander's priorities. Fixing force health protection has been our first priority, and as PACOM's no notice or short notice Joint Task Force (JTF), we have to be ready when the call comes. In the near future, we will add primary care, periodic health appraisals, and physical exams to our medical readiness initiatives. We also want to provide a service for our family members to assist them with their acute care needs when their only alterative is a visit to the emergency room.

Every successful surgeon has an exceptional medical planner. I am fortunate to have LTC Brady Reed as my deputy. He has been tireless in improving the Joint Special Operations Task Force-Philippines (JSOTF-P) medical capabilities and in helping to stand up this TSOC Surgeon's directorate. Incidentally, the JSOTF-P Surgeon's position is a six-month deployment, with a DEROS late NOV 08. If you have SOF experience, and are interested in authentic "By, Through and With" Special Operations medicine, give us a call. The other key member of a surgeon's cell is the senior enlisted advisor. I was blessed to pull MSG Kurt Schnupp out of the J-3's shop. He has impressive credentials including the experience of running guerilla hospitals in both Afghanistan and Iraq. He has already proven to be a great asset in planning medical operations, training our force, and deploying as a seasoned Special Forces Medical Sergeant. He deployed with me in support of Cobra Gold 2008, Korat, Thailand (May) and went back as our JTF Operations SGM during Cobra Gold II (Aug) at Lop Buri, Thailand. One of our important training initiatives is to incorporate Tactical Combat Casualty Care into our quarterly training schedule.

Speaking of training initiatives, with the Special Operations Medical Association's (SOMA) annual meeting fast approaching, it is not too early to start planning on maximizing your medical NCOs' attendance. For Special Forces Command, the key to getting approval of GWOT funding is to emphasize that this is a TRAINING venue, and valuable pre-mission training. Funds will not be approved to attend conferences. As an added bonus, because the break-out sessions at SOMA have gone so well, Group Surgeons can give their 18Ds credit for non-trauma module training. I encourage the Senior Enlisted Advisors and the Battalion and Group surgeons to promote this activity for their 18Ds early. It's an extraordinary opportunity for camaraderie and Lessons Learned in a beautiful setting.

SOCEUR

Rusty Rowe, MD
LTC USA
SOCEUR Surgeon

After a year as the Special Operations Command Europe (SOCEUR) Surgeon, I am finally able to provide a quick snapshot of the successes in our medical section. Actually, I finally gave in to Rocky's insistence to write something from the oldest Theater Special Operations Command. My sincere thanks to LTC Pete Benson and Maj Dan Donahue for opening the office and leaving the lights on. Their work was exceptional in establishing the groundwork to embed our medical expertise and relevance throughout the entire TSOC staff and its subordinate units.

We continue to come to work out of sheer curiosity for what will happen that day. Our medical planners are actively engaged in the medical support to both Romania and Mauritania. Since both exercises have conflict surrounding them, the coup in Mauritania and the hostilities between Georgia and Russia, we continue to adjust for the ever changing world. Our medical crisis planning associated with the past Non-Combatant Evacuation Operation in Chad and the rioting in Azerbaijan has helped prepare us to support COMSOCEUR's options with the current crises erupting throughout the EUCOM Area of Operations.

Besides support to the components, we are also heavily involved in developing casualty evacuation plans for use in Africa and Eastern Europe. Based on experience evacuating critical casualties from Mali, the team has been able to push the need for responsive evacuation and mobile surgical capability to the forefront of the TSOC commander's agenda.

Thankfully, the SOCAFRICA medical staff has continued to build its capability as we work to transition the mission in Africa to COL Frank Anders and his staff. We are mutually supporting the OEF-Trans Sahara missions as they move to become fully operational — a date we will celebrate wholeheartedly. Take it, Frank!

Special Forces Surgeon

USASFC

Peter J. Benson, MD
LTC (P), USA
Command Surgeon

This spring a command-sponsored Special Forces Symposium covered a range of operational and strategic issues, trends, and concerns across the Regiment. This also served as an opportunity to reflect on the current state of Health Service Support (HSS) within Special Forces. The delivery of the most appropriate and coordinated HSS to the Regiment is critical to the fulfillment of its role and expertise in Unconventional Warfare. Each Special Forces Group has a range of medical specialists: Special Forces Medical Sergeants (SFMS), Special Operations Combat Medics, physician assistants, surgeons, veterinarians, dentists, psychologists, operations officers, environmental science officers, logisticians, physical therapists, and technicians. Each has a vital role to play in the delivery of HSS and so must be properly selected, trained, equipped and sustained.

The selection and training of Special Forces medical personnel is a critical component to meeting our operational requirements. One of the gaps in our current training programs for SFMS, technicians, physician assistants, surgeons and other professional staff is operational training in the planning and application of HSS to Special Forces operations. The training of SFMS and professional providers focuses largely on clinical skills and medical competency. The AMEDD Medical MOS and Branch courses, professional residencies and the SFMS course lack fundamental training useful to the integration and employment of HSS in support of Special Forces.

The ongoing nature of Special Forces operations in the GWOT will require skillful and intelligent application of medical planning, logistics, and clinical operations to be successful in the austere, immature theatre of operations. A review of the training programs, with a view of updating the programs of instruction or additional courses is required. New lessons learned in combat need to be inculcated, validated techniques retained, and old doctrine updated. We should add HSS tactical and operational planning training, exercises, and simulations to our medical courses and also address them in the Special Forces Officer qualification course. Leveraging medical humanitarian assistance and civil military operations in Special Forces operations in the Global War on Terrorism is equal to if not more important than force health protection. Ensuring that our Soldiers are properly trained and equipped to support the mission is paramount.

I invite all Special Forces medical providers, leaders, and staff to capture lessons learned and document relevant suggestions on improving tactics, techniques, training, and doctrine and forward them to the USASFC Surgeon's Office, at peter.benson@ahqb.soc.mil or wareo@ahqb.soc.mil. Maintaining the appropriateness and relevance of our medical training and doctrine will be the guarantee of our success in the future.

Education & Training

USSOCOM Education and Training Update

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Executive Editor's Note: Since departing the national registry, a healthy debate has raged on need for civilian certification of what is truly a SOF military skill set. SOCOM built the ATP as its certification process to mirror various civilian standards, hence the Curriculum Evaluation Board process. The debate on whether or not to obtain civilian recognition (either by ATP card recognition through out DOD and beyond or by equivalency testing) continues. We also have a Requirements Board. Clearly, mission, requirements, lessons learned and/or MET-T does not drive this. In the GWOT, other involved government agencies are seeing the usefulness of tactical medic certification and are exploring their options with us.

WHAT GOOD IS THIS ATP CARD OUTSIDE DOD?

About a month ago, the United States Special Operations Command (USSOCOM) Surgeon's Office Department of Medical Education and Training, sent a survey to all of the Advanced Tactical Practitioners (ATPs) on record. We also sent links and PDFs of the survey to the Senior Enlisted Medical Advisors throughout the Command for distribution to the ATPs. We wanted to know what the SOF Medic is doing while he is deployed in support of the GWOT. We also asked for good and bad comments about the ATP test, Tactical Medical Emergency Protocols (TMEPs), the recommended drug list, as well as training needs and perceptions. So far, we've had an awesome response rate and some great feedback. We are about halfway done with data collection and can already see interesting trends in what guys are experiencing, treating, and what procedures the ATPs are doing.

One theme we got quite a few comments on (even though I didn't ask about it) is the SOF Medic and civilian equivalent certification. This is a long story and if you've been around for a year or two, you know how it's evolved. In the mid 1990s SOF Medics were allowed to sit for the National Registry of Emergency Medical Technicians – Paramedic (NREMT-P) examination. The NREMT-P certification became the standard for all SOF Medics. Then around 2001, the state of USSOCOM developed the SOF Paramedic certification and gave cards to those who completed SOF Medic training and were NREMT-P certified. In 2003, USSOCOM sent guidance to the components to direct medical certification of SOCM graduates away from the NREMT-P, (all Services) to one interoperable standard. It was also time for a re-direct

away from the curriculum based on Department of Transportation (DOT) and street paramedic medicine to war time Special Operations Medicine.

Feedback from the components and Medics in the field resounded with a need to get away from the NREMT-P certification and curriculum and incorporate more Special Operations Military type medicine (Sick Call, Tactical Combat Casualty Care (TCCC), surgical skills). None of these are addressed in the DOT curriculum requirements for the paramedic level provider and to this day there is nothing above the paramedic level, outside of DoD, to address the advanced skills of the SOF Medic.

Since the first Pararescueman and Joint Special Operations Medical Training Center (JSOMTC) classes of 2006, we have been giving the ATP test to all students of the JSOMTC and Pararescue School. It is a test by the SOF Medic leadership for the SOF Medic. It tests all Services' SOF Medics to one interoperable standard. Many ask why there is no civilian equivalent to the SOF Medic and what the ATP card does for me? Well, the ATP certification ensures you meet the interoperable standard set forth by the leadership in the SOF Medic community; you know that if a SOF Medic takes a patient from you on the battlefield or works with you on the battlefield, he has been tested to that interoperable standard.

An advanced level street provider is a hot topic in the civilian sector and has been for a few years. There is a growing number of people without health insurance and more frequent overcrowding of emergency department and acute care clinic waiting rooms. Two of the Emergency Medical Services (EMS) world heavy hitters weighed in

with their solutions and I am re-printing their articles from the *Journal of Emergency Medical Services* (JEMS). After those articles you will find the USSOCOM Curriculum and Examination Board's (CEB's) solution for an advanced level street provider and training program. This military solution has been around for a while since the first Special Forces Medic graduated in the early 1960s.

The JSOMTC is currently accredited by the Committee on Accreditation of Educational Programs for the EMS Professions (CoAEMSP). This is what is required of an EMS teaching program. The JSOMTC also meets the DOT standards in its curriculum, yet the school still cannot get a site code for students to sit for the NREMT-P examination unless all students are required to take the examination. There are good ideas out there and people want an advanced level of certification that looks a lot like the SOF Medic. Yes, we want the SOF Medic to be able to sit for the NREMT-P exam, but it shouldn't be the certifying exam because it's not the right exam. It must be mentioned that all of the PJ students go through a formal NREMT-P program by Eastern New Mexico State University prior to doing military medicine training; and yes, they do sit for the NREMT-P exam through that university.

Can a paramedic manage sick call? Can a paramedic suture a wound? Can a paramedic diagnose and treat someone who needs antibiotics? Can a paramedic, all by his lonesome, manage a seriously injured patient for 72 hours without medical control? Can a paramedic insert a chest tube in less than two minutes? These are some of the things a civilian equivalent examination would need to assess in an ATP type Medic.

We have a good (ATP) exam, and are working to make it better and get it recognized more throughout the civilian community. It will take some time, but we are working towards an end we can all be satisfied with and get the SOF Medic recognized for the extreme value he brings to the battlefield and the street. A telling quote I received in an e-mail from an EMS higher-up about JSOMTC Medics taking the paramedic test: "Let's just wait till this shootin' war is over with." Probably not a bad plan, since we need a shootin' war test.

BLEDSOE'S EMS SCOPE OF PRACTICE MODEL: ANOTHER PERSPECTIVE

Bryan Bledsoe
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Editor's note: For details on the National EMS Scope of Practice Model proposed by a group of EMS leaders (selected by the National Association of State EMS Directors and with funding from NHTSA), read "Educators Wrestle with Proposed Scope of Practice Model," October 2004 Insider and the Priority Traffic article "WANTED: Input on Proposed Provider Names & Scopes of Practice," November 2004 JEMS.
Visit www.emsscopeofpractice.org to review the model and submit comments to the group by January 2005.

The new EMS Scope of Practice document is an interesting and somewhat controversial plan for the future of EMS in the United States. I have to admit that I don't totally agree with all facets of it — but at least we are looking in the right direction. However, as I travel this great land, I have encountered a good number of people and organizations that oppose the National EMS Scope of Practice model. The reasons vary. But, regardless of the politics, we must come up with EMS provider levels that are based on a preponderance of the scientific data. I'll tell you what I would do — I'll call it Bledsoe's EMS Scope of Practice Model. Now, this is not something I just came up with. This all comes from a few lectures I gave back in the 1990s at the Texas EMS Conferences. I just polished it up to incorporate some of the concepts and ideas in the new National EMS Scope of Practice proposal.

SKILLS AND KNOWLEDGE LEVELS

Emergency Medical Responder (EMR) — Emergency Medical Responders (EMRs) would correspond to the current first responder level. Providers would be AED and AED-Instructor certified, and BLS and BLS-Instructor certified. Public safety and similar personnel would receive additional education in weapons of mass destruction and homeland security. They would be able to apply AEDs, administer oxygen, use basic airway adjuncts and be able to administer medications by auto-injector (e.g., epinephrine and bioterrorism antidotes). Education: Approximately 80 hours.

Emergency Medical Technician (EMT) — This level would simply be called Emergency Medical Technician (EMT) and not "EMT-Basic" or "EMT-Ambulance" as in times past. The EMT would be the minimal level to work on an EMS transport vehicle. The new EMT would have the current EMT skills and knowledge. In addition, the EMT would be able to place a mechanical airway such as a CombiTube, LMA or similar airway (not an endotracheal tube). They would be certified in AED use and instruction. They could administer aspirin, nebulized bronchodilators, nitrous oxide/oxygen, nitroglycerin, epinephrine 1:1,000 and glucagon. In addition, they could help patients with patient-administered medications. They should be able to start and maintain IV lines, manage rate and volume-controlled ventilators, verify and monitor en-

dotracheal tubes, use waveform capnography, and perform pulse oximetry and blood glucose monitoring. Education: Approximately 200 hours.

Vocational Paramedic (VP) or Technical Paramedic (TP) — The Vocational or Technical Paramedic would be called a "Paramedic" but would have skills primarily designed for the urban or suburban setting. The vocational Paramedic would carry enough medications to run a cardiac arrest for 15 minutes. They would be able to intubate and use alternative airways. They would be able to administer first-round ACLS drugs, treat pain with fentanyl or morphine, give nebulized bronchodilators, treat CHF with nitrates and diuretics, start IVs and IOs, treat ACS with aspirin, nitrates, morphine, and such. They would have limited 12-lead ECG skills; instead of independent interpretation, they would rely on the computer or medical control for interpretation. Waveform capnography would be a standard of care. This level is ideal for dual or multiple-mission services where the Paramedic must also serve as a firefighter, police officer, or similar responsibility. Education: 800 hours.

Licensed or Professional Paramedic (LP) — The Licensed or Professional Paramedic would be also called a "Paramedic." This role would be for rural and similar settings where transport times exceed 15 minutes. Also, these providers would be ideal for services that are dedicated purely to EMS. They would have all current paramedic skills including RSI, use of pressors, ability to administer fibrinolytic therapy, ability to manage the difficult airway, decompressing chests, interpreting complex 12-lead ECGs, and would carry considerably more medications than other providers, depending on transport time and other factors. They would have some independent practice and preventive medicine skills (e.g., feeding tube, Foley catheter replacement, immunizations). They would be the senior EMS provider on most EMS scenes. Education: Associate's degree.

Critical Care Paramedic (CCP) — The Critical Care Paramedic would be a Professional Paramedic with at least four years of field experience who has taken a critical care course similar to nursing (not the two-week variety). They would be able to handle the full gamut of critical care transport including: airway and vent management, complicated medication therapies, central venous access, blood administration, interpretation of common lab and diagnostic studies, and other advanced skills typically associated with critical care medicine. All flight Paramedics would need this level of certification. Education: Associate's degree with additional year of Critical Care Transport (CCT) education.

Specialty Paramedic — The Specialty Paramedic would be a Professional Paramedic with additional education in a given area. These areas would include: industrial medicine, sports medicine, public health, tactical medicine, military medicine (Special Forces) and similar fields. Industrial Medicine Specialty Paramedic would receive education related to their industry (e.g., off-shore, chemical plants, large buildings). Specialized skills might include suturing of simple wounds, treatment of eye injuries and removal of corneal and conjunctival foreign bodies and similar skills. They would also receive additional education in safety and accident prevention. Advanced military Medics (Special Forces, Air Force PJs, Air Force Independent Duty Corpsmen) would be a type of specialty medic certified in both the military and civilian arenas. The specialty would involve great emphasis on battlefield medicine but also on areas that are considerably different from civilian paramedics (e.g., emergency dental care, prolonged patient care, emergency veterinary care, and independent duty field care). Sports Medicine Medics would have additional training in prevention of athletic injuries (e.g., taping, splinting), on-field emergency care, and would be able to make decisions about returning a player to the game. Tactical Medics would receive additional education on prolonged care, specialized trauma care and similar education. Education: Associate's degree (or similar) and additional education in area of specialization.

Independent Practice Paramedic (IPP) — The Independent Practice Paramedic is a Licensed or Professional Paramedic who has completed an Advanced Practice Paramedic or Independent Practice Paramedic program. This would somewhat parallel the Physician's Assistant model. This level of provider could function as a high-level field practitioner providing treat-and-release care (e.g., simple sutures, G-tube replacement, tracheostomy changes, Foley changes, homebound IV therapy, dislocation reductions, nail trephination, use of local anesthesia and similar skills) for selected cases. They could be educated as a rural independent practitioner with additional basic general medicine skills (e.g., simple diagnosis and treatment, suturing, abscess I&D) — essentially to provide care for 24 to 48 hours for simple cases until the patient could get to a physician. Education: Bachelor's degree in EMS in area of specialization.

There, that's it, fairly simple. All of this should be based on the preponderance of current scientific evidence such as the Ontario Prehospital ALS (OPALS) study and other current research. If prehospital endotracheal intubation continues to show to be problematic, pull it back to the Professional Paramedic level and above, where there would be more experience and more opportunity to perform the procedure. We should no longer think of Emergency Medical Responders and Emergency Medical Technicians as being basic life support providers; that concept went out

years ago. All levels of EMS providers are partners on the same continuum of care. The more severe the emergency, the more EMS provider levels should be educated to manage it. The less severe (or more infrequent) the emergency or problem, the fewer EMS providers will be educated to manage it. This follows the old supply-and-demand theory.

Although these levels should be nationally standardized, they should be seen as minimum standards. Each state and geographic region should still be able to change the mission and scope of practice to meet the needs of the population at risk. There's a vast difference in the patient population and the practice of a paramedic working in Brooklyn, N.Y., when compared with that of a paramedic in the frontier Texas town of Terlingua. Local or regional medical control should be customized to the system and the population at risk.

In our society, we don't need the highest level of care provider on each and every emergency run (although we think we do). We must take into consideration such things as transport time, other responsibilities, patient population, quality of first responders, available resources, funding, and similar information to determine what level of care provider should be available. But, as a rule of thumb, the farther an EMS provider is from a hospital, the greater should be their education, skills repertoire and formulary.

That's my story, and I'm sticking to it. What are your thoughts?

A Missing Link:

How the new level of Advanced Practice Paramedic would fill the gap

William E. Brown, RN, MS, NREMT-P
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Medical directors must often trust supervisors who exemplify the Peter Principle — those who advance to their highest level of competency and are then promoted to and remain at a level at which they're incompetent. Meanwhile, true leaders within their systems are being held back.

Some medical directors are impeding advancement of their systems by delaying implementation of certain skills, procedures or processes thinking *I can't let some Paramedics provide the treatment unless everyone is trained*. So although Paramedics — currently the highest level of EMS licensure — are initiating progressive interventions in some systems, neither comprehensive core patient care nor professional needs are really being addressed.

Many systems are functioning as they were originally designed 20 years ago. Some systems have hundreds of Paramedics. Street-level providers and medical directors can identify those with advanced knowledge and skills, but there's no valid way to have them identify themselves, or for the system to reward them for their accomplishments. Many Paramedics are standing around scenes holding IV bags, while others are cognitive "machines" making all of the decisions and assuming patient-care responsibility for the same title, pay and recognition.

The Need for a Career Ladder

Using the principle of the lowest common denominator is holding back our systems. Fundamentally, there's no way to separate the few from the masses, the best and the brightest, the cognitive leaders from the average, and to allow these few to work with medical directors to lead EMS systems into the future.

There's no EMS career ladder. Paramedics aren't staying in the profession, with many leaving the field to find more fulfilling and higher paying healthcare work. Many of these Paramedics have the affective skills to assess and treat patients from a physiological approach and have furthered their education beyond entry level—becoming the "go-to" guys.

When we adopt new technologies, many providers learn by the trial-and-error method. There are no field-level experts to teach the masses on the basis of their experiences with these technologies. Research is being accomplished by physicians, not Paramedics. Patients are assessed, treated and released, often by the crew that arrived and not by Paramedics with advanced assessment skills.

The Fundamentals of APP

During development of the National EMS Scope of Practice, a level called APP (Advanced Practice Paramedic) was introduced to the nation. A great concept: Paramedics with advanced clinical competencies, further EMS-related education, and permission to provide certain care under medical direction. The APP level would be an extension of medical direction, a level needed in EMS.

After national review, without being fully understood and vetted, the level was dropped from the Scope of Practice. It was a concept introduced before its time. Misunderstood, the APP concept met an early death. But times have changed. There's a way to define this new certification, and only you — the best Paramedics — can chart your own course.

An APP would extend the medical director's abilities. EMS system research and effectiveness would be

their purview. When new interventions are under consideration, the APPs would be the first to introduce them by cleaning up the bugs, teaching providers on scene and adapting the practice system wide.

On arrival, other Paramedics would yield the cognitive responsibility for the patient to APPs. The career of APPs would be inhibited only by their own ability to succeed. Their specific scope of practice could vary from system to system depending upon local needs.

IMPLEMENTING APP

This level wouldn't require unique licensure. It would be a specialty certification — earned through continuing education, advanced competencies and clinical requirements. It would require paramedic experience and endorsements as part of the certification process.

It wouldn't be inclusive but exclusive. It's not for everyone — only those who have the ability to excel and the desire to serve.

At the 2008 EMS Today Conference in March, I will present a lecture on this new concept. I encourage you to attend and begin the process of creating this specialty certification sorely needed in our profession. There's a credible way to make this happen and develop it into what we need to better serve our patients, advance ourselves and improve our EMS systems. Come join me in an exploration of how to implement APPs nationwide.

BREAKING THE SOUND BARRIER (EVOLUTION OF THE ADVANCED TACTICAL PRACTITIONER)

Rick Hammesfahr, MD.; Troy Johnson, MD; Bob Hesse, RN, NREMT-P; Bryan Bledsoe, MD

The speed of sound is 343m/s (770mph) at 20 C (68 F). Early attempts at achieving this speed in aerial flight were problematic due to the immense amount of turbulence that was encountered when approaching this speed. It was not until the speed of sound was exceeded that it was learned that the buffeting stopped and normal, controlled flight resumed. This analogy seems to apply whenever the topic of advanced practice Paramedics is brought up. An incredible amount of buffeting and turbulence occurs when approaching this topic, making the process problematic at best.

It is with this in mind that the members of United States Special Operations Command (USSOCOM) Curriculum and Examination Board (CEB) read William Brown's commentary ('A Missing Link', JEMS February, 2008) concerning the Advanced Practice Paramedic with much interest. It must be said at the outset that the US-SOCOM CEB does not pretend to have the solution or universal knowledge to crack this concept, nor make it a reality for our counterparts in the civilian sector. We do not believe that our current concept is the final evolution of the level of advanced prehospital practitioner. Our quest for defining the role of an advanced practice Medic has just now reached a stage of maturation where we can critically look at the progress that has been made as we continue to move forward.

What we (USSOCOM CEB) can currently offer are five years of developmental experience and countless man-hours spent developing a workable concept of an advanced tactical prehospital practitioner. As a result of the work of this multidisciplinary committee and that of the Requirements Board (RB) of USSOCOM, it has been possible to identify, develop, and implement the Advanced Tactical Practitioner (ATP) caregiver concept. The ATP represents the highly trained Special Operations Medic who is further trained to deliver a selected level of medical care normally reserved only for mid-level practitioners such as physician assistants and nurse practitioners, as well as physicians. Through advanced training and certification processes, the ATP learns to address specific complex traumatic and medical problems encountered on the modern battlefield by the Special Operations Forces, and to provide advanced medical care for troops in austere conditions when there are no other more advanced medical providers available.

THE EVOLUTION OF THE ATP

The need for the development of the ATP certification arose from the recognition that the current certification process, while working well for the civilian sector, was not answering the requirements of the military. In the 1990s, Congress recognized the need to accredit military healthcare providers. In fulfilling this mandate, the National Registry of Emergency Medical Technicians (NREMT) was utilized as the licensing and oversight agency for medical training of military Medics. With the different levels of certification, it was possible to develop different levels of training which would then allow for different levels of clinical responsibility (Emergency Medical Technician – B, I, P). The degree of medical skills that were allowed by the healthcare provider increased as the level of certification increased. This certification process provided a manageable way to implement a graduated assumption of clinical responsibility, and would dictate which clinical techniques could be performed by the different levels of training. In addition, the curriculum development and testing process was being developed

outside of the military, thus allowing for independent verification that the standards were being followed by the military health providers. This process was implemented in the 90s, as the civilian Emergency Medical Service (EMS) system recognized that the EMS providers could make a difference in the survival of patients in the prehospital setting. However, the training and certification was based on the civilian paradigm that definitive care was readily available and the clinical time of responsibility was limited.

Unfortunately, as global events developed along with the military actions in Somalia, Bosnia, and Desert Storm, the dynamics of warfare and the non-linear battlefield made us relearn the lessons from previous conflicts. Medical personnel stretched across the globe in the fight against the Global War on Terrorism (GWOT) required the SOF Medics to consistently provide medical care in situations that fell outside of the standard EMT training and certification parameters. They were required to perform increasingly sophisticated invasive medical procedures, and to assume greater responsibility for prolonged patient care.

Over the years, the literature has noted that the survival rates of victims depends on the close proximity of, and the timing of, getting the patient more definitive care at the earliest opportunity. Likewise, battlefield experience has also shown that the survival rate of injured Soldiers depends on the close proximity to definitive care. Moving a combat injured patient, particularly in the Special Operations environment, to this definitive care setting is often impractical or impossible. Getting enough "doctors" to the front-lines is equally impractical. Therefore, some of the medical skills usually reserved for civilian medical professionals are taught to enlisted Medics. Currently, in the civilian sector these skills are not taught to Paramedics for different reasons (high risk/legal, lack of a suitable certification process, lack of sufficient sustainment training or too time consuming during the educational process under current educational guidelines).

As a result, the SOF Medics were receiving the same certification (EMT-P) as the civilians, but were required to have a different knowledge base and skill set in order to provide the care that was needed for their environment. Some of the medical procedures being performed by the Special Operations Forces Medic were not recognized as being within the skill set of the EMT-P, and therefore were not technically certified or authorized by the NREMT certification. Minor surgery, prolonged nursing care, suturing techniques, and medical decision making were out of the question in the civilian world under the NREMT-P certification, but were routinely required of SOF Medics in different areas of the world.

There was a divergence of the medical requirements of the civilian EMS world and military SOF Medic world developing. While the cognitive knowledge and psychomotor skills set for the SOF Medics were not covered by standard United States EMT-P training, the ability to successfully utilize these skills was required. The Special Operations Combat Medic (SOCM), ATP occupational model was developed. This was based on SOF mission activities and the patient populace within those mission parameters, rather than the overall country's general patient populace. To achieve this goal, in addition to the basic core training required for the SOCM Medic (old designation of SOF EMT-P), additional subject matter and training was also necessary. In essence, the SOF Medics were required to meet the requirements for EMT-P, and then received additional advanced training that was not required on the civilian side. Since this was a novel concept, the SOF Medic received no recognition through any type of formal certification or licensing process.

The ATP is a unique hybrid Medic, whose baseline knowledge starts with meeting the cognitive and psychomotor requirements as a Nationally Registered EMT. From there, education and training focus on a myriad of both medical and trauma management problems. Although trauma plays a large and important role in their training, unique military and wilderness environmental problems are also highlighted. Since the Special Operations environment extends to virtually any place on the globe, regardless of time, season, or weather, the ATP must be multifaceted. They are prepared to treat patients in all environmental extremes, perform preventive medicine, dispense and administer medications, and perform multiple procedures. This is a small example of the depth and breadth of knowledge and skill which must be met by the ATP. The scope of practice for the ATP is broad, yet controlled. It has successfully answered the challenge of providing a medically trained individual who is able to provide care in situations where definitive treatment may be hours, or even days away. Combined with very limited resources, the ATP must be able to think out of the box and be able to sustain care.

Because of the different medical requirements (between the civilian and military) that developed, it was only natural that different licensing and certification requirements be developed to maintain the necessary certification of the military healthcare providers. The NREMT certification did not address or certify the SOF Medics to operate with the higher skill sets that were becoming increasingly necessary in the GWOT. Unfortunately, there was not a single national or international recognized prehospital curriculum or certification process that encom-

passed the knowledge base or psychomotor skills needed to successfully conduct medical operations within all of the USSOCOM operational missions.

Since there was no certification process that authorized the procedures that were being performed or the degree of independent medical activity that was being performed, it became necessary to develop a new level of medical certification. After conversations with the National Registry yielded no solutions, the Commander of USSOCOM directed the USSOCOM Surgeon to develop a method of training and certifying SOF Medics to requirements that would ensure mission success. The new level of certification had a number of goals:

- Withstand outside scrutiny of inspecting or accrediting educational agencies.
- Certify the SOF Medics for their unusually high degree of medical techniques and advanced nursing care that must be administered prior to evacuation.
- Develop a curriculum that would allow for the certification process.
- Develop the legal basis and framework under which the new certification process could be developed and implemented.

While this initially seems to be a relatively straight-forward task – develop a new level of certification, the implementation was slow and complex. Before developing the ATP certification, which would authorize the higher knowledge base, skill set, and level of medical authority of the SOF Medic, it was necessary to:

- Develop a departmental structure comprised of pre-existing personnel within the USSOCOM Headquarters / Component Commands and volunteer healthcare providers and educators from the conventional military and civilian medical communities.
- Mirror business practices and medical credentialing processes to that of State and provincial governments' Bureaus of Emergency Medical Services.
- Establish a RB, composed of operational level enlisted medical operators and physicians, to develop an educational needs assessment, including identification of the fundamental tasks (a Critical Task List [CLT]) that the Special Operations Force enlisted Medic should be capable of successfully performing, while providing sound medical care. Essentially, the CLT would form the basis for the scope of practice for the new ATP certification.

- Develop a medical curriculum and certification process through the employment of a specialized CEB, comprising professional healthcare providers and educators from various backgrounds and communities. Specifically, the CEB comprises subject matter experts selected from the conventional side of military medicine, the SOF side of military medicine, and the civilian world of medicine. The Board members consisted of military physicians, civilian physicians, military educators, civilian educators, and military medical Operators. This balance allowed a number of different perspectives to be introduced throughout the development process.
- Seek accreditation by the Committee on Accrediting Emergency Medical Services Programs (CoAEMSP) for the medical training centers of USSOCOM.

From a practical viewpoint, the RB developed the CTL necessary for the ATP portion of the course. It was then given to the CEB which:

- Developed the recommended Terminal Learning Objectives and Enabling Learning Objectives that would satisfy the requirements for testing of the knowledge required by the CTL. (Teaching would remain the responsibility of the Joint Special Operations Medical Training Center and the Pararescue School at Kirtland Air Force Base.)
- Developed the test bank of questions that would eventually become the basis for the ATOPcertification exam.
- Developed the testing process for this exam.
- Developed the review process for determining question validity.
- Developed a study guide for the ATP students for the certification test.
- Developed the administrative oversight process for the testing process.
- Developed the TMEPs for a set of medical conditions that would further define independent medical care by the ATP. This also led to the establishment of medical protocols for use in the Special Operations environment when direct medical control and oversight was either operationally impractical or impossible.

As the Special Operations environment is an ever-evolving one, the question of the development process and subject matter process is also an ongoing process as medical technology and treatment approaches change. Finally, as knowledge from "Lessons Learned" studies becomes available, the ATP certification process will be adapted to reflect the updated knowledge and procedural changes.

Once certified, the ATP certificate is valid for two years, and is then renewed after attending the Special Operations Combat Medic Sustainment Skills Course (SOCMSSC) and obtaining the required additional CME.

The CoAEMSP has recently reviewed the curriculum at the Joint Special Operations Medical Training Center (JSOMTC), and has certified that the JSOMTC is CoAEMSP compliant.

In summary, the current process has allowed for the successful development of a certification process to ensure that medical training supports mission requirements while simultaneously ensuring quality that will meet external scrutiny. The "state-like agency" (USSOCOM-SG), with overall certification and licensing responsibility, has allowed for the establishment of a quasi-independent Board for the purpose of ATP certification. This, in turn, has resulted in the successful development of a certification process that recognizes the advanced clinical skills and knowledge required by the SOCM Medic; and allows for uniform education of the SOCM level Medic in the Special Operations environment in all Services (Army, Navy, Air Force, Marine). In developing the TMEPs, the CEB attempted to mirror civilian paramedic guidelines when they were applicable and established others where gaps were identified. This required extensive 'out of the box' thinking, particularly when dealing with situations where resource constraints and prolonged evacuation times dominated the decision making process (i.e., limited weight and space requirements for the medical backpack, supplies, and medications). However, focusing on the end state and the fulfillment of the mission requirements allowed solutions to be developed, that initially seemed unachievable.

Following this, sustainment training was developed with a two-year time limited certificate to assure that practicing ATPs were kept abreast of new advances and changes in protocols and medical knowledge. Constant feedback from the field, and the ever changing Special Operations environment, continued to drive these protocols forward. This was fundamentally achieved by what Mr. Brown coined as the 'cognitive leaders', who were field-level experts.

COGNITIVE LEADERS

The 'cognitive leader' Medic was the linchpin for all of this to be accomplished. He is the individual who drives innovation and forces others to think beyond their currently perceived environment; the individual who asks not "why," but "why not;" the professional who focuses on what they are seeing every day whether it be in the streets of New York City or Baghdad, and determines how care and skills can be utilized with maximum effect and efficiency for better patient or casualty outcome. While this has happened previously at the local or unit level, USSOCOM centralized these thinkers and collectively established universal innovations. Many of these cognitive leaders came directly from the field for input, prior to then returning back to the operational environment. This process has allowed USSOCOM to break through the barriers (non-certified practices and procedures that the SOCM was doing outside the scope of practice of the EMT-P) of traditional prehospital medical thinking and implement some truly innovative solutions on an organization-wide basis, utilizing near real-time feedback as well as evidence-based practice. By allowing this freedom of thought, these new cognitive leaders could bring novel solutions to the highest level in the shortest period of time. As always, organizational change is not always easy and many concepts never made it beyond the "good idea" phase for multiple reasons; but the innovation that was accomplished by listening and encouraging these profound thinkers fundamentally improved the system of medical care in the prehospital environment.

THE JOURNEY TOWARDS THE SPEED OF SOUND

Germany, Great Britain, the United States, as well as countless individuals all greatly contributed to the successful flight of Chuck Yeager in his X-1 aircraft on 14 October 1947, when he broke the sound barrier during level flight. We feel the maturation and success of the Advanced Practice Paramedic is likewise going to take the same cooperation among many individuals, agencies and states. Our experience is offered as a starting point, and perhaps as a framework for discussion to investigate this concept in the civilian environment. Austere and rural environments, as well as expeditionary medicine, seem to have direct corollaries to our environment. It has been a long five years for those of us involved in this process. We can only hope that we are now at a stage where meaningful discussions with other agencies concerning the development of the advanced prehospital Medic will allow a smooth ride, beyond the speed of sound and beyond the turbulence.

CARBON MONOXIDE POISONING

We had intended on putting the following educational slides on Carbon monoxide (CO) poisoning written by Dr. Byan E. Bledsoe, a founding member of the CEB and well known EMS educator in the most recent Training Supplement; however, do to the size of the supplement, we chose to put it in this edition. I found this as a supplement to the December 2007 JEMS – Journal of Emergency Medical Services magazine. CO poisoning is an extreme and frequent hazard encountered by civilian firemen and paramedics throughout the world. It is an expectation when dealing with combustion and confined spaces, similar to what we are seeing on the Iraqi battlefield in some situations. Collapsed buildings and fire from hostile and non-hostile activities are common. Winter heating and poor ventilation are common in most buildings throughout the country. I found this article to be a great reference for SOF Medics on the subject.

CPT Scott Gilpatrick

Case Study

A 26-year-old mother of two visits her family physician complaining of a severe headache that does not go away following repeated doses of Excedrin®. He performs a detailed neurological exam and finds nothing specific. Because it is winter, he decides to treat her for sinusitis as this may be the cause of her headaches. She is sent home with a prescription for amoxicillin (Amoxil) and acetaminophen with codeine (Tylenol #3). The next day her headache is worse and she is now vomiting. Her children have been visiting her ex-husband and are scheduled to return the next day. Finally, she is too weak to drive and calls 9-1-1. Based on the evaluation and coding of the call in dispatch, an ambulance crew is dispatched. The crew evaluates her and then transports her to the emergency department. There, she is triaged and placed into a minor treatment room. The emergency physician evaluates her and finds nothing specific. He orders an IV of normal saline and medication is administered for vomiting and for pain. To be safe, he orders a computed tomogram (CT) scan of the patient's brain. The results of the CT scan are negative. The emergency physician is comfortable that the patient does not have a life-threatening neurological condition and discharges her home with instructions to continue the amoxicillin and acetaminophen with codeine and follow-up with her family practitioner. He writes her a prescription for promethazine (Phenergan) suppositories to help with the nausea and vomiting. When she arrives home by taxi, her ex-husband is waiting in the car to transfer the children to her.

The next morning, she awakens to the same headache. Her children have slept with her and are difficult to awaken. Once up, they have trouble walking and stumble and fall. She again summons 9-1-1. Because there are three patients, a first responder crew along with two ambulances are dispatched.

The ALS firefighter first responder crew arrives on scene. The house is warm and has a slight odor of natural gas. The weather is cold and the patient has been sleeping in a small room with a space heater. The Lieutenant on the engine calls for a chemical detector. Carbon monoxide is detected in the house at levels ranging from 1,200 ppm to 1,680 ppm. An additional ambulance is summoned. The children and mother are removed to the ambulances and high-concentration oxygen administration started. The heater is shut off and removed for inspection. All windows in the house are opened and exhaust fans are placed for ventilation. A dead kitten is found in the children's bedroom.

The mother is returned to the same emergency department where she had been the night before. Her carboxyhemoglobin level is 29%. She is evaluated and admitted and undergoes hyperbaric oxygen therapy.

The children are transported to the regional children's hospital. The boy, aged 4 years, has a carboxyhemoglobin level of 14%. The girl, aged 2 years, has a carboxyhemoglobin level of 17%. Both are admitted and observed. Both do well and their respective carboxyhemoglobin levels fall during the next 24 hours. They are discharged and ultimately do well with no long-term ill effects. The mother is discharged 48 hours after admission. She too does well with no long-term problems. The fire department and building inspectors find the house unsuitable for habitation and the family moves in with the maternal grandmother. Litigation is being considered against the family physician, the emergency physician who cared for her on the initial visit, and the EMS crew who failed to recognize the possibility of carbon monoxide poisoning during the first transport.

INTRODUCTION

Carbon monoxide is the most common cause of poisoning in industrialized countries, including the United States and Canada. Fire department (FD) personnel are often the first to encounter victims of carbon monoxide poisoning. In addition, because of the nature of the profession, firefighters are at increased risk of occupational exposure to carbon monoxide (see Figure 1•).

In this presentation we will review the chemistry, incidence, pathophysiology, detection, long-term effects, and treatment of carbon monoxide poisoning. There will be an emphasis on new technologies that now allow the

◆ *Carbon monoxide* is a colorless, odorless, highly poisonous gas that is formed by the incomplete combustion of carbon or of a carbonaceous material (e.g., gasoline)

Fire department (FD) personnel are often the first to encounter victims of carbon monoxide poisoning.

Figure 1.
Firefighters are at increased risk of occupational exposure to carbon monoxide.

✦ *Cyanide* – any of the various salts or esters of hydrogen cyanide containing a CN group, especially the extremely poisonous compounds potassium cyanide and sodium cyanide.

✦ *Carbon-containing fuels* – fuels that contain the element carbon and include fossil fuels (e.g., gasoline, oil, kerosene) as well as biological sources (e.g., wood, grass).

✦ *Bond* – an electrical force linking atoms.

✦ *Endogenous* – produced or growing from within.

✦ *Exogenous* – derived or developed from outside the body; originated externally.

✦ *Methylene chloride* – a colorless liquid, practically nonflammable and nonexplosive; used as a refrigerant in centrifugal compressors, a solvent for organic materials, and a component in nonflammable paint-remover mixtures.

....
Carbon monoxide (CO) is an odorless, colorless, tasteless gas.
....

diagnosis and monitoring of patients exposed to carbon monoxide in the prehospital setting. In addition, we will investigate the incidence and significance of combination poisonings with *cyanide* and carbon monoxide.

CHEMISTRY OF CARBON MONOXIDE

Carbon monoxide (CO) is an odorless, colorless, tasteless gas. It is non-irritating and results from the incomplete combustion of *carbon-containing fuels*. The CO molecule consists of one carbon atom and one oxygen atom joined by a triple *bond*. CO is an extremely stable molecule (see Figure 2●).

While CO is often associated with fossil fuels, it is important to remember that it also results from the incomplete combustion of wood and charcoal. CO is a major source of poisoning in many third-world countries where much of the cooking occurs over wood-fired stoves and ovens. It is also prevalent when wood-fired heaters are used to warm a structure.

SOURCES OF CARBON MONOXIDE

There are two primary sources of CO. These are classified as either *endogenous* or *exogenous*. In addition, the hydrocarbon *methylene chloride* is also a source of CO.

Endogenous Sources

Small amounts of CO are routinely produced through endogenous sources. These primarily result from the normal breakdown of *hemoglobin* in a process called heme *catabolism*. In certain disease states, the breakdown of hemoglobin is increased. These conditions include such things as the *hemolytic anemias* and can also occur in *sepsis*.

Figure 2.
The carbon monoxide molecule consists of one atom of carbon bound to one atom of oxygen through a triple bond.

Education and Training

Figure 3.
Any combustible item should be considered a possible source of CO.

Exogenous Sources

Certainly, most CO exposure is related to exogenous causes. Among these are house fires, automobile exhaust fumes, fumes from propane-powered vehicles (e.g., forklifts), heaters, indoor stoves, camp stoves, boat exhaust fumes, gas-powered electrical generators, cigarette smoke, and smoke from charcoal-fired cook stoves and ovens. Essentially, any combustible item should be considered a possible source of CO (see Figure 3•).

Methylene chloride is an organic hydrocarbon consisting of two hydrogen atoms and two chloride atoms bound to a carbon atom. It is often used as an industrial solvent, particularly as a paint remover and adhesive remover. Methylene chloride is converted to CO in the liver after inhalation. Persons exposed to high levels of methylene chloride can develop carboxyhemoglobinemia and the signs and symptoms of CO toxicity.

INCIDENCE OF CARBON MONOXIDE POISONING

As discussed previously, CO is the leading cause of poisoning deaths in industrialized countries. In fact, CO may be responsible for half of all poisonings worldwide. Approximately 40,000 to 50,000 emergency department visits annually are due to CO poisoning. In the United States, as many as 5,000 to 6,000 people die annually as a result of CO poisoning.

When studied, most accidental CO poisonings were found to be due to house fires, automobile exhaust fumes, indoor heating systems, gasoline-powered portable electric generators, stoves and other appliances, charcoal grills, camp stoves, water heaters, and boat exhaust fumes (see Figure 4•). There is an increased risk of accidental CO deaths in patients who are male, older than age 65, and who are intoxicated with ethanol. Accidental CO deaths tend to peak during winter months. This is primarily related to the use of heating systems or portable electric generators combined with closed windows. There is often a significant increase in CO poisoning following disasters and storms. Such an increase was seen following hurricanes Katrina and Rita in 2005. In addition, the severe winter storms that struck Seattle and the Pacific Northwest in early 2007 were associated with a significant increase in CO-related poisonings. This increase in CO poisoning was primarily related to the use of gasoline-powered portable electric generators and fuel-powered heaters following a loss of utilities.

+ *Hemoglobin* – a complex protein containing iron that carries oxygen in the blood.

+ *Catabolism* – the breakdown of more complex substances into simpler substances with the release of energy.

+ *Hemolytic anemia* – anemia resulting from the abnormal destruction of red blood cells, as in response to certain toxic or infectious agents and in certain inherited blood disorders.

+ *Sepsis* – the presence of pus-forming bacteria or their toxins in the blood or tissues.

+ *Carboxyhemoglobinemia* – an increase in the amount of carboxyhemoglobin in the blood.

Figure 4.
House fires are a major
source of CO poisoning.

Carbon Monoxide Poisoning and Pregnancy

CO poisoning in the pregnant female is a particular danger. The developing fetus contains a type of hemoglobin that is different from adult hemoglobin. *Fetal hemoglobin (HgF)* is the principal type of hemoglobin found during fetal development and has a much greater affinity for oxygen compared to adult hemoglobin. This assures that the developing fetus has adequate oxygen stores during the crucial stages of development. Fetal hemoglobin is largely replaced by adult hemoglobin (HgA) shortly after birth. In addition to an increased affinity of fetal hemoglobin for oxygen, there is also an increased affinity for CO. Thus, while the mother may experience mild to moderate symptoms following CO exposure, the fetus may have devastating damage. Intrauterine exposure to CO has been associated with an increased incidence in *cerebral palsy*, seizure disorders, and death. This factor is one of the physiologic reasons that pregnant women should not smoke.

CARBON MONOXIDE EXPOSURE

Small quantities of CO are present in the environment and are referred to as primary sources. Environmental exposures are typically less than 0.001% (10 ppm). As one would expect, environmental CO levels are higher in urban and heavily industrialized areas. Primary sources of environmental CO include volcanic gases, brush fires, and human pollution. The amount of CO in the environment varies significantly from year to year depending upon climatic changes and volcanic activity (see Table 1).

CO exposure in living organisms is directly related to four factors:

- *Minute volume*—the minute volume (V_{min}) is the amount of air exchanged in the lungs during one minute. It is a function of the respiratory rate and the tidal volume. The tidal volume (V_t) is the amount of air in each breath that reaches the point in the alveoli where gas exchange can occur. Minute volume is reflected in the following formula:

$$V_{min} = V_t \times \text{respiratory rate}$$

- *Duration of exposure*—the duration of exposure is the amount of time that the organism is exposed to CO. As a rule, the longer the duration of exposure, the more severe the poisoning.
- *CO concentration*—the concentration of CO in the atmosphere is directly related to the severity of poisoning. High levels of CO will cause signs and symptoms of

Source	Exposure (ppm)
Fresh Air	0.06–0.5
Urban Air	1–30
Smoke-Filled Room	2–16
Cooking on Gas Stove	100
Actively Smoking a Cigarette	400–500
Automobile Exhaust	100,000

Table 1. CO Exposure Levels Based upon Environmental Factors

toxicity much faster than lower levels. However, even low levels of CO can ultimately result in toxicity.

- *Oxygen concentration*—Because CO competes with oxygen for the *oxygen-binding sites* on hemoglobin, the concentration of oxygen in the atmosphere directly affects the rate and degree of CO exposure. In environments with oxygen concentrations less than that of the atmosphere (normally 21% at sea level), the risks of developing CO toxicity from exposure are increased. This is a particular problem in closed-space rescue situations and a significant problem in the mining industry. The role of oxygen concentration is important when considering treatment strategies. As oxygen and CO compete for the same binding sites, increasing the concentration of inhaled oxygen (FiO_2) can help minimize the binding of CO to hemoglobin and can, in fact, displace some CO that has already bound to hemoglobin. Furthermore, increasing the FiO_2 will help promote the removal of carboxyhemoglobin from the circulation.

✦ *Oxygen-binding sites* – iron-containing parts of hemoglobin where oxygen binds for transport to the peripheral tissues.

✦ *FiO₂* – the concentration of inspired oxygen; usually represented as a decimal (0.21) but also as a percentage (21%).

Several government agencies have established exposure limits for CO. The Occupational Health and Safety Administration (OSHA) has set an exposure level of 50 ppm (as an 8-hour time-weighted average). The National Institute of Occupational Safety and Health Administration (NIOSHA) of the Centers for Disease Control and Prevention (CDC) has set an exposure level of 35 ppm (as an 8-hour time-weighted average). The NIOSH level is lower because it is based upon the negative cardiac effects of CO.

CO is a particular risk for firefighters. Many of the environments encountered by firefighters have the potential for having elevated CO levels. Sources of CO exposure for firefighters include: structure fires, apparatus fumes, portable equipment fumes (e.g., gasoline-powered saws and generators), underground utility fires, and closed-space rescue situations (see Figure 5•).

Figure 5.
Many of the environments encountered by firefighters have the potential for having increased CO levels.

PATHOPHYSIOLOGY OF CARBON MONOXIDE POISONING

The pathophysiology of carbon monoxide poisoning is actually quite complex. While CO poisoning was first described in 1857 by French physician Claude Bernard, it has only been in recent years that the pathophysiology of CO poisoning has been elucidated.

CO EFFECTS ON HEMOGLOBIN

CO competes with oxygen for the oxygen-binding sites on hemoglobin. Each hemoglobin molecule contains four oxygen-binding sites. These binding sites contain iron and form a complex referred to as *heme*. The heme structure is, in turn, connected to the protein segments of hemoglobin (see Figure 6●). Because of its molecular structure, CO will bind to hemoglobin with an *affinity* that is greater than 200 times that of oxygen. The binding of CO to hemoglobin results in the formation of a compound called *carboxyhemoglobin (COHb)*. As CO levels increase in the blood, oxygen molecules will actually be displaced from hemoglobin causing a premature release of the remaining oxygen in the tissues. Furthermore, CO will prevent oxygen molecules from binding to hemoglobin (see Figure 7●). Carboxyhemoglobin cannot carry oxygen. As CO poisoning increases, and carboxyhemoglobin levels rise, the amount of hemoglobin that is saturated with oxygen, called *oxyhemoglobin (O₂Hb)*, is increasingly diminished. This ultimately affects organ systems that are highly dependent upon *aerobic metabolism* and thus oxygen.

As a general rule, once CO binds to hemoglobin and forms carboxyhemoglobin, it can only be removed via degradation of carboxyhemoglobin. That is, carboxyhemoglobin is ultimately removed from the circulation and destroyed. The normal *half-life* of carboxyhemoglobin, when the patient is breathing room air, is 240 to 360 minutes (4–6 hours). The half-life of COHb can be decreased to 80 minutes with the administration of 100% oxygen. The administration of oxygen under pressure, termed *hyperbaric oxygen (HBO) therapy*, further reduces the half-life of COHb to approximately 22 minutes.

CO Effects on Myoglobin and Other Iron-Containing Proteins

In addition to binding to hemoglobin, CO also binds to other iron-containing proteins. These include *myoglobin* and *cytochrome* among others. The effects of CO on myoglobin are particularly important. Myoglobin is an iron-containing protein similar to hemoglobin and is found in selected tissues, particularly muscles, and serves as a storage site for oxygen. Myoglobin is especially important in the heart. A reduction in functional myoglobin results in decreased oxygen levels in the heart. This could lead to cardiac ischemia, dysrhythmias, and other types of cardiac dysfunction. Cytochrome is important in the cellular production of energy. The effects of CO on cytochrome molecules are very similar to the effects of cyanide.
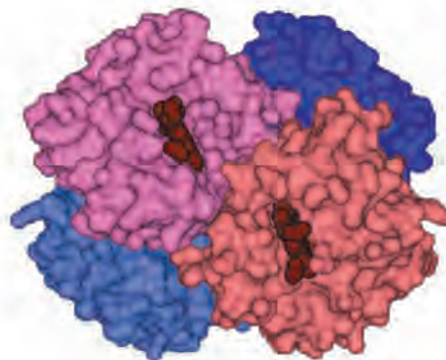
Figure 6.
Each hemoglobin molecule contains 4 iron-containing (heme) oxygen binding sites.
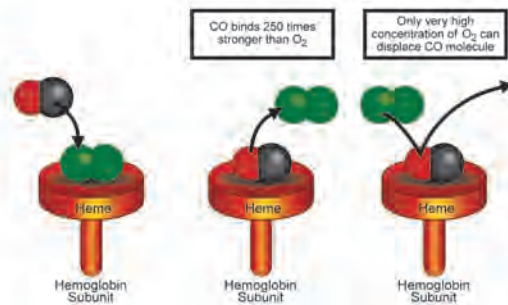
Figure 7.
CO binds to the heme binding sites on hemoglobin with 250 times the affinity of oxygen. Only very high concentrations of oxygen will begin displacement of the bound CO molecules.

Normal Carboxyhemoglobin Levels

Some levels of carboxyhemoglobin are normally present in the blood—either from environmental exposure or endogenous sources. These levels are, of course, higher in tobacco smokers. Endogenous CO production usually results in carboxyhemoglobin levels (COHb) between 0.4 and 0.7%. Persons who smoke one pack of cigarettes per day will often have COHb levels ranging from 5–6%. Persons who smoke two to three packs per day will often have levels ranging between 7 and 9% (or even higher) depending on the cigarette type and filter. CO production from cigar smoking varies significantly. COHb levels of up to 20% have been reported with cigar smoking. However, these levels are extremely variable depending on whether or not the smoker inhales the cigar smoke and the duration of exposure. COHb levels are higher in urban commuters when compared to their suburban and rural counterparts (see Table 2). Interestingly, CO toxicity is a particular concern for persons working in toll booths—particularly in urban areas where cars idle. COHb following methylene chloride exposure (100 ppm for 8 hours) can result in levels of 3–5%.

Impact of CO on Body Systems

The impact of CO poisoning on major body systems is quite varied. Body systems that are highly reliant upon aerobic metabolism are particularly vulnerable to the effects of CO. Of these, the central nervous system and the cardiovascular system are most frequently affected.

Central Nervous System

As a rule, the impact of CO on the central nervous system causes nervous system dysfunction. This results in impairment manifesting as headache, dizziness, confusion, seizures, and ultimately coma. It has been well documented that there are now long-term complications associated with CO exposure. These are primarily *cognitive* and *psychiatric* problems, and cardiovascular disease.

Cardiovascular System

The cardiovascular system is also adversely affected by CO. This usually manifests as depressed myocardial function and results in numerous signs and symptoms. These include such things as chest pain, hypotension with tachycardia, cardiac dysrhythmias, myocar-

✦ *Cytochrome* – any of a group of cell proteins (hemoproteins) that serve a vital function in the transfer of energy within cells.

✦ *Cognitive* – relating to the mental process of knowing, including aspects such as awareness, perception, reasoning, and judgment.

✦ *Psychiatric* – pertaining to a mental disturbance or derangement.

Source	COHb (%)
Endogenous	0.4–0.7
Tobacco Smokers:	
1 pack/day	5–6
2–3 packs/day	7–9
Cigars	Up to 20
Urban Commuter	5
Methylene chloride (100 ppm for 8 hours)	3–5

Table 2. Normal Carboxyhemoglobin Levels.

dial ischemia and ultimately *ventricular fibrillation*. Most deaths from CO poisoning are due to ventricular fibrillation. It has been shown that CO has adverse long-term effects on the cardiovascular system. For example, the risks of a premature cardiac death are higher in patients who sustain a myocardial injury during the initial CO insult.

Other Body Systems

In addition to the central nervous system and cardiovascular system, other body systems are also adversely affected by CO poisoning. For example, metabolic derangements are common following CO exposure. Initially, *respiratory alkalosis* occurs primarily from hyperventilation. Later, and with severe exposures, *metabolic acidosis* is noted.

The respiratory system is also adversely affected by CO. In approximately 10 to 30% of patients with CO poisoning, pulmonary edema will occur. This can result from the direct effect of CO on the alveolar membranes. It can also occur with left ventricular failure that is secondary to myocardial depression. Because CO is often associated with nausea and vomiting, the possibility of aspiration as a cause of acute pulmonary edema must also be considered. In addition, because of the effects of CO on the central nervous system, *neurogenic pulmonary edema* must also be considered.

Ultimately, especially with significant exposures, *multiple organ dysfunction syndrome (MODS)* can result. MODS occurs when two or more organ systems fail to maintain their essential functions. The mortality rate with MODS is quite high.

Summary of CO Effects

In summary, the pathophysiological effects of CO can be detailed as follows:

- *Limits oxygen transport*—CO binds more readily to hemoglobin than oxygen, forming carboxyhemoglobin, which cannot transport oxygen.
- *Inhibits oxygen transfer*—CO changes the structure of hemoglobin thus causing the premature release of oxygen into the tissues.
- *Causes tissue inflammation*—Poor and inadequate tissue perfusion initiates and maintains an *inflammatory response*. This response may, at times, further injure body cells and tissues.
- *Causes reduced cardiac function*—CO is a myocardial depressant and adversely affects myocardial function. This can lead to dysrhythmias, myocardial ischemia, and even myocardial infarction. Long-term cardiac effects, including an increased risk of premature cardiac death, have been documented.
- *Causes vasodilation*—Vasodilation, as detailed previously, can cause syncope and worsen tissue perfusion. This vasodilation is primarily mediated through the increased release of gaseous *nitric oxide*. Nitric oxide oxidizes hemoglobin forming *methemoglobin*. As methemoglobin levels increase, the oxygen-carrying capacity of the blood falls.

Long-Term Effects of CO Exposure

It is now recognized that the adverse effects of both acute and chronic CO exposure can result in long-term problems for those exposed. This has particular application to firefighters. It has long been known that up to 45% of on-duty firefighter deaths are due to cardiovascular disease. As a rule, these deaths have been attributed to coronary artery disease. A recent study found that most on-duty firefighter deaths occur during active fire suppression activities (See Table 3). However, deaths were reported during all aspects of firefighter duties including non-fire suppression activities. It has been suggested that many of these deaths are due to a lack of physical fitness, obesity, and similar risk factors. While it would seem intuitive that cardiovascular risks in firefighters should be similar to those of the population as a whole, there are other factors that must be considered.

As discussed previously, the pathophysiology of CO poisoning is actually quite complex. In fact, we still do not fully understand its effects. However, it is becoming clear that the adverse effects of CO poisoning are not simply limited to the initial insult. In certain patients, either following single or repeated exposure, an inflammatory response begins that may lead to many chronic disease processes.

Duty	Deaths N = 449
Fire Suppression	144 (32.1%)
Alarm Response	60 (13.4%)
Alarm Return	78 (17.4%)
Physical Training	56 (12.5%)
EMS and Non-Fire Emergencies	42 (9.4%)
Fire Station and Other Nonemergency Duties	69 (15.4%)

Table 3. Deaths from Coronary Heart Disease among Firefighters Based on Duty Type*
*Modified from Henry CR, Satran D, Lindgren B, et al. "Myocardial injury and long-term mortality following moderate to severe carbon monoxide poisoning." *JAMA.* 2006; 295:398–402.

Typically, following CO exposure, there will be a phase of decreased oxygen levels in the blood (hypoxemia). This is usually followed by a period of re-oxygenation when the victim is removed from the toxic environment and oxygen administered. It also occurs when carboxyhemoglobin is broken down and replaced with normal hemoglobin. The effects of CO-mediated hypoxemia are dependent upon any underlying disease that might be present (such as emphysema or heart disease). These periods of hypoxemia often result in the formation of dangerous chemicals called *free radicals*. Free radicals are highly reactive chemical compounds and can cause significant damage to the cells of the body. An increase in free radical compounds results in what is known as *oxidative stress*. Oxidative stress can injure cells, tissues, or organs and is associated with the development of many diseases including atherosclerosis, Parkinson's disease, Alzheimer's disease, and several other chronic disease processes. Thus, oxidative stress can cause injury to oxygen-sensitive tissues, such as the brain and the heart, beyond those caused by the initial hypoxemic insult.

As discussed previously, CO poisoning can occur following both acute and chronic exposures. Both acute and chronic exposures can result in long-term, often permanent, problems. CO is an occupational risk for firefighters. Although a well-fitted self-contained breathing apparatus (SCBA) can protect the firefighter from environmental gasses, the SCBA is often not worn through all phases of fire operations. It is not uncommon to see elevated COHb levels up to 5% during the overhaul phase of operations—when the SCBA is often removed.

The heart is highly dependent on a constant supply of oxygen to function normally. Thus, the heart is highly susceptible to decreases in available oxygen. It is also susceptible to oxidative stress. As discussed above, myocardial injury can result from tissue hypoxia as well as cellular damage due to the release of free radicals. Myocardial injury can manifest as failure of the heart to pump adequately or as cardiac ischemia. It has been demonstrated that victims of moderate to severe CO poisoning are at increased risk of later developing cardiovascular complications and early death. These complications occur in all age groups regardless of the patient's underlying health status. In a 2005 study, researchers in Minneapolis studied 230 victims of CO poisoning and found that myocardial injury is common in moderate to severe CO poisoning. In this study, two groups of patients were identified. The first group of patients was young (average age 43 years) and had few cardiac risk factors. The second group was older (average age 64 years) and had more cardiac risk factors. These patients were followed for an average of 7.6 years after their initial poisoning. Based upon this study, the following factors were found to be predictors of myocardial injury:

- Male gender
- Hypertension
- Glasgow Coma Score < 14

No other risk factors were found. Interestingly, of the 85 who had myocardial injury, 32 (38%) eventually died. In contrast, only 22 (15%) of the 145 patients who did not sustain myocardial injury eventually died. The authors wrote, "While the precise mechanism for the increase in mortality is not clear, cardiovascular death was much more common

+ Free radical – a highly reactive oxygen-containing molecule with an unpaired electron in the outer shell. Free radicals can damage important cellular molecules such as DNA or lipids or other parts of the cell.

+ Oxidative stress – a general term used to describe the steady state level of oxidative damage in a cell, tissue or organ, caused by reactive oxygen species (free radicals).

(44% vs 18%) among patients who initially sustained myocardial injury." Myocardial damage following CO poisoning has been reported in children. In one study of pediatric CO poisoning, the risk of death improved with hyperbaric oxygen therapy.

Although most studies have addressed immediate deaths from CO poisoning, other research is starting to demonstrate that long-term mortality may be related to both acute and chronic CO exposure. In a Swedish study, researchers measured COHb levels in men who never smoked and correlated these with subsequent mortality. The COHb levels in the never smokers ranged from 0.13% to 5.47%. Never smokers with COHb levels in the top quartile (25%) had a significantly higher incidence of cardiac events and deaths compared to those in the lowest quartile. They concluded that the incidence of cardiovascular disease and death in nonsmokers was related to COHb levels and suggested that measurement of COHb levels should be a part of risk screening for cardiovascular disease.

Like the heart, the brain is highly dependent upon a constant supply of oxygen. CO poisoning can interrupt oxygen delivery to the brain causing brain hypoxia. This is later followed by oxidative stress. The detrimental effects of hypoxia and oxidative stress can be either temporary or permanent.

Both acute and chronic neurological problems have been documented following CO poisoning. These occur regardless of whether the CO exposure is acute or chronic. It is believed that the mechanism of brain injuries is also related to the production of free radicals—primarily nitric oxide (NO). NO is normally found in the body and causes vasodilation. It can also injure or kill cells through oxidative stress. NO levels are increased with CO exposure.

Numerous neurological findings have been reported following CO exposure. These are primarily affective (mood) and cognitive (thought) in nature. In a study of 127 CO poisoned patients, researchers found that depression and anxiety were common. In fact, depression and anxiety were present in 45% of the patients at 6 weeks and in 44% of the patients at 6 months. Depression and anxiety were higher initially in patients whose CO exposure was due to a suicide attempt. However, at 12 months post-exposure, there were no differences in anxiety and depression levels between those exposed to CO accidentally or as a suicide attempt.

A phenomenon called *delayed neurologic syndrome (DNS)* has been identified as a complication of acute and chronic CO poisoning. In DNS, recovery from the initial CO poisoning is seemingly apparent only to have the victim develop behavioral and neurological deterioration anywhere from 2–40 days later. The true prevalence of DNS is uncertain with estimates ranging from 1–47% after CO poisoning. It is clear that patients who have more CO poisoning-related symptoms initially appear more apt to develop DNS. In addition, DNS is more common when there is a loss of consciousness in the acute poisoning. DNS has also been reported in children. Scientific studies are mixed as to whether hyperbaric oxygen therapy prevents DNS. Other neurologic complications, such as *parkinsonism*, have been reported with DNS.

It has been demonstrated that most duty-related firefighter deaths result from cardiovascular disease. Certainly, cardiovascular risk factors such as smoking, obesity, lack of exercise, and dietary indiscretion are somewhat similar in firefighters to that of the population as a whole. Thus far, studies of duty-related firefighter deaths have not identified employment as a particular risk factor for the development of cardiovascular disease and ultimately death. However, these studies have not looked at the effects of CO poisoning (both acute and chronic) as a confounding variable in firefighter duty-related deaths. In addition, additional knowledge about CO poisoning suggests that chronic exposure to CO-induced free radicals, and resultant oxidative stress, may, in fact, be a major occupational risk factor for cardiovascular disease and early death. In addition, exposure to cyanide and other toxic gasses may compound the effects of CO in firefighters. Firefighters should minimize, as much as possible, their exposure to CO. In addition, more research is needed to further define the link between occupational CO exposure and the development of cardiovascular and neurologic disorders among firefighters.

+ *Delayed neurologic syndrome (DNS)* - a constellation of neurologic signs and symptoms seen after moderate to severe carbon monoxide poisoning.

+ *Parkinsonism* - a group of nervous disorders similar to Parkinson's disease, marked by muscular rigidity, tremor, and impaired motor control and often having a specific cause, such as the use of certain drugs or frequent exposure to toxic chemicals.

Populations at Risk

Several patient populations are at increased risk for significant CO poisoning. Persons at the extremes of age, the very young and the elderly, are at increased risk of developing toxic effects from CO due to alterations in their physiology. As well, persons with heart disease are more vulnerable to the ill-effects of CO. They are already having problems related to poor or inadequate myocardial oxygenation. The added effects of CO for these patients can be problematic or even fatal. Pregnant women, for reasons previously detailed, are at risk for the adverse affects of CO. This is primarily due to the effects of CO on the fetus rather than the mother. The fetus is oftentimes more affected by CO than the mother because the fetus primarily has fetal hemoglobin while the mother primarily has adult hemoglobin. This occurs because fetal hemoglobin has a higher affinity for CO than it does for oxygen.

Patients with a decreased oxygen-carrying capacity, such as those with anemia (e.g., iron-deficiency, sickle cell), are also at increased risk for developing toxic effects from CO because of the already limited oxygen-carrying capacity of their blood. Finally, patients with chronic respiratory disease (e.g., asthma, COPD, cystic fibrosis) are at increased risk because their respiratory system is already compromised and inefficient in hemoglobin oxygenation. Any decline in oxygen levels from CO exposure will exacerbate the situation (see Table 4).

SIGNS AND SYMPTOMS OF CARBON MONOXIDE POSIONING

The signs and symptoms of carbon monoxide poisoning are vague and nonspecific. The signs and symptoms closely resemble those of other diseases. Thus, CO poisoning is often called "the great imitator." It is for this reason that CO poisoning is often misdiagnosed. CO poisoning is often diagnosed as a viral illness (e.g., influenza), acute coronary syndrome, and even migraine.

CO poisoning is typically classified as either *acute* or *chronic*. Acute carbon monoxide poisoning results from a short exposure to a relatively high level of carbon monoxide. Chronic CO exposure, on the other hand, results from long or recurrent exposures to relatively low levels of carbon monoxide (see Table 5).

Acute CO Poisoning

The signs and symptoms of acute CO poisoning are quite diverse (see Figure 8●). Some patients will develop certain signs and symptoms while others will not. Table 6 lists signs and symptoms associated with acute CO poisoning. The signs and symptoms of chronic CO poisoning are essentially the same as those with acute CO poisoning. However, their onset and severity may be extremely varied.

As a rule, the signs and symptoms of acute CO poisoning worsen with increasing levels of COHb. Table 7 illustrates the signs and symptoms of CO poisoning and the associated classification.

● *Acute* – having or experiencing a rapid onset and short but severe course.

● *Chronic* – a condition that is long-lasting or recurrent.

COHb levels do not always correlate with signs and symptoms nor do they predict sequelae.

- Children
- Elderly
- Persons with heart disease
- Pregnant women
- Patients with increased oxygen demand
- Patients with decreased oxygen-carrying capacity (e.g., anemias, blood cancers, sickle cell disease)
- Patients with chronic respiratory insufficiency
- Firefighters
- Miners

Table 4. Patient Groups at Risk for CO Poisoning.

Malaise	Confabulation	Visual disturbances
Flu-like symptoms	Agitation	Syncope
Fatigue	Nausea	Seizures
Dyspnea on exertion	Vomiting	Fecal incontinence
Chest pain	Diarrhea	Urinary incontinence
Palpitations	Abdominal pain	Memory disturbances
Lethargy	Headache	Gait disturbances
Confusion	Drowsiness	Bizarre neurologic symptoms
Depression	Dizziness	Coma
Impulsiveness	Weakness	Death
Hallucination	Confusion	

Table 5. Signs and Symptoms of CO Poisoning.

COHb	Severity	Signs and Symptoms
<15–20%	Mild	Headache, nausea, vomiting, dizziness, blurred vision
21–40%	Moderate	Confusion, syncope, chest pain, dyspnea, tachycardia, tachypnea, weakness
41–59%	Severe	Dysrhythmias, hypotension, cardiac ischemia, palpitations, respiratory arrest, pulmonary edema, seizures, coma, cardiac arrest
>60%	Fatal	Death

Table 6. Classifications of CO Poisoning.

Interestingly, the cherry red skin color so often associated with CO poisoning is actually an unreliable finding.

It is important to point out that COHb levels do not always correlate with signs and symptoms nor do they predict sequelae. Interestingly, the cherry red skin color so often associated with CO poisoning is actually an unreliable finding. When present, it is usually associated with a significant CO exposure.

Chronic Carbon Monoxide Poisoning

It has been well established in the scientific literature that there are numerous long-term complications from carbon monoxide poisoning. Again, as discussed earlier, these primarily affect the neurologic and the cardiovascular systems because these systems are most oxygen dependent.

Figure 8.
The signs and symptoms of CO poisoning can range from slight headache to cardiac arrest.

	Duration	Symptoms
50	8 hours	OSHA minimum
200	2–3 hours	Mild headache, fatigue, nausea, dizziness
400	1–2 hours	Serious headache—other symptoms intensify. Life-threatening > 3 hours
800	45 minutes	Dizziness, nausea and convulsions. Unconscious within 2 hours. Death within 2–3 hours.
1,600	20 minutes	Headache, dizziness, and nausea. Death within 1 hour.
3,200	5–10 minutes	Headache, dizziness, and nausea. Death within 1 hour.
6,400	1–2 minutes	Headache, dizziness, and nausea. Death within 25–30 minutes.
12,800	1–3 minutes	Death

Table 7. Compounding Effects of Exposure Factors (Timing and CO Concentration) on Signs and Symptoms of CO Poisoning.

- Memory loss
- Confusion
- Ataxia
- Seizures
- Urinary incontinence
- Fecal incontinence
- Emotional lability
- Disorientation
- Hallucinations
- Parkinsonism
- Mutism
- Cortical blindness
- Psychosis
- Gait disturbances
- Other motor disturbances

Table 8. Signs and Symptoms of Delayed Neurological Syndrome (DNS).

Neurological Complications of Chronic CO Poisoning

One of the well-documented long-term effects of chronic CO poisoning is delayed neurologic syndrome (DNS). As stated previously, the actual incidence of DNS is somewhat uncertain. It is clear that DNS is more common in patients who are symptomatic initially following CO exposure. This is particularly true for patients who suffer loss of consciousness during the initial CO exposure. The development of DNS is somewhat enigmatic. Generally, recovery from the initial CO poisoning is essentially normal. However, between 2 and 40 days later, the patient begins to develop behavioral and neurological deterioration. The most common signs and symptoms of DNS include: memory loss, confusion, ataxia, seizures, urinary incontinence, fecal incontinence, emotional lability, disorientation, hallucinations, Parkinsonism, mutism, cortical blindness, psychosis, gait disturbances, and other motor disturbances (see Table 8).

Cardiovascular Complications of Chronic CO Poisoning

In a long-term study of patients who sustained moderate to severe CO poisoning, it was found that patients who suffer a myocardial injury during the initial exposure were at a significantly increased risk of sustaining early cardiac death. Patients in the same study who did not sustain myocardial injury during the acute CO exposure did not appear to exhibit an increased risk of early cardiac death. Although the exact cause remains a mystery, theories point to the inflammatory effects of CO poisoning as a likely cause.

✦ *Lability* – constantly undergoing change or something that is likely to undergo change.

✦ *Mutism* – the condition of being unable or unwilling to speak as a result of a physical or psychological disorder.

✦ *Cortical blindness* – a loss of vision in a normal-appearing eye caused by damage to the visual area in the brain's occipital cortex.

Other Effects of Chronic CO Poisoning

Several studies have indicated that psychiatric symptoms, especially depression and anxiety, can exist for up to 12 months following CO exposure. In one study, the incidence of depression was higher at six weeks in patients who had attempted suicide by CO. However, at 12 months post-exposure, there was no difference in the rates of symptoms between those with accidental CO exposure and those with exposure during an attempt at suicide.

CARBON MONOXIDE DETECTION

Carbon monoxide detectors have now been widely available for more than a decade. However, even today, these remain vastly underutilized. There are numerous models of inexpensive CO detectors available for the home (see Figure 9•). It is important to point out that in 1998, Underwriters Laboratories (UL) revised the guidelines for CO detectors. Thus, units made before 1998 should not be used.

Handheld CO detectors have been available for some time. Noncommercial detectors will only detect CO. Commercial detectors, such as those used by most fire departments, measure several gases. The most commonly measured gases are CO, oxygen, *hydrogen sulfide*, and combustible gases (see Figure 10•). Until recently, biologic detection of CO required hospital-based arterial blood gas sampling or venous blood analysis. Exhaled CO monitoring has been available for some time. Exhaled CO normally correlates with approximate COHb levels ($\pm$ 5%). The device must be calibrated using a cylinder of 100 ppm CO. Now, technologies developed to detect biological carboxyhemoglobin levels in the prehospital and emergency department setting are available. This technology, referred to as *CO-oximetry*, functions in a fashion similar to that of pulse oximetry (see Figure 11•). However, unlike pulse oximetry, CO-oximetry can detect *deoxyhemoglobin (Hb)*, oxyhemoglobin (O_2Hb), carboxyhemoglobin (COHb), and methemoglobin (METHb). The CO-oximeter can provide the following values: oxygen saturation (SpO_2), carboxyhemoglobin percentage (SpCO), methemoglobin percentage *(SpMET)*, and pulse rate. CO-oximetry uses a finger probe similar to that of pulse oximetry (see Figure 12•). However, instead of measuring only 2 wavelengths of light, the CO-oximeter is able to measure 8 different wavelengths. Thus, it can measure four types of hemoglobin instead of two. Research has demonstrated that carboxyhemoglobin levels as measured by CO-oximetry closely correlate to those measured using hospital-based technologies.

Figure 9.
Household CO detector.

Figure 10.
Hazardous gas detector common to fire department operations.

Figure 11.
Modern CO-oximeter.

Light Emitting Diodes (LEDs)

Recessed Photo Detector
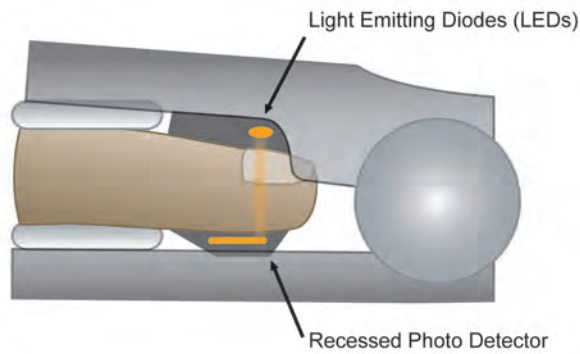
Figure 12.
CO-Oximetry finger probe. The CO-oximeter finger probe measures 8 wavelengths of light compared to 2 wavelengths with standard pulse oximetry.

Because the signs and symptoms of CO poisoning are so vague and nonspecific, CO exposure and poisoning are easy to miss. Failing to detect and diagnose CO poisoning can result in the patient being allowed to return to the contaminated environment with devastating outcomes. Missed CO-poisonings are a particular area of legal liability for fire and emergency personnel. Because of the associated risk, and insidious nature of CO poisoning, CO-oximetry should be considered for all firefighter and EMS operations (see Figure 13●).

TREATMENT OF CARBON MONOXIDE POISONING

It is important to have a low threshold for treating victims of CO exposure. The Centers for Disease Control and Prevention (CDC) have established diagnostic criteria for CO poisoning. CO poisoning can be diagnosed through biological testing when carboxyhemoglobin levels (SpCO) exceed 5% in nonsmokers and 10% in smokers. At present, there is no environmental test for confirmation of CO poisoning. In addition, the CDC has established diagnostic categories for CO poisoning. These are:

- *Suspected*—there is a potentially-exposed person, yet no credible threat.
- *Probable*—there is a clinically-compatible case where a credible threat exists.
- *Confirmed*—there is a clinically-compatible case where biological tests have confirmed exposure.

The treatment of CO poisoning should be based upon the severity of symptoms.

The treatment of CO poisoning should be based upon the severity of symptoms. As a rule, treatment is generally indicated when the SpCO exceeds 12 to 15%. It is important to always be prepared to treat the complications of CO poisoning such as seizures, cardiac dysrhythmias, and cardiac ischemia.

After the patient has been removed to a safe area, it is important to begin the administration of high concentration oxygen. This will serve to maximize hemoglobin oxygen saturation. As oxygen levels in the blood increase, some carbon monoxide molecules will be displaced from hemoglobin. Consider the use of continuous positive airway pressure (CPAP) to fully oxygenate hemoglobin (see Figure 14●). Furthermore, research studies have shown an improvement in neurologic outcome and cardiac complications following early administration of high concentrations of oxygen.

It has been common practice to place patients with moderate to severe CO poisoning in a hyperbaric oxygen (HBO) therapy chamber (see Figure 15●). This increases the atmospheric pressure around the patient and serves to drive oxygen into the tissues and to fully saturate remaining hemoglobin oxygen binding sites. Although widely used, there is no significant body of research that demonstrates that patient outcomes are better following HBO therapy. Regardless, it is still commonly used. The benefits of HBO therapy include the alleviation of tissue hypoxia and a reduction in the half-life of carboxyhemoglobin. Normally, the half-life of carboxyhemoglobin is four to six hours. Through HBO therapy,

Correspondence
Letters to the Editor & Apologies to the Readers

CORRECTIONS

Correction to the **Book Review** in the Spring Edition titled The Dressing Statio: A Surgeon's Odyssey, by Jonathan Kaplan. The review was submitted by COL Warner Farr, not COL Frank Anders as printed.

LETTERS TO THE EDITOR

I just received the winter 08 JSOM edition today. Well done! Lots in there for Medics to MOs. I like the format and content. Keep up the excellent work!

Ian Torrie MPH, MD, ABPM(OM), LCDR

SF Medic Receives Second Highest Medal

Compiled from reports by Army News Service, Fayetteville Observer and Yuma Sun

Republished with permission. Originally published in the July 2008 Mercury, an Army Medical Department publication.

MSG Brendan O'Connor

A 20-year veteran, MSG Brendan O'Connor, formerly a senior Medic on a 2nd Battalion, 7th Special Forces Group (Airborne) Operational Detachment Alpha, was presented the Distinguished Service Cross for valorous actions during Operation Enduring Freedom.

"For the men who were with him that day, Master Sergeant O'Connor is a savior," said Admiral Eric T. Olson, Commander of United States Special Operations Command, who presented the award to O'Connor. "For all Americans, he is a hero, and for all members of Special Operations across the services, he is a source of enormous pride."

O'Connor was instrumental in keeping his team alive during an intense battle with more than 250 Taliban fighters in southern Afghanistan on June 22, 2006. While making a temporary stop during a patrol, his team and their attached Afghan National Army soldiers were attacked from all sides with small-arms fire, heavy machine guns, rocket-propelled grenades, recoilless rifles, and mortars.

During more than 17 hours of sustained combat that followed, O'Connor and his team fought off wave after wave of Taliban attackers from a group of small compounds. Much of the combat was so close that the

defenders of the compounds could hear cursing and taunting from the enemies who swarmed the perimeter.

After hearing that two Soldiers were wounded at another location, O'Connor removed his body armor so he could press his body into a shallow ditch, then low-crawled some 200 feet under heavy machine gun fire to treat and extract his wounded comrades. One teammate commented that as he was crawling, machine gun fire "mowed the grass" around him. O'Connor then carried a wounded Soldier back to a safer area, again passing through intense fire.

One Soldier with a massive leg injury died, but O'Connor was able to save MSG Matthew Binney, also a Special Forces Medic, who had been shot in the head, shoulder, and arm. He then helped organize the continuing defense of the compound and eventual evacuation of the team.

"I don't think that what I did was particularly brave" said O'Connor. "My friend needed help and I had the opportunity to help him, so I did. I think I'm lucky to get this sort of recognition; there are so many other Soldiers who do similarly brave things overseas and are happy with just a pat on the back when they get home."

The DSC is the second highest award for valor, surpassed only by the Medal of Honor. "I've never been more honored, but this medal belongs to my whole team," said O'Connor. "Every member was watching out for the other, inspiring each other, and for some, sacrificing for each other. We all fought hard, and it could just as easily be any one of them standing up here getting it pinned on; every one of them is a hero," he said.

Four other members of the team, including Binney, received the Silver Star, the Army's third-highest award for valor. Binney recovered from his wounds after treatment at Walter Reed and Womack Army Medical Centers, and now is a pre-medical student at the University of Arizona.

Excerpt from the August 2008 *Tip of the Spear*, TSgt Victoria Meyer, USSOCOM Public Affairs

Two legendary members of Special Operations Forces were recently recognized for their contributions to Special Operations. In separate ceremonies, Gunnar Sonsteby, a World War II resistance fighter, and Army COL John Holcomb, commander of the U.S. Army Institute of Surgical Research, were awarded the USSO-COM Medal.

The USSOCOM Medal was established in 1994 to recognize individuals who have made significant contributions to the defense of the United States through Special Operations. Through the years, only 50 people have been recognized with the medal, including former leaders of USSOCOM, civilian supporters of SOF, and Operators who laid the groundwork for today's SOF.

COL John Holcomb also has had a great impact in the Special Operations community. COL Holcomb is a highly decorated surgeon who has made great strides in combat medicine. He started his medical career after graduating from the University of Arkansas Medical School in 1985. Once completing his surgical training in El Paso, Texas, he was assigned to work with the Joint Special Operations Command at Fort Bragg, N.C. He deployed as the Ranger Task Force surgeon in Mogadishu, Somalia. During the Battle of Mogadishu in October 1993, he worked nonstop for 36 hours performing emergency surgeries on the critically wounded who came into the field hospital.

After Mogadishu, COL Holcomb changed his focus to researching and improving combat casualty support in order to increase survival rates. He focused his efforts on finding ways to stop or minimize blood loss to increase the chance of survival in the field. The current field tourniquet is one of his many developments.

ADM Olson presented the medal to COL Holcomb at Fort Sam Houston, Texas, July 23. "Numerous people are alive today because of changes John has made in techniques and training in regards to trauma care," ADM Olson said at the medal ceremony. "It is because of John and who he is and the kind of energy and passion he brought to (his work) that makes it easy to select him for the medal," ADM Olson added.

AFSOC Pararescueman receives 2008 AFSA Pitsenbarger Award

From the August 2008 *Tip of the Spear*
Capt Amy Cooper
AFSOC Public Affairs

An Air Force Special Operations Command Pararescueman has been named the 2008 Air Force Sergeants Association Pitsenbarger Award winner for his heroic actions during an October 2007 firefight against enemy combatants in Afghanistan.

TSgt Davide Keaton, 24th Special Tactics Squadron, is personally responsible for saving the lives of five people during a shootout against Taliban fighters. The five lives he saved; however, were not those of his Coalition teammates; they were those of three Afghan children and two Afghan women who were used as human shields by the enemy.

The day of this particular mission started out no differently than others he experienced during his deployment, for which he was the sole pararescueman with an elite Special Operations team.

"We train the way we fight," Keaton said. "I woke up that day with the same mentality. You have to be on top of your game or bad things can happen."

That training would be put into action when his team was attacked with small-arms fire and rocket-propelled grenades. Once under attack, Keaton risked his own life, moving 150 meters to reach a victim — a seven-year-old Afghan boy shot in the pelvis.

"When I came up to the first little boy, my heart stopped for a second," said Keaton. "He had a serious gunshot wound and had to be taken care of right away."

Keaton used his own body to shield the boy from gunfire while tending to his wounds and then moved him to cover 30 meters away. After stabilizing the first victim, Keaton again braved the barrage of gunfire to find other victims. His second patient, an eight-year-old boy, also had multiple gunshot wounds. After treating the bleeding and stabilizing the boy's spine, he carried the child to the casualty collection point. When he got there, his third victim, an 11-year-old girl, was there in need of treatment.

"I'd never been in an operation like this," Keaton said. "I had my hands full. It seemed like the kids were coming one at a time."

Keaton remained focused despite the young age of his patients.

"You don't think about it," he said. "You just revert back to what you do in training — stabilize them and get them out as quick as possible."

Running low on supplies, Keaton improvised gauze out of clothing to stop his victims' bleeding. After stabilizing his second and third victims, Keaton exposed himself to gunfire, not once, but two more times to aid two Afghan women, one with a severe abdominal wound and near death.

Keaton and his team were eventually able to load the victims on a casualty evacuation helicopter. During the 30-minute flight back to base, he continued to administer trauma care to the victims. To ensure his victims received immediate surgical care upon arrival, Keaton made contact with the hospital via the aircraft's communication system, relaying patient history and medical conditions. Thanks to his efforts, all five patients survived. However, Keaton refuses to take full credit for the lives he saved.

"It's a team effort," he said. "I couldn't have done it by myself. As a PJ, I only have two hands. My teammates helped out, holding things here and there." "There's no doubt in my mind she would have died where she was if we hadn't been persistent and taken care of her," said Keaton, referring to the woman with a gunshot wound in her abdomen.

For Keaton, the experience was part of what he described as the "deployment of a lifetime."

"I was extremely busy," he said. "I was working with some of the best guys in the business. Unfortunately, things like this happen. Bad guys do bad things."

What's New?

Tactical Combat Casualty Care Guidelines

July 2008

Note: Changes from the TCCC guidelines published in the 2006 Sixth Edition of the Prehospital Trauma Life Support Manual are noted in **bolded text.**

Basic Management Plan for Care Under Fire

1. Return fire and take cover.

2. Direct or expect casualty to remain engaged as a combatant if appropriate.

3. Direct casualty to move to cover and apply self-aid if able.

4. Try to keep the casualty from sustaining additional wounds.

5. Airway management is generally best deferred until the Tactical Field Care phase.

6. Stop *life-threatening* external hemorrhage if tactically feasible:
   - Direct casualty to control hemorrhage by self-aid if able.
   - **Use a CoTCCC-recommended tourniquet for hemorrhage that is anatomically amenable to tourniquet application.**
   - **Apply the tourniquet proximal to the bleeding site, over the uniform, tighten, and move the casualty to cover.**

Basic Management Plan for Tactical Field Care

1. Casualties with an altered mental status should be disarmed immediately.

2. Airway Management
   - a. Unconscious casualty without airway obstrution:
     - Chin lift or jaw thrust maneuver
     - Nasopharyngeal airway
     - Place casualty in recovery position
   - b. Casualty with airway obstruction or impending airway obstruction:
     - Chin lift or jaw thrust maneuver
     - Nasopharyngeal airway
     - Allow casualty to assume any position that best protects the airway, to include sitting up.
     - Place unconscious casualty in recovery position.
     - If previous measures unsuccessful:
     - Surgical cricothyroidotomy (with lidocaine if conscious)

3. Breathing
   - **a. In a casualty with progressive respiratory distress and known or suspected torso trauma, consider a tension pneumothorax and decompress the chest on the side of the injury with a 14-gauge, 3.25 inch needle/catheter unit inserted in the second intercostal space at the midclavicular line. Ensure that the needle entry into the chest is not medial to the nipple line and is not directed towards the heart.**
   - **b. All open and/or sucking chest wounds should be treated by immediately applying an occlusive material to cover the defect and securing it in place. Monitor the casualty for the potential development of a subsequent tension pneumothorax.**

4. Bleeding
   - **a. Assess for unrecognized hemorrhage and control all sources of bleeding. If not already done, use a CoTCCC-recommended tourniquet to control life-threatening external hemorrhage that is anatomically amenable to tourniquet application or for any traumatic amputation. Apply directly to the skin 2-3 inches above wound.**
   - **b. For compressible hemorrhage not amenable to tourniquet use or as an adjunct to tourniquet removal (if evacuation time is anticipated to be longer than two hours), use Com-**
   bat Gauze as the hemostatic agent of choice with WoundStat as the backup (if the primary agent is not successful at controlling the hemorrhage or if the wound characteristics call for a granular agent). Both agents should be applied with at least 3 minutes of direct pressure. Before releasing any tourniquet on a casualty who has been resuscitated for hemorrhagic shock, ensure a positive response to resuscitation efforts (i.e., a peripheral pulse normal in character and normal mentation if there is no traumatic brain injury (TBI).
   - **c. Reassess prior tourniquet application. Expose wound and determine if tourniquet is needed. If so, move tourniquet from over uniform and apply directly to skin 2-3 inches above wound. If tourniquet is not needed, use other techniques to control bleeding.**
   - **d. When time and the tactical situation permit, a distal pulse check should be accomplished. If a distal pulse is still present, consider additional tightening of the tourniquet or the use of a second tourniquet, side by side and proximal to the first, to eliminate the distal pulse.**
   - **e. Expose and clearly mark all tourniquet sites with the time of tourniquet application. Use an indelible marker.**

5. Intravenous (IV) access
   - Start an 18-gauge IV or saline lock if indicated.
   - If resuscitation is required and IV access is not obtainable, use the intraosseous (IO) route.

6. Fluid resuscitation
   Assess for hemorrhagic shock; altered mental status (in the absence of head injury) and weak or absent peripheral pulses are the best field indicators of shock.
   - a. If not in shock:
     - No IV fluids necessary
     - PO fluids permissible if conscious and can swallow
   - b. If in shock:
     - Hextend, 500-mL IV bolus
     - Repeat once after 30 minutes if still in shock
     - No more than 1000 mL of Hextend
   - c. Continued efforts to resuscitate must be weighed against logistical and tactical considerations and the risk of incurring further casualties.
   - d. If a casualty with traumatic brain injury (TBI) is unconscious and has no peripheral pulse, resuscitate to restore the radial pulse.

7. Prevention of hypothermia

a. Minimize casualty's exposure to the elements. Keep protective gear on or with the casualty if feasible.
b. Replace wet clothing with dry if possible.
c. Apply Ready-Heat Blanket to torso.
d. Wrap in Blizzard Rescue Blanket.
e. Put Thermo-Lite Hypothermia Prevention System Cap on the casualty's head, under the helmet.
f. Apply additional interventions as needed and available.
g. If mentioned gear is not available, use dry blankets, poncho liners, sleeping bags, body bags, or anything that will retain heat and keep the casualty dry.

8. Penetrating Eye Trauma
If a penetrating eye injury is noted or suspected:
   a. Perform a rapid field test of visual acuity.
   b. Cover the eye with a rigid eye shield (NOT a pressure patch).
   c. Ensure that the 400mg moxifloxacin tablet in the combat pill pack is taken if possible and that IV/IM antibiotics are given as outlined below if oral moxifloxacin cannot be taken.

9. Monitoring
Pulse oximetry should be available as an adjunct to clinical monitoring. Readings may be misleading in the settings of shock or marked hypothermia.

10. Inspect and dress known wounds.

11. Check for additional wounds.

12. Provide analgesia as necessary.
   a. Able to fight:
   These medications should be carried by the combatant and self- administered as soon as possible after the wound is sustained.
   - Mobic, 15mg PO once a day
   - Tylenol, 650mg bilayer caplet, 2 PO every 8 hours
   b. Unable to fight:
   Note: Have naloxone readily available whenever administering opiates.
   - Does not otherwise require IV/IO access
   - Oral transmucosal fentanyl citrate (OTFC), 800ug transbucally
   - Recommend taping lozenge-on-a-stick to casualty's finger as an added safety measure
   - Re-assess in 15 minutes
   - Add second lozenge, in other cheek, as necessary to control severe pain.
   - Monitor for respiratory depression.

- IV or IO access obtained:
- Morphine sulfate, 5mg IV/IO
- Reassess in 10 minutes.
- Repeat dose every 10 minutes as necessary to control severe pain.
- Monitor for respiratory depression
- Promethazine, 25mg IV/IM/IO every 6 hours as needed for nausea or for synergistic analgesic effect

13. Splint fractures and recheck pulse.

14. Antibiotics: recommended for all open combat wounds.
   a. If able to take PO:
   - Moxifloxacin, 400mg PO one a day
   b. If unable to take PO (shock, unconsciousness):
   - Cefotetan, 2g IV (slow push over 3-5 minutes) or IM every 12 hours or
   - Ertapenem, 1g IV/IM once a day

15. Communicate with the casualty if possible.
   - Encourage; reassure
   - Explain care

16. Cardiopulmonary resuscitation (CPR)
Resuscitation on the battlefield for victims of blast or penetrating trauma who have no pulse, no ventilations, and no other signs of life will not be successful and should not be attempted.

17. Documentation
Document clinical assessments, treatments rendered, and changes in the casualty's status **on a TCCC Casualty Card.** Forward this information with the casualty to the next level of care.

Basic Management Plan for Tactical Evacuation Care
* Note: The new term "Tactical Evacuation" includes both Casualty Evacuation (CASEVAC) and Medical Evacuation (MEDEVAC) as defined in Joint Publication 4-02.

1. Airway Management
  a. Unconscious casualty without airway obstruction:
    - Chin lift or jaw thrust maneuver
    - Nasopharyngeal airway
    - Place casualty in recovery position
  b. Casualty with airway obstruction or impending airway obstruction:
    - Chin lift or jaw thrust maneuver
    - Nasopharyngeal airway
    - Allow casualty to assume any position that best protects the airway, to include sitting up.
    - Place unconscious casualty in recovery position.
    - If above measures unsuccessful:
    - Laryngeal Mask Airway (LMA)/intubating LMA or
    - Combitube or
    - Endotracheal intubation or
    - Surgical cricothyroidotomy (with lidocaine if conscious).
  c. Spinal immobilization is not necessary for casualties with penetrating trauma.

2. Breathing
  a. In a casualty with progressive respiratory distress and known or suspected torso trauma, consider a tension pneumothorax and decompress the chest on the side of the injury with a 14-gauge, 3.25 inch needle/catheter unit inserted in the second intercostal space at the midclavicular line. Ensure that the needle entry into the chest is not medial to the nipple line and is not directed towards the heart.
  b. Consider chest tube insertion if no improvement and/or long transport is anticipated.
  c. Most combat casualties do not require supplemental oxygen, but administration of oxygen may be of benefit for the following types of casualties:
    - Low oxygen saturation by pulse oximetry
    - Injuries associated with impaired oxygenation
    - Unconscious casualty
    - Casualty with TBI (maintain oxygen saturation > 90%)
    - Casualty in shock
    - Casualty at altitude
  d. All open and/or sucking chest wounds should be treated by immediately applying an occlusive material to cover the defect and securing it in place.

Monitor the casualty for the potential development of a subsequent tension pneumothorax.

3. Bleeding
  a. Assess for unrecognized hemorrhage and control all sources of bleeding. If not already done, use a CoTCCC-recommended tourniquet to control life-threatening external hemorrhage that is anatomically amenable to tourniquet application or for any traumatic amputation. Apply directly to the skin 2-3 inches above wound.
  b. For compressible hemorrhage not amenable to tourniquet use or as an adjunct to tourniquet removal (if evacuation time is anticipated to be longer than two hours), use Combat Gauze as the hemostatic agent of choice with WoundStat as the backup (if the primary agent is not successful at controlling the hemorrhage or if the wound characteristics call for a granular agent). Both agents should be applied with at least 3 minutes of direct pressure. Before releasing any tourniquet on a casualty who has been resuscitated for hemorrhagic shock, ensure a positive response to resuscitation efforts (i.e., a peripheral pulse normal in character and normal mentation if there is no traumatic brain injury (TBI).
  c. Reassess prior tourniquet application. Expose wound and determine if tourniquet is needed. If so, move tourniquet from over uniform and apply directly to skin 2-3 inches above wound. If tourniquet is not needed, use other techniques to control bleeding.
  d. When time and the tactical situation permit, a distal pulse check should be accomplished. If a distal pulse is still present, consider additional tightening of the tourniquet or the use of a second tourniquet, side by side and proximal to the first, to eliminate the distal pulse.
  e. Expose and clearly mark all tourniquet sites with the time of tourniquet application. Use an indelible marker.

4. Intravenous (IV) access
  a. Reassess need for IV access.
    - If indicated, start an 18-gauge IV or saline lock
    - If resuscitation is required and IV access is not obtainable, use intraosseous (IO) route.

5. Fluid resuscitation
   Reassess for hemorrhagic shock (altered mental
         status in the absence of brain injury) and/or
         change in pulse character.
   a. If not in shock:
      - No IV fluids necessary.
      - PO fluids permissible if conscious and can
         swallow.
   b. If in shock:
      - Hextend 500ml IV bolus.
      - Repeat once after 30 minutes if still in shock.
      - No more than 1000ml of Hextend.
   c. Continue resuscitation with packed red blood
         cells (PRBCs), Hextend, or Lactated Ringer's
         solution (LR) as indicated.
   d. If a casualty with TBI is unconscious and has
         a weak or absent peripheral pulse, resuscitate
         as necessary to maintain a systolic blood pres-
         sure of 90mmHg or above.

6. Prevention of hypothermia
   a. Minimize casualty's exposure to the elements.
         Keep protective gear on or with the casualty if
         feasible.
   b. Continue Ready-Heat Blanket, Blizzard Res-
         cue Wrap, and Thermo-Lite Cap.
   c. Apply additional interventions as needed (see
         Box 21-3).
   d. Use the Thermal Angel or other portable fluid
         warmer on all IV sites, if possible.
   e. Protect the casualty from wind if doors must
         be kept open.

7. **Penetrating Eye Trauma**
   If a penetrating eye injury is noted or suspected:
   a. Perform a rapid field test of visual acuity.
   **b. Cover the eye with a rigid eye shield (NOT
         a pressure patch).**
   **c. Ensure that the 400mg moxifloxacin tablet
         in the combat pill pack is taken if possible
         and that IV/IM antibiotics are given as out-
         lined below if oral moxifloxacin cannot be
         taken.**

8. Monitoring
      - Institute pulse oximetry and other electronic
         monitoring of vital signs, if indicated.

9. Inspect and dress known wounds if not already done.

10. Check for additional wounds.

11. Provide analgesia as necessary.
      a. Able to fight:
         - Mobic, 15mg PO once a day
         - Tylenol, 650mg bilayered caplet, 2 PO every
            8 hours
      b. Unable to fight:
         Note: Have naloxone readily available when-
            ever administering opiates.)
         - Does not otherwise require IV/IO access:
         - Oral transmucosal fentanyl citrate (OTFC)
            800ug transbucally
         - Recommend taping lozenge-on-a-stick to
            casualty's finger as an added safety measure.
         - Re-assess in 15 minutes.
         - Add second lozenge, in other cheek, as
            necessary to control severe pain.
         - Monitor for respiratory depression.
         - IV or IO access obtained:
         - Morphine sulfate, 5mg IV/IO
         - Reassess in 10 minutes
         - Repeat dose every 10 minutes as necessary to
            control severe pain.
         - Monitor for respiratory depression.
         - Promethazine, 25mg IV/IM/IO every 6 hours
            as needed for nausea or for synergistic analgesic
            effect.

12. Reassess fractures and recheck pulses.

13. Antibiotics: recommended for all open combat wounds.
      a. If able to take PO:
         - Moxifloxacin, 400mg PO once a day
      b. If unable to take PO (shock, unconsciousness):
         - Cefotetan, 2g IV (slow push over 3-5 minutes)
            or IM every 12 hours, or
         - Ertapenem, 1g IV/IM once a day

14. Pneumatic Antishock Garment (PASG) may be useful
      for stabilizing pelvic fractures and controlling pelvic
      and abdominal bleeding.
      Application and extended use must be carefully moni-
      tored. The PASG is contraindicated for casualties with
      thoracic or brain injuries.

15. Document clinical assessments, treatments rendered,
      and changes in casualty's status **on a TCCC Casualty
      Card**. Forward this information with the casualty to
      the next level of care.

Thoughts on Aid Bags
Part One

Michael R. Hetzler, 18D; Justin A. Ball, 18D

Special Operations Forces (SOF) have evolved and developed immeasurably during the first seven years of this Global War on Terrorism (GWOT). Even though we've met the challenges presented with a great deal of success, we continue to find ourselves in environments where individually we have had no specific training or exposure. Medics in the direct action (DA) role can arguably find themselves in one of the most challenging environments possible, and it now occurs more frequently with our target sets and the urban environments in which they occur. Regardless of experience, an expectation for preparedness still exists to handle these situations even though they may have never been dealt with in the past.

An assault Medic's role differs from any other, in that he must be able to operate with a minimum of pre-mission planning time yet be prepared for all medical contingencies. These can range from a single patient with a simple gunshot wound to an entire assault force buried in rubble from a building collapse. All this must be accomplished while maintaining the ability to shoot, move, and communicate effectively.

In order to reduce the stress that inevitably comes from trying to prepare for so many trauma scenarios, some basic aid bag packing principles may prove beneficial. Unfortunately, too many still deploy with an aid bag packed for schoolhouse Combat Trauma Management training. With the high operational tempo and turnover of personnel, it is difficult to find the time to develop solutions for everything en masse. It is also unrealistic to set a standard on how to pack an aid bag for all missions. The solution is a basic theory to start from so that every Medic can meet a standard of preparedness for DA missions.

This article is the first of two meant to provide some lessons learned, as well as tactics, techniques, and procedures (TTPs) in preparing aid bags and Class VIII supplies for casualty care in the DA role. These theories are oriented primarily toward the present environment of Operation Iraqi Freedom (OIF). They are based on the assumptions of maintaining a constant battlefield advantage in both fire superiority and manpower as well as always having capable evacuation assets within a twelve hour response time. Again, by no means are these articles meant to dictate complete and irrefutable parameters. As with any issue and any Medic, a variety of opinions, theories, and experiences exist, so restricting oneself to a single method could reduce effectiveness. Because scope of practice and theories of care directly reflect Tactical Combat Casualty Care (TCCC) and Damage Control Resuscitation (DCR) guidelines, equipment and supplies mirror those as well. We also hope that these articles may provide some insight in packing aid bags for other missions and operational environments.

The TCCC protocols were established in 1996 primarily from lessons learned due to experiences in So-

malia in 1993. They have become the standard for both military trauma training and civilian Pre-Hospital Trauma Life Support guidelines. The TCCC's identification of causes of combat mortality and essential procedures for their treatment (i.e., tourniquets, needle decompression, etc.) has greatly assisted the Medic in focusing the cube space of his gear to the most relevant life threats. The three phases of care defined by TCCC standards are: Care Under Fire, Tactical Field Care, and Evacuation Care, all of which provide a framework for the SOF provider to effectively deal with combat trauma, guide treatment, and load out medical gear to the most appropriate times in the fight.

DCR guidelines are championed primarily by the U.S. Army Institute of Surgical Research and specifically focus on the prevention of the "Lethal Triad" of hypothermia, presenting coagulapathy, and acidosis in the trauma patient. All three concerns have shared requirements which depending on the success of treatment, can be either mutually beneficial or mutually damaging. These DCR strategies also provide strict parameters for the monitoring and treatment of each concern during aggressive hypotensive and hemostatic resuscitation from the point of injury to the operating room. Ensuring that these goals are met provides a more scientific and therapeutic approach to combat trauma for the most efficient care possible. Additionally, this supports both the TCCC and the next level of care of damage control surgery in the hospital.

THREAT BASED PLANNING

A continuing challenge for the SOF Medics and their commands is to remain aware of the ever evolving set of threats that are characteristic to the enemy currently being faced. To do so requires the constant evaluation of enemy TTPs and their associated wound patterns to make adjustments in supplies and plans. SOF Medics need to read, research, and talk with other Medics (both current and rotating out), and with Intelligence sections, to find out what the enemy is doing on the battlefield. This information will then allow the Medic to better prepare for the specific types of wounds that may be encountered. Since terrorist and insurgent forces have the innate ability to change their tactics and operations within the most minimal amount of time, the Medic should be concerned with what they are doing no matter how long they may have been out of theater. As years have passed, it is easy to see that terrorist and insurgent forces have professionalized over time and their tactics and weapons have become more effective. Knowing the evolving wound patterns will provide the Medic with the information needed to organize aid bags more effectively.

The historical gunshot, rocket-propelled grenade, and fragmentation wounds of earlier wars are still seen daily, but stood alone in the early months. Then, as experience and expertise developed in Iraq, terrorists evolved their tactics to use improvised explosive devices (IEDs), vehicle-borne IEDs, and suicide bombers. The IEDs went from a simple bag with a trip wire, to blasts directed from above to target the soft or open overheads of HMMWVs and other vehicles, to utilizing large buried bombs. They then utilize creative materials such as incendiary or choking agent (e.g., chlorine) chemicals for increased effectiveness. Explosively formed projectile technologies were imported next and are still used with a clear increase in capability and devastating effect, even with respect to armored vehicles. House-borne IEDs are now becoming more and more frequent as the enemy looks for additional ways to gain high payoffs with a relatively low cost in both money and manpower, while challenging us with more extensive overpressure and collapse concerns.

Another early tactic was the use of suicide bombers, either in targeted attacks, or opportunistically when coalition forces happened to assault an occupied objective. The wearing of suicide vests by foreign fighters and cell leaders not only allows the enemy to hit targets of opportunity, but also allows them to specifically target members of SOF during offensive operations. Overpressure is a by-product of these weapons and, although not easily understood and measured, its effects in causing traumatic brain injuries are now quantified by their recognition as the hallmark wound of this conflict. Collapse scenarios also come in to play as another by-product of explosive tactics. Not only are these on the rise now, but were seen as early as 2004 when Iraqi army and police elements were first targeted in these traps. Another threat emerged as the accessibility of former Iraqi army ordnance dried up or was secured; IED factories began to develop home made explosives (HMEs) in order to sustain their efforts. It is estimated that over 60% of all explosives presently used in Iraq are HMEs.[1] As the enemy develops, experiments with, and perfects new recipes, the ingredients themselves have become threats in the form of hazardous materials. These hazardous materials have already affected coalition forces in Iraq and undoubtedly will again.

The question to always ask is, 'What's next?' This is where all medical elements need to talk with their own operations and intelligence sections to keep apprised of what's happening on the battlefield. Enemy effects and our preparation and response to them can be predicted, so it is important that every attempt be made to be proactive and not just reactive on the battlefield. Many of the tactics in

the previous two paragraphs have seen extensive historical employment in the West Bank, Gaza Strip, Europe, and Chechnya long before 9/11.

GENERAL

The overall approach is not the packing of a single aid bag, but to understand and develop a depth of care and supplying it with appropriate levels of Class VIII to meet the challenges in all levels of care. Combat casualty care, and the supplies that facilitate that care, start with each Soldier's individual first aid kit, and incrementally increase in application and amount to meet mission requirements and any worst-case scenario. Attempts should be made to pack the aid bags and then stage them per priority of their use; the specific types and abundance of medical supplies in the proper location will ensure success. Planning and packing in each bag should always be based on judgment of the worst-case scenario; this is, of course, based on mission analysis, threats, and assets.

Cross-loading medical supplies ensures that everyone is carrying medical gear that he/she personally packed and is up to date. Personal packing also allows the Medic to concentrate cube space in his/her own kit toward including more advanced items and it creates redundancy in equipment and supplies that can cover multiple contingencies. For example, if every Soldier of a thirty-man element carries a bleeder pack, a chest kit, a hemostatic dressing, a tourniquet, and a war wound kit, this means that together they will independently carry approximately 60 rolls of Kerlex®, 30 ACE wraps, 30 cravats, 30 hemostatic dressings, 30 tourniquets, 60 morphine auto injectors, 30 fentanyl lozenges, 30 tabs of avalox (Moxifloxacin), and 30 pills of Zofran ODT. Then, if three other team members carry a more robust med kit as cross-trained Medics, this provides an additional three cric kits, three intraosseous kits, three bags of Hextend, three hemostatic dressings, and three more injectable antibiotic kits. This stock should significantly ease the burden of supply on the Medic.

In planning for casualty care the SOF Medic should always develop, use, and pack supplies that have multiple applications. Every item that is put into the aid bag takes up space and has weight so it is important to attempt to pack only those items that are multifunctional. For example, Kerlex® can be used as pressure to pack wounds, protection to dress wounds, provide padding and guarding for impaled objects, wipe away dirt and blood for access and treatment, etc. An ACE wrap can provide pressure and work in conjunction with Kerlex® to arguably provide the most functional pressure dressing kit there is; it can also work as a hasty tourniquet and be used for splints and rags. The Tac-Wrap can be used for splint-ing, a pressure dressing for the abdomen, pelvis, leg, shoulder, neck, axillary, and chest, splinting applications, and even casualty transport.

Conservation of supplies should be a priority in the mind of the Medic and should be exercised just as what has been taught in guerilla warfare practices. Those same habits will provide success even on today's more developed battlefield. These practices have been taught by good NCOs and the schoolhouse for decades and the importance of safeguarding supplies has not decreased in any way. It starts with quality training, competence and confidence in skills, and using only what is needed to treat wounds and injuries.

Preparation is 80% of success. The time put into preparing, packing, and practicing with the aid bag will pay back tenfold when it is needed the most. Packaging all the items together that will be required to do a procedure ("kitting" your procedures), deciding what to pack and where to place it in the aid bag, and ensuring the depth of supplies is paramount. Additionally, conducting good training and rehearsals that will test and challenge plans and preparation, as well as reviewing after action reports, will continue to provide confidence and proper coverage.

It is important that the aid bag is opened every couple of weeks to assure familiarity with its contents, especially if it hasn't been used in some time. Aid bag drills, where the aid bag is laid out as if treating a casualty and then trying to find items in the aid bag without looking, as taught and practiced during the Q-Course, are still applicable now; no matter how good the Medic is. Always, it is important to be critical with the packing list during inspections to make sure nothing is ever forgotten, at any level of care.

Kitting procedures allows the Medic to assemble all the supplies and equipment that are needed for any procedure into a single water-resistant bag: either a zipper seal bag or, for more durability, a vacuum sealed bag. (Figures 1a and 1b) Kitting procedures will allow for modularization of the aid bags and will provide flexibility for any changes needed and extra supplies for repacking. These kits also provide the Medic with both the tools and confidence for good care under the worst conditions. Combining all equipment and supplies into any procedure kit will automatically save time and provide clarity under the many stressors of engagements; thus putting them back into autopilot and negating higher cognitive thought while always providing positive progress. Having and seeing the items together will automatically prompt the Medic into the next step which increases efficiency and decreases confusion. Additionally, develop "cheater cards" for each specific kit either for the individual Medic or others to achieve the same purpose. Handing any kit to

Figure 1a Here are a few examples of procedure kits and an example of an inventory list developed for packing specific procedure kits.

Figure 1b Example of an anesthesia kit and an inventory list developed for packing.

Cricothyroidotomy Kit

- Betadine Swab
- #10 Scalpel
- Cric Hook
- 10cc Syringe
- 7.0 – 7.5 Tube
- Securing Material / Suture Material

IM Antibiotic Kit

- Betadine Swab
- 3cc Pre-filled Syringe
- 20g Needle
- 1g Cefotan / Rocephin / Ertapenem

a trained team member immediately lets him know what is expected without explanation.

If the decision is made to vacuum seal equipment and supplies be careful with tubes, bags, and balloons as some machines may employ too much vacuum that could cause medical grade plastic to adhere to itself, lose its intended shape or purpose, and possibly even tear the more sensitive parts such as the balloons on intubation tubes. It is good to mark every kit with the name of the procedure in big, black letters on either two inch white medical tape, or using a paint marker for easy recognition under stress. Make sure to turn all medications and vials out so that they can be seen with their names and expiration dates for quick reference through the packaging. We recommend a small cut in the top corner of every bag marked with a piece of tape above and below to serve as quick opening tabs. Record the packing date on the kit for reference as well. Generally, the goal is to rotate kits out of the aid bag every year to decrease the chance of malfunctions from normal wear and tear over time. This is true for every level of coverage whether it is individual first aid kits, vehicle bags, or resupply bags. Ensure those older rotated kits are used during training to reconfirm your packing list and develop everything you carry.

Take responsibility for everything that is carried. This means, "train with everything you pack" and have confidence in it. If the decision is made to carry a new occlusive dressing, or even a new style of Kerlex®, it should be opened and used at least two or three times to gain knowledge and confidence in their use. If commercially developed and packaged products are used, remember that they can vary in types, supplies, packing methods, and (most especially) their quality control – so know everything that is carried inside and out.

DEPTH OF SUPPLY

Having a depth of supplies is no different than having a defense in depth or depth on a battlefield. It means layering and prioritizing the placement of supplies and equipment to provide more complete coverage and to be more effective when it is needed the most. Standardizing what each Soldier carries and how he carries it provides the basic medical logistics support that is needed at the point of injury. That first line of supply is backed up with vehicle, outstation, or mass casualty bags that would cover trauma even if they had to stand alone as the only source of supply. This, in turn, allows the Medic to decrease and prioritize what is personally carried in both the assault and backup aid bags to provide a higher, more effective level of care at the point of injury.

For this theory to reach its potential, cross training has to be extensive and continuous. Training the team to

standards and then holding them to those standards is paramount in making them force multipliers. Those skills may even save your own life one day. On an assault team everyone should be proficient in the primary survey and the appropriate actions at each level of combat casualty care, tourniquet use, airway management, occlusive dressings, relief of a tension pneumothorax, effective use of pressure as well as hemostatic dressings, packaging, and transport. Cross-trained team Medic skills can include advanced airway management, intravenous or intraosseous access, antibiotic therapy, and a full and complete secondary survey.

Cross-trained team Medics take coverage one level higher by providing both advanced procedure capabilities as well as a more specialized medical kit for more critical situations. Their equipment and supplies should directly mirror the training and level of care that is decided for them, so these skills need to be held to a standard. Even if the team Medic doesn't employ them, the medical kits they carry can provide the Medic with critical backup supplies (Figure 3). Cricothyriodotomy kits, Hextend®, parenteral antibiotic kits, and epinephrine autoinjectors are some supplies that may be included here. Individual first aid kits should be maintained as well.

Figure 2   Inventory for IFAKs carried by every Soldier.

Figure 3 Suggested inventory for a Team Medic Kit.

As the first line of supply, every Soldier should carry the medical supplies that are meant to save his or her own life. It is these supplies that provide the Medic with a bank of Class VIII for trauma care (Figure 2). Tourniquets are the most valuable stopgap to uncontrollable extremity hemorrhage, so it is important to ensure that every Soldier carries one on the front of their gear, accessible by either hand, and easily identifiable at all times. Every Soldier should be trained to access and employ them on themselves with one hand, on any extremity, and at any time necessary. Pressure dressings, or "Bleeder kits" can come in a variety of components such as a four-inch ACE wrap, two Kerlex® for packing bowl shaped wounds, and a cravat for miscellaneous use. More developed and multifunctional equipment and supplies are coming out on the market now such as the Oales bandage which can be used as a basic dressing, a pressure dressing, or traumatic amputation dressing. It even has limited occlusive dressing applications. Additionally, Chest kits should contain two Ashermans (ACS™), Hyfins, or simple Hydrogel along with a 10 gauge three-inch hard needle large and long enough to cover most chest sizes. Lastly, most Soldiers can carry a small 250cc normal saline IV starter kit – again primarily as back-up for fluids, since most care they provide should center on hypotensive resuscitation.

Vehicle aid bags provide a mobile supply cache and the next line of supply. They should be task organized as per A B Cs, with kits to support the level of training that is given to the teams. One bag per vehicle or team is generally enough and again provides depth in supplies for mass casualty events that a vehicle would likely be a part of. Every vehicle should also have a "litter kit" with a sensitive items bag. This bag can be a duffel bag, an aviator's kit bag, or a commercially made product, providing the ability to consolidate and control the casualties' weapons, ammo, and radios minimizing the risk of loss. Hypothermia control is another part of the litter kit. Pre-placing a space blanket, or passive rewarming blankets and headgear automatically gives the ability to protect the patient against a known contributor to mortality such as the 'lethal triad' (Figure 4).

CARE UNDER FIRE KIT FOR THE MEDIC

What the Medic carries on their body also contributes to effectiveness, speed, and depth of supplies. Based off the TCCC concept of Care Under Fire, a Medic needs to have an immediately available pouch of lifesaving equipment (Figure 5). If removal of the aid bag has to be completed to accomplish this, both time and economy

Figure 4 Several examples of commercially available Litter Kits; a commercial Sensitive Items Bag sits to the far left but this can be replaced by any duffel or kit bag.

Figure 5 Above: Where and how a Medic carries his equipment is limited only by his imagination and training.

Below: Recommended inventory for items carried on a Medic's body.

Care Under Fire
Medic Supplies on Body

- Bandage Scissors x 2
- Lights on Body x 2
- Window Punch x 1
- Marker x 1
- Alcohol Pen x 1
- 4 x 4's
- Casualty Cards x 5
- Pulse Ox x 1
- 10g Hard Needle x 2
- Ammonia
- Exam Gloves x 3 pr
- PO Antibiotic Tab x 6
- Morphine INJ x 2
- Trauma Supplies
  - Kerlex x 4
  - 4" ACE Wrap x 2
  - Hemostatic Dsg x 2
  - Occlusive Dsg x 2

of effort are lost. The placement and choice of equipment is based on buying enough time to get to the next stage (Tactical Field Care). There the patient is in a more secure area and the Medic is free to lower security, remove his aid bag, and begin more thorough assessment and treatments. We recommend a "one is none, two is one" for the less appreciated but more essential items on your body (i.e., bandage scissors and light sources).

Some suggestions:
- Carry extra tourniquets so you'll never come up short.
- Carry casualty cards in a pocket for easy accessibility and to remind you of their use.
- Always have two methods and sizes of permanent markers to use on casualties or on the casualty cards.
- Consider carrying a small zipper lock bag of 4 x 4's so there is a fast and simple method to wipe blood away from wounds to ensure that the extent of damage can be seen.
- Carrying easily accessible (pockets, assault vest, etc) lifesaving materials and kits for those procedures that may save a life within seconds requires some thought and self critique. Usually having an emergency cricothyroidotomy kit easily accessible to treat a severe maxillofacial compromise saves both the time and frustration of having to go into an aid bag. Having 10-gauge hard needles accessible for an emergency needle decompression is another logical point for handling breathing emergencies.
- Try to have several types of hemostatic adjuncts to treat circulatory emergencies. Clamps, extra tourniquets, hemostatic dressings, and maybe a bleeder kit in a pocket will again save the frustration of taking off and getting into an aid bag when time counts most.

TACTICAL FIELD CARE, THE ASSAULT AID BAG

An Assault Aid Bag is usually designed and configured to provide a stop gap, and life saving procedures coming off of the Medic's back. It should not be so large and cumbersome that it cannot be sat on, (in the seat of a helicopter or HUMVEE) climb over a wall, or move through a door with another Soldier while not knocking each other over. This aid bag combined with a Back Up Aid Bag for more extensive resuscitation or a mass casualty event again allows the Medic to layer supplies and treatments; and while doing so, more specifically task organize what is being carried and what can be done because of that depth.

EVACUATION CARE, THE BACK-UP AID BAG

As mentioned before, the Back-up Aid Bag can and will provide anything that may be needed for longer

term casualty sustainment, or those supplies needed for a mass casualty event. This aid bag is generally not carried on a Medic's back, but certainly can be if the mission analysis warrants it. In theory, it can be dropped at a breach to be retrieved later, prepositioned on a vehicle to be recalled when needed, or left on an aircraft to be dropped in, in an emergency. The assault aid bag, the back-up aid bag, and their equivalents will be covered extensively in the next article.

After any casualty event, make sure to employ some habits that will continue to ensure success. Our enemy is very creative with information operations; we must ensure that we do not provide them with anything that they can be used against us in the media. At the point of injury, pick up every single scrap of cloth, dressing, or trash, and sterilize the treatment areas just as if leaving a patrol base. When casualties are turned over and the Medic has returned to base, it is important to immediately refit every bag that was used. The Medic does not want to be caught unprepared in continuing mission sets or engagements. Make sure to have those essential kits and supplies packed well beforehand and ready so there is no waste of time preparing equipment verses planning or recovering. Deploy with a trauma box already packed with prepared kits and items, enough to repack the entire assault bag and ready kit, and to assist in backfilling the mass casualty bag if necessary.

We hope that this, the first of two articles, will provide Medics who find themselves in direct action missions with some foundation to develop their logistical and Class VIII support as well as provide lessons learned and insight to aid bag packing and treating casualties in the field. The next article will go into greater depth specifically covering the Assault Aid Bag and the Back-up Aid Bag in this environment.

The authors are assigned as 18Ds to USASOC and have accumulated 43 months of deployed time in both OEF and OIF between them.

Canine Tactical Field Care Part One The Physical Examination and Medical Assessment

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Abstract

Military and law enforcement agencies have seen a dramatic increase in the utilization of working canine officers both at home and in foreign deployments. Due to the fact that professional veterinary care is often distant from internal disaster or foreign deployment sites, the military medic, police tactical medic, or other first-response medical care provider may be charged with providing emergency or even basic, non-emergency veterinary care to working canines. The medical principles involved in treating canines are essentially the same as those for treating humans, but the human healthcare provider needs basic information on canine anatomy and physiology and common emergency conditions in order to provide good basic veterinary care until a higher level of veterinary care can be obtained. This article represents the first in a series of articles designed to provide condensed, basic veterinary information on the medical care of working canines, including police canines, federal agency employed working canines, and search-and-rescue dogs, in addition to Military Working Dogs (MWD), to those who are normally charged with tactical or first responder medical care of human patients.

As a result of the terrorist tactics of the enemy in the Global War on Terrorism, especially the use of improvised explosive devices and enemy combatants hiding themselves within a civilian population, the U.S. military and U.S. law enforcement agencies have seen a dramatic increase in the utilization of working canine officers both stateside and in foreign deployments.[1,2,3] A recent article in the *JSOM* has offered a good overview of the care of the MWD and how the care of these valuable assets should fit into the operations of military medical personnel.[4] A knowledge base is also developing in the standard veterinary literature as a result of the increase in utilization of working dogs by police and other federal and civilian disaster response agencies, and the care of these dogs by veterinary and non-veterinary medical personnel in the deployment location.

While the U.S. Army Veterinary Service is tasked with providing veterinary care to both MWDs and other U.S. government working dogs,[4,5] the reality is that often these dogs and their handlers find themselves in situations far from the nearest available military veterinary care provider.[4,6] Even within the United States, canine units are tasked for natural disaster response, terrorism incidents, and search-and-rescue missions that may take them hours to days away from the nearest practicing veterinarian.[4,6] For police dogs owned by civilian agencies

or search-and-rescue dogs owned by private individuals, veterinary care is obtained according to the policies and budgets of the individual canine units. As a result, and as a result of the relative scarcity of the Veterinary Medical Assistance Teams provided to the continental United States (CONUS) disasters by the American Veterinary Medical Association and the Federal Emergency Management Agency, many units rely on the local "human" medical infrastructure to provide emergent care until the canine unit can return to its home base.[7]

Thus, in many cases, the military medic, police tactical medic, or other first-response medical care provider may be charged with providing emergency or even basic, non-emergency veterinary care to working canines, either to keep the dog healthy and working its mission, or to keep the dog alive and stable long enough to be transported to a higher level of veterinary emergency care.[4,6,7]

This article represents the first in a series of articles designed to provide condensed, basic veterinary information on the medical care of working canines. These articles will discuss police canines, federal agency employed working canines, search-and-rescue dogs, in addition to MWDs, and canines who are normally charged with tactical or first-responder medical care of human patients. By reading these articles and

retaining the provided Canine Field Care Card (Table 1 pg. 59), military, police, and other first-responder medical personnel should be able to provide basic first-aid and trauma care to canine patients for up to one hour, or until direct care by a licensed veterinarian can be established.

Because only a handful of conditions are the major causes of morbidity and mortality in working canines, and only some of these conditions require intervention before standard veterinary care is available, the basic notions behind Tactical Combat Casualty Care (TCCC) training can be applied to Canine Field Care.[4,6] For this reason, the number of conditions that this article series will cover is limited to those conditions that would be immediately life threatening in the field and yet amenable to medical intervention. Thus, the following topics will be covered in the series:

- *Part One:* Physical Examination and Medical Assessment of the Canine Patient
- *Part Two:* Massive Hemorrhage Control and Physiologic Stabilization of the Volume Depleted, Shock-Affected, or Heatstroke-Affected Canine Patient
- *Part Three:* The Canine Emergency Airway and Thoracic and Abdominal Trauma
- *Part Four:* Gastric Dilatation and Volvulus, Other Gastrointestinal Disturbances and Toxicoses
- *Part Five:* Common Orthopedic and Other Traumatic Injuries

EXTRACTION AND HANDLING OF THE CANINE CASUALTY

It is important for the canine caregiver to remember that injured or sick dogs may be experiencing fear and/or pain, and may not respond normally to verbal commands or handling situations. For this reason, it is critical that the care provider first ensure the safety of himself and the dog by placing a muzzle on the dog's head to restrain the mouth and a leash on the dog to keep him physically restrained prior to attempting extraction.

The best muzzle to use for medical care would be a muzzle that is 1) easy to place; 2) allows for restraint of the mouth in as closed a position as possible; 3) allows for loosening without removal for as much examination of the mouth, muzzle, and head as possible; to avoid aspiration in case of vomiting; to facilitate panting for heat expulsion; or for placement of an emergency airway or mouth gag and stomach tube. Although a basket muzzle will achieve some of these objectives, it will not temporarily close the jaws for restraint of the teeth nor will it allow for easy airway or stomach tube manipulation. Finally, the leash can be passed through the strap of the muzzle to retain the muzzle on the head and neck. The

best leash for medical purposes is a leash with a noose function that will not allow the dog to "back out" of his collar, or a leash attached to a choker chain. If the working leash does not fit this description, one can be fashioned easily by placing a slip knot on the end of a piece of rope or cord and passing the other (free) end of the rope back through the slip knot.

As outlined in a previous article by COL Vogelsang, CASEVAC would be the rule rather than the exception for the MWD, due to asset utilization restrictions and in-flight medical capabilities for MEDEVAC or STRATEVAC of the canine casualty.[4] In the civilian sector, the individual canine unit is responsible for arranging canine casualty evacuation utilizing immediately available resources. Most commonly, the canine casualty must be moved in a non-medical vehicle due to the need to reserve medical vehicles for potential human casualties.

The canine casualty should only be moved in such a way as not to risk human casualties in the process, either by exposing the handler or caregiver to enemy fire or to significant hazards in the rescue or disaster environment. In many cases, a dog can be manually moved a sufficient distance to provide a safe place for canine tactical field care. Upon movement of the canine to a safe environment for the instigation of medical care, the available medical personnel can commence the physical examination and patient assessment.

In most cases where the handler or medical provider must transport the canine officer, the dog can be walked out or manually carried. Sometimes however, the dog will struggle significantly, require hoisting for extraction, or the distance may be too far for the dog to walk, in which case, an extraction harness would be beneficial. A harness that provides a secure extraction harness for one man to manually extract the canine officer may be constructed of 1" tactical webbing secured into a circle and fashioned around the dog's head and neck and extremities and through a shielded carabiner as in Figure 1.

Figure 1
Canine Extraction Harness, on "Bear," a 95-lb canine officer.

In some situations, it may be beneficial to strap the canine patient to a backboard to facilitate evacuation with minimal movement of the spine.

THE PHYSICAL EXAMINATION AND PATIENT ASSESSMENT

The details of a thorough physical exam of the MWD have been previously described.[4] For the purposes of completeness, to offer a second perspective on the emergency physical of the canine patient, and to associate the description of the physical examination with the photographs and references included in this article, the physical examination of the working canine will be described again here.

The body systems of most concern to the emergency veterinary care provider are the cardiovascular, respiratory, musculoskeletal, neurological, and gastrointestinal. Some deployment situations will also call for examination of the lymph nodes, skin, and haircoat. For the purposes of this article, due to the limited number of conditions that will require medical intervention in the field, we will focus on the cardiovascular, respiratory, neurological, musculoskeletal, and gastrointestinal systems.

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

Once the dog and its mouth are made safe for handling, the physical examination may commence. The best location for auscultation of the heart is just caudal to the left elbow, very low (ventral) on the chest, where one can, with slight pressure, feel the heartbeat on the fingertips (Figure 2).[4] Normal canine heart sounds are very similar to humans, with two audible heart sounds in a typical "lub-dub" pattern. Working dogs will normally have a significant sinus arrhythmia at rest, which results in a more rapid heartbeat during inspiration and an easily detected slowing of the rhythm during expiration.[8] Ar-

rhythmias of medical concern in dogs will not change as a result of the respiratory pattern.

Pulses can be detected most easily at the femoral triangle, very proximal on the medial aspect of the pelvic limb and just over the femur.[4] In most dogs, there is a slight depression in the tissues over the femoral triangle, where the femoral artery is palpated easily (Figure 3). The pulse should be strong and easily palpated and synchronous with the heartbeat.

Figure 3 Pulse Palpation

The normal heart rate and pulse rate will be 60 to 90 bpm at rest, and up to 120 to 140 bpm immediately after exercise or work.[4,8,9] One can auscultate the heart while palpating the femoral pulse to attempt to detect pulse deficits, which can be an indication of cardiovascular shock or medically-significant cardiac arrhythmias.

Figure 4   Gums and Capillary Refill Time Evaluation

Mucus membranes can be observed at the gums over the tooth roots in areas that do not contain large amounts of black pigment (Figure 4). The gums should be pink, not pale or gray, or blue or bright cherry red. Upon the application of slight digital pressure, the gums should

Figure 2 Heart Auscultation

blanch white then return to pink within two seconds of removing the pressure, which is known as the capillary refill time (CRT).[4,9] In some aggressive dogs, evaluating the CRT at the gums can be difficult and dangerous. This should only be attempted if the dog is wearing a well-fitted adjustable muzzle that clamps the jaws shut. Alternatively, the CRT can be assessed on the prepuce or vulva.

Pulse rates higher than 130 bpm, even after exercise, are warning signs of potential volume depletion and potential cardiovascular shock. If the pulse rate is high in the face of weakening femoral pulses, pale mucus membranes, and prolonged CRT, the canine is exhibiting signs of cardiovascular shock.[4,9] The second article in this series will address volume depletion, hemorrhage, and the assessment and treatment of shock in the working canine patient.

Figure 5 Lung Auscultation

The nostrils should be unobstructed by debris or body fluids and should slightly open with each inspiration. The lungs are best auscultated higher (more dorsally) on the back, over the caudal ½ of the ribcage (Figure 5). It is this author's experience that normal lung sounds in the working canine are louder than in a human, especially immediately after working or other strenuous exercise. The normal respiratory rate is 10 to 30 breaths per minute,[4,8,9] with panting occurring after even mild exercise or during any period of ambient temperature in excess of 80 to 85 degrees Fahrenheit.

Dogs cannot sweat and must pant and have moisture evaporation from the mouth and nares in order to be able to expel excess body heat. Conductive cooling through footpads and body surfaces against cooler objects can also aid in temperature regulation. The rectal temperature of a working dog at rest should be between 100.5 and 101.5 degrees Fahrenheit.[9] In some dogs, rectal temperatures of 105 to 107 degrees Fahrenheit during exercise can be normal.[10] However, the body

temperature should immediately begin to return to normal upon cessation of exercise. After 10 to 15 minutes of rest, the normal temperature should not exceed 104.0 degrees Fahrenheit during exercise. Temperatures lower than this range could be found in non-exercising dogs in colder climates, but in any case the rectal temperature should be higher than 99.5 degrees Fahrenheit, or hypothermia should be suspected.[4]

A rectal temperature higher than 105 degrees Fahrenheit is a critical indicator; this canine patient is likely unable to control his own body temperature and is at immediate risk of decompensation and disseminated intravascular coagulation secondary to heat stroke.[11] Rectal temperatures higher than this are evidence of severe fever or hyperthermia (heatstroke) and should be addressed with immediate cooling measures such as cool water baths or hyperthermia treatments systems, as well as evaluation of hydration and electrolyte status and general physical examination.[4,11] A following article in this series will address the differentiation of fever (pyrogen-mediated) and heatstroke (hyperthermia) and their treatment in more detail (Part Two of this series).

MUSCULOSKELETAL AND NEUROLOGICAL SYSTEMS

The musculoskeletal and neurological systems can be assessed throughout the physical examination by observation of gait, posture, behavior, and cranial nerve function. A normal dog's gait will be brisk, with each limb being brought forward for weight bearing and each paw being placed on the ground with the pad-side down (Figure 6a).

Figure 6a. Normal Foot Placement

An exaggeration or deficiency of the forward motion of the limb, or the inability to place the pes (paw) in the correct position for weight bearing is usually an indication of traumatic injury or neurologic deficit. Fractures or significant ligamentous injuries will result in

disuse of the affected limb, either instantaneously, or as soon as the adrenergic surge from excitement is depleted (within a few minutes). In cases of non-displaced fractures or incomplete ligament tears, the dog will be able to bear some weight on the affected limb but will exhibit a significant limp.

Due to the quadrupedal gait of dogs, it can be difficult to detect which limb is affected in a mild orthopedic injury situation. However, in mild orthopedic injuries, the dog should still be able to place the pad side of the paw cleanly on the ground for weight bearing.

Figure 6b. Abnormal Foot Placement

If the canine is unable to place the pad side of the paw on the ground (Figure 6b), there is likely a peripheral or spinal nerve injury and the neurological system must be examined more closely. Spinal injuries or traumatic injuries to the hips will frequently result in dragging of the pelvic limbs and significant pelvic limb paresis (weakness). It is not uncommon for spinal nerve injuries in dogs to be asymmetrical, or more pronounced on one side of the body than on the other.

It is important to note that one of the most common injuries to working dogs is lameness due to a laceration or a small foreign body embedded in one of the pads of the pes. Foreign bodies can also be stuck between the digital pads or the digital and carpal pads resulting in lameness without a true injury.

The posture of a normal dog will be with the head held high and above the shoulders, with the tail held level, or held low and loosely but not against the perineum (Figure 7). If the head is held even with or below the shoulders, the dog is either experiencing significant pain and/or fear and should be handled with extreme care for the safety of the dog and the personnel involved. The same assessment can be made if the tail is tucked tightly against the perineum, or between the legs.

A low-held head posture or a significantly hunched posture in the thoraco-lumbar spine can be an indication of severe neck or back injury, possibly including injury to the spinal cord or spinal nerve roots. Peripheral nerve injuries can be evaluated by the placement reaction noted above (Figures 6a & 6b) and by performing a toe-pinch withdrawal test on each digit. If the dog does not respond to toe pinch by withdrawing the foot after pinching each toe, peripheral nerve damage or spinal nerve damage is suspected. A skilled and experienced veterinary care provider can assess patellar and other spinal reflexes, but these are difficult to assess in a field care situation. If a spinal injury is suspected, the patient should be restrained, ie., placed on a backboard, in a comfortable position to limit mobility during transport and exacerbation of injury.

The care provider can assess cranial nerve function by observing spontaneous or intentional movement of the eyes, ears, jaw, head, and tongue. The normal head posture is with the axis of the eyes parallel to the ground, with no spontaneous horizontal or vertical nystagmus of the eyes and no bobbing of the head (discounting movement related to panting).

The normal canine will be able to move the ears up and down, forward and back in response to pinching or tickling. The eyes should move easily side to side and should exhibit normal positional nystagmus when the head is placed in various positions. The tongue should be able to move to either side of the mouth when stimulated, and should be withdrawn quickly if pinched. The eyelids should be bilaterally symmetrical and the dog should be able to blink both eyes if approached by the index finger.

Canines have a membrane-covered cartilaginous flap that normally rests in the ventromedial aspect of each conjunctival sac. This membrane is normally not visible or only partially visible, but can start to protrude across the cornea in a dorsolateral direction in cases where the dog is sedated, depressed, intoxicated, se-

Figure 7 Normal Posture

verely dehydrated, has Horner's syndrome, or has had a traumatic injury or other inflammatory event in the affected eye.

GASTROINTESTINAL SYSTEM

The gastrointestinal system of the canine officer is susceptible to rapidly developing medical problems. Among the problems most commonly seen in working canines are vomiting, diarrhea, and bloat, or gastric dilatation and volvulus (GDV). In a recent study of working dogs deployed to terrorism-affected sites during the response to the September 11, 2001 attacks in New York and at the Pentagon, 21 of the 96 (22%) dogs evaluated had gastrointestinal tract signs while deployed, including vomiting and diarrhea.[7] MWDs also experience significant morbidity and mortality from gastrointestinal diseases, including GDVs.[4]

Dogs experiencing nausea will frequently hypersalivate prior to the onset of vomiting. They also will frequently exhibit a hunched posture and tension of the stomach prior to vomiting. Many substances when ingested will stimulate a vomiting response from a dog including bacteria-contaminated water, animal carcasses or feces, many plants, foreign objects, organic solvents, petroleum products, heavy metals, caustic substances, and the exudate from the skin of a toad.

Most of the substances that cause vomiting will also cause diarrhea within a few hours. Additionally, stress-induced diarrhea is common in dogs undergoing tremendous work stress or emotional stress (such as separation from the owner or a natural disaster).[7]

While vomiting (and sometimes diarrhea) may be physiologically necessary in order to remove the offending substance, in many cases the vomiting continues due to over-stimulation or irritation of the stomach and medical intervention is required to prevent dehydration and / or severe electrolyte disturbances. Diarrhea may persist due to bacterial toxins, and ongoing infectious, parasitic, or inflammatory process, or due to the ingestion of a diarrhea-inducing toxic substance.

In a normal dog, the abdomen will be soft and easily palpated. A skilled veterinarian can palpate parts of the liver, spleen, small intestine, colon, bladder, and sometimes the kidneys. However, in a scared, injured, or acute abdomen dog, the abdomen will be hard and the dog will resist abdominal palpation by tensing the stomach muscles and sometimes by vocalization or attempting to bite.

Canine "bloat," or gastric dilatation and volvulus, is an immediately life-threatening condition that can occur at any time with no warning in large breed dogs, including the breeds commonly used as military and police working dogs such as German Shepherds, Labrador Retrievers, Golden Retrievers, large mixed breeds, and others.[4,9,12]

The physical exam findings consistent with bloat are a hard, turgid abdomen, with a tympanic swelling behind the rib cage, rapidly progressing cardiovascular shock, vomiting or non-productive retching, a dog in lateral recumbency or a severely hunched standing posture, and gasping for air and / or vocalizing in pain and distress. The fourth article in this series will cover in detail the diagnosis and appropriate emergency medical interventions for canine gastric dilatation and volvulus.[4,9,11]

By utilizing the skill set that a provider has developed in his career and following this outline for the emergency physical exam of the canine officer, a military Medic, police medic, paramedic, EMT, or other medical personnel should be able to provide lifesaving tactical medical care to canine officers in the field. The forthcoming four articles will focus on the details of providing tactical field care (consistent with the Tactical Field Care phase of TCCC theory) to canine officers experiencing specific emergency medical conditions common to working dogs.

Following is a table that contains normal physiological parameters and physical exam findings for working canines in the weight range of 85 to 110 lbs. The drug doses denoted with an asterisk are from the "Shock" article in the textbook "The 5-Minute Veterinary Consult."[13] Other values are condensed and edited from articles referenced herein[4,11,12,14] and are consistent with those used by this author in private practice on working canines. This card may be photocopied and laminated for the use of individual *JSOM* subscribers.

Table 1. Canine Field Care Card

Parameter	At Rest	Exercise	Drug Dose	Standard Dose	CV Shock Dose
Temp.	100.5-101.5	101.0-104.0	Crystalloids	2.0-3L / 24hr	10-20ml/kg/hr *
Heart Rate	60-75	75-130	Hespan (hetastarch)	n/a	5ml/kg bolus* 20 ml/kg max
Resp. Rate	10-20	30-panting	Dexamethasone	n/a	0.1-0.2mg/kg IV*
Mucus mm	Pink	Bright pink	Diphenhydramine	2 mg/kg q 6-8 hrs	n/a
CRT	1-2 secs	1 sec	Diazepam	0.2-0.3mg/kg slow IV	Seizures: 1.0mg/kg IV bolus to effect
Pulses	Moderate	Bounding	Fentanyl Morphine	1-5mcg/kg/hr IV 0.5-2.0mg/kg IM	n/a
Heart Sounds	Behind left shoulder	Sinus arrhythmia at rest	Water	Maintenance: 2.0-3L / 24hr	Exercise: 5-15L / 24hr
Resp Sounds	Caudal ½ of thorax	Louder than human	Food	Maintenance: 4-6 cups dry / 24hr	Exercise: 8-12 cups / 24hr

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Intermittent Hypoxic Exposure Protocols to Rapidly Induce Altitude Acclimatization in the SOF Operator

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JSOM Disclaimer: This article is a single anecdotal case report and not a formal study of any kind.

Abstract

In August 2007 a three-man Special Operations Forces (SOF) Team attempted a rapid ascent of Mt Rainier after a five-day intermittent hypoxic exposure (IHE) protocol in a Colorado Exercise Room. The following article discusses the process used by the team to select the five-day IHE protocol as well as the science upon which IHE protocols for altitude acclimatization is based. The experiences of the team as they attempted to summit Mt Rainier at greater than 14,000 feet are summarized with a focus on acute mountain sickness (AMS) and its possible prevention with IHE.

The subject of rapid acclimatization to prevent AMS is important to the SOF community in order to quickly operate at high altitudes without succumbing to AMS or being forced to a lower altitude. Although medical literature is thinly populated with rigorous studies of IHE to prevent AMS, recent good studies, especially from Dr. Stephen Muza at the U.S. Army Research Institute of Environmental Medicine (USARIEM), validate some IHE protocols. This research is reviewed in the following article to help determine an appropriate IHE protocol for the SOF community.

Introduction

Intermittent, normobaric, hypoxic exposure (IHE) protocols may induce ventilatory acclimatization and reduce acute mountain sickness (AMS). SOF Operators such as Pararescuemen (PJ) and other members of SOF ground force teams are more susceptible to AMS because they are called upon to quickly react to objectives at altitudes which may induce AMS. These Operators must physically exert themselves immediately upon arrival to high altitude, without the benefit of slow ascent acclimatization protocols, substantially adding to the risk of developing AMS.

The use of medications such as acetazolamide to prevent AMS are not ideal. Acetazolamide must be taken days before the ascent to high altitude in order to be effective. Acetazolamide also has side-effects such as parasthesias and potentially leads to a performance decrement.

AMS is diagnosed after a rapid ascent of unacclimatized persons. By definition AMS casualties experience a headache early on followed by fatigue, dizziness, and anorexia. Nausea is common. Sleep is fitful. AMS may lead to vomiting, difficulty breathing, and irritability. A useful test which is easily administered to climbers in order to diagnose and grade AMS is the Lake Louise AMS score. This test classifies AMS starting with high-altitude headache, then mild AMS, moderate to severe AMS, and finally high altitude cerebral edema (HACE). AMS may progress to life-threatening HACE.

Susceptibility to AMS is not conclusively understood. Some people are thought to be inherently susceptible to AMS. If an individual developed AMS on a previous ascent, they are more likely to experience AMS on subsequent ascents. What protects individuals from AMS? This is not clear either, although recent sojourns lasting five or more days to high altitude (greater than 3000m) within the previous two months appears protective.[1] In the March 2004 "Altitude Acclimatization Guide" published by the USARIEM, Dr. Stephen Muza advised that IHE protocols using a system such as the Colorado Exercise Room (CER) or a similar mask device or tent may provide ventilatory acclimatization and reduce AMS.[2] These systems provide a normobaric, hypoxic environment typically by replacing oxygen with nitrogen in the inspired air. For instance, in the CER, a hypoxic environment which simulates altitudes up to 15,000 ft is

Inside Hypoxic Chamber at 12,500ft

safely made possible by programming a monitor, then circulating air into oxygen scrubbers, which is then pumped back into the room (see photo). Carbon dioxide (CO_2) monitoring is necessary to maintain a safe concentration of inspired gasses. In early 2008, Dr. Muza published a study of volunteers to determine that a three hour IHE protocol for six to seven days reduced AMS by 20% and increased resting SaO2 by one to three percent.[3] This was a good study, but it did not involve any testing outside of the lab. In other words, all participants were studied in the lab and not on top of a mountain.

While multiple IHE protocols exist, none has been optimized for the SOF community; nor has any one IHE protocol been adequately "street tested." Most studies of IHE for altitude acclimatization are performed in a lab setting. These protocols often are not realistic for SOF operators because they require three to twelve hours of IHE per day for greater than five days. Other protocols to speed acclimatization and/or enhance athletic performance include hypoxic exposures in which the participant exercises in a hypoxic environment for times ranging from less than to greater than one hour. Other protocol questions yet to be answered include how long the effects from the IHE protocol can be sustained. (Some studies indicate that the AMS benefits probably disappear between 24 and 96 hours after the last hypoxic exposure.) A follow-on question is what, if any, maintenance dose of IHE is required to sustain acclimatization. In other words, would it be possible to undergo an initial IHE protocol and then sustain its benefits by "re-dosing" every 72 to 96 hours? The ability to apply this sort of maintenance dosing may allow longer lasting acclimatization with IHE.

With these questions in mind, we determined a protocol with the SOF Operator in mind. We then fielded this protocol with a three-man team who rapidly ascended Mt Rainier (greater than 14,000ft) within 24 hours of the last hypoxic exposure.

Our protocol consisted of 1.5 hours a day of IHE in a CER to 12,500ft for five consecutive days. Based on previous studies we were hopeful by the last day of IHE to experience an increase in resting SaO2 of 1.5% compared to pre-IHE SaO2 levels. (Although scientific work remains to help predict who in the SOF community will get AMS, a promising and noninvasive measure of ventilatory acclimatization is an increase in resting SaO2 by 1 to 3 % from pre-IHE levels.)[3] The following is a summary of the SOF team's experience with an IHE protocol in a Colorado Exercise Room with a follow-on rapid ascent of Mt Rainier.

RESULTS

In our experience, we found that 1.5 hours (which included the 15 to 20 minutes it takes to reach an altitude of 12,500ft in the CER) a day for five days was an acceptable routine. During chamber time, operational and administrative planning was conducted as well as packing gear and performing educational activities such as refreshing mountaineering skills. We also found that by limiting the CER to altitudes of 12,500 ft or below, participants were less likely to experience lightheadedness, fatigue, or other hypoxic symptoms. In our CER, a maximum capacity of four participants could safely perform non-exertional activities without increasing CO_2 levels.

The final day of IHE actually required two chamber exposures within a 24-hour period. Although on days one to three the IHE exposures were spaced apart by approximately 24 hours, on day four, a 1.5-hour chamber exposure ended at 1000 local time with a repeat, fifth chamber exposure occurring at 0100, approximately 15 hours after the morning treatment.

Individual resting SaO2 measurements were recorded pre- and post-IHE treatments. All individuals experienced a slight increase in resting SaO2, but only one individual met the goal of a 1.5% increase in resting SaO2 after the fifth hypoxic exposure. Another experienced an increase in SaO2 of only 1%. The third had a negligible increase in SaO2 although he had the highest pre-IHE resting SaO2 at 12,500ft in the CER of 90% (see Table #1).

Table #1	Pre-IHE SaO2 (at 12,500ft in CER)	Post-IHE SaO2 (at 12,500ft in CER)
Climber #1	86%	88%
Climber #2	88%	89%
Climber #3	90%	90%

None of the team of climbers had been to high altitude (greater than 9,000ft) for more than five consecutive days within the previous two months, although Climber #2 had been at 9,000ft for four days one month prior to undergoing the IHE protocol. None of the climbers had previously experienced AMS of a severity which required treatment or a descent. All members of the team began their sojourn from the same initial altitude of

300ft ASL. Lastly, other than IHE no climbers used any other measures such as acetazolamide to prevent AMS.

Approximately three hours after the last hypoxic exposure, all climbers flew on a commercial aircraft to Seattle, WA, boarded a commercial vehicle, and by 1200 local, arrived at Mt Rainier National Park. Approximately 12 hours after the last hypoxic exposure, all climbers had trekked to 10,000ft ASL for a three-hour rest. Approximately 24 hours after the last hypoxic exposure, all climbers arrived at about 14,000ft ASL and remained for one hour. Weather conditions prevented an ascent to the summit and all climbers returned to 4,000ft ASL at 36 hours after the last hypoxic exposure. The group spent a total of eight hours above 10,000ft. No climbers experienced moderate or severe AMS; however, during the three-hour rest phase at 10,000ft, no climber was able to sleep despite having undergone a moderate amount of sleep deprivation and exertion during the previous 24 hours. No climber required treatment nor needed to descend due to AMS or any other condition.

A Lake Louise AMS Score, a common and practical measure of AMS, was calculated for each climber after reaching an altitude of approximately 14,000ft (see Table #2). For this calculation, the rest at 10,000ft was included in which the climbers attempted to sleep. When combined with a clinical assessment that includes change in mental status, ataxia, and peripheral edema, a Lake Louise Score of five or more correlates with AMS. None of the team had a score greater than four.

Table # 2	Lake Louise Score
Climber #1	4 (moderate nausea/vomiting + insomnia)
Climber #2	2 (insomnia)
Climber #3	2 (insomnia)

DISCUSSION

Athletes benefit from living at high altitudes and training at low altitudes. The "live high, train low" method results in measurable physiologic changes such as increased hematocrit.[4] The SOF community can benefit from this concept.

A protocol to decrease incidence of AMS during rapid ascent to high altitude using IHE, though not proven, is promising. Other acclimatization protocols such as the seven-day IHE protocol recently studied by Dr. Muza also appear promising.[3] We chose a five-day, 1.5-hour protocol that limited the train-up altitude to 12,500ft in order to minimize symptoms while in the CER and to minimize the train-up time. We found that taking the CER to 15,000ft during the IHE train-up brought about side-effects such as fatigue and dizziness that impaired our ability to perform other tasks such as packing and rehearsing mountaineering techniques. The length of each CER session was 1.5 hours. This time was chosen since it was the minimum exposure time proven effective in Dr. Muza's study.[3]

Our experience using a five-day, 1.5-hour per day IHE protocol was positive. This schedule was acceptable and did not adversely impact other daily duties. By maintaining a chamber altitude no higher than 12,500ft, participants were able to carry on non-exertional activities without experiencing disruptive, hypoxic symptoms. With a non-exertional protocol, multiple participants were able to train-up in the chamber while maintaining safe CO_2 levels.

In our practical application of this IHE protocol, it was possible for climbers to develop AMS. All rapidly ascended to above the 8,000ft threshold in which many will experience AMS.[5] AMS is expected to develop in about 33 to 45% of climbers who rapidly ascend to high altitude at the latitude of Mt. Rainier. The team remained above 8,000ft for approximately 10 hours — an amount of time long enough to induce AMS. Added to this rapid ascent, the climbers immediately exerted themselves, an activity known to increase the incidence of AMS.

The insomnia experienced by the group may have been a symptom of AMS, but no one experienced any additional, debilitating signs or symptoms except Climber #1 who vomited one time. All were able to successfully climb to and sustain an altitude greater than 13,000ft for at least one hour.

It is not conclusive that the five-day, 1.5-hour per day IHE protocol helped in the successful mission completion of this group of SOF Operators. The small number of climbers, the lack of a control group, as well the lack of application of other strict research criteria prevents drawing a correlation between the IHE protocol and the successful ascent to high altitude. Although at least one of the three climbers would be expected to suffer AMS based on the parameters of this sojourn, none developed AMS. AMS did not cause any of the climbers to abort the mission nor were they impaired by AMS. Although physiologic changes were minimal in this group, the simulation of actual high altitude during the IHE protocol may have provided other benefits. The hypoxic environment of the CER may have provided awareness of typical AMS symptoms such as lightheadedness, headache, nausea, and memory/performance difficulties. This awareness of hypoxic symptoms gained at low altitudes may have added awareness at high altitudes and helped with control of AMS symptoms.

Further validation of this protocol is necessary. More direct measurements of physiologic changes such as resting heart rates and SaO_2 changes at high altitude with a control arm of climbers who did not undergo the

IHE protocol would increase validity. A more formal assessment of a larger team to detect signs and symptoms of AMS would increase power and validity. This assessment might consist of recording Lake Louise scores, retinal disk diameter measurements, SaO2, and other vital signs.

Although the group went to high altitude rapidly, it could have gone higher. In fact, a rapid ascent to extreme altitudes above 18,000ft for longer than four hours would help validate the IHE protocol given that a larger percentage of the team would be expected to experience AMS.

Finally, a protocol shorter than five days, although preferable, is not likely to succeed. Other than providing situational awareness of hypoxic symptoms, a shorter protocol is unlikely to induce significant physiologic changes in that amount of time.

Is a five-day, 1.5-hour per day IHE protocol, even if proven to be effective with further study, acceptable for acclimatization prior to typical SOF missions? A five-day IHE protocol certainly limits the scenarios for IHE's use. One example of a possible application is preparing a rescue team to be available ahead of a high altitude mission.

An additional goal of any IHE protocol is to maintain the acclimatization that is gained from the protocol on a long-term basis. If intermittent, "maintenance" dosing in the CER is performed every 72 to 96 hours, then could a SOF Operator be maintained in an acclimatized state, ready to go to high altitude at a moment's notice?

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TSgt Jason Andrews on the trail to base camp at 10,000ft

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Acute Mountain Sickness Prophylaxis in the SOF Operator

Andre M. Pennardt, MD; Timothy Talbot, MD

Special Operations Forces (SOF) may be required to conduct missions in mountainous terrain without prior acclimatization and while exceeding normally recommended ascent rates, making them more susceptible to high altitude illness. SOF medical personnel must be familiar with prophylactic measures against high altitude illness to reduce its potential detrimental impact on mission completion.

Brian Delmonaco, Jason Andrews, and Aaron May authored the article "Intermittent Hypoxic Exposure Protocols to Rapidly Induce Altitude Acclimatization in the SOF Operator" in this issue of *JSOM*. They utilized a Colorado Exercise Room to induce normobaric hypoxia through dilution of oxygen content, thereby achieving a specified PIO_2 to simulate a corresponding altitude. The authors hypothesize that this may provide sufficient hypoxic stimulus to rapidly achieve ventilatory and hematological adaptive responses in the unacclimatized Operator in order to decrease the incidence of acute mountain sickness (AMS) when exposed to the hypobaric hypoxic environment of altitude. Recent work by Dr. Stephen Muza noted that the literature on intermittent hypoxic exposure (IHE) for inducing altitude adaptation is still in the early phases with only five out of twenty-five available studies actually using normobaric hypoxia.[1] While he noted that adaptation (ventilatory and hematologic) is a function of PIO_2 and not absolute barometric pressure, several of the studies suggested higher rates of AMS in subjects exposed to hypobaric hypoxia (more accurately reflecting high altitude conditions) when compared to normobaric hypoxia. Also of note, there did not appear to be any correlation between IHE exposure and hematologic adaptation to altitude in any of the studies cited. While the authors should be commended for suggesting a potential alternative method of preparing Operators to rapidly ascend to high altitude, the use of chemoprophylaxis such as acetazolamide (Diamox) and dexamethasone (Decadron) currently offer far greater utility in the prevention of AMS and other high altitude illness.

The authors quote a study by Dr. Muza that demonstrated a 20% reduction in AMS and a 1 to 3% increase in resting SaO_2 through use of a week-long protocol of IHE for three hours daily. However, this reduction in AMS is significantly less than that seen with the use of prophylactic medications in other studies. Dr. Delmonaco and colleagues designed an alternate IHE protocol of 1.5 hours daily for five days with the desired goal of achieving a 1.5% increase in resting SaO_2. This goal was only achieved for one of the three climbers in this article, which argues against the effectiveness of this protocol. While one of the three could statistically be expected to develop AMS on Mount Rainier, it is quite feasible that based on such a small study group, none would have developed AMS even without undergoing IHE. Although insufficient to meet a case definition of AMS, the reported insomnia and nausea/vomiting during the Rainier climb suggest that detrimental effects from high altitude may have occurred despite IHE.

We disagree with the authors' statement that acetazolamide must be taken "days in advance in order to be effective." A number of studies have demonstrated the efficacy of this drug to significantly reduce the incidence of AMS when initiated 24 hours in advance of arrival at high altitude.[2,3] Since acetazolamide is an effective treatment of AMS, its use should offer at least some protection even if started on the day of the mission. While parasthesias are a known potential side-effect, this can be mitigated by using smaller doses of acetazolamide. One study demonstrated that acetazolamide 125mg PO BID is not significantly different in efficacy from 375mg PO BID.[4,5] The primary drawback of acetazolamide is its contraindication in individuals with known sulfa allergies (or side-effects in persons with unknown sulfa allergies).

Dexamethasone is also highly effective in reducing the incidence of AMS.[2,6-8] Care must be taken to ensure that dexamethasone is not discontinued while still at altitude due to the potential of rebound upon with-

drawal. The combination of acetazolamide and dexamethasone has been shown to be more effective than either alone.[8] We recommend a dose of 4mg PO BID if dexamethasone is chosen as a prophylactic agent. Since mood disorders are a potential side-effect, SOF medical personnel may prefer to reserve the use of dexamethasone for situations when AMS symptoms are seen despite acetazolamide prophylaxis.

Some studies have suggested the use of gingko biloba as being effective in the prevention of AMS; however, other studies have found no demonstrable benefit.[2,3,10-12] We cannot conclusively recommend gingko biloba as effective prophylaxis against AMS based on these conflicting scientific studies. However, since the prolonged routine use of gingko biloba has no appreciable side-effects, SOF personnel could consider this medication at a dose of 120mg PO BID when deployed to environments with potential high altitude missions.

The limited availability of IHE systems (e.g., Colorado Exercise Room) reduce their utility to SOF. Unless the system is deployable, SOF personnel can only undergo initial and maintenance IHE "dosing" in CONUS, which essentially negates the time benefit over chemoprophylaxis that Dr. Delmonaco and colleagues suggest. During the time frame required for deployment, AMS chemoprophylaxis could likely be effectively initiated. We encourage the authors to continue to attempt to develop an effective protocol that produces reproducible, significant reductions in AMS and can be validated using sufficiently large study groups. Such a protocol may yet prove to be of benefit in the future for select SOF elements that are on alert for high altitude missions. Until then, acetazolamide 125 to 250mg PO BID and/or dexamethasone 4mg PO BID remain the clear choices for the prevention of acute mountain sickness in SOF.

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A Series of Special Operations Forces Patients with Sexual Dysfunction in Association with a Mental Health Condition

Gregory Lang, MD

Abstract

The Department of Defense has placed considerable emphasis on the identification of post-traumatic stress disorder (PTSD) in military personnel returning from Iraq and Afghanistan, and several mandatory screening tools are currently used by primary care clinicians to assist in this effort. PTSD has been shown to impair emotional and social functioning, and to affect physical health and quality of life. Previous research has identified that combat veterans meeting diagnostic criteria for PTSD are more likely to experience some form of sexual dysfunction. This article presents four clinical cases of Special Operations Forces (SOF) patients who experienced sexual problems in association with symptoms of PTSD. Mandatory screening forms may be able to identify a subset of patients with PTSD; however, the perceived stigma of PTSD may prevent SOF personnel from seeking appropriate care. On the other hand, the barriers to care for sexual dysfunction have been reduced in recent years. Young, healthy male combat veterans who seek treatment for sexual dysfunction should be questioned about symptoms of PTSD.

Background

Several recent studies of military personnel serving in Operations Iraq Freedom (OIF) and Enduring Freedom (OEF) have confirmed previous research that exposure to combat is associated with mental health problems to include post-traumatic stress disorder (PTSD), major depression, and substance abuse.[1,2] In a longitudinal cohort of 88,235 U.S. Soldiers returning from OIF who completed both a Post-Deployment Health Assessment (PDHA) and a Post-Deployment Health Re-Assessment (PDHRA), the overall rate of mental health problems for active duty Soldiers ranged from 17% on the PDHA to 27% on the PDHRA.[2] This same study found that the rates of symptoms that screened for PTSD increased from 12% on the PDHA to 17% on the PDHRA. These numbers are consistent with previous studies that have reported a higher prevalence of PTSD in Vietnam veterans as compared to the general population of the United States.

PTSD is the development of characteristic and persistent symptoms along with difficulty functioning after exposure to a life-threatening experience or to an event that involves either a threat to life or serious injury.[3] PTSD is an anxiety disorder, and patients who suffer from it often experience nightmares, flashbacks, difficulty sleeping, or feeling detached. Frequently, PTSD is associated with other co-morbid psychiatric disorders to include mood, dissociative, anxiety, substance-related, and personality disorders. These co-morbid conditions can impede recovery and can lead to an increased risk of functional impairment in other areas. Often, patients with PTSD will present to primary care clinics with physical health problems related to their functional impairment which may mimic other medical conditions. Unrecognized PTSD as the underlying diagnosis may result in inadequate treatment or the inappropriate provision of medical or surgical care.

Several authors have proposed that sexual dysfunction is a common physical and behavioral impairment frequently experienced by patients with PTSD. Earlier studies of Vietnam veterans suggested that there is a relationship between PTSD and increased rates of sexual problems. In 1992, Litz et al. compared the self-reported physical health complaints of male Vietnam combat veterans both with and without PTSD. Veterans with PTSD were significantly more likely to report problems with sexual disinterest (37%) and impotence (32%) in contrast to those without PTSD (12% and 6%, respectively).[4] Five years later, Letourneau et al. surveyed 90 male Vietnam veterans enrolled in an outpatient Veterans Affairs PTSD clinic using a self-reported

inventory of sexual satisfaction. The study found that 82% of the respondents experienced significant sexual difficulties, and 69% had erectile problems.[5] Though significantly limited by the survey return rate and the inability to generalize the findings to all combat veterans with PTSD, the results provided support for the hypothesis that veterans with PTSD are more likely to experience sexual problems than those without PTSD.

More recently, an Israeli study reported that two groups of male PTSD patients (those who were treated with selective serotonin reuptake inhibitors [SSRI] and those that were untreated) experienced decreased levels of sexual desire and arousal, decreased frequency of sexual activity and orgasm, and decreased overall satisfaction as compared to normal controls.[6] In 2002, Cosgrove et al. surveyed an age-matched group of outpatient veterans treated at a Veterans Administration medical center, and found that veterans with PTSD had lower scores for sexual function and overall satisfaction. Furthermore, 85% of those with PTSD experienced erectile dysfunction (ED) as compared to 22% of the veterans in the matched control group with those in the PTSD group reporting a higher prevalence of moderate to severe ED.[7] All together, these survey results indicate that male patients with PTSD frequently have associated problems with sexual function.

Unfortunately, patients and healthcare providers alike are frequently reluctant to discuss sexual topics. Reasons given by physicians have included not knowing what questions to ask, feeling uncomfortable with the subject of sexuality and the language of sex, and fears of insulting the patient.[8] Similarly, patients may feel embarrassed by their perceived failure to live up to the cultural icon of maleness. From a clinical perspective, this could be especially concerning in the Special Operations community where young men who experience sexual dysfunction may see it as a weakness in the warrior ethos to seek help for these problems. Sexual dysfunction however, can be an objective sign of an underlying mental health problem; whereas, many of the other symptoms of PTSD are less obvious to the patient. Thus, it is important to ask questions that might identify a psychological etiology when an otherwise healthy young male presents with a sexual problem, as that will influence treatment options. What follows is a brief synopsis of the presentation and management of four patients with sexual dysfunction and mental health issues who were seen over the course of one year in a primary care clinic.

PRESENTATION OF CASE ONE

Staff Sergeant SH is a 29-year old married Caucasian male non-rated crew member (NRCM). His initial clinical encounter relative to his current condition occurred in conjunction with his annual Class 3 Flying Duty Health Screen (FDHS) — commonly referred to as a flight physical. SH had no significant previous medical or surgical history. He reported no prescription medications and only occasional use of over the counter (OTC) medications. SH was known by this physician for more than two years prior to the visit, during a period which they had both flown together on multiple missions in support of Operation Enduring Freedom (OEF). In addition, it was known that SH had lost several close unit friends and associates in a rotary wing aircraft mishap within the previous year. He initially expressed no specific complaints; however, the physician, aware of the patient's recent loss, spent a good deal of time discussing the events surrounding the mishap and their potential impact on the patient himself. It was apparent that this tragedy had significantly distressed the patient by the notable changes in his affect and his speech compared to the many previous mission-related encounters. Whereas SH had been quick with a smile and had spoken in an animated tone, he now presented with a flattened affect and spoke in a detached tone of voice.

The obvious changes in SH's behavior were concerning for possible interference with performance of crew duties; therefore, specific questions were asked in this case to verify that SH was not a risk to safety of flight. He indicated that he occasionally had some mild apprehension about flying since the mishap, but he had no doubts that he could perform his duties to the required standards. SH did not display any behaviors that raised the level of concern to the point of restricting him from flight duty; however, he agreed to meet with the unit psychologist to discuss his combat experience as a door gunner and his feelings about the death of his close friends. He was instructed to call to make an appointment within the next two weeks. The remaining portion of his FDHS was unremarkable. Upon completion of the flight physical, SH was asked if he had any questions or concerns. At that point, he reluctantly asked if he could discuss a personal matter.

SH then described how he had been experiencing difficulty in maintaining an erection during sexual intercourse with his wife. He stated that this situation had started approximately three months prior. Initially it had occurred infrequently, but had worsened to the point that he was now experiencing ED every time he and his wife attempted intimacy. He and his wife had been married for over six years and had one child. He discribed their relationship as monogamous

since they were married, with no unusual marital conflicts or recent changes in their relationship. He said that he was both physically and emotionally attracted to his wife, and he was certain that she felt the same except that she had expressed some concern recently about his inability to maintain an erection during intercourse. He indicated that prior to the start of his problem, he and his wife had sexual relations an average of two to three times per week. However, in the previous month their intimate relationship had been almost nonexistent due to performance anxiety on his part. He confirmed that he continued to experience nocturnal erections, but he was now so worried about his ED that he had avoided any sexual contact with her in the past few weeks.

MANAGEMENT OF CASE ONE

Erectile dysfunction is the persistent inability to attain or maintain penile erection sufficient for sexual intercourse. Erection is one of four main components of male sexual function, the others being desire (libido), ejaculation, and orgasm. A problem with any one or more of the four components can be referred to as sexual dysfunction. ED can be due to organic or psychogenic causes. The organic causes can be further divided into vasculogenic, neurogenic, and hormonal. These are often differentiated by the patient's history. Psychogenic causes are suggested based on factors such as a young age with abrupt onset, the persistence of nocturnal erections, the presence of excessive stressors, or mental status findings indicative of depression or anxiety. In this case, SH is a young, otherwise healthy male who confirmed the physical ability to attain an erection by his report of nocturnal episodes. His clinical presentation pointed to a change in his mental status after the traumatic deaths of his friends while performing the same job that he did. Furthermore, he was now experiencing increasing anxiety over his ability to engage in sexual relations with his wife.

The physician believed that SH's erectile dysfunction was a result of an underlying mental health problem. SH agreed to see the unit psychologist within the next 48 hours after an explanation of how stressors could lead to impaired sexual functioning. The psychologist made a diagnosis of PTSD and recommended that the patient begin a regular counseling program as therapy. At the follow-up appointment with the flight surgeon, SH was given a prescription for vardenafil with the expectation that he would use the medication for two or three times before attempting sexual intercourse without any assistance.

Although two studies have reported improvement in erectile function, orgasmic function, and sexual desire with the use of sildenafil in PTSD patients with ED,[9,10] vardenafil was chosen due to local formulary limitations. Subsequent long-term follow-up with SH has shown improvement in his mood and affect. He continues to experience intermittent ED which has been improved with occasional refills of vardenafil, though he reports that he has been able to engage in sexual intercourse with his wife without medication as well. SH has continued his counseling with the psychologist, and to date he has not required any medication for treatment of his PTSD.

PRESENTATION OF CASE TWO

Chief Warrant Officer 3 TM is a 37-year old separated Caucasian male pilot who presented to the flight surgeon after calling to make a same-day appointment to discuss an urgent concern. When TM met with the physician, he stated, "I need some help." Elucidation of the situation took quite some time, but amounted to an individual who was struggling with alcohol abuse and a crisis in his marital relationship. TM described a slowly evolving history of emotional divorce from his wife over the past five years. He was unable to put a date on anything specific that had happened; however, they had separated approximately six months ago. Similarly, he had difficulty pinpointing the start of his alcohol abuse, but he had come off of a drinking binge several weeks ago and realized that his life was in disarray and that he needed help.

TM stated that he had been deployed to Operation Iraqi Freedom (OIF) multiple times over the past several years. He related that in his job as a pilot, it was a matter of routine that he was involved in Special Operations missions that resulted in enemy fire directed at his aircraft. Additionally, he had witnessed the death or wounding of enemy and friendly forces on several occasions. Some of these had included close friends in his unit. TM stated that these experiences weighed heavily on his mind. Demonstrating a great deal of personal insight, TM felt that his use of alcohol was a method of psychological escape. He now realized that the alcohol was making things worse. Furthermore, he knew that he had erected an emotional barrier to prevent feeling any psychological pain. Unfortunately, this had led to problems in his personal life where he had stopped showing any kind of emotions.

TM had previously sought medical attention approximately one year prior at the request of his wife when his emotional detachment had become too much for her. He was seen by another primary care provider

and started on citalopram, a selective serotonin reuptake inhibitor (SSRI), for an unlisted diagnosis. TM was erroneously allowed to continue performance of his aviation duties in contravention of the Army Aeromedical Policy Letter covering use of SSRIs. He had no follow up appointments with that provider; and though he did notice some improvement in his mood, he ended up discontinuing the medication after about four months because he experienced erectile dysfunction.

Since stopping the citalopram, TM had continued in a downward spiral, becoming more emotionally distanced from his wife and drinking more alcohol on a more frequent basis. Fortunately, he had not yet had any legal troubles as a result of his abuse; however, he was now experiencing anger management problems along with what he described as a "heightened state of anxiety." Things that he previously would have shrugged off or dealt with rationally now would get him agitated, and he described frequently "blowing up" over petty issues at home and at work. His anxiety had worsened so that it was now interfering with his sleep, and he was averaging only four hours of sleep a night. He described difficulty falling asleep and also problems with waking up in the middle of the night. He was unable to identify anything specific that he was worried about, but he described it as "always feeling on the edge."

Further questioning revealed that he had contacted his wife who had recommended that he seek professional counseling, and together they had been seeing a local civilian psychologist for the past month with noticeably positive results. His true reason for seeking further medical assistance was with regard to his flight status and his continued problems with lack of sleep and constant anxiety. Although he and his wife were attempting to reconcile their relationship and he was going on three weeks of abstinence from alcohol, he now had enough insight to realize that his self-destructive behaviors were still interfering with his performance as a pilot, and he was asking for a period of duties not to include flying "grounding" so that he could focus on restoring his mental health. TM said he was willing to consider medication at this point if it would be helpful.

MANAGEMENT OF CASE TWO

TM's previous history of ED was associated with the use of medication. It has been suggested that as many as 25% of cases of ED are caused by medication side-effects.[8] Of note, SSRIs are well known to cause ED and ejaculatory dysfunction, and it is for this reason that male patients frequently discontinue use of SSRIs. TM did not recall being informed of this when he was prescribed citalopram; however, his ED may have been exacerbated by his abuse of alcohol which, when used in excess, is associated with decreased libido and ED. The flight surgeon recommended that TM strongly consider another trial of medication for treatment of his symptoms that were highly suggestive of PTSD. The patient was given the names of several prescription drugs, as he expressed an interest in doing some online research before trying any long-term medication. In the meantime, he was prescribed clonazepam to reduce his level of anxiety and aid in sleep. TM was counseled that clonazepam could cause decreased libido and had a high potential for abuse, and it was only to be for short-term use. He was given an unspecified period of grounding from aviation duty while his treatment plan was worked out.

Prior to his first follow-up appointment, TM's off-post psychologist was contacted. His record indicated that he had already been diagnosed with PTSD and was undergoing counseling; however, the psychologist agreed that TM would benefit from the addition of medication to his therapy. When TM returned to the clinic the following week, he reported that he had experienced significant improvement in his sleep and a decreased level of anxiety with the use of clonazepam. He agreed to a trial of escitalopram, but he was concerned that it too would cause ED. He and his wife had reinitiated sexual relations, and he did not want the medication to cause an additional stress in that aspect of their reconciliation, so he was given a limited supply of vardenafil to help alleviate his apprehension of starting the SSRI. His long-term follow-up has been significant for the discontinuation of clonazepam after reaching a therapeutic dose of escitalopram. TM has continued with individual and marital counseling, and he reports that he has experienced fewer problems with sexual dysfunction as a side-effect of this second SSRI.

PRESENTATION OF CASE THREE

Staff Sergeant NK is a 26 year-old married Caucasian male NRCM who reported to sick call and asked to see his battalion flight surgeon to discuss a sensitive matter. NK was known by the flight surgeon for several years, having been deployed to OEF and flown missions together on many occasions. In addition, NK had been treated by the same physician three years prior for an unrelated long-term medical issue that had taken several weeks of close contact to resolve. Prior to this visit, NK had been a jovial, energetic individual who felt free to carry on a spirited conversation with the flight surgeon during all previous encounters. However, during this appointment NK appeared despondent and much less energetic than his usual self. In an unusually quiet voice, NK explained that he was having problems "getting it

up" and he was worried that his wife would find him unappealing if he were unable to be intimate with her.

NK related that he still found his wife emotionally and sexually attractive, but for the past two months he had experienced difficulty in getting an erection when they attempted sexual intimacy. They had been unable to have sexual intercourse in at least six weeks because he could not achieve a firm enough erection, which was putting an unusual strain on their relationship. As a result, they were having difficulties communicating in other areas of their marriage. Until recently, they had gotten along fine, although he did mention that his wife had been complaining to him about his frequent deployments. From his recollection, he had been away from home for the majority of the previous year.

NK reported that he had frequently awoken with a full erection in the past month; however, he expressed a decreasing desire to initiate sexual relations with his wife as well as diminished interest when she was the one to initiate any sexual intimacy. He confirmed that he had been able to masturbate without difficulties, and he was not doing it too excessively as to interfere with sexual intercourse. Rather, he related that he found it hard to get in the mood for sex at all recently, which he had never experienced before. Other than a history of one episode of appropriately treated, sexually transmitted Chlamydia prior to his marriage, his past medical and surgical history was non-contributory. NK was not taking any prescription or OTC medication. His exam was unremarkable with normal male genitalia and a normal prostate.

MANAGEMENT OF CASE THREE

NK's case of sexual dysfunction suggested both a decrease in libido and ED. His history and exam virtually ruled out a vasculogenic or neurogenic etiology. A hormonal cause could not be excluded although it was unlikely. To be certain, a serum thyroid stimulating hormone (TSH), testosterone, and prolactin were ordered. The physician offered to the patient that his sexual dysfunction could be an indication that he was experiencing psychological problems. At that point, NK revealed that he had recently been experiencing vivid dreams and nightmares of his experiences while flying in OIF and OEF. Intrusive thoughts had begun to distract him during the day making it difficult to relax. Because of this, he had seriously considered requesting a transfer to the unit's training company in order to spend more time at home with his wife. NK agreed to meet with a psychologist based on the recommendation of the physician who was concerned for

a diagnosis of PTSD. At his follow-up appointment, he was informed that his lab results were within normal limits. NK stated that he had not made an appointment with a psychologist yet, but he would do so upon return from his next deployment, which was scheduled to begin the following week.

PRESENTATION OF CASE FOUR

Staff Sergeant RD is a 32-year old married male caucasian NRCM who had been seen many times over the past six months for follow-up of his injuries sustained during a rotary wing aircraft mishap. His injuries from that incident included a ruptured intervertebral disc at L4-L5, chronic low back pain, bilateral lower extremity radiculopathy, and PTSD diagnosed by the unit psychologist. Orthopedic evaluation had recommended non-surgical management for the lumbar spine, and RD was being followed by both neurology and the pain clinic for continued problems with sciatica and paresthesias in both legs below the knee. Electromyography (EMG) had been non-diagnostic.

RD had been on several different prescription medications for management of his chronic pain and radiculopathy. Recently, his medications had included amitriptyline, meloxicam, and acetaminophen. He stated that for the past two months he had been using the amitriptyline infrequently and only when he had difficulty sleeping at night. He continued to see the unit psychologist on a regular basis for his diagnosis of PTSD. Although medication had been discussed, RD opted to try counseling by itself for the present. His symptoms had waxed and waned over the past six months, and his current issues included feelings of detachment, decreased range of affect, difficulty falling asleep, and increased irritability.

At one of his follow-up appointments, he was asked about any sexual problems he might be experiencing. At first RD avoided the issue, but when the physician explained that it was relatively common for patients with PTSD to experience sexual dysfunction, RD acknowledged that he had been having occasional difficulties in getting sexually aroused since the mishap had occurred. The problem was isolated to situations in which his wife attempted to initiate sexual intimacy. He described that he found it difficult to relax when she made advances. Instead, he felt "uptight" and "wound up", and he experienced the feeling that he wanted her to "back off." Most of the time, her attempts at intimacy were thwarted; however, on those occasions when it did lead to sexual contact, he related that it would take a long time for him to attain an erection; and that there were some times when it was not possible for them to

have sexual intercourse. Conversely, he made it clear that he did not experience any dysfunction when he was the one initiating the sexual behavior. So far, this had not been a major issue in their marital relationship, but he expressed concern that his wife might become discouraged by his repeated rejections of her sexual advances.

MANAGEMENT OF CASE FOUR

RD's case of sexual dysfunction was complicated by several factors. A history of trauma to the spinal cord made a neurogenic cause possible; however, this was not considered likely as RD was able to engage in normal sexual activity when he was the one making the advances. Also, he was taking a tricyclic antidepressant for radiculopathy, and this class of medication is commonly associated with decreased libido and ED. Finally, RD had been diagnosed with PTSD, which, as discussed, is often associated with sexual dysfunction. A thorough history and exam were able to eliminate a neurolgic etiology, and RD was advised to discontinue the amytriptyline in an attempt to eliminate a medication side effect as a cause. RD and the physician discussed his rejections of his wife's sexual behavior in the context of his increased irritability and his trouble unwinding. A brief explanation of human sexual physiology helped him to understand that arousal is mediated by parasympathetic activity which can be dominated by an imbalance of sympathetic activity common to patients with PTSD thus leading to sexual dysfunction. RD agreed that he and his wife would meet with the psychologist to discuss alternative methods of initiating sexual activity. The use of medication such as vardenafil was not recommended in this case since he was capable of engaging in normal sexual intercourse.

DISCUSSION

Male sexual functioning consists of desire (libido), erection, ejaculation, and orgasm. A normal male sexual response requires an intricate interaction between vascular, neurologic, hormonal, and psychologic systems. Disorders of these systems can lead to sexual dysfunction in any of the four main components. The goal of the primary evaluation of the patient who presents with sexual dysfunction is to identify the medical or psychologic factors that may be contributing to the problem in order to guide treatment options. A thorough history is the most important aspect of the initial evaluation. In most cases, patients are willing to discuss sexual function and are relieved when healthcare providers address the topic. Dialogue can be facilitated by providing information about conditions commonly associated with sexual dysfunction followed by a question about the pa-

tient's specific situation, as in case four. Healthcare providers should use correct terminology, but should avoid excessively technical language. The patient should be encouraged to communicate which components of sexual function are problematic. A history of sexual dysfunction that suggests an organic etiology should be appropriately evaluated by physical exam with special attention given to the cardiovascular, neurologic, and genitourinary systems. Additionally, some basic laboratory studies may be indicated to include serum TSH, testosterone, and prolactin measurements as in case three. A psychologic etiology should be considered based on a history that suggests such, or if the exam and lab results are normal.

Sexual dysfunction is a pervasive problem in the population of combat veterans diagnosed with PTSD.[5,7] When a male patient complaining of sexual dysfunction is a young, healthy service member or veteran, the healthcare provider should consider that the problem is associated with a mental health condition. The patient should be asked open-ended questions about his deployment history, exposure to combat, and any experiences or events that involved either a threat to life or serious injury. The servicemember with symptom clusters of persistent re-experiencing of a traumatic event, persistent avoidance of stimuli associated with the event, and increased arousal is likely to have PTSD as in cases one and three. Conversely, the patient with a known diagnosis of PTSD should be questioned about sexual function as in case four. The use of a phosphodiesterase type-5 inhibitor medication such as vardenafil can provide some improvement in sexual function; although, that is not a cure for the underlying condition. The primary healthcare provider should recommend that the patient with symptoms of PTSD be evaluated and treated by a mental health provider if that has not occurred yet.

There are several possible explanations of how PTSD can either cause or lead to sexual dysfunction:
- Patients with PTSD often have a restricted range of affect, and experience feelings of detachment or estrangement from others. The patient in case two provides an illustration of this. Such symptoms can lead to diminished interest in sexual behavior and decreased sexual satisfaction.
- Alcohol abuse is a frequently reported co-morbid condition, and this in itself can be the cause of decreased libido and ED.
- Several classes of medications used to treat PTSD, such as SSRIs, are well known to have side-effects such as ED, delayed ejaculation, and anorgasmia.
- PTSD is an anxiety disorder. The imbalance of

adrenergic hormones found in patients with PTSD can interfere with relaxation which is essential to attaining and maintaining erectile rigidity, as seen in cases three and four.

This article presented four cases of SOF personnel who were seen in a primary care clinical setting and found to have sexual dysfunction in association with a mental health condition. Given that the estimated prevalence of PTSD in Soldiers returning from OIF may be anywhere from 10 to 20%, it is possible that there are many cases of undiagnosed PTSD in the SOF community. The perceived stigma of this diagnosis could be a potential barrier to seeking treatment. As an example, the patient in case two revealed that he had been seeing an off-post psychologist only after continued questioning, and he did not mention that he had already been diagnosed with PTSD. However, increased awareness of human sexual functioning and mass media advertisement of treatment for ED has reduced the barriers to healthcare for sexual dysfunction. Young, healthy male servicemembers may feel more comfortable seeking treatment for sexual problems than for symptoms of PTSD. The fact that a high percentage of combat veterans with PTSD report sexual problems should lead primary care providers to screen for PTSD in otherwise healthy patients who present with sexual dysfunction.

Authors Note: The cases are real; however, the ranks and initials used are factitious.

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MILD TRAUMATIC BRAIN INJURY: SITUATIONAL AWARENESS FOR SPECIAL OPERATIONS MEDICAL PROVIDERS

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OBJECTIVES

1) Physicians will select from a range of guidelines to optimize diagnoses, treatment and referral for patients with mTBI resulting in optimum health and functioning.
2) Nurses will be cognizant of mTBI signs and symptoms and provide care in order to maximize health and functioning.

ABSTRACT

Compared with risk for the civilian population, the likelihood of sustaining a traumatic brain injury (TBI) is substantially higher in United States Special Operations Command (USSOCOM) personnel due to a high operations tempo in training and through multiple deployments in the Global War on Terrorism (GWOT). Although penetrating trauma to the head is easier to identify, more attention needs to be paid by Special Operations Forces (SOF) medical personnel to the signs and symptoms of this "invisible" injury, some of which may occur weeks to months after suspected mild traumatic brain injury (mTBI). The term "mild" when describing TBI can be misleading because blast-exposed personnel can be severely compromised cognitively and emotionally. Labeled by some as the "signature wound" of the GWOT, mTBI continues to be a growing health concern of our individual servicemembers, in addition to commanders, medical providers, families, veterans' organizations, and communities. Since every blast-wave is different depending on type of explosive material and reflecting surface as well as individual differences and situational factors (e.g., pre-morbid intelligence; sitting in vehicle versus head exposed in gun turret), it is impossible to determine which individual, exposed to a blast, will manifest persistent problems weeks to months later following the acute blast. The mechanism of injury following a blast is often not as clear as it may first seem. A servicemember can first be hit with a blast overpressure, then thrown with force against an object, and then be hit in the head by flying debris. Servicemembers may be exposed to one or numerous traumas or blasts and not develop symptoms, or have symptoms that range from mild to severe that last for days, months, or even a lifetime. This article selectively reviews current literature about mTBI and highlights etiology, evaluation, and treatment options for SOF medical providers. What is currently known about the physics of blast-waves and the four major modes of injury following concussion-blasts will be summarized. To complicate the diagnostic picture, Soldiers can have co-morbid post-traumatic stress disorder (PTSD) either from circumstances of the blast injury or develop PTSD from a combat event unrelated to the blast injury. This article discusses these diagnostic changes.

Key Words: mild traumatic brain injury, mTBI, post-traumatic stress disorder, PTSD, blast injury, closed head injury, Operation Iraqi Freedom, OIF, Operation Enduring Freedom, OEF, improvised explosive device, IED.

INTRODUCTION

The goal of this paper is to educate SOF providers to identify, treat, case-manage, and refer SOF patients who experience symptoms of mTBI in order to maximize their physical and emotional health so that they may return to active duty. In turn, these medical providers also need to educate their SOF personnel, commanders, and family members with regard to mTBI. If a servicemember is too injured or dysfunctional to continue on active duty, SOF providers may need to provide the liaison for that individual for a medical evaluation board and follow-up care with the Veterans Administration (VA).

When servicemembers are first treated on the battlefield for severe physical trauma, seemingly less severe brain injuries may be initially overlooked. As should be their primary concern, medical providers in the battle space first focus on Trauma Combat Casualty Care. Penetrating (open) or moderate-to-severe closed injury with respiratory or hypovolemic compromise is usually recognized in theatre and treated accordingly at Roles Two and Three. The Army literature is no longer using Levels or Echelons of Care and has adopted the NATO terminology of Roles with some modifications;

the documents provide the explanations. A review of the levels of medical treatment will not be discussed in this paper; however, interested readers can review this information at Joint Publication 4-02, Health Service Support, October 2006 or FM 4-02.2, Medical Evacuation, May 2007. Higher Roles of care (usually in Germany or in CONUS) continue evaluation and treatment of moderate, severe, and penetrating brain injury that has already been identified.

This article will focus on the neurobehavioral sequelae of mTBI. In this context, the word "mild" refers only to the acute forces (e.g. blunt-force trauma or blast-exposure) that caused the closed-head trauma and to the acute symptoms experienced by the combatant. Serious symptoms can persist or develop weeks to months after a seemingly "mild" instance of closed-head trauma for several reasons. First, acute problems are frequently overlooked due to the presentation on injury — either serious or life-threatening symptoms take precedence after the servicemember experiences a brief period of loss of consciousness and then returns to duty. Second, SOF personnel are highly motivated to perform their duties and to "improvise, adapt, and overcome," factors that potentially interfere with completing a mis-

sion. Therefore, they paradoxically may try to minimize or even deny symptoms to themselves (and caregivers) in order to cope with those very same symptoms. Third, the effects of new symptoms may only fully manifest when warriors return to the home-front and are confronted by multiple duties and challenges that are not necessarily present during a mission (e.g., family life, making appropriate social decisions, managing finances, etc.) In this regard, family members, close friends in the same unit, or supervisors may be invaluable collateral informants when a service-member is clearly struggling but denying symptoms. Fourth, serious symptoms and persistent dysfunction can and does occur in the context of normal neurological exams, normal EEGs, and normal MRI and CT scans following blast-exposure. Finally, if patients have sustained frontal lobe damage they may not be fully aware of their new deficits and limitations due to lack of insight into their own daily functioning.

Due to the advances in battlefield medicine (particularly medical techniques and evacuation) as well as body armor used by military personnel, mortality has significantly declined in current operations in the GWOT compared to past conflicts. Individuals who may have died in previous wars due to injury to the head, neck, and upper extremities are now surviving at much higher rates.[1] However, the same body armor that saves life can contribute to brain injury. Because each blast-wave differs (depending on type of explosive material and reflecting surface as well as individual differences in brains in terms of neuroanatomy, density of neurons in specific regions, etc.), it is impossible at this time to determine which individual will develop clinically significant problems after mTBI due to blast-exposure. A patient may be exposed to one or numerous blasts yet not develop symptoms, or have symptoms that range from mild to severe that last for days, months, or over a lifetime.

The exact proportion of troops who have mTBI is not known, although it has been reported as high as 18% in news articles citing Army medical officials. Many troops and VA patients have reportedly developed "persistent post-concussive syndrome (PCS)," characterized by common symptoms such as irritability, memory problems, headache, tinnitus, and difficulty concentrating.[2] As a result, the Department of Defense (DoD) and the Department of Veterans Affairs have implemented population screening procedures for mTBI. Despite these steps, little is known about the epidemiology of mTBI due to blast-exposure and its association with adverse health effects.[3] Furthermore, there is still considerable debate regarding the brain-related ver-

sus psychosocial factors that may contribute to persistent PCS following blunt-force trauma.[4]

BACKGROUND AND SIGNIFICANCE

As of April 30, 2008, 31,848 servicemembers have been wounded in action in OIF/OEF. Thirty-two percent of the most seriously injured requiring medical evacuation from theater to Walter Reed Army Medical Center had a documented TBI. Over 90% of combat-related TBI are closed-head injuries with most servicemembers sustaining an mTBI.[5] Eighty-eight percent of military personnel treated at Role (Echelon) II medical units in Iraq had been injured by improvised explosive devices (IED)s or mortars. Many (47%) of these injuries involved the head. Similarly, 97% of the injuries to one Marine unit in Iraq were due to explosions (65% IEDs, 32% mines).[6] The Centers for Disease Control and Prevention estimates that 5.3 million Americans currently have a long-term or lifelong need for help to perform activities of daily living as a result of TBI, and 40% of those hospitalized for TBI had at least one unmet need for services one year after injury. The most frequent unmet needs were: improving memory and problem solving; managing stress and emotional upsets; controlling temper; and improving one's job skills.[7]

Considered against the backdrop of thousands of years of human evolution, brain injuries due to high speed motor vehicle crashes, explosive IED blasts, and bullet wounds are relatively new phenomena. This primitive protection provided by the combination of the skull, three membranes surrounding the brain, and the cerebrospinal fluid (CSF) has not had sufficient time to respond to evolutionary pressures to protect human beings from the technological advances of modern warfare during the last two centuries. At best, the covering of the cerebral hemispheres affords us modest protection against minor falls or being hit in the head by wooden clubs and small rocks wielded by other human beings, rather than the forces generated by extreme blast over-pressures due to roadside bombs or by high speed collisions with windshields, telephone poles, or other vehicles.[8]

In 1915, "shell shock" was initially conceptualized as due to the effects of a neurological lesion, the result of powerful compressive forces (mostly from artillery and mines). However, doubts soon arose about the contribution of direct cerebral trauma to shell shock, and some expressed the view that the symptoms were more psychological than organic in origin, even to the extent of characterizing them as "traumatic neuroses." Servicemembers who developed somewhat

similar symptoms miles from the front or were never exposed to blast injuries only confused the picture for WWI medical providers. This caused military doctors and patients to believe that shell shock was environmentally or contextually determined and the way in which healthcare and compensation were organized served to reinforce both symptoms and disability. Vigorous debate ensued between various schools of thought that led to a series of novel managerial interventions designed to limit what had become an epidemic of patients and war pension claims.[9] Over 90 years later, this vigorous debate continues academically and politically, but we are far closer in the identification, understanding, evaluation, and management of mTBI related to blast-exposure, as well as co-morbid post-traumatic stress disorder (PTSD) and differentiating between the two. Increased awareness and much additional research should aid in understanding these complex phenomena related to the GWOT and ultimately lead to improved treatment for servicemembers.

In Fiscal Year 2007, the Congressionally Directed Medical Research Programs' Psychological Health and Traumatic Brain Injury (PH/TBI) allotted $150 million and $151 million for future research for mTBI and PTSD respectively. Key priorities of the PH/TBI Research Program are to complement ongoing DoD efforts to ensure the health and readiness of our military forces and to support the Department of Defense Psychological Health and Traumatic Brain Injury Center of Excellence in its efforts to advance and spread PH/TBI knowledge, enhance clinical and management approaches, and facilitate other vital services to best serve the needs of military families impacted by PH problems and or TBI.[10]

ETIOLOGY

For the purpose of this paper, we will focus on TBI caused by explosive force caused by IEDs, rockets, land mines, breaching operations, etc. However, within USSOCOM, personnel also experience head trauma by other means: hand to hand combative training, airborne and air assault operations, demolitions training, .50 caliber weapons firing, shallow water blackout with subsequent asphyxiation, falls, and motor vehicle accidents on and off duty (list not all inclusive). Blast injuries are divided into four types, and in many cases personnel sustaining a mild, moderate, severe, or penetrating TBI suffer three to four types of blast injuries (in some cases all four). Primary blast injuries are caused by the direct effect of the blast wave or primary injuries which will be discussed in more detail below; secondary injuries are caused by other objects that are accelerated by the explosive waves, i.e., penetrating trauma from the explosive device (shrapnel) and subsequent surrounding structure (wood, glass, rocks, concrete, etc.); tertiary injuries are caused by movement of the victim being thrown or structural collapse (fractures and penetrating injury as well as open head fractures and closed head trauma from coup-contrecoup injuries); quaternary injury results from burns, asphyxia from being buried in debris, or exposure to toxic inhalants. One implication of the concepts of secondary and tertiary blast-exposure injuries is that there is often some ballistic or blunt-force component to the head following blast-concussion due to IEDs.

Shock wave blasts from IEDs, rocket-propelled grenades, and land mines are the leading cause of mTBI for active duty military personnel in combat zones. In prior military conflicts, TBI was present in roughly 14 to 20% of surviving casualties. Reports indicate 12,274 servicemembers have sustained a TBI in OIF and OEF as of March 24, 2007 but that number could grow much higher.[11] Currently, we lack the data to establish a dose-response curve for individuals with multiple blast-exposures and to predict the potential effects of such variables as inter-blast interval or the interactive effects of both blunt-force trauma and blast-exposure for a single given individual.

Primary blast injuries can be characterized as barotrauma caused from either significantly high over-pressurization or under-pressurization relative to atmospheric pressure following an explosion. Body organs are damaged by pressure changes at air-fluid interchanges due to the high-frequency stress wave and low-frequency shear wave. Over-pressure or under-pressure waves predominate depending on the characteristics and location of the blast. This blast wave causes a wide range of physical problems on the human body to include: ruptured tympanic membranes, pulmonary damage and air embolization, rupture of hollow viscera, ruptured orbital globe, and brain injuries caused by concussion (coup-contrecoup injuries due to blast wave), as well as barotraumas caused by acute gas embolism.[13,14]

An explosion is an event that occurs when a substance rapidly releases energy and produces a large volume of gaseous products. High explosive, thermobaric, and nuclear detonations all provide this change in potential energy to kinetic injury in a very short period of time. The extreme compression of molecules by this change in energy creates bands of locally high pressure, the blast wave which moves outwards from the epicenter of the blast. These blast waves travel faster than the speed of sound. Blast products – gas, particles, and debris of the container and items in proximity to the ex-
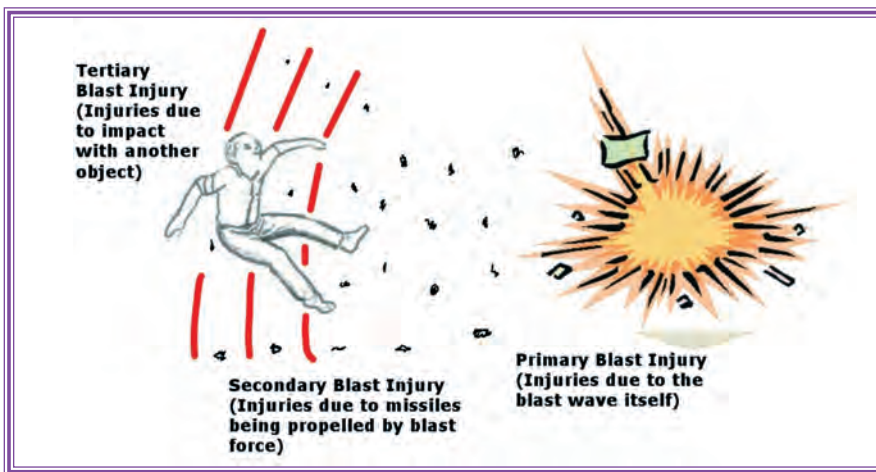
Figure 1. Illustration of primary, secondary, and tertiary injury from blast; quaternary not pictured (illustration by Charles Stewart M.D.)

plosive (including human remains) also spread outwards, but travel much more slowly. When a high explosive detonates, it is converted almost instantaneously into a gas at very high pressure and temperature. For example the major ingredient in Composition C4 (Cyclotrimethylenetrinitramine or RDX [Royal Demolition Explosive]) can generate an initial pressure of over four million pounds per square inch (4x10E6 PSI). The temperature can be as high as 3,000 degrees Celsius — more than twice that generated by a conventional explosive. The blast wave can travel at approximately 10,000 feet per second. Body armor provides a false sense of security during an explosive detonation. The body armor does protect the victim from shrapnel and to a lesser extent, objects picked up and flung by the blast wave, but it also provides a reflecting surface that can concentrate the power of the explosion as the blast wave reflects off of the armor front and back. Since the bulk of injuries from an explosive device are from secondary objects flung by the blast wave, the advantages of body armor outweigh the risk of enhancement of the blast wave. The medical provider should not assume that body armor will protect the victim from an explosion-related injury.[14]

During explosions, high pressure gases rapidly expand from the original volume and generate a marked pressure wave – the "blast wave" that moves outward in all directions. The result is a sudden shattering blow on the immediate surroundings. Furthermore, a blast-wave that would cause only modest injury in the open can be lethal if the victim is in a confined area (e.g., a basement) or near a reflecting surface such as a solid wall or a building (or body armor). If the pressure wave is near a solid barrier (e.g., a narrow alleyway), the pressure exerted at the reflecting surface may be many times that of the incident blast-wave.[15] In mTBI, neurological deficits seen days to weeks after blast exposure may be caused by "microshearing" of axons and dendrites and/or their synapses generalized throughout the brain due to this blast wave (further research in this area is warranted). However, axonal stretching of neurons that survive may also play a part in the development of brain dysfunction.[16]

There is simply no question that body armor provides substantial protection against projectile injury. What has not yet been quantified is the contribution of the armor to primary blast injury. The potential reflection of blast waves by armor may be particularly important in the genesis of traumatic brain injury, since the helmet can act as a focusing reflector of waves, with the brain at the center point of the focus.

Co-morbidity

PTSD, mood, and substance use disorders frequently co-occur with mTBI or persistent PCS head trauma and can significantly complicate diagnosis, treatment, and the recovery process. Post-TBI symptoms such as poor sleep, poor memory/concentration, and irritability are common in PTSD, mTBI, and major depressive disorder (which may be triggered by either PTSD or mTBI).

PTSD has been found to be strongly associated with mTBI, as well as blast-exposure and participation in combat. It was also demonstrated that mTBI was associated more with loss of consciousness versus altered consciousness or being "dazed" or having one's "bell rung." In a nonrandom sample of two Army brigades likely to be representative of servicemembers serving in ground-combat units in Iraq, 15% of servicemembers reported an injury during deployment that involved loss of consciousness or altered mental status and thus, by definition, incurred at least one mTBI. This 15% was significantly more likely to report high combat exposure and a blast mechanism of injury than others servicemembers in the study who reported other types of injuries. Forty-four percent who reported loss of consciousness met criteria for PTSD, compared with 27.3% of those with altered mental status, 16.2% of those with other injuries, and 9.1% of those with no injuries. In this study, the association between mTBI and

PTSD remained significant after combat experiences had been controlled for.[3] However, given this data, providers should also be hesitant to lump all symptoms under only a TBI diagnosis. Feeling disoriented or not remembering injuries or blasts can also occur in the context of PTSD due to the psychological process of severe dissociation. It is important to note that military personnel with mTBI have a greater risk for many types of health-related problems but should not necessarily be led to believe that they have sustained a brain-injury that will result in permanent behavioral or cognitive changes. "Normalization" of symptoms, rec-

Stress inoculation in terms of training and conditioning also plays an important role in the overall outcome of the development of mTBI and PTSD. However, it is important to recognize that markedly elevated levels of cortisol and other glucocorticoids are associated with intense combat-related stress. Some evidence exists to suggest that high levels of stress may damage sensitive brain tissues (e.g., hippocampus) or disrupt the healing processes in brain tissue following mTBI.

While it is likely still several years away, the military has ongoing research to place sensors in every ballistic helmet to measure the effects of blasts and alert
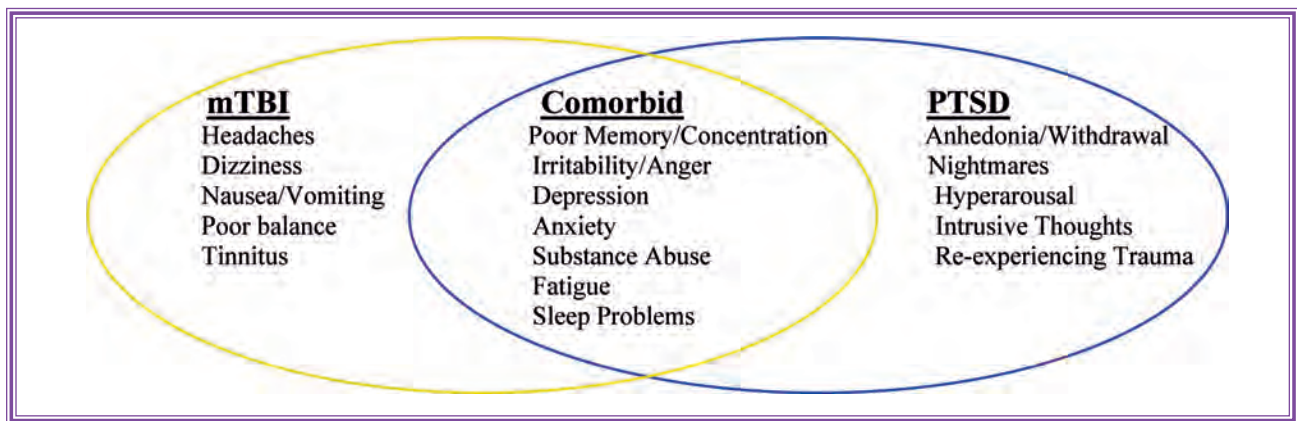

Figure 2. Symptoms common to both mTBI and PTSD

ognizing post-traumatic stress reactions, supportive care, and reassurance from care-providers may minimize the unnecessary attribution of normal stress reactions to minimal or nonexistent neuropathology and facilitate resilience after mTBI.[4]

PREVENTIVE MEASURES

Protective factors that prevent and reduce PTSD or in some cases symptoms following a mTBI are routinely seen in SOF personnel. These include psychological assessment in many personnel, above average intelligence, increased training, high unit morale, esprit de corps and camaraderie, maturity, and studies from SERE school that show SOF personnel are more stress hardy (biologically) in terms of dealing with acute and long term stress.[17,18,19] The possibility exists that although deployments in this population are more frequent than conventional forces, deployments are in shorter duration and may be protective in terms of individual psychological and physical "resetting." Another interesting phenomenon reported in the literature is that heat acclimation (chronic exposure to moderate heat) can also provide resistance to TBI.[20]

medical providers to potential blast injury. In a recent news article, the deputy coordinator for the DoD's Blast Injury Research Program Coordinating Office commented that this technology's first hurtle will be to prove that a sensor reading can be matched to a specific event.[21] Currently, there are systems being field tested by at least two contracting agencies, one of which is already in the theatre of operations in several thousand servicemembers.

EVALUATION

The military has instituted the Military Acute Concussion Evaluation (MACE) for use on the battle-field. Instructions for its use are available at http://www.dvbic.org/cms.phpp=Medical_care. This is a post-injury assessment measure and is designed for use fairly immediately following a TBI. There are no data to support its use beyond the acute injury period, although it may have sensitivity to persistent cognitive deficits after the first week. Key points to remember about the MACE are that the cutoff score for possible mTBI is 25 (although scores of 26 or 27 call for follow-up), and the MACE should be administered within 24
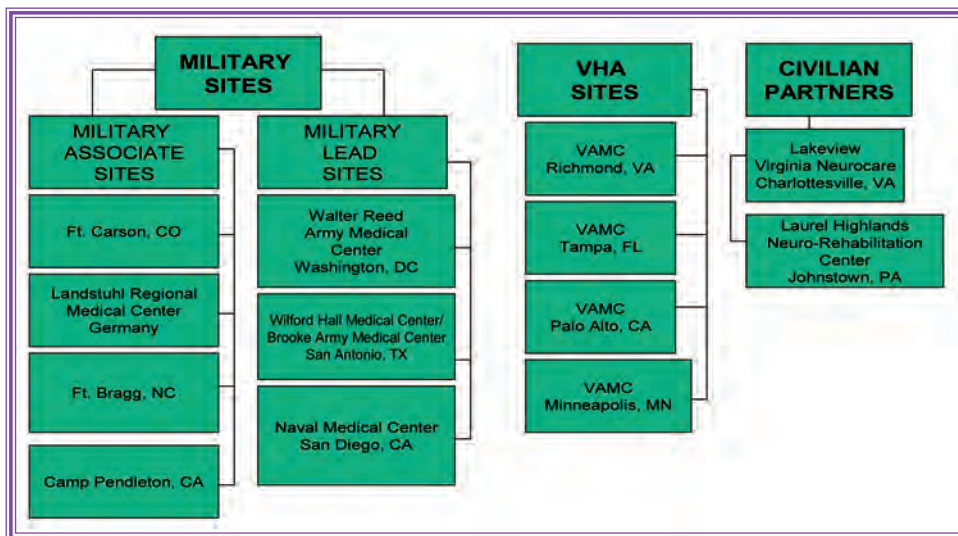
Figure 3. Organization of the Defense and Veterans Brain Injury Center locations.[24] The DVBIC is composed of seven military facilities, four VAMCs, and two civilian community reentry programs. Initiatives can be found on the center's website at http://www.dvbic.org.

hours of blast-exposure or blunt-force head trauma. Serial exams may be of use to coordinate return to duty or further evaluation and treatment. Although the majority of patients with mTBI recover quickly with minimal intervention, there is a subset that develops lingering symptoms that interfere with social and occupational functioning. Since patients with mTBI may not come to clinical attention for a variety of reasons, the purpose of assessment may vary slightly based on the timing of presentation following injury (Defense and Veterans Brain Injury Center: Updated mTBI Clinical Guidance).[22]

Most patients seeking medical care in a primary care setting are seen using the primary symptom-based approach where the medical provider treats the patient according to the most prominent symptoms. The patient informs the treating provider of an ailment causing some level of distress, discomfort, or dysfunction and the provider decides on a treatment to resolve the ailment. Tests are ordered and possibly a referral to a specialist. However, if a new symptom arises or becomes problematic, this process is repeated and can be time consuming leading to frustration for the patient and provider as well as missed diagnoses. For most medical patients, the primary system-based approach to patient care works; however, it has been shown to delay care when treating TBI. For TBI and blast-related polytrauma, focusing on the mechanism of injury approach, rather than solely on primary symptoms, can create a more comprehensive and integrated program of care. Patients have a case-manager assigned for screening,

are evaluated by a psychiatrist and/or neurologist, and are referred to multiple specialists for evaluation such as a psychiatrist, neuropsychologist, speech pathologist, audiologist, rehabilitation therapist and/or social worker based on individual needs.[23] This in-depth screening leads to a comprehensive treatment plan with higher rates of resolution for TBI. This model is currently used to treat blast related trauma including TBI at the Veterans Health Administration's Polytrauma Rehab Centers, DVBICs and Walter Reed's Psychiatry Continuity Service for the treatment of PTSD.

Deployed care providers can find clinical practice guidelines for the assessment and treatment of acute mTBI at http://www.pdhealth.mil/downloads/clinical_practice_guideline_recommendations.pdf for the three roles (levels) of care in theatre. The algorithms should not be interpreted as a substitute for sound clinical judgment. Operational and tactical considerations may in some instances override the CPG.[25]

Common symptoms following blast-exposure or blunt-force trauma include:
- difficulty organizing daily tasks
- blurred vision or eyes tiring easily
- headaches
- ringing in the ears
- feeling sad, anxious or listless
- easily irritated or angered
- feeling tired all the time
- feeling light-headed or dizzy
- trouble with memory, attention or concentration
- more sensitive to sounds, lights, or distractions
- impaired decision-making or problem-solving
- difficulty inhibiting behavior or behaving impulsively
- slowed thinking, moving, speaking, or reading
- easily confused, feeling easily overwhelmed
- change in sexual interest or behavior (Force Health Protection and Readiness Policy and Programs: Combat Trauma Quick Facts).[26]

Table 1. Traumatic Brain Injury[27]

Mild TBI	Moderate TBI	Severe TBI
Normal Structural Imaging	Normal or abnormal structural imaging	Normal or abnormal structural imaging
LOC = 0-30 minutes*	LOC > 30 min and < 24 hours	LOC > 24 hours
AOC = a moment up to 24 hours	AOC > 24 hours. Severity based on other criteria	
PTA = 0-1 day	PTA > 1 and < 7 days	PTA > 7 days

LOC -Loss of consciousness
AOC- Alteration in consciousness
PTA- Post-traumatic amnesia

*An inconsistency currently exists between published guidance and the published V codes for mild TBI when loss of consciousness is between 30 and 59 minutes. Until this consistency is resolved, Service and military medical personnel are to report in the attached format using criteria published above.[19]

Other symptoms commonly seen are alteration in sense of smell and taste, involuntary muscle tightness or stiffness, weakness in one side of the body, seizures, problems with perception and direction, increased need for simple/concrete directions, untriggered mood swings, and loss of one's social network resulting in isolation (Defense and Veterans Brain Injury Center: Signs and Symptoms of Traumatic Brain Injury located at www.dvbic.org).[28]

A recent study of 682 blast victims in Iraq revealed that the ear was the organ most vulnerable to blast over-pressure. The overall incidence of tympanic perforation was 35% in this population, and this type of injury was a significantly associated with loss of consciousness (and by definition at least mTBI). SOF medical providers treating perforated tympanic-membranes need to have a high index of suspicion for co-morbid mTBI and should routinely screen for neurological symptoms with the MACE.[29] However, petechiae in the oropharynx may be more sensitive in the diagnosis of blast injury and subsequent mTBI and therefore, medical providers should routinely include this in their examination for suspected head trauma.[30]

Formal neuropsychological testing is ideally conducted six to twelve months post-injury when most of the cognitive improvement following an mTBI has already occurred. Neuropsychological testing is generally conducted prior to the initiation of formal cognitive rehabilitation in order to guide the treatment plan. However, testing may be done anytime in assessment and management of mTBI. Neuropsychological testing may also be useful following the completion of a rehabilitation plan to evaluate outcomes. Treatment need not be delayed while awaiting neuropsychological testing.[22]

Functional neuroimaging [(functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT)] has been shown to be more useful and provide greater specificity in the evaluation of mTBI than structural neuroimaging with MRI or computed tomography (CT), as demonstrated by associations between brain activation and clinical outcomes.[31] Unfortunately, many treating locations do not have access to facilities that provide these studies. The most common types of non-penetrating traumatic brain injury are diffuse axonal injury, contusion, and subdural hemorrhage. When considering radiological work-up, MRI is more sensitive than CT in detecting diffuse axonal injury, however most cases of mTBI appear normal on CT and MRI. T2 weighted magnetic resonance (MR) images, especially fluid attenuated inversion recovery (FLAIR) images, are best for visualizing non-hemorrhagic lesions. Previous studies have shown that common locations of injury seen on scans would explain the symptoms of mTBI (memory, mood, attention, concentration, etc.). The most common locations for diffuse axonal injury are the corticomedullary (gray matter-white matter) junction (particularly frontotemporal), internal capsule, deep gray matter, upper brainstem, and corpus callosum. The most common locations for contusions are the superficial gray matter of the inferior, lateral, and anterior aspects of the frontal and temporal lobes, with the occipital poles or cerebellum less often involved. The most common locations for subdural hemorrhage are the frontal and parietal convexities.[6] Recently, it has been suggested that diffusion tensor imaging (DTI) with MRI may ultimately prove valuable for demonstrating neuronal abnormalities in the acute phase of mTBI.[32]

fMRI relies on magnetic properties of hemoglobin to create images of blood flow to the brain. Unlike CT and MRI, fMRI detects abnormal brain function, not structure. Patients are scanned while performing a cognitive task such as remembering a number. Increased regional neuronal activity results in increased blood flow and a change in the ratio of oxyhemoglobin to deoxyhemoglobin. This altered ratio appears as a bright area of activation, which often is

superimposed over a surface-rendered projection of the brain. Although there is no radiation exposure, the patient must be highly cooperative for the exam; however, this method shows the best correlation to clinical outcome compared to other radiological modalities.[33]

Lastly, secondary to increased impulsivity commonly seen after head trauma especially to the frontal lobe, it is recommended that screening for increased alcohol and other substance use disordered be performed. A good screening tool for alcohol is the alcohol use disorders identification tool or AUDIT.[34]

MANAGEMENT

As mission dictates, servicemembers who fall below cut off scores on the MACE or experience persistent problems with cognitive or sensory function (e.g., confusion, memory lapses, hearing loss, or blurred vision that does not resolve) should be pulled from the fight or placed on a one-week profile for limited duty at a minimum. Personnel should be screened at a minimum for neuropsychological symptoms after two to three months to ensure adequate documentation of symptoms, as the majority of cases or persistent PCS resolve after three months. Concussion research from sports medicine, primarily from boxing and football, suggested that returning an athlete to the field or boxing too early may put them at greater risk of having another concussion. Unfortunately, due to the nature of blast injury there is no clear timeline on return to duty for military personnel. The sequelae of each injury and prognosis will be based on the factors we have discussed above. Instead, return to duty from a military standpoint must be decided by an informed medical care provider based on that individual patient's mTBI, symptoms, and recovery. To promote faster recovery and manage symptoms, personnel should be directed to:

- Get plenty of rest & sleep.
- Increase activity slowly.
- Carry a notebook (write things down if trouble remembering) or use a PDA.
- Establish a regular daily routine to structure activities.
- Do only one thing at a time if easily distracted; turn off the TV or radio while at work.
- Check with someone trusted when making major life decisions.
- Avoid activities that could lead to another brain injury (contact sports, motorcycles, skiing, etc.).
- Avoid alcohol as it may slow healing of the injury.

- Avoid pseudo-ephedrine-containing projects as they may also increase symptoms (check labels on cough, cold, allergy, and diet medications).
- Avoid excessive use of over-the-counter sleeping aids (they can slow thinking and memory).[26]

Using medications to manage post-TBI syndromes is difficult and controversial due to lack of evidence in most studies, as well as the possibility of unintended side-effects worsening symptoms or creating new ones (e.g. decreased libido due to SSRI antidepressants). The general rule is to start slow at low dose and monitor closely side-effects and benefit of target symptoms. Unfortunately, no standard regimen exists, but there are numerous case studies and anecdotal evidence for medications to alleviate symptoms related to mood, sleep, and memory. No strong evidence exists that drugs are effective for mTBI-related neurobehavioral disorders, although weak evidence shows such drug classes, such as psychostimulants (dextroamphetamine, methylphenidate), can reduce symptoms of apathy, inattention, and slowness as well as improve impulsivity, memory, and concentration. Smaller studies of anticonvulsants used in treating post-TBI showed that valproic acid might improve behavioral control and decrease aggression, and it did not worsen performance on neuropsychological testing; carbamazepine reduced agitation in seven TBI patients and reduced anger in eight of ten others; gabapentin caused paradoxical effects in two TBI patients; and lamotrigine improved agitation in one TBI patient.[35] Both valproic acid and carbamazepine require periodic blood tests, and thus their use prevents an individual servicemember being deployable to an active combat zone. As stated, there is little data on medication efficacy and side-effects with co-morbid TBI. Medications discussed below are used/avoided as discussed based on known efficacy/side-effect profile both from on-label and from studied off-label use.

Headache is a remarkably common symptom of TBI. In part this is true because of the nature of TBI – an injury to the head which houses the brain is likely to cause headache. Indeed the headache of concussion is one of the most common initial symptoms. In the TBI clinic at Ft Bragg, most servicemembers with TBI suffered TBI weeks, months, or even years prior to presentation. Most report headaches that meet criteria for chronic daily headache beginning within weeks of the event that produced the TBI. Careful history and exam elicits multiple symptoms and signs of muscle involve-

ment in head and neck. Often these signs and symptoms have been present and worsening for months.

Initially, treatment should be conservative, consisting of a triptan, an anti-depressant with at least class C evidence for efficacy in headaches and a sleep-aid such as Ambien. Later, more aggressive therapy can be initiated such as pulsed steroids (dexamethasone 8mg BID x four to five days every other week), naproxen 500mg TID, baclofen 20mg TID, a proton pump inhibitor such as omeperazole, and ice packs to neck and occiput muscles BID to QID. Patients are taught specialized stretches and referred for physical therapy, chiropractic, and massage therapy as well. Three types of anti-inflammatory medications are used as are conservative therapies such as stretching and massage along with and specialized therapies such as chiropractic and physical therapy. The military would refer to this hit-hard-and-all-at-once technique as the "combined arms approach."

With chronic daily headache comes the opportunity for analgesic overuse syndrome (rebound headache). This is seen frequently in this patient population. Treatment is by standard guidelines: two months of analgesic "washout" during which no analgesics except celecoxib and/or steroids are used; celecoxib and steroids are not usually associated with overuse syndrome. A rescue medication such as a triptan may be used sparingly.

A prophylactic medication is often indicated for the resolution of chronic daily headache. For many servicemembers with TBI and even mild cognitive impairment, medications with sedating effects such as amitriptyline have an effect out of proportion to dose, causing increased cognitive slowing and impairment enough to significantly impact ADLs as reported separately by patients and spouses. In those without cognitive impairment, all those with proven efficacy (such as amitriptyline, topirimate) are effective in TBI without undue side-effects.

Low-dose, slowly titrated topirimate, despite its cognitive side-effects, has proven quite effective in the Ft Bragg TBI clinic for headache resolution when titrated over four weeks from 25mg QHS to 50mg BID. Nortriptyline has also been effective, titrated over four to five weeks from 25mg QHS to 100-125mg QHS.

An abortive headache treatment is often indicated, even in overuse syndrome. A variety has been studied. Midrin and zolmitriptan are generally effective for migraine headache although their use is recommended sparingly. In the Ft Bragg TBI clinic, frovatriptan has shown good efficacy as an abortive therapy even in non-migrainous headaches. Steroid and ketorolac injections can also be used as indicated.

Insomnia is a persistent and difficult-to-treat symptom of TBI. Zolpidem has been used in the Ft Bragg TBI clinic with some success but typically the doses needed are on the high side – zolpidem 10mg or zolpidem CR 12.5mg QHS. The medication is also sedating and can produce amnestic side-effects. There is little data suggesting that amnestic side-effects are contra-indicated in TBI or in TBI w/cognitive impairment but it seems counter-intuitive to prescribe an amnestic to an amnestic patient. Many using zolpidem report daytime somnolence and a "hangover" feeling throughout the early part of the day at these doses; most report a lack of effectiveness at lower doses. In the Ft Bragg TBI clinic, eszopiclone has been tried at different doses with best success with the 1mg formulation: 1 to 2mg QHS; patient may take the remainder of the nightly maximum 3mg for overnight awakenings. Example: Patient takes 2mg to fall asleep at 11 pm. He awakens at three am with difficulty going back to sleep. He takes the remaining 1mg, returns to sleep, wakes three or so hours later to the alarm without the "hangover" sensation.

Attention and concentration are often troublesome issues after TBI. The Ft Bragg TBI clinic has used stimulants approved for attention deficit hyperactivity disorder (ADHD) and attention deficit disorder (ADD) for a limited number of TBI patients with mixed success. Methylphenidate has been titrated from 5mg QAM to 10mg BID; atamoxetine 10mg/day titrated up to 40mg/day; and buproprion in the XL formulation 150mg titrated as high as 450mg/day.

Although there is little data that supports the use of selective serotonin reuptake inhibitors (SSRI) or serotonin-norepinephrine reuptake inhibitors (SNRI) post-TBI, they are commonly used to treat co-morbid mood, PTSD, and sleep disturbance as well as adjunctive therapy for post-concussive headache in TBI patients. Commonly used SSRIs prescribed off-label in this population include fluoxetine, sertraline, paroxetine, citalopram, and escitalopram. Commonly prescribed SNRIs off-label include venlafaxine and duloxetine. Second generation antipsychotics (olanzapine, risperidone, quetiapine, ziprasidone) are also frequently used off-label for mood stabilization, anger outbursts, irritability, sleep disturbance, and agitation. For the individual patient who is diagnosed with both PTSD and mTBI, the prescribing healthcare provider needs to make a decision whether to target the symptoms of PTSD first (e.g., nightmares, hyper-arousal) or address the symptoms of mTBI first and then treat any residual PTSD. We are not aware of any current guidelines to assist clinicians in

Table 2. Concussion Management Grid for treatment of common symptoms.[22]

Symptom Cluster	Presenting Symptoms or Complaints Assess frequency, severity, aggravating factors	Special Assessment related to complaint	Assessment Red Flags And Immediate Referral	Treatment Options by Symptom Cluster NOTE: Treat headache, sleep & irritability first as other symptoms often improve with pain control & rest Inclusion does not imply FDA approved use. See full prescribing information.
Headache	Headache Sensitivity to light/sound Tinnitus Nausea	**Examine:** Neurologic exam Musculoskeletal exam including cervical spine **Refer:** Any abnormality- 24 hours referral to Neurology	Neurology referral Worsening headache Seizures Blackout **Emergency Department (ED)** Fever Stiff neck	Episodic: (prn at HA onset, up to 3 days/week): ibuprofen 600-800 mg,; Naproxen; Triptans, compazine, Phenergan **Chronic Daily Headache (Preventive)**- onset ~4 weeks Propranolol 10- 240mg (BP & PTSD effects) Amitriptylline or Nortriptylline 10-100mg q HS (sleep) AED's gabapentin 300-900 mg q HS to BID sodium valproate 500-1500 mg (draw levels) topirimate 25-100mg q day to BID
Vision	Blurry vision Double vision (diplopia) Difficulty reading or focusing	**Examine:** Fundoscopic exam, visual acuity, visual fields Consider fluoresceine exam of cornea if foreign body suspected	Neurology referral Papilledema Cranial nerve deficit **Optometry or ophthalmology referral** Evidence of foreign body (FB)	Optometry evaluation- request binocular testing
Balance & Hearing	Dizziness Vertigo Balance difficulties Coordination problems Ringing in the ears	**Examine:** Dix-Hallpike Maneuver, Romberg, Cerebellar function (finger to nose, rapid alternating movement), nystagmus ENT/Audiology- otoscopic exam, bedside hearing test, audiogram if avail **Administer:** consider Dizziness Handicap Inventory (DHI) normal ≤ 11	Neurology referral Lateral abnormality, nystagmus, abnormal Romberg **ED or emergent Neurosurgery referral** CSF leak **ENT referral** Hemotympanum, FB, TM perforation	ENT/Audiology/Vestibular PT referral depending on local resources if Positive Dix-Hallpike- or DHI > 11 or persistent dizziness complaints
Sleep	Fatigue/Loss of energy Difficulty falling asleep Difficulty staying asleep Easily tired Nightmares/sleep walking	**Administer:** Epworth Sleepiness Scale, consider PSQI **Examine:** neck size, airway, height, weight **Evaluate:** sleep routine, medication/supplement use, alcohol & substance abuse, sleep activity, nightmares, frightened arousal Pittsburgh Sleep Quality Index (PSQI – not included in the package, but available at http://www.sleep.pitt.edu/	**Sleep Study referral** Apnea ESS>12 (Epworth Sleepiness Scale) BMI >30 (Body Mass Index)	Zolpidem 5-10 mg qHS max duration 10 days Trazodone 25-50 mg qHS max dose 150 mg (sleep maintenance) Amitriptyline 25 mg qHS max dose 100mg (headache benefit) Quetiapine 25 mg qHS Max dose 100mg (PTSD, nightmare benefit)
Irritability	Anger Depression Mood swings Anxiety Tension Easily overwhelmed	**Administer:** PCL-M Screening Questionnaire, consider PHQ-9 or other depression inventory **Evaluate:** specific history & symptoms: physical fighting, alcohol intake, relationship problems, suicidal, homicidal	**Behavioral Health referral** Outward violence Excessive alcohol intake Suicidal ideation Homicidal ideation	Sertaline 25-50 mg qD Titrate q7-10d max dose 150mg/d Citalopram 10 mg/day titrate to max dose 40 mg/day Allow 3-4 week therapeutic trial of each drug **Refer:** treatment failure of two meds
Cognition	Memory loss or lapse Forgetfulness Poor concentration Decreased attention Slowed thinking Executive dysfunction	**Administer:** MACE if injury within 24 hours, Other neurocognitive testing as available (eg ANAM or other neuropsychological testing) **Gather:** Collateral information from family, command and others		Normalize sleep & nutrition Pain control **Refer:** Speech/language pathology Occupational therapy Neuropsychology

making this determination. However, the above being said, many of these medications can cause side-effects that may need to be avoided if they have too sedating effects and/or have depressant effects. This includes tricyclic anti-depressants such as trazodone; many SSRIs such as mirtazapine, venlafaxine, duloxetine, quetiapine; almost all AEDs including gabapentin and pregabalin; beta-blockers, calcium-channel-blockers, and most muscle relaxers, such as cyclobenzaprine, and methocarbamol. Another way to look at this is to say the primary care/neurologist's headache and anti-depressant formulary has been mostly swept away.

In many cases of mTBI, patients are also taking medication for physical pain symptoms related to injury, mood, PTSD, headache, and sleep. It is not uncommon for these patients to be prescribed seven or eight different medications, which can increase the risk of drug-drug interaction as well as dependence. Providers should make it a rule to closely monitor target symptoms and whether certain medications are needed long-term and gradually wean medications over time since the majority of patients with mTBI will improve over time. This will also help in reducing further stigma that the service member has a serious medical condition as well as assist in a faster return to duty.

SUMMARY AND CONCLUSIONS

Due to the increased survivability compared to other conflicts and types of blast exposure as well as training, SOF military personnel are at markedly increased risk for mTBI. Therefore, it is of paramount importance for SOF medical providers to understand the process of evaluating and treating this "silent" disorder in order to maximize the functioning of our SOF warriors. Although much remains to be learned, we offer the following, preliminary, clinical guidelines for consideration in summary:

1. Patients in the field who produce failing scores on the MACE screening instrument, who experience injuries to the tympanic membranes following blast-exposure, who sustain serious head and neck injuries, and who manifest or complain of persistent cognitive and sensory deficits following explosions are likely to be at extremely high risk for suffering TBI.

2. Many experts believe that the majority of civilian blunt-force mTBI patients experience full recovery by

three to four months post-accident. Therefore, unless the occurrence of a brain injury has been established beyond doubt following blast exposure, providing supportive care and reassurance should facilitate the expectancy of full recovery in Special Forces combatants who have been exposed to blast-waves at close range.

3. When applied to mTBI, the word "mild" refers only to the acute change in functioning following blast-exposure or blunt-force trauma; it does *not* apply to the patient's long-term clinical outcome. Therefore, it is possible to experience one or more instances of mTBI and sustain serious cognitive, affective, and behavioral symptoms that persist and require medical treatment. Serious residual symptoms of mTBI following blast-exposure may exist even when the neurological exam, structural neuroimaging, and standard EEG are all normal.

4. While it is generally agreed upon that 10 to 15% of civilian patients with blunt-force mTBI will continue to experience moderate to severe symptoms that do not fully remit with the passage of time, we currently lack such data for military personnel with mTBI due to blast-exposure.

5. Because no two blast-exposures are exactly alike, we cannot predict which blast-exposed patients will fully recover and which ones will go on to develop problems which do not fully resolve, such as persistent symptoms of Post-Concussive Syndrome.

6. For a variety of reasons, SOF personnel may be reluctant to describe the full extent of cognitive and behavioral changes following blast-exposure. When this occurs, collateral informants such as family members, fellow unit members, or supervisors may provide useful information regarding possible changes in neurobehavioral functioning.

7. For blunt-force mTBI, functional neuroimaging (PET, SPECT, fMRI) is more likely to provide evidence of cerebral dysfunction than is structural neuroimaging (CT, MRI). In the future, this could well prove to be the case for mTBI patients with blast-exposure. Special MRI studies using new DTI technology also appear to have similar potential.

8. Some symptoms of mTBI due to blast-exposure overlap those of PTSD and secondary depression, which frequently occur co-morbidly with mTBI.

9. Double-blind, placebo-controlled studies supporting the efficacy of specific medications for treating symptoms associated with mTBI are almost completely lacking. Nevertheless, guidelines and rationales do exist for the use of various classes of psychotropic medications to treat persistent symptoms of mTBI.[36,37]

10. Given our limited knowledge base, it generally makes more sense to think in terms of using medications to target specific symptoms (e.g., stimulants for reduced concentration and persistent fatigue; mood-stabilizers with anticonvulsant properties for irritable or unprovoked aggression, etc.) than to think in terms of treating a well-defined clinical "syndrome" with a single medication.

11. When using medications to treat symptoms of mTBI, it is best to "go low and slow" in terms of titrating dosages because: (a) many SOF patients self-monitor for possible side-effects; and (b) there is often an anti-medication bias among military personnel (i.e., "real men don't take pills") that needs to be overcome if pharmacological treatment is to be accepted.

12. When mTBI and PTSD co-occur in the same patient it seems prudent to target the symptoms of one condition at a time for treatment with medication. There are currently no accepted guidelines as to whether to treat mTBI or PTSD first.

13. Behavioral treatments and cognitive rehabilitation can be useful adjuncts to medical treatment once the mTBI patient reaches the home-front. Family education is also critical, so that significant others can better understand the SOF patient's problems and needs.

14. In the unfortunate event that a patient must be separated from military service, the servicemember should be encouraged to "grieve" for the loss of his military career and encouraged to take full advantage of VA services and benefits as soon as possible when discharged. SOF medical providers need to be aware of the USSOCOM Care Coalition (http://www.socom.mil/care_coalition /) and refer SOF patients into this program according to long term needs and definitely if they are going through medical evaluation board proceedings.

15. Over the next few years, there is likely to be a flood of new research on the effects and treatment of blast-exposure. SOF and military care-providers will need to update themselves on at least a yearly basis with regard to new developments in the clinical assessment and treatment of mTBI due to blast-exposure.

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Spontaneous Pneumopericardium, Pneumomediastinum, and Subcutaneous Emphysema in a 22-year old Active Duty Soldier

David Thompson, MPAS, PA-C

USASOC Sustainment Brigade and Womack Army Medical Center, Department of Emergency Medicine

Abstract

A radiological case study of spontaneous pneumopericardium, pneumomediastinum, and subcutaneous emphysema is reported in a 22-year old active duty male Soldier undergoing survival, evasion, resistance, and escape (SERE) training and presenting for evaluation of sore throat and retrosternal chest pain. The patient is one of several that presented with similar symptoms in a 24-hour period. After close observation, he was released to his unit and recovered well.

Key Words: pneumopericardium, pneumomediastinum, subcutaneous emphysema, SERE

Background

Pneumomediastinum (PM) was first described by Laennec in 1819 as a consequence of traumatic injury. Spontaneous pneumomediastinum (SPM) was reported in 1939 by Hamman, for whom the Hamman sign is named. Pneumomediastinum is defined as free air or gas contained within the mediastinum, which almost invariably originates from the alveolar space or the conducting airways. The etiology of PM is multifactorial. Many authors distinguish SPM as a form of PM that is not associated with blunt force or penetrating chest trauma, endobronchial or esophageal procedures, neonatal lung disease, mechanical ventilation, chest surgery, or other invasive procedures.[1]

PM rarely leads to clinically significant complications. More commonly, the associated or precipitating condition underlying PM may be the cause of significant illness. On rare occasions, tension PM has been reported in which elevated mediastinal pressure leads to diminished cardiac output because of direct cardiac compression or reduced venous return. When extensive subcutaneous and mediastinal gas is present, airway compression may also occur.

The generally accepted explanation for the development of PM is that following alveolar rupture, gas can dissect along the perivascular sheath into the mediastinum to produce pneumomediastinum. Symptoms of pneumomediastinum include a sensation of fullness in the chest, pleuritic chest pain that may radiate to the shoulders, dyspnea, coughing, hoarseness, and dysphagia. Crepitation in the neck due to associated subcutaneous emphysema may be present, and a crackling sound heard over the heart during systole (Hamman's sign) may be appreciated upon auscultation.[2]

The dissection of free air may not be confined solely to the mediastinum. Zylak et al. note that the mediastinum communicates with the submandibular space, the retropharyngeal space, and vascular sheaths within the neck.[3] In addition, two routes of communication with the retroperitoneum have been noted: via a tissue plane extending through the sternocostal attachment to the diaphragm, as well as periaortic and periesophageal fascial planes. As a result, air present within the mediastinum may dissect through these tissue planes, causing pneumopericardium, pneumothorax, subcutaneous emphysema, pneumoperitoneum, or pneumoretroperitoneum.[4]

Pneumomediastinum is a relatively rare condition. PM has been described in the literature as a complication of a scuba diving related injury. A single case was described by Holmes in *Military Medicine* in 1999 about a Soldier who developed PM after exposure to high concentration smoke.[5] Grossman described 10 student aviators in the Israeli Air Force who experienced a single, uncomplicated episode of PM unassociated with flying.[6]

Case Report

A 22-year old white male presented to the emergency department after transport by front line ambulance

from the troop medical clinic (TMC) at an outlying clinic to rule out pneumothorax. He was complaining of a sore throat, neck pain, and shortness of breath with exertion. He denied chest pain. Noted by the triage nurse was subcutaneous emphysema to the anterior neck. The patient had symptoms for two days after prolonged screaming and being slapped in the face during training at the SERE (survival, escape, resistance, and evasion) course. The patient also reported slight retrosternal chest pain, essentially resolved after his transport to the ER. Past medical and surgical history, family medical history, and social history were all unremarkable as was his review of symptoms.

Physical examination revealed a well developed, well nourished white male Soldier in no acute distress, sitting upright on the ER gurney. His vital signs were: temperature 97.8, pulse 73, respiratory rate 16, blood pressure 116/72, and oxygen saturation 97% on room air, 100% on three liters of oxygen. The patient exhibited a normal head, eyes, ears, nose, and throat exam, with easily palpable subcutaneous emphysema on the anterior neck and upper chest. His breath sounds were clear to auscultation bilaterally. His cardiac examination revealed a regular rate and rhythm, but had an easily heard crackling sound with systole best heard at the lower left sternal border. The remainder of his examination was entirely within normal limits.

A posterior, anterior, and lateral chest radiograph and soft tissue neck films were ordered. (See Figure 1 - 3) Tracking of subcutaneous air was easily seen on the soft tissue neck. There was also evidence of pneumopericardium and pneumomediastinum on the chest radiograph. There was no evidence of pneumothorax or pneumoperitoneum.

The patient was observed for several hours in the emergency department. He had a stable ER course without change in condition. His case was discussed with the referring physician assistant and he was discharged to his unit with a "no flying" profile for two weeks and scheduled follow up at his TMC.

DISCUSSION

Spontaneous pneumomediastinum is an uncommon finding in clinical practice. It is often associated with pneumopericardium and subcutaneous emphysema. It can be associated with complications of pneumothorax (1 to 25% mortality rate after treatment if associated with COPD or AIDS) as well as boerhaave syndrome (esophageal rupture following vomiting; mortality rate as high as 50 to 70%).[7,8] Other predisposing conditions associated with high mortality

rates include trauma (blunt and penetrating, especially high velocity injury), asthma, and tracheobronchial perforation. Typically, without any complications, PM has a low mortality rate.

The diagnosis of PM can be confirmed on the basis of chest and neck radiographs. Typically, a radiolucent band is seen along the cardiac border on the posteroanterior film and retrosternally on the lateral view. No specific treatment is required, but inhalation of 100% oxygen is recommended to hasten resorption of extraalveolar gas. Rarely, mediastinotomy may be required to relieve a tension pneumomediastinum.[9,10]
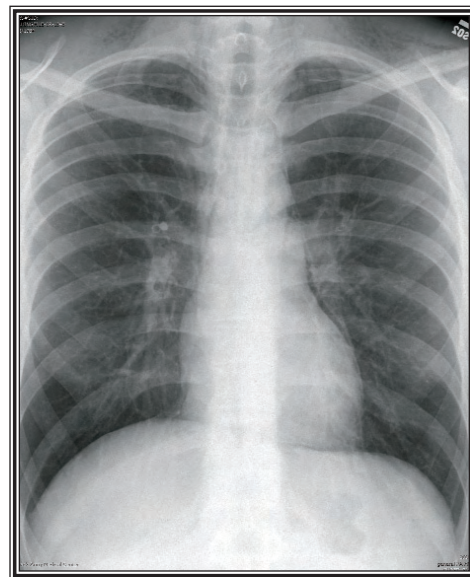

Figure 1

Figure 2

Spontaneous Pneumopericardium, Pneumomediastinum and Subcutaneous Emphysema in a 22-year old Active Duty SoldierMental Health Condition

89

Figure 3

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Continuing Medical Education Test

Mild TBI: Situational Awareness for Special Operations Medical Providers

1. True or False: Serious symptoms can persist or develop weeks to months after a seemingly "mild" instance of closed-head trauma.

2. Persistent post-concussive syndrome (PCS) is characterized by common symptoms such as
   a. irritability.
   b. memory problems.
   c. headache.
   e. difficulty concentrating.
   f. All of the above

3. True or False: The Centers for Disease Control and Prevention estimates that 10% of those hospitalized for TBI had at least one unmet need for services one year after injury. The most frequent unmet needs were: improving memory and problem solving; managing stress and emotional upsets; controlling temper; and improving one's job skills.

4. Secondary blast injuries are caused by
   a. direct effect of the blast wave.
   b. other objects that are accelerated by the explosive waves.
   c. movement of the victim being thrown or structural collapse.
   d. burns, asphyxia from being buried in debris, or exposure to toxic inhalants.

5. Quaternary blast injuries are caused by
   a. direct effect of the blast wave.
   b. other objects that are accelerated by the explosive waves.
   c. movement of the victim being thrown or structural collapse.
   d. burns, asphyxia from being buried in debris, or exposure to toxic inhalants.

6. Disorders that frequently co-occur with mTBI or persistent PCS head trauma and can significantly complicate diagnosis, treatment, and the recovery process are
   a. PTSD
   b. obsessive compulsive disorder
   c. substance use disorders
   d. All of the above
   e. A and C

7. True or False: In a nonrandom sample of two Army brigades likely to be representative of servicemembers serving in ground-combat units in Iraq, 15% of servicemembers reported an injury during deployment that involved loss of consciousness or altered mental status and thus, by definition, incurred at least one mTBI. This 15% were significantly more likely to report high combat exposure and a blast mechanism of injury than others servicemembers in the study who reported other types of injuries.

8. The military has instituted _____ for the evaluation of TBI on the battlefield
   a. Post-truamatic Checklist-Military (PCL-M).
   b. Automated Neurological Assessment Metrics (ANAM).
   c. Military Acute Concussion Evaluation (MACE).
   d. Mini Mental Status Evaluation (MMSE).

9. True or False: When administering the MACE, key points to remember are that the cutoff score for possible mTBI is 24 and the MACE should be administered within 48 hours of blast-exposure or blunt-force head trauma.

10. Common symptoms following blast-exposure or blunt-force trauma include
    a. feeling tired all the time.
    b. feeling light-headed or dizzy.
    c. being more sensitive to sounds, lights, or distractions.
    d. changes in sexual interest or behavior.
    e. A and C
    f. All of the above

11. True or False: A patient that experiences loss of consciousness for 25 minutes, with post-traumatic amnesia for 15 hours after a fall would be classified as a moderate TBI.

12. Sensitive markers in the evaluation of mild TBI include
    a. tympanic perforation.
    b. MRI.
    c. petechiae in the oropharynx.
    d. CT scan.
    e. A and C

13. True or False: Although not FDA recommended, medications commonly "used off-label" to treat symptoms of mTBI include SSRI's (sertraline), sleep medications (zolpidem), mood stabilizers (valproic acid), second generation antipsychotics (quetiapine), and stimulants (methylphenidate).

14. True or False: Serious residual symptoms of mTBI following blast-exposure may exist even when the neurological exam, structural neuroimaging, and standard EEG are all normal.

15. Military personnel in the field likely to be at extremely high risk for suffering TBI
    a. produce failing scores on the MACE screening instrument.
    b. have sustained serious head and neck injuries.
    c. manifest or complain of persistent cognitive and sensory deficits following explosions.
    d. All of the above

If you are a physician, PA, or nurse, send in the Uniformed Services University of the Health Sciences (USUHS) Evaluation Form with your test.

If you are a Medic, Corpsman, or PJ, send the SOCOM Evaluation Form with your test.

Article

Mild TBI: Situational Awareness for Special Operations Medical Providers

	3 - Agree	**2 - Neutral**	**1- Disagree**

Educational Value: **3 2 1**

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Mild TBI: Situational Awareness for Special Operations Medical Providers

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5. A. B. C. D.

6. A. B. C. D.
7. A. TRUE B. FALSE.
8. A. B. C. D.
9. A. TRUE B. FALSE
10. A. B. C. D. E. F.

11. A. TRUE B. FALSE
12. A. B. C. D. E.
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Article
Mild TBI: Situational Awareness for Special Operations Medical Providers

	3 - Agree	2 - Neutral	1- Disagree

Educational Value: 3 2 1

I learned something new that is important.   _ _ _
I verified some important information.   _ _ _
I plan to discuss this information with colleagues.   _ _ _
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Readability Feedback:
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Mild TBI: Situational Awareness for Special Operations Medical Providers

Multiple choice

1. A. TRUE B. FALSE
2. A. B. C. D. E. F.
3. A. TRUE B. FALSE
4. A. B. C. D.
5. A. B. C. D.

6. A. B. C. D.
7. A. TRUE B. FALSE.
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10. A. B. C. D. E. F.

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Trench Foot: The Medical Response in the First World War 1914–18

Robert L. Atenstaedt, MA, MPhil, MSc, DPhil, MPH, MB, BS, MFPH

ABSTRACT

The approaching 90-year anniversary of United States entry into the Great War is an apt time to examine the response to trench foot (now called nonfreezing cold injury [NFCI]) in this conflict. Trench foot appeared in the winter of 1914, characterized by pedal swelling, numbness, and pain. It was quickly recognized by military medical authorities. There was little debate over whether it was frostbite or new condition, and it was quickly accepted as a specific disease. The major etiologies proposed were exposure, diet, and infection. The opinion emerged that it was caused by circulatory changes in the foot caused by cold, wet, and pressure. Predisposing factors included dietary inadequacy and fatigue. A number of labels were first given to the disease. However, the name "trench foot" was eventually officially sanctioned. Trench foot became a serious problem for the Allies, leading to 75,000 casualties in the British and 2000 in the American forces. Therapy for trench foot involved a number of conventional, tried-and-tested, and conservative methods. Some more innovative techniques were used. Amputation was only used as a last resort. Prevention involved general measures to improve the trench environment; modification of the footwear worn by the men; and the provision of greases to protect them from moisture. The medical reaction to this condition seems to have been relatively effective. The causation was identified, and prophylactic measures were introduced to fit this model; these seem to have been successful in reducing the prevalence of the condition by 1917–18.

Reconstructing Lives — A Tale of Two Soldiers

Susan Okie, MD

EXTRACT

Jason Pepper can't see the deer and wild turkeys that feed in the pasture in front of his new home, an hour's drive from Nashville. But when he sits and smokes on his front porch, he likes knowing they're out there — and even more, he savors the silence. Pepper, who was blinded by a bomb in Iraq in 2004, completed a rehabilitation program for blind veterans last year at the Edward Hines, Jr., Veterans Affairs Hospital in Illinois, learning to find his way using a cane and a personal global positioning system (GPS) device. With this device he was . . .

Emergency Department Visits for Behavioral and Mental Health Care After a Terrorist Attack

Charles DiMaggio, PhD, MPH, PA-C, Sandro Galea, MD, DrPH, Lynne D. Richardson, MD

ABSTRACT

STUDY OBJECTIVE: We assess emergency department (ED) utilization by a population whose healthcare encounters can be tracked and quantified for behavioral and mental health conditions in the aftermath of the terrorist attacks of September 11, 2001. **METHODS:** We assessed presentations to EDs by using Medicaid analytic extract files for adult New York State residents for 2000 and 2001. We created 4 mutually exclusive geographic areas that were progressively more distant from the World Trade Center and divided data into 4 periods. All persons in the files were categorized by their zip code of residence. We coded primary ED diagnoses for posttraumatic stress disorder, substance abuse, psychogenic illness, severe psychiatric illness, depression, sleep disorders, eating disorders, stress-related disorders, and adjustment disorders. **RESULTS:** There was a 10.1% relative temporal increase in the rate of ED behavioral and mental health diagnoses after the September 11, 2001, terrorist attacks for adult Medicaid enrollees residing within a 3-mile radius of the World Trade Center site. Other geographic areas experienced relative declines. In population-based comparisons, Medicaid recipients who lived within 3 miles of the World Trade Center after the September 11, 2001, terrorist attacks had a 20% increased risk of an ED mental health diagnosis (prevalence density ratio 1.2; 95% confidence interval 1.1 to 1.3) compared to those who were non–New York City residents. **CONCLUSION:** The complex role that EDs may play in responding to terrorism and disasters is becoming increasingly apparent. To the best of our knowledge, this is the first report of a quantifiable increase in ED utilization for mental health services by persons exposed to a terrorist attack in the United States.

Chirurgica Taurina: A 10-Year Experience of Bullfight Injuries

Rudloff, Udo MD; Gonzalez, Victor MD, FACS; Fernandez, Eduardo MD, FACS; Holguin, Esteban MD; Rubio, Gustavo MD; Lomelin, Jorge MD; Dittmar, Michael MD; Barrera, Rafael MD

ABSTRACT

BACKGROUND: Despite recent efforts to improve medical treatment for injured bullfighters, including the foundation of a scientific society for bullfight injuries, serious injuries, in particular in villages and smaller arenas, still do occur. We are not aware of any series in the English literature that aimed to study the specific mechanisms, types, and outcomes of these injuries. **METHODS:** A review of the trauma registry of injured bullfighters who suffered any type of trauma during bullfighting and received emergency therapy by the Surgical Trauma Services between 1994 and 2004 at the Plaza de Toros Nuevo Progreso, Guadalajara, Mexico. **RESULTS:** In all, 68 out of 750 bullfighters (9.06%) required emergency assistance during bullfighting. Trauma to the upper and lower extremity was most common (66%), followed by injuries to the inguinal (8%) and perineal area (7%). Extremity injuries included penetrating wounds requiring operative debridement in 64% of cases, articular dislocations in 4%, closed fractures in 4%, and open fractures in 1% of cases. Major vascular injuries occurred in 5% of the cases. Penetrating inguinal and penetrating perineal injuries were associated with major vascular injuries to the femoral vessels, necessitating operative repair in 33% of the cases. **CONCLUSION:** A considerable risk of serious, life-threatening injuries is inherent to bullfighting. Penetrating inguinal and perineal trauma with injury to the femoral vessels represents a specific, potentially fatal injury. A low threshold for exploration of these penetrating injuries in injured bullfighters is associated with a favorable outcome. Appreciation of the unique mechanisms and types of injuries related to bullfighting should lead to target intervention and help the evolvement of improved emergency treatment in organized bullfighting.

Aortic Rupture in High-Speed Skiing Crashes

Heller, Georg MD; Immer, Franz F. MD; Savolainen, Hannu MD; Kraehenbuehl, Eva S. MD; Carrel, Thierry P. MD; Schmidli, Juerg MD

ABSTRACT

BACKGROUND: New equipment and techniques in winter sports, such as carving skis and snowboards, have brought up new trauma patterns into the spectrum of leisure trauma. The injuries resemble high-energy trauma known from road crashes. The aim of the present study was to assess the incidence of acute traumatic descending aortic rupture in recreational skiing-crashes. **MATERIAL:** Between January 1995 and December 2004, 22 patients were admitted to our hospital for aortic rupture. Four patients had skiing crashes (18.2%). Mean age was 31 years; all patients were male. In two cases, aortic rupture was associated with fractures of the upper and lower extremities. One patient additionally had a cerebral contusion with an initial Glasgow Coma Scale score of 13. In two patients, isolated aortic rupture was diagnosed. **RESULTS:** Two patients were treated by graft interposition, and one by endograft. One patient arrived under mechanical resuscitation without blood pressure. He died at admission. He had been observed for 5 hours in another hospital, complaining of severe intrascapular back pain, before transport to our trauma unit for unknown bleeding. In the other three cases, treatment was successful. **CONCLUSION:** Rescue services and paramedics should be aware of this new type of injury. Acute aortic rupture has to be considered as possible injury in high velocity skiing crashes.

Malaria Risk Assessment and Preventive Recommendations - A New Approach for the Canadian Military

Schofield, Steve; Tepper, Martin; Tuck, Jeremy J. H.

ABSTRACT

Western militaries deploying to international locations are often confronted with the threat of malaria. For the Canadian military, the consequent response has been prescriptive—any risk of malaria warrants use of personal protective measures and chemoprophylaxis. In reality, however, malaria risk is highly variable and a one-size-fits-all strategy to mitigation may not be appropriate. In line with this, the Canadian military has revised its approach to malaria risk assessment and preventive response. More effort is now spent on predictive modeling and, where risk is deemed to be low, chemoprophylaxis may not be recommended. We describe here an application of the revised methodology to the recent Canadian military deployment to Kandahar province, Afghanistan.

Chest Wall Thickness in Military Personnel - Implications for Needle Thoracentesis in Tension Pneumothorax

Harcke, H. Theodore; Pearse, Lisa A.; Levy, Angela D.; Getz, John M.; Robinson, Stephen R.

ABSTRACT

Needle thoracentesis is an emergency procedure to relieve tension pneumothorax. Published recommendations suggest use of angiocatheters or needles in the 5-cm range for emergency treatment. Multidetector computed tomography scans from 100 virtual autopsy cases were used to determine chest wall thickness in deployed male military personnel. Measurement was made in the second right intercostal space at the midclavicular line. The mean horizontal thickness was 5.36 cm (SD = 1.19 cm) with angled (perpendicular) thickness slightly less with a mean of 4.86 cm (SD 1.10 cm). Thickness was generally greater than previously reported. An 8-cm angiocatheter would have reached the pleural space in 99% of subjects in this series. Recommended procedures for needle thoracentesis to relieve tension pneumothorax should be adapted to reflect use of an angiocatheter or needle of sufficient length.

Smokeless Tobacco Use in Military Personnel

Peterson, Alan L.; Severson, Herb H.; Andrews, Judy A.; Gott, Sherrie P.; Cigrang, Jeffrey A.; Gordon, Judith S.; Hunter, Christine M.; Martin, Gary C.

ABSTRACT

Military personnel are more than twice as likely as civilians to use smokeless tobacco (ST), and recent studies indicate that military prevalence rates are rising. However, few studies have examined factors related to ST use in the military. The present study evaluated the characteristics of ST use in 785 active duty military personnel. The results indicated that the average age of initiation was 17.7 years, participants had used ST for 12.3 years, and they used approximately four tins or pouches of tobacco per week. Army personnel were more likely than Air Force personnel to be older, to have used ST longer, and to be heavier users. Officers had used ST longer than enlisted personnel and were more likely to have had a recent quit attempt. Enlisted personnel were more than three times as likely to report concurrent cigarette smoking. These results indicate that there are significant differences in ST use patterns in military personnel, and cessation programs should be tailored to meet these differences.

Parachute ankle brace and extrinsic injury risk factors during parachuting

JJ, Darakjy S, Swedler D, Amoroso P, Jones BH.

ABSTRACT

Introduction: This study examined the injury prevention effectiveness of the parachute ankle brace (PAB) while controlling for known extrinsic risk factors. **Methods:** Injuries among airborne students who wore the PAB during parachute descents were compared with injuries among those who did not. Injury risk factors from administrative records included wind speed, combat loads, and time of day (day/night). Injuries were collected in the drop zone. **Results:** A total of 596 injuries occurred in 102,784 parachute descents. In univariate analysis, students not wearing the PAB (Controls) were 2.00 [95% confidence interval (95% CI) = 1.32-3.02] times more likely to experience an ankle sprain, 1.83 (95% CI = 1.04-3.24) times more likely to experience an ankle fracture, and 1.92 (95% CI = 1.38-2.67) times more likely to experience an ankle injury of any type. PAB wearers and Controls had a similar incidence of lower body injuries exclusive of the ankle [risk ratio (Control/PAB) = 0.92, 95% CI = 0.65-1.30]. After accounting for known extrinsic injury risk factors, Controls were 1.90 (95% CI = 1.24-2.90) times more likely than PAB wearers to experience an ankle sprain, 1.47 (95% CI = 0.82-2.63) times more likely to experience an ankle fracture, and 1.75 (95% CI = 1.25-2.48) times more likely to experience an ankle injury of any type. The incidence of parachute entanglements that persisted until the jumpers reached the ground were similar among PAB wearers and Controls [RR (Control/PAB) = 1.17, 95% CI = 0.61-2.29]. **Conclusion:** After controlling for known injury risk factors, the PAB protected against ankle injuries, and especially ankle sprains, while not influencing parachute entanglements or lower body injuries exclusive of the ankle.
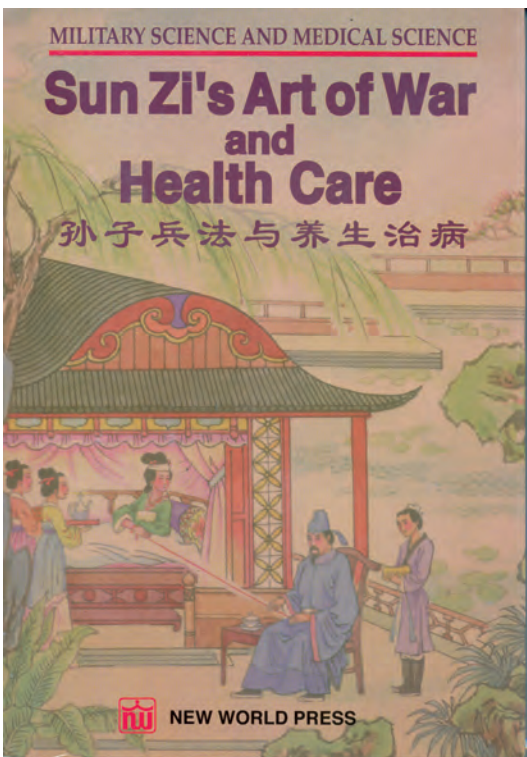
Sun Zi's Art of War and Health Care

Rusong Wu, Wang Hongtu, and Huang Ying.
Beijing, China: New World Press, 1997. ISBN 7-800-05376-8, paperback, 400 pages.

Reviewed by COL Warner Farr, MD

A common operational issue in Special Operations Forces (SOF) medicine is interfacing with the practitioners of medical philosophies and disciplines from other cultures while trying to use our western medical practices and skills to our advantage. It does not take a SOF practitioner long to realize that he or she must take into consideration the local customs and medical ways; and if those local practices can be co-oped into the treatment plan, then so much the better. In fact, since we do not want to attempt to arbitrarily raise the standard of care for an entire region just for a short time and then lower it again after the mission is over and we leave, attributing our success to our mastery of local ways and the power of local healing practices may actually be better in the long term.

One of the most widespread non-western medical systems is the Chinese traditional medicine (CTM) with its acupuncture meridians and channels, deficiencies and excesses, the five elements (wood, fire, earth, metal, and water), heat and cold, body resistance, and yin and yang. This book has an interesting authorship. It is written by a threesome of Chinese, two of them military officers from the Peoples Liberation Army: a Sun Tzu "Art of War" doctoral tutor, an expert in CTM (the lone civilian), and a military surgeon. It is an interesting read and a deep look at how another culture views both anatomy and physiology and how they approach a patient's care. The authors are quick to point out that CTM was evolving at exactly the same time in Chinese history as Sun Tzu was in the "Warring States Period" of 770-221 B.C. "The Art of War" was of the same era as "The Yellow Emperor's Canon of Internal Medicine."

The 43 chapters illustrate the relationship between CTM and Chinese military strategy. The text is bi-lingual (English and Chinese). The book attempts to explain the theories of traditional Chinese medicine by clinical examples of a historical nature while focusing on the theory that medicine and warfare are similar pursuits. They believe that Sun Tzu's rules of warfare as written in "The Art of War," apply as succinctly to practicing medicine as they do to practicing war. The authors point out that combating disease is like combating the enemy and that in disease and war, prevention is preferable, pointing out "preventing a disease is like deterring an enemy." They believe that choosing a doctor is like choosing a military commander and that applying medicines is like using military forces.

A typical quote is "Saving people from war is like saving a patient from illness. A good doctor writes prescriptions according to the patient's condition. A good general plans a battle according to the enemy situation. The 13 chapters of the Art of War are actually prescriptions for treating disease." Topics covered to stress this commonality include terrain and topography, mental calm, good timing, exploiting circumstances, different approaches to disease, and holistic treatments. A portion of the book, larger that I expected, is devoted to placebos and also how to engage the mental attitude of the patient to make the treatment more effective.

With the collapse of centralized Soviet healthcare in the Central Asian states, those peoples are increasingly turning to traditional medicines. Centers for the study and understanding of folk medicine are opening throughout Central Asia, a geographic area of interest to our national policy. Their physicians tap into Central Asia's rich medicinal texts, both modern and historical, which focus on the local flora and fauna as remedies for ills. This medicine draws on a rich and diverse heritage from pre-Islamic shamanist traditions, Islamic practices before the Soviet period, Indian, Near East, and CTM from China and Tibet. Therefore, CTM is broader than just China.

All in all, this is an interesting read which strikes home with its Sun Tzu similes and will make you want to learn more about CTM. It is a short read with 150 pages in Chinese and 250 in English.

Some final quotes:

"Choosing a doctor is like selecting a military commander. A good commander should be selected to conduct war, and a good doctor should be chosen to treat diseases. The reasons are the same."
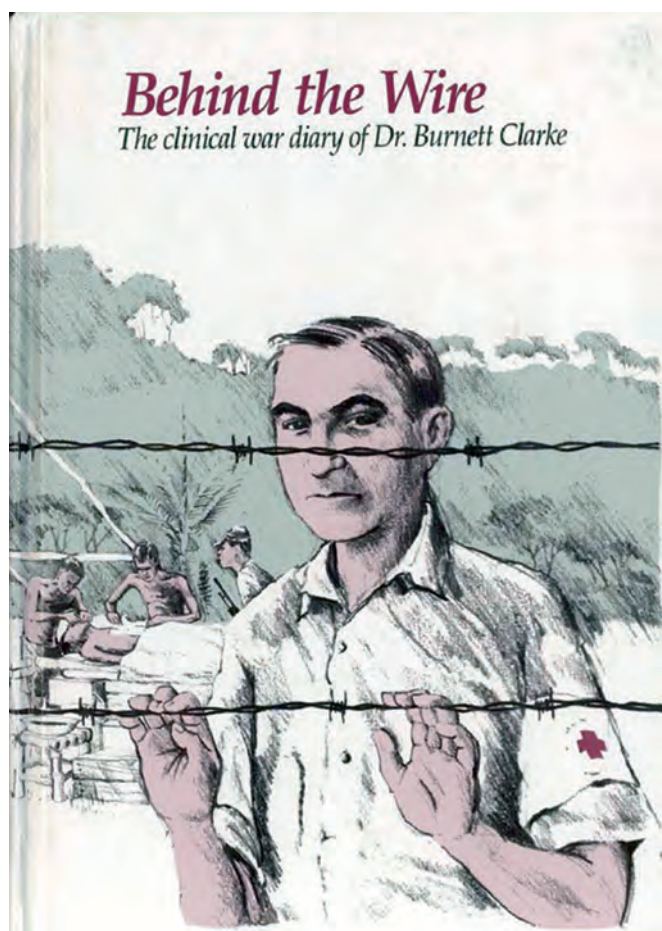
"Applying medicine is like using military forces. Military forces are cruel, dangerous, and violent. So are medicines."

Behind the Wire
The Clinical War Diary of Major Burnett Clarke,

First published - April 1989. Published by: University of Queensland, Royal Children's Hospital, Brisbane Q.4029 Australia

Review by Frank Anders, MD

Titles can be misleading. This is the posthumously published diary of Major Burnett L. Clarke. Dr. Clarke was a hospital-based radiologist and radio-oncologist in Australia before World War II making him one of the world pioneers in his field. His specialty credentials are impressive with his Diploma in Medical Radiology and Electrology received at Cambridge in 1923. The next two years he spent here in the U.S. at the Mayo Clinic in postgraduate radiology.

Dr. Clarke joined the Australian Army Medical Corps at the outbreak of the war (for you young folks that was 1939) but was not posted forward from Australia to Singapore until the war came to the Pacific in 1941. On February 15, 1942, after a number of patients and staff were massacred by the advancing Japanese at the British Hospital at Alexandria on the island, Singapore fell. That day, he and 15,000 other Aus-

tralians became prisoners. Over one hundred medical officers were among those taken prisoner. Within a very short time the lack of electricity and adequate water supply made X-rays impossible and skin disorders were becoming rampant. Major Clarke was asked to become the camp dermatologist.

With the help of a fellow prisoner named Murray Griffin, who was a talented artist, Dr. Clarke chronicled a large assortment of skin lesions from the time of his capture until the war ended. These skin disorders were brought on by the tropical environment and lack of hygiene complicated by starvation. He also describes the effect of the rudimentary treatments afforded him. The editor, Professor John Pearn, notes that the keeping of diaries was not tolerated by the Japanese. The only reason this one survived is that Dr. Clarke was very careful not to mention the torture and barbarous treatment of the prisoners by their captors. That part is reflected by the death of 4,250 of the Australians in the camp by the end of hostilities.
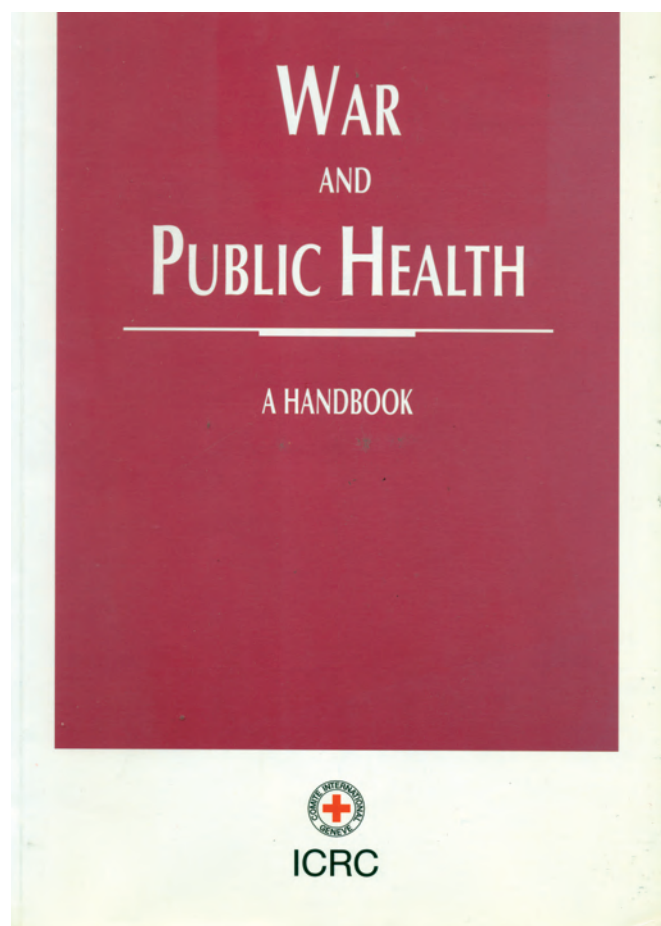
The book is limited to the description, diagnosis, and treatment of skin ailments observed in the POW camp but is a good source of information on dermatology in an austere setting. The units of measure are early 20th century British so you will need a conversion table.

War and Public Health: A Handbook

Review by Joe Patterson

COL Farr gave the other guys in the office real books to review. I got the textbook …. If you're looking for the nuts and bolts of conducting public health activities in a theater of operations, *War and Public Health, A Handbook* isn't for you. If you're a logistics or non-public health medical professional looking for a broad overview, it fits the bill. *War and Public Health, A Handbook* takes a broad look at the entire process of handling public health in a complex humanitarian emergency. There are no comprehensive instructions for making potable water, formulas for determining the number of camp toilets required, or how to eradicate scabies. The author instead focuses on the big picture of recognizing issues, the mechanisms that must be addressed to solve them, and how the entire effort nests in the larger framework of conflict. *War and Public Health, A Handbook* is essentially a textbook and is linked to the International Committee of the Red Cross's Health Emergencies in Large Populations course in the book's Foreword.

Broken down into 10 chapters, Dr. Perrin walks the reader through a broad range of public health considerations with the first chapter devoted to planning. Approximately half of the book discusses functional life support areas like nutrition, water, diseases, and medical care, while the remainder looks at broader structural issues such as how to design a health care delivery system, the impact of natural disasters in third world war zones, protecting victims of armed conflicts, and an introduction to humanitarian ethics.

Perrin continually reminds the reader of issues which should be obvious but are frequently neglected in the confusion of this stressful environment. Emphasizing that there is no one clear solution for all circumstances, he coaxes the reader to examine the entire set of mechanisms which caused a public health crisis to emerge and how best to mitigate that crisis.

War and Public Health, A Handbook is beneficial for military personnel who expect to be engaged in large public health crises in any setting, not just those resulting from war. While he does get into the weeds in some cases, his higher-level focus of understanding the emergency is more fitting for the layperson rather than the dedicated public health professional.

Combat Surgeons

John Laffin
Sutton Publishing Limited, Pheonix Mill, Thrupp, Stroud, Gloucestershire, GL5 2BU, 1970, 1999 ISBN 0 7509 2173 0, 232 pages.

Review by CPT Scott Gilpatrick
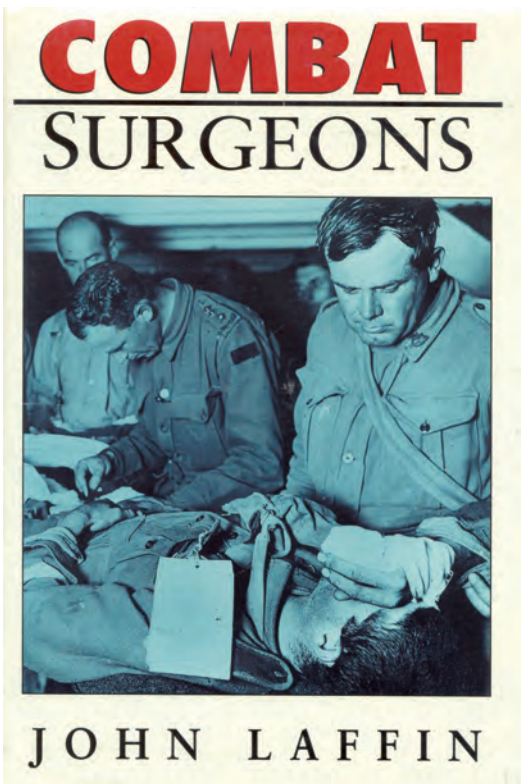
The cover represents the book well: An Australian surgeon doing surgery back in 1917 during some battle we've never heard of, while some bloke holds an ether soaked cloth over the patients mouth. Glancing at it or even briefly studying it, you might think "BORING!", and if not a military medical history buff, this book might have the same effect on the reader as 10mg of Ambien. I went into the read very skeptical as I couldn't bear the thought of having to digest the embellished stories of yet another bunch of super-doctors who saved the war while on call in Hell.

What you do get from this read is a great history lesson on military medicine, as told by a former infantryman who himself was wounded in battle. He has written over 70 books on military history and as stated on the jacket, the material is presented very "unemotionally". I found it amazing that he employed no researchers when he wrote this and states, "I only have myself to

blame for my errors", and like all good Soldiers, he thanks all the doctors and generals who helped him with his research, and as well, he thanks his dear late wife for her support and help. So with a newfound respect for the author, I went forward through the chapters, to find that he really did do some unbelievably extensive research.

I really was taken by the first chapter: "Glorious Dead and Gallant Wounded". It is filled with the authors "unemotional" thoughts on war, the role of medical personnel, the experiences medical personnel encounter during war, and how it affects them both physically and mentally. Some of his thoughts certainly apply today: "In no two fields of human activity has so much ingenuity been displayed as in the martial infliction of death and wounds, and in the treatment of these wounds." There is no gloriousness in death or gallantry in injury on the battlefield. All you have to do is ask the TBI patient who can't remember his own phone number, or the former college athlete sitting in a wheelchair changing out his colostomy bag. They don't see anything gallant about that.

The first few chapters set the stage for the rest of the book that tells of what military medicine has done for armies throughout time. How initiatives for better hygiene and living conditions were all started by medical personnel attached to military units, even back in ancient Egypt and Rome. Preventive medicine is certainly a huge issue, championed by the unit surgeon in every conflict since the beginning of time. The author describes in detail every conflict and how it was ravaged by death and disability caused by poor hygiene among large groups of troops. The first ambulance was devised during the Byzantine Empire by employing leather straps to carry wounded on the left side of their horse. It goes on from there, up to about the first Gulf War, all supported by some neat pictures and charts with lots of statistics.

For the SOF Medic reader, you get stories of guys who had it really tough "back in the day" and an appreciation for advances in modern medicine. It's great to see evidence-based decisions at work. As warfare and weaponry become more lethal, the Medics and Docs on the battlefield must get smarter and learn to adapt. *Combat Surgeons* is a chronological record of how much smarter we have become.

U.S. Army Special Operations in World War II

David W. Hogan, Jr.

Review by Capt Keith Vollenweider, MSC
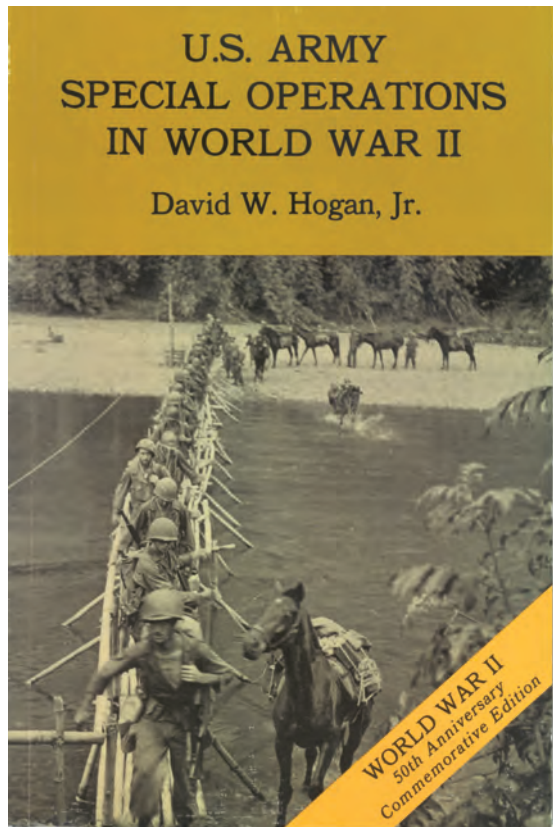
Despite a great deal of popular media related to World War II and the exploits of Rangers in general, a relatively small amount of historical analysis has been done of Special Operations in WW II. David W. Hogan, Jr.'s book, *U.S. Army Special Operations in World War II,* is a comprehensive yet brief synopsis of the development of Army Special Operations units during the war, and the use and misuse of these units. Covering four theaters of operations, Mediterranean, Europe, Pacific, and China-Burma-India, the book looks at many Special Operations topics, from their successes, such as taking of key locations prior to invasion by conventional forces, to the training of local fighters. Particularly interesting is the recruiting and training that went into the creation of these units, with many benefiting from the much more advanced state of British special operations during the early stages of American involvement in the war. Also discussed is the ongoing challenge to justify the existence of Ranger units to leaders trained in conventional force applications and the resulting use of Special Forces units as line infantry on numerous occasions. The book describes some well known units, such as Darby's Rangers and Merrill's Marauders, as well as hybrids, such as the Jedburghs, and partisans, including Filipino guerrilla groups and the Kachins of northern Burma.

Because Special Operations currently encompasses a wide variety of operations, the book intentionally leaves out some areas, such as Civil Affairs and Psychological Operations, and focuses primarily on Ranger (commando) and guerrilla activities, the gathering of intelligence by partisans, as well as activities of the Office of Special Services (OSS). Included is the historical debate over the impact of Special Operations in WW II, with views ranging from extremely minor contributions in the overall war effort to MacArthur equating some contributions by Ranger led guerrillas to an entire frontline division. Published nearly 20 years ago, *U.S. Army Special Operations in World War II* remains relevant and makes multiple references to lessons learned that have not been entirely implemented to this day. As a study, the book is an excellent source of information on the founding of today's Rangers units, as well as the OSS, and gives proper credit and honor to many that sacrificed to ensure victory in the war.

Does Intraosseous Equal Intravenous?
A Pharmacokinetic Study

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ABSTRACT

Study Objective: Despite the growing popularity of intraosseous infusion for adults in emergency medicine, to date there has been little research on the pharmacokinetics of intraosseously administered medications in humans. The objective of the study was to compare the pharmacokinetics of intraosseous vs intravenous administration of morphine sulfate in adults. **Methods:** The study followed a prospective, randomized, crossover design. Each subject was equipped with an indwelling intraosseous access device and an intravenous line. Subjects were randomized to receive a 5mg bolus of morphine sulfate infused intraosseously or intravenously, followed by the alternate administration route 24 hours later. Serial venous blood samples (5mL) were taken at baseline and at 13 time points over 8 hours postinfusion. Blood samples were analyzed for morphine concentration by radioimmunoassay. Pharmacokinetic parameters were calculated from the data, including maximum plasma concentration (C_{max}), time to maximum concentration (T_{max}), and area under plasma concentration-time curve (AUC), among others. Data were analyzed by analysis of variance. **Results:** No statistically significant differences were observed between intraosseous and intravenous administration of morphine sulfate for nearly all of the pharmacokinetic parameters including C_{max} (235 $\pm$ 107 vs 289 $\pm$ 197ng/mL, mean $\pm$ SD, IO vs IV, respectively), T_{max} (1.3 $\pm$ 0.5 vs 1.4 $\pm$ 0.5 minutes), and $AUC_{(0-\infty)}$ (4372 $\pm$ 1785 vs 4410 $\pm$ 1930ng min^{-1} mL^{-1}). There was; however, a statistically significant difference in the volume of distribution in the central compartment, V_d (P = .0247), which in the opinion of the investigators was thought to be due to a minor deposition effect near the intraosseous port or in the bone marrow. **Conclusion:** The results support the bioequivalence of intraosseous and intravenous administration of morphine sulfate in adults.

1. INTRODUCTION

1.1. Background

The intraosseous space of the bones has been used to administer fluids and medications in emergency medical situations since World War II.[1] In pediatric medicine, intraosseous infusion has long been the standard of care when traditional intravenous access is difficult or impossible.[2]

Advances in medical device technology over the past few years have resulted in a number of devices that greatly facilitate intraosseous infusion of drugs and fluids in adults. Such devices penetrate through the hard cortex of adult bone to the highly vascularized in-

traosseous space by means of specially designed needles or needle sets. As a result of the introduction of these devices, the 2005 Advanced Cardiac Life Support guidelines of the American Heart Association now specifically recommend intraosseous infusion for adults when intravenous access is unavailable.[3] The guidelines state that intraosseous administration is safe, effective, and equivalent to intravenous administration.

As the life-saving capability of intraosseous infusion becomes well known among emergency medical personnel, a frequently asked question is whether intraosseous infusion is equivalent to conventional intravenous infusion. Although the physiologic and

pharmacodynamic effects of intraosseously administered fluids and medications have been widely observed and documented for decades,[4-9] few studies compare the pharmacokinetics of medications administered via the intraosseous route to intravenous infusion. The studies that do exist were conducted in anesthetized animal models.[10-16] To date, no study has compared the pharmacokinetics of intraosseously administered medication to intravenously administered medication in conscious human subjects. The growing popularity of intraosseous infusion for adults necessitates a validation of the pharmacokinetic profile of intraosseously administered medications relative to traditional intravenous administration.

1.2. Goal of this investigation

Accordingly, the goal of this investigation was to compare the pharmacokinetics of intraosseously vs intravenously administered morphine sulfate in human subjects. For several reasons, it was not feasible to conduct such a study in healthy volunteers or emergency patients using available adult intraosseous devices. As such, the investigators used implanted intraosseous devices for the administration of drugs in patients with cancer who had previously failed at least one attempt at conventional intravenous access. Morphine sulfate was chosen as the study drug because some of the study patients required analgesics. Pharmacokinetic parameters calculated from serum levels of morphine in this study therefore served as surrogate markers for expected drug levels in emergency patients. Primary outcome measures were standard pharmacokinetic parameters, including maximum plasma concentration (C_{max}), time to maximum plasma concentration (T_{max}), and area under the concentration-time curve (AUC).

2. METHODS
2.1. Study design

The study design was a Latin square crossover, with each subject serving as his or her own control. Subjects received a single dose of morphine sulfate administered through an implanted intraosseous port (described below) or through a standard intravenous line, followed by a second dose of morphine sulfate via the alternate administration route no sooner than 24 hours later. Serial blood samples were collected via a second intravenous line. Samples were collected before dosing (baseline); at the end of infusion (1 minute); at 2, 5, 10, 15, 30, 45, 60, 90 minutes; and at 2, 3, 4, 6, and 8 hours postinfusion. Plasma samples were subsequently analyzed for morphine sulfate concentration. Standard pharmacokinetic parameters for both intraosseous and intravenous administration were then calculated from the concentration values.

2.2. Setting

The study was conducted on inpatients at 8 clinical centers across the country: St. Luke's Lutheran Hospital (San Antonio, TX), Arlington Cancer Center (Arlington,TX), Huntsville Hospital (Huntsville, AL), the University of Arizona Medical Center (Tucson, AZ), Brooke Army Medical Center at Fort Sam Houston (San Antonio, TX), the University of Texas Health Science Center (San Antonio, TX), the University of Southern California Medical Center (Los Angeles, CA), M.D. Anderson Cancer Center (Houston, TX), and Lutheran General Hospital (Park Ridge, IL). The study protocol was approved by the Institutional Review Boards at all 8 study centers.

2.3. Selection of participants

Individual study sites were responsible for recruiting and enrolling patients. The study was conducted in patients with cancer because these patients often suffer from lack of venous access and need supportive medications, including morphine sulfate, which can only be administered intravenously. To be eligible for inclusion in the study, subjects had to be at 18 years of age or older, with a confirmed diagnosis of cancer. Subjects had to have previously failed at least one attempt with a conventional intravenous access device (defined as vein inaccessibility, clotting of the vein or intravenous line, infection, or extravasation necrosis around the intravenous line). Subjects had to have adequate organ function (bone marrow, liver, kidney) confirmed by laboratory tests and a normal chest x-ray within 2 weeks before device implantation. All subjects provided written informed consent before participating in the study.

The intraosseous infusion device was implanted in the iliac crest of the pelvis. As such, subjects were ineligible for inclusion in the study if they exhibited any condition that rendered the iliac crest unsuitable for implantation, such as multiple myeloma, advanced osteoporosis, osteogenesis imperfecta, or tumor involvement in this area of the pelvis (determined by computed tomography or magnetic resonance imaging scan within 21 days before implantation.) In addition, subjects had to have an iliac crest at least 10.0mm wide at the implantation site and a maximum distance from the skin to the implantation site of no more than 2.5cm (determined by computed tomography or magnetic resonance imaging scan).

Subjects were also ineligible for the study if they had any evidence of active infection, if their body weight exceeded 125% ideal body weight, if they had a life expectancy of less than 12 weeks, or if they had a performance status ≥ 2 according to Southwest Group criteria for oncology patients.

2.4. Interventions
2.4.1. Intraosseous access device

An intraosseous access device (Osteoport, Life-Quest Medical, San Antonio, TX) was implanted in the iliac crest of all study subjects. The access device consisted of a port (reservoir) capped with a self-sealing silicon septum, through which medications could be given repeatedly (Fig. 1). The reservoir was connected to a hollow orthopedic screw (shaft) through which medications and fluids reached the intraosseous space. After implantation, the device was completely contained under the skin.

Fig. 2 Infusion through the device

Fig. 1 Implantable intraosseous infusion device

2.4.2. Implantation of the intraosseous access device

The intraosseous access device was implanted in the study subjects under either general or local anesthesia by surgeons trained in intraosseous implantation. A curvilinear incision was made adjacent to the anticipated site of the intraosseous access port (approximately 6cm posterior to the anterior superior iliac spine). Guidewire pins were used to define the planes of the inner and outer walls of the pelvis. A custom orthopedic drill bit, centered between the guide wires, was used to drill the hole for the intraosseous port. After irrigating the hole with saline, the self-tapping intraosseous port was gently inserted into the hole with a custom driver and then hand tightened to ensure proper seating within the bone (Figs. 2 and 3).

Placement of the port was confirmed by intraoperative xray. Patency of the port was confirmed by flushing the port with saline. The seal around the port was confirmed by direct observation after infusion of saline with methylene blue dye. Subjects were evaluated 24 to 72 hours postoperatively and at biweekly intervals thereafter.
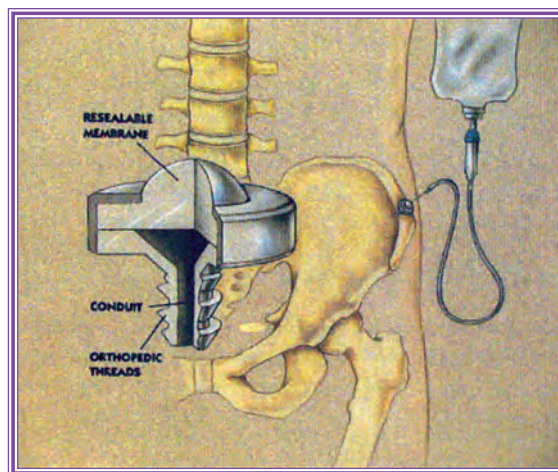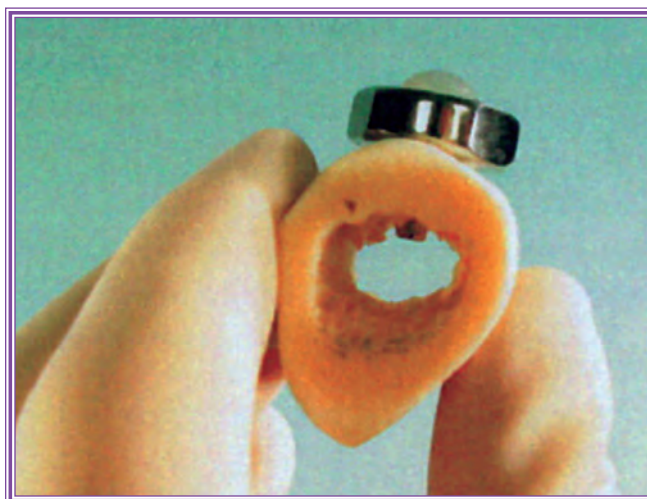

Fig. 3 Placement of the device in bone

2.4.3. Accessing the intraosseous port

Before accessing the port, the skin surrounding the port site was prepared with an antiseptic cleanser. The silicon septum of the port was located by palpation. Once located, a noncoring needle or catheter attached to a clamped air-free extension tube was inserted into the port perpendicular to the septum. The extension tube was unclamped once the correct position of the needle or catheter was confirmed. Patency of the intraosseous access port was maintained by flushing after each use with preservative-free heparin.

2.4.4. Pharmacokinetic study protocol

Pharmacokinetic studies for each subject were conducted within 2 weeks of implantation of the intraosseous

port. Subjects were randomized into 2 groups. The first group received a bolus of morphine sulfate through the intraosseous access port, followed by a second bolus, intravenously, 24 hours later. The second group received the same procedures in reverse order.

Randomization of the order of morphine sulfate delivery routes was accomplished by each study site calling the central data center and receiving an assignment from the study nurse, who alternated the order of delivery routes as each patient was enrolled. The sequence was blinded to the individual investigators at the study sites. Because of the nature of the study, neither the investigators nor the participants could be blinded as to the assignment of order of drug delivery routes.

The study dose consisted of a 5mg bolus of morphine sulfate administered over a 15-second period, followed by 2mL of normal saline infused over a 45-second period. Tubing lengths were identical for both intraosseous and intravenous infusions.

Serial blood samples (5mL) were collected from a second intravenous line before dosing (baseline); at end of infusion (1 minute); at 2, 5, 10, 15, 30, 45, 60, 90 minutes; and at 2, 3, 4, 6, and 8 hours postinfusion. Blood samples were collected into heparinized tubes and centrifuged at 2000 revolutions per minute for 15 minutes within 30 minutes of collection. The plasma was then removed and transferred to polyethylene tubes, which were labeled and stored at –208C until analysis.

Upon completion of the pharmacokinetic study, patients were followed for up to 180 days to determine the long-term tolerance to the intraosseous access port. There were no adverse events related to the pharmacokinetic study.

2.5. Methods of measurements
2.5.1. Morphine sulfate plasma concentrations

Morphine sulfate concentration for each plasma sample was determined by radioimmunoassay (COAT-ACOUNT, Diagnostic Products Co, Los Angeles, CA) at Maryland Medical Laboratory (Baltimore, MD). The range of the assay was 2.5 to 125ng/mL. The sensitivity of the assay was 2.5ng/mL, and the accuracy of the assay ranged from 93.4% to 97.8%.

2.6. Data collection, processing, and outcome measures
2.6.1. Pharmacokinetic calculations

For each subject, plots were constructed of plasma concentration of morphine sulfate vs sampling time. Standard pharmacokinetic parameters were then calculated from the data and the plots. For each subject, the maximum plasma concentration for morphine sulfate

(C_{max}) and its corresponding time (T_{max}) were recorded for the subject's observed plasma concentration-time profile following infusion by each delivery route.

Individual elimination rate (k_{el}) values were determined by linear regression of the respective natural logarithm of morphine plasma concentrations vs time during the terminal phase. Either the final 5 or the final 6 points were used in the calculation of each k_{el} value, which ever resulted in the regression line with the greater correlation coefficient. Elimination half-life ($t_{1/2}$) was calculated as $0.693/k_{el}$.

The AUC and the area under the first moment time curve (AUMC) were calculated by the linear trapezoidal rule up to the last measurable data point with extrapolation to infinity (∞).

The apparent volume of distribution at steady state (V_{dss}) was calculated as V_{dss} = Dose x AUMC (0-∞) / AUC^2 (0-∞). Plasma clearance (Cl_p) was calculated
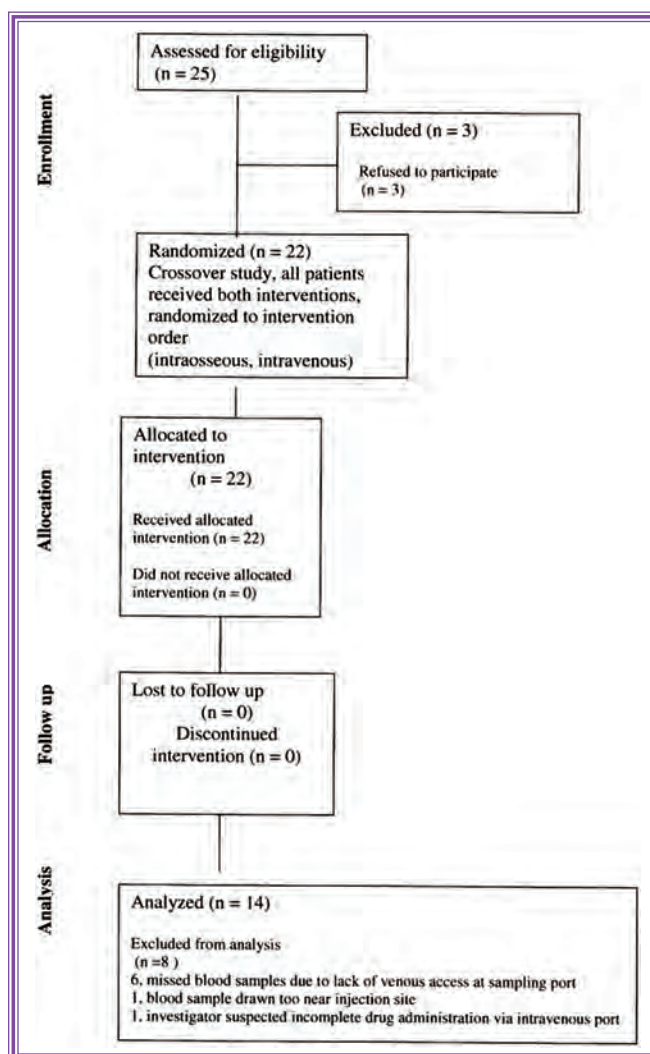

Fig. 4 CONSORT flow diagram

as: $Cl_p = $ Dose / AUC(0-∞). The volume of distribution of the central compartment (V_d) was calculated as:

$$V_d = \text{Dose} / \text{AUC}(0\text{-}\infty) \times k_{el}$$

2.7. Data analysis

Mean pharmacokinetic parameters for each administration route were compared by analysis of variance for significant differences due to intraosseous or intravenous administration route, sequence of administration, and subject within sequence. For all analyses, effects were considered to be statistically significant if $P \leq .05$.

The primary objective of the study was to determine the systemic bioavailability of morphine sulfate administered by the intraosseous and intravenous route in the same patients. Power calculations were based on the AUC as the primary pharmacokinetic parameter. The study was designed to detect a 10% difference in the AUC means with 80% power using a 2-sided paired t test.

Mean ratios of intraosseous/intravenous were calculated for all pharmacokinetic parameters, along with 90% confidence intervals around the ratios. SAS version 6.07 software (SAS Institute, Cary, NC) software was used for the statistical analysis.

3. RESULTS

3.1. Characteristics of study subjects

Eight clinical centers enrolled 25 subjects (9 men, 16 women) with a mean age of 57 years (range, 27-77 years). All subjects had metastatic disease at the time of placement of the intraosseous port and had failed at least one attempt at conventional intravenous access. Primary cancer diagnoses included breast cancer (9 subjects), gastrointestinal cancer (5 subjects), lung cancer (4 subjects), ovarian cancer (2 subjects), renal cancer (1 subject), leukemia (1 subject), multiple myeloma (1 subject), osteosarcoma (1 subject), and chondrosarcoma (1 subject).

The flow of subjects through the study is shown in Fig. 4. Three subjects declined to participate in the pharmacokinetic study. Pharmacokinetic data were obtained from 22 subjects. Full sets of evaluable pharmacokinetic data were available for 14 subjects. For the remaining 8 subjects, missed blood samples occurred at or near the expected maximum morphine concentration due to lack of venous access at the sampling port (6 subjects), blood samples drawn too near the injection site (1 subject), or because the investigator suspected incomplete administration of morphine via the intraosseous port (1 subject).

3.2. Main results

Mean plasma morphine sulfate concentrations vs sampling time are displayed in Fig. 5. The results of the

analysis of variance revealed no significant differences between the intraosseous and intravenous route of administration on the plasma morphine concentration vs sampling time data. Likewise, there were no significant differences between the 2 administration routes in many of the pharmacokinetic parameters, including $AUC_{0\text{-}t}$, $AUC_{0\text{-}\infty}$, C_{max}, T_{max}, Cl, V_{dss}, k_{el}, and $t_{1/2}$, indicating that intraosseous and intravenous delivery routes for morphine were essentially equivalent (Table 1). There was, however, a statistically significant difference in the volume of distribution in the central compartment, V_d ($P = .0247$), which in the opinion of the investigators was thought to be due to a minor deposition effect near the intraosseous port or in the bone marrow.
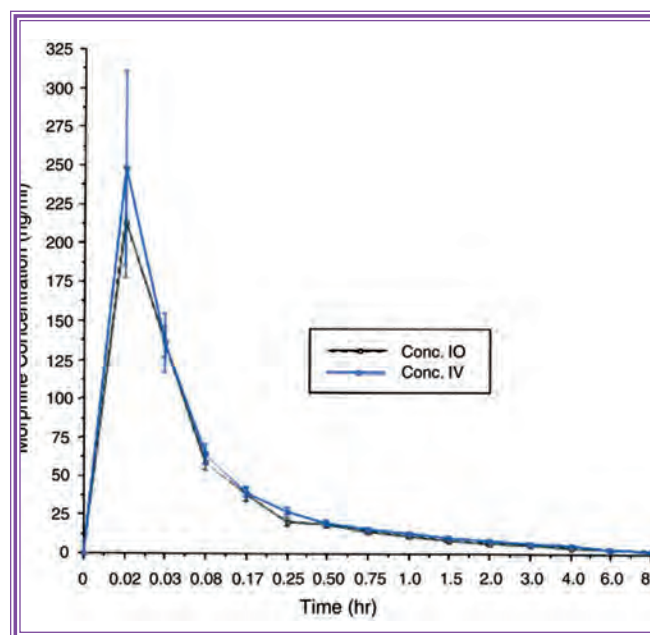

Fig. 5 Plasma concentration (mean F SEM) vs time curve (0-8 hours) of morphine sulfate in 14 subjects after a 5mg bolus of morphine sulfate administered intraosseously (dashed line) or intravenously (solid line).

There were no significant differences due to sequence of administration or subject within sequence. Comparison of the intraosseous/intravenous ratios of the mean values (Table 1) indicates that the peak concentration (C_{max}) for morphine was 19% less than delivered by the intravenous route. However, the $AUC_{0\text{-}\infty}$ intraosseous/intravenous ratio indicates that intraosseous administration only resulted in a 1.0% lower exposure to morphine than by the intravenous route. The untransformed 90% confidence interval for the ratio of C_{max} was 54% to 109%. The 90% confidence intervals for the ratios of $AUC_{0\text{-}t}$ and $AUC_{0\text{-}\infty}$ were 76% to 104% and 81% to 116%, respectively.

Table 1 Mean pharmacokinetic values following intraosseous and intravenous administration of morphine sulfate (n= 14 subjects)

Parameter	Intraosseous route ($\pm$SD)	Intravenous route ($\pm$SD)	Intraosseous/Intravenous	
$AUC_{(0-T)}$ (ng min^{-1} mL^{-1})	3637 $\pm$ 1282	4047 $\pm$ 1540	0.9	
$AUC_{(0-\infty)}$ (ng min^{-1} mL^{-1})	4372 $\pm$ 1785	4410 $\pm$ 1930	0.99	
C_{max} (ng/mL)	235 $\pm$ 107	289 $\pm$ 197	0.81	
T_{max} (min)	1.29 $\pm$ 0.469	1.36 $\pm$ 0.497	0.95	
Cl (mL kg^{-1} min^{-1})	20.2 $\pm$ 7.62	20.6 $\pm$ 9.41	0.98	
V_d (L/kg)	4.81 $\pm$ 1.66	3.62 $\pm$ 1.41[a]	1.33	
V_{dss} (L/kg)	3.49 $\pm$ 1.30	2.80 $\pm$ 1.20	1.25	
ke (min^{-1})	0.005 $\pm$ 0.004	0.006 $\pm$ 0.003	0.83	
$t_{1/2}$ (min)b	140 $\pm$ 108	118 $\pm$ 56	1.19	
a There was a significant greater Vd calculated after intraosseous infusion (P = .0247). There were no other statistically significant differences between the parameters for the intraosseous vs the intravenous administrations.				
b Harmonic mean.				

3.3. Limitations

The major limitation of this study is that the data evaluated only morphine sulfate and may not apply to other classes of drugs. A second limitation is the exclusion of 8 patients due to a lack of complete data sets, although this limitation is not uncommon among pharmacokinetic studies in subjects with such severe comorbidities, such as cancer. Despite this, the statistical analysis reached the required power level to attain statistically valid conclusions regarding the bioequivalence of morphine administration among the 2 delivery routes. A further limitation is that although the investigators were interested in the pharmacokinetics of intraosseously administered medications in emergency medicine, it was not possible to conduct a study in healthy volunteers or emergency patients using intraosseous devices designed for emergency use.

4. DISCUSSION

When emergency professionals give drugs or fluids to patients in life-threatening situations, they need to know that the route of administration can deliver clinically effective doses to target organs in reasonable times. Many emergency patients are in a state of shock where the body's natural defenses shut down peripheral circulation. This makes it difficult or impossible to access peripheral veins for delivery of life-saving drugs and fluids.

In such cases, practitioners have looked for alternate routes of drug administration such as intramuscular, intranasal, subcutaneous, sublingual, rectal, and endotracheal. Although all these routes can be effective in certain circumstances, few offer the speed and bioavailability of the intravenous route. Two alternate vascular access routes that have gained popularity recently are the central venous lines and intraosseous vascular access.

Although intraosseous infusion of drugs and fluids for adults is rapidly becoming the standard of care in the emergency medical community,[3] the scientific question remains — "Does the intraosseous route of administration equal the intravenous route for such indications?" Dye and radioactive tracer studies indicate that drugs given intraosseously enter the central circulation within seconds, comparable to peripheral intravenous lines.[17] In addition, studies have shown the pharmacological effects of drugs, such as epinephrine on heart rate and blood pressure, are equivalent when given via either route.[4,18] Several pharmacokinetic studies in animals indicate that the intraosseous route is equivalent to the intravenous route for a wide variety of medications.[10-16]

To date, there has been only one other published study on the pharmacokinetics of intraosseously administered drugs in humans; that study compared the venous concentrations of lidocaine administered via intraosseous injection or by maxillary infiltration injection in dental patients. The investigators found that the 2 drug administration routes resulted in identical plasma concentrations of lidocaine for each of the 9 time points sampled.[19]

The answer to the question, "Does intraosseous equal intravenous?" required a prospective, randomized, multicenter trial in human subjects. Therefore, we conducted this trial comparing the intraosseous route to the intravenous route of drug administration to provide the rigorous scientific data necessary for statistical significance. Data from the present study suggest that intraosseous infusion of medications is a viable alternative and pharmacokinetically equivalent route for morphine administration in human patients with difficult venous access. Because the basic mechanics, anatomy, and physiology of intraosseous infusion are ostensibly the same across patient populations, the results of the study should readily extrapolate to emergency patients. The study was conducted with patients with cancer; however, aside from their disease, the patients were relatively healthy, ambulatory patients with good vital signs. The intraosseous device provided access

to the intraosseous space to study the pharmacokinetics of intraosseously administered medications. Although the basic anatomy and physiology of intraosseous infusion should be substantially equivalent across most types of medications and fluids for patients with intact circulatory status, the authors caution that the study results may not be generally applicable across all medication classes, intraosseous anatomical sites, and patient populations.

Because emergency medical personnel are mostly focused on effect and time to effect for fast-acting medications in emergency situations, the most relevant pharmacokinetic parameters from the current study are C_{max} (peak concentration) and T_{max} (time to peak concentration). There were no significant differences in these 2 parameters between the intraosseous and intravenous routes of morphine administration, indicating similar bioavailability between the 2 routes.

Other emergency medications have a longer duration of effect. In the current study, a similar pattern was observed in the short- and long term (8-hour study period) pharmacokinetics of intraosseously administered morphine sulfate, as evidenced by the equivalent intraosseous/intravenous ratios for AUC. The intraosseous/intravenous ratios of mean AUC values were 0.90 (90%) for $AUC_{(0-t)}$ and 0.99 (99%) for $AUC_{(0-\infty)}$. The 90% confidence interval for the ratio of $AUC_{(0-\infty)}$ (81%-116%) falls within the 80% to 120% criterion generally recognized as an acceptable level for comparison of the pharmacokinetics of different routes of administration of medication.

The plasma concentration vs sampling time curves for both routes of administration were similar, as were nearly all the pharmacokinetic parameters. There was a statistically significant difference in V_d, the volume of distribution in the central compartment. It is the opinion of the investigators that this could have been due to a deposition effect near the intraosseous access port or in the bone marrow. However, there was no significant difference in Vdss, the apparent volume of distribution at steady state, suggesting that the amount of residual morphine near the intraosseous port or in the bone marrow was minimal.

Although the current study was conducted on patients with cancer, the study has obvious implications for intraosseous infusion of medications in emergency medicine. Because most emergency medications are expected to reach target organs or exert their effect systematically within minutes, the pharmacokinetic equivalency of intraosseous and intravenous administration of morphine sulfate (particularly at the earlier sampling times, ie, at 2, 5, 10, 15, and 20 minutes) reinforces the applicability of intraosseous delivery for emergency medicine. The results of the study indicate that there was no significant delay in morphine sulfate reaching the systemic circulation via the intraosseous route. In addition, morphine sulfate is frequently used in emergency medicine for treatment of myocardial infarction, congestive heart failure, and pain control.

In summary, this pharmacokinetic study supports the bioequivalence of intraosseous and intravenous administration of morphine sulfate in human subjects. Data are limited to morphine sulfate and may not apply to other classes of drugs. However, with the more widespread use of intraosseous drug delivery in emergency medicine, there is great impetus to validate the pharmacokinetic profiles of other classes of commonly used emergency medications.

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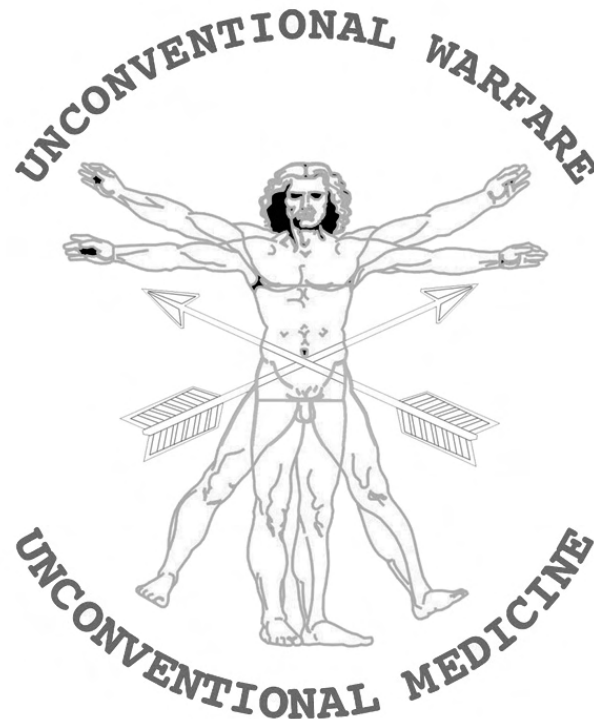
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Tourniquets for the Control of Traumatic Hemorrhage:
A Review of the Literature

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REVIEW

The use of tourniquets for the control of hemorrhage from traumatic injury has been long debated. Opinions on the utility and safety of their use in this setting have alternated between strong endorsement and outright vilification of the device, with each of the camps backing up their contentions with varying levels of anecdotal evidence. The debate is largely fueled by experiences of military surgeons during wartime and the results have changed with changing times, differing systems, and circumstances in which they have been utilized. Review of the evidence available in the English language medical literature seems to indicate that while neither camp is entirely correct, neither seems to be entirely without merit. The preservation of life — even at the potential expense of a limb- should without a doubt take precedence, but this should not lead to the abandonment of all possible efforts to minimize the length of time that the tourniquet is in place and the thereby reduce the attendant risk of complications.

The literature regarding tourniquets, their use, outcomes, and complications was collected by a literature search of various pertinent databases. These included PubMed/MEDLINE, Ovid, EBSCOHost, and CINAHL utilizing keywords including, but not limited to, "tourniquet," "extremity," "hemorrhage," "bleeding," "combat," etc. The retrieved articles were assessed for pertinent information and the references they cited were accessed and reviewed to minimize the chance of pertinent sources being overlooked.

Extremity hemorrhage remains a common and significant cause of preventable trauma fatalities, both in the civilian world and the military theater, accounting for approximately 9% of fatalities in military actions.[1-7] Dorlac et al. reported on preventable fatalities involving isolated extremity wounds presenting to two civilian trauma centers, and found that they occurred as 0.02% (N = 14) of the traumas seen at the facilities, with 50% caused by gunshot wounds and the remainder due to lacerations or stab wounds. Eight of the patients in this group had injuries that would have potentially benefited from management with a tourniquet.[8] Rocko et al. reported on similar injuries, discussing eight cases where earlier attempts as hemorrhage control might have resulted in patient survival.[9]

The frequency of significant vascular injury from penetrating trauma among military personnel has been reported by Rasmussen et al. as 6.6% (N = 209). These were casualties from Operation Iraqi Freedom treated at the Air Force Theater Hospital at Balad Air Base, Iraq with 79% (N = 166) of those cases involving the vasculature of the extremities, with the majority of these patient reaching definitive care in under an hour.[10] This is in stark contrast to many of the previous experiences with tourniquets, which indicates why an understanding of these circumstances is important in comprehending why the opinions that are held about tourniquets exist and what they mean for the current practitioner.

The first use of a tourniquet to attenuate hemorrhage from injury is not known with absolute certainty but the existence of similar devices has been described back to at least the Greeks.[11] Galen, the best known of the Roman surgeons, criticized the use of tourniquets as simply forcing more blood from a wound and this opinion was still repeated many years, even centuries, later by other authors.[12] This is likely based upon observation of patients with tourniquets that are applied with insufficient pressure to compress the artery while restricting the venous drainage of the affected limb.

The famous medieval physician de Chauliac described constricting bands for the reduction of pain and control of hemorrhage during amputation in 1586 and Ambrose Pare was noted to employ a similar technique.[13] The use of a triple band tourniquet system during amputations was attributed to Leonardo Botallo in the 16th century, and the use of tourniquets under similar circumstances was described by von Gersdoff in his Feldtbuch der Wundtartzney (Field Manual of Wound Medicine) published in 1517.

Wilhelm Fabry first described the basis for what most envision today as a "tourniquet," namely a device employing a windlass in 1593.[14]

A French surgeon at the Siege of Besancon in 1674 by the name of Etienne Morel was described as employing a rudimentary tourniquet during combat medical care.[15,16] A "screw compressor" was pictured in Johannes Scultetus' surgery text during the 17th century, but this design was apparently limited in its utility due to issues with slippage and other factors.[17] The problem with slipping was reduced by Petit with his improved design that was introduced in the early 18th century and allowed it to be utilized further up on the limb.[18] Petit is also the source of the term "tourniquet" which he derived from the French verb for "to turn" (tourner).[19]

Much of the early criticism of the use of tourniquets stemmed from the delayed access to definitive care on the battlefield in many conflicts. MacLeod's treatise on the Crimean War questioned the benefit of tourniquets due to the seemingly insignificant number of vascular injuries that were seen in that conflict. This is more likely the result of those who would have benefited exsanguinating on the field while the battle was still ongoing and therefore never being seen by a surgeon, as he himself more or less stated.[20] This is a major issue with many of the early writings that contributed to attitudes towards tourniquet use in that lack of effective evacuation of wounded Soldiers proved to make the statistics provided and outcomes cited, at best, of dubious value and, at worse, useless as a reference for decision making. In effect, the tourniquet bore more than its fair share of the blame for negative outcomes stemming from multiple factors including poor planning, lack of education of troops about the proper care of wounds, and the marginal medical logistics that all conspired to yield less than optimal results.

The American Civil War provided even more evidence of the dire consequences of failing to prepare for massive numbers of wounded Soldiers. Surgeons were often seriously lacking in any experience dealing with traumatic injuries, let alone that of a recent nature sufficient to maintain skills. The variability of entry level training of physicians was also so great as to make broad characterizations of it is nearly impossible,[19] and the lessons of prior combat surgeons — as questionable as some of them may be from our current perspective — on the European continent seldom was known to the average military surgeon during the Civil War. The appreciable lack of medics was also a contributing factor, despite Letterman's establishment of an Union military ambulance system on the Napoleonic model, leaving men with minimal, if any, first aid training laying for hours, or even days in a few cases, on a battlefield. Gross addressed this in his 1861 text, where he implied that the supplies for a crude tourniquet should be part of the kit for every Soldier, and the instruc-

tions on their use be provided, lest the Soldiers "perish simply from their own ignorance."[19] Both in the Manual of Field Surgery and his later work *A System of Surgery*, Gross was highly critical of his fellow surgeons and laid the blame for the demise of many Soldiers squarely at their feet: "I do not envy the man his feelings who. through ignorance, inattention, or indecision, allows his patient to perish from loss of blood when he ought to have saved him."[21]

The use of tourniquets, both improvised and those of professional design (most notably that of Petit) under circumstances where surgical intervention — and admittedly a crude form by modern standards — could not be counted upon for hours or longer proved to be less than desirable from the standpoint of limb salvage. Even in the face of severe pain associated with prolonged limb ischemia, many of the Soldiers were loathe to loosen or remove a tourniquet for fear of further bleeding: "Very many of these wounded came into the hospital with extemporaneous tourniquets tightly applied, and their hands and forearms swollen and livid in consequence. This dread of hemorrhage is simply another proof of the inexperience of the troops."[22] Similar fear of recurrent bleeding is still common among troops today although the issue could likely be lessened through better education of Soldiers about the nature of war wounds.

The excessive and inappropriate use of tourniquets by insufficiently trained and frightened Soldiers on the battlefields of the Civil War led many surgeons to decry their use altogether. This included such extreme stances as that it was "far safer to leave the wound to nature, without any attempt to arrest the flow of blood than depend upon the common army tourniquet" as was attributed to one surgeon who was present at the Battle of Bull Run (Manassas).[23] This attitude of course is the result of the frequent amputations that followed such battles and the use of tourniquets. However, it is also the opinion of someone who fails to taken into account the role the system in which tourniquets were being utilized played in the development of gangrene and ischemic complications. Given that after the first battle, some wounded men were left on the battlefield for days before evacuation, few modern parallels can be drawn. The outcome of both battles, a poorly structured ambulance corps, and other factors that provoked a disastrous outcome for the casualties led to the reform of the medical operations of both sides. The improvements were demonstrated at the Battle of Antietam later that same year which is considered by most historians to be the turning point of the Civil War in regards to medical care.[24]

While the overwhelming opinion of surgeons towards the use of tourniquets was negative, little evidence beyond anecdotal opinions exists on which to judge the rate of tourniquet induced complications resulting in amputation that would have not have otherwise occurred.[21]

The few sources that do cite data rely upon the questionable statistics that were included in MacLeod's Crimean War history, thereby grossly underestimating the frequency of vascular injury. Confederate Surgeon General Chisolm admitted in his text, while attempting to discourage the use of tourniquets that when vascular injuries do occur, the patient often exsanguinates so quickly that intervention is "of little avail."[25] Thus, he blatantly disregarded the most obvious — and probably least debatable — indication for the use of tourniquets, that being the attempted preservation of life at any cost, including the sacrifice of an extremity.

The "disasters" that stemmed from such hindrances even provoked knee-jerk reactions that may well have cost Soldiers their lives for little benefit, such as that proffered by Tuffier who was a respected surgeon with the French Army during the First World War. He recommended that as soon as ambulance crews encountered a patient with a tourniquet in place that it be removed.[26] Given that the patient most likely had been laying in "no man's land" for many hours with the tourniquet in place, the likelihood of the immediate removal of the tourniquet offering any improvement in the outcome for the limb is highly suspect and the possibility of provoking further hemorrhage would more likely be the result.

One of the most dramatic, and retrospectively shortsighted, denunciations of tourniquets can be found in Injuries and Diseases of War, which was a British manual that was reprinted in the United States in 1918:

> "The systematic use of the elastic tourniquet cannot be too severely condemned. The employment of it, except as a temporary measure during an operation, usually indicates that the person using it is quite ignorant both of how to stop bleeding properly and also of the danger to life and limb caused by the tourniquet . . . If an orderly has applied a tourniquet, it is the duty of the medical officer who first sees the patient to remove it at once, and to examine the limb so as to ascertain whether there is any bleeding at all, and if there is, to use proper measures for its arrest."

Once again, the admonition never to allow a tourniquet to be left in place beyond the prehospital phase of care was repeated due to the risk of pain, infection, and amputation.[27] While immediate conversion to less aggressive measures of hemorrhage control are optimal, such across the board advice is most likely the source of the modern day hesitancy to utilize tourniquets in any manner. One must question whether this belief arose as the product of a seriously flawed system of medical care, as obviously existed, rather than an inherent flaw in the idea behind the use of tourniquets.

More useful information regarding tourniquets, still largely applicable, was provided by Tuttle:[28]

1. Never cover over or bandage a tourniquet.
2. Write plainly on the emergency medical tag the word "tourniquet."
3. If the injured man is conscious, he should be instructed to tell every medical officer with whom he comes in contact that he has a tourniquet on.

Tuttle also emphasized the use of arterial "pressure points" to "buy time" in which other methods of control can be employed, including the application of a tourniquet.

Bailey in his seminal text on war surgery, published during the Second World War, gave a great deal of attention to the subject of tourniquets and indicated that tourniquets have a place in management of arterial bleeding that fails to respond to other interventions. He also suggested the preemptive application of a loosely applied tourniquet in cases of secondary hemorrhage and their use to provide a bloodless surgical field.[29] The latter use has become commonplace in hospitals around the world today, through the application of pneumatic tourniquets in orthopedic procedures.

The text also reinforced the need for proper and early identification of those patients with tourniquets in place, through proper labeling. Increased bleeding from insufficient pressure, as mentioned above, was also pointed out as a potential hazard of the use of tourniquets, while at the same time the use of excessive pressure was discouraged due to the risk of local skin damage and other complications. A quote from Bailey is one of the best summations of the subject matter found anywhere, stating that a tourniquet should be "regarded with respect because of the damage it may cause, and with reverence because of the lives it undoubtedly saves. It is not to be used lightly in every case of a bleeding wound, but applied courageously when life is in danger."[29]

During the preparations for the invasion of Normandy in 1944, the Allied Forces medical personnel were provided with a text that included instructions for the care of vascular injuries. Part of this advice was a statement that any limb requiring a tourniquet that remained in place during evacuation would most likely require amputation but that any suspected or known injury to the blood vessels was sufficient reason to send a tourniquet along with the patient during transport should the need for it arise.[30]

One of the best articles with the sole purpose of examining issues related to tourniquet use in a large group was written during WWII by Wolff and Adkins which looked at a series of over 200 wounded servicemen who had tourniquets applied. The authors were critical of the strap and buckle tourniquet issued by the Army, due to its inadequate occlusive pressures and the tendency to dig into tissues. They also described occlusive times of up to six hours with no clinically significant damage depending on which extremity was involved and the environmental con-

ditions; anecdotal reports from cases occurring during the wintertime indicated that cold temperatures and resultant cooling of the affected limb might lead to minimal negative effect on the limb despite prolonged ischemic times. Wolff and Adkins rank among the staunchest advocates of the use of tourniquets in combat casualty care during WWII. They firmly denounced the fears of damage stemming solely from the use of the tourniquet, finding not a single case of gangrene directly attributable to the use of such a device alone, nor were thromboembolic events, skin damage, excessive edema, or nerve damage reported during the postoperative management of any of their patients.[31]

The United States Army Medical Department, in a review of the medical services of World War II, stated that Soldiers frequently misused tourniquets, failed to alert staff at aid stations of their presence, and otherwise contributed to negative outcomes stemming from the use of tourniquets. This was such a widespread problem that their use was restricted in one unit that the senior surgeon ordered that the only reason for the use of such a device was for the control of "active spurting hemorrhage from a major artery." The directive was also issued to reinforce the proper documentation of the placement of a tourniquet to allow rapid notification of upper echelon personnel.[3,32] The early advice to loosen the tourniquet every 30 minutes to allow perfusion of the limb via collateral circulation due to the fact that the practice put a patient at risk of bleeding to death by slow degrees was also replaced with orders that a tourniquet that should only be removed by a medical officer. This opinion continues to be common practice today.[26,33]

It should be noted, for the sake of full disclosure, that perhaps not all of the blame for poor outcomes should be trained at the tourniquet or the men applying them, or the system in which they functioned – although admittedly the delays in access to operative intervention undoubtedly played a role as did the inappropriate battlefield care of the wounded. The operative techniques employed by military surgeons for vascular trauma suffered, secondary to both the case volume and a failure of the military medical system to learn the lessons of prior conflicts. Ligation of arteries was a common practice especially during the early stages of the war, and one that produced a high rate of gangrene as documented in the literature.[34,35] This is in no way a condemnation or an attack on the skill and dedication of the surgeons who served the militaries of all the combatant nations, but rather another sad example of history repeating itself when appropriate lessons are either not learned or not applied. This is supported by the fact that as the war progressed, amputation rates decreased as surgeons gained experience with the injuries common on the battlefield, in which they were not well educated prior to their deployment due to oversight on the part of their commanders.

One of the most notable military surgeons de-

ployed to Korea was Dr. Carl Hughes and his publications on combat related vascular trauma provide valuable insight into the progress that was made during the intervening years between then end of WWII and the start of hostilities in Korea. While he was openly critical of the manner in which many tourniquets during that conflict were applied,[36] he has been quoted as recently saying "I do not recall ever seeing limb loss as a result of a tourniquet. They were important, even life saving, in Korea. Successful use of the tourniquet depends on what it is made of, and how it is applied."[24] The recounted experiences of Jahnke, Hughes, and others during this time also serve to dispel the myth that a tourniquet is invariably associated with amputations, while reinforcing the role that evacuation delays played in amputation following tourniquet application, as more attempts were made at limb salvage through vascular repair techniques.[37,38]

Improvised tourniquets were commonplace during the conflict in Vietnam and their use by medics was deemed to be more judicious by some of the attending surgeons with at least one (JE Hutton) attributing this to the fact that "most of our medics were college graduates, were bright and well trained."[24] Also the preemptive use of fasciotomies became more common as a step in combating compartment syndrome associated with prolonged tourniquet use, which was much less frequent than encountered in any previous war due to the unprecedented use of helicopters as a primary means of casualty evacuation. It has been said repeatedly before that many Soldiers wounded in southeast Asia owe their lives to the "Dustoff" crews (that is, United States Army medical evacuation helicopter crews), but perhaps this is better rephrased as many of the wounded owe their lives and their limbs to these brave souls.

However, not all surgical authorities serving in the Vietnam War have such uniformly positive assessments of the use of tourniquets. Dr. Norman Rich reported the anecdotal case of an upper arm injury that was bleeding because of the presence of the tourniquet, the removal of which staunched the hemorrhage.[24] He later went on to state that the necessity of the use of tourniquets in Vietnam was an infrequent occurrence.[39] Regardless of their stance on this issue, the dedication, resourcefulness, and talents of the Vietnam medical personnel are largely responsible for the current era of limb salvage that stems from rapid evacuation and early and aggressive operative intervention.[10]

Until recent years, the staunchest supporters of the use of tourniquets were the Israeli Defense Forces (IDF), and widespread use by the IDF yielded some of the best data available on the complications associated with modern battlefield use of tourniquets. Despite what may best be described as overzealous utilization by Soldiers, there has been a paucity of complications reported and those that

have occurred are most often temporary in nature. The isolated incidents of permanent complications were associated with prolonged use of a tourniquet and serve as further evidence that the opinion of tourniquets as invariably damaging to the limb is misguided.[40]

Despite the methodological misgivings of a few,[41] the Lakstein study- particularly when considered along with other reports that are discussed elsewhere in this paper, shows that tourniquets are an acceptably safe and effective means of hemorrhage control on the modern battlefield where rapid access to definitive intervention is the rule, rather than the exception. The use of tourniquets amongst Special Operations troops has been particularly widespread in the U.S. military for quite some time, and the experiences of the Rangers in Somalia provide additional evidence of the benefits offered by the use of tourniquets by military personnel.[5] Other special operations units also encourage tourniquet use for hemorrhage control in combat situations.[42-44]

The aggressive use of tourniquets among trauma patients transported to the Air Force Theater Hospital at Balad led to no cases of serious complication, even when taking into account infrequent cases of inappropriate use (in the setting of no major arterial injury). This is presumably due to the rapid evacuation of casualties and the short time to operative intervention, often less than one hour.[10] Chambers reported even more rapid arrival of patients at facilities with surgical capability in his paper reporting the experiences of the United States Marine Corps' Forward Resuscitative Surgical System.[45] This contrasts with the average time for similar cases in the Vietnam War where the time to operation for a majority of patients was variously reported as 90 minutes for all patients with ballistic injury,[46] and up to five and a half hours for injuries to the popliteal artery treated aboard a United States Navy hospital ship.[47] Regardless of which study is relied upon, there was an improvement over the average of 9.2 hours reported in the Korean War.[48]

The data from Balad is comparable to the earlier report based upon patients treated at Walter Reed Army Medical Center,[49] but rate of vascular injury is significantly higher than reports that looked at rates of similar injury among military personnel in Vietnam who survived to be treated at military medical facilities, which routinely reported rates of between 2–3%.[50,51] In the report from Iraq, Rasmussen and his colleagues suggested several possible reasons for the disparity, including better documentation of vascular trauma among casualties and increased survival of patients with peripheral vascular trauma due to improvements in body armor lessening mortality from thoracoabdominal trauma.[10]

Walters and Mabry stated that the proper use of tourniquets could potentially prevent seven of every 100 deaths due to combat related injury.[33,52] A similar positive attitude can be found in many of the recent articles dealing with tourniquets. The review by Welling et al. contains several anecdotal statements from experienced military physicians who indicate the utility of the tourniquets in modern combat and the lack of significant complications.[17] The military's Emergency War Surgery text explicitly supports the use of tourniquets in combat, encourages risk to benefits assessment in any setting other than active combat but admonishing that no life should be lost due to hesitance from perceived risks of limb loss.[53] The author of this paper has personal anecdotal experience with the successful prehospital use of a blood pressure cuff to control arterial bleeding while pressure dressings were applied to a combative patient with an amputation of the hand secondary to a lawnmower accident.

The fact is that many of those who perish in combat do so rapidly and before evacuation to combat hospitals or aid stations can be accomplished, with the majority being due to hemorrhage with the source of the bleeding in many cases being an extremity wound. As Welling pointed out, the only chance to save these lives rests with the medics and the Soldiers themselves.[17] Given the nature of care under fire — the risks to the caregiver, the need for rapid extrication of the wounded to cover, and the frequency of mass casualty events — to express expectation that direct pressure can be utilized as a first line response under such circumstances is to speak to one's lack of awareness of the circumstances faced by the medic and the wounded alike. It is for this reason that the United States military has emphasized the use of tourniquets during the prehospital care of wounded and sought out a design that was able to be self-applied by a wounded Soldier.[43,54] Not only does a properly applied tourniquet control hemorrhage[55-57] and allow time for the gravely wounded to reach definitive care, they also provide the chance for the medic to render care to other injured persons. Such practices may also facilitate transport of casualties, especially in the case of multiple victims.

The control of hemorrhage in the civilian setting is less fraught with serious risk to the first responder and therefore is much more able to follow the traditional stepwise approach recommended by most authorities. The advice of Rich and Spencer, which includes packing of the wound with associated arterial hemorrhage, direct pressure, and pressure dressings[39] is probably the best approach when sufficient manpower and safe circumstances to allow intervention by trained and skilled providers. Outside of situations necessitating expedient evacuation of casualties, the use of a tourniquet will be necessary only infrequently but should be considered in any case where hemorrhage is ongoing and life threatening. This approach is similar to that recommended by Aucar and Hirshberg,[58] as well as those recommended by the Advanced Trauma Life Support manuals,[59,60] and the U.S. Army Survival Manual[61] which

is widely distributed to the general public through a civilian publisher.

However, the safest approach in the case of the marginally trained and inexperienced person with basic first aid training is probably to rely upon simple direct pressure or basic forms of pressure dressing. This is due to a lack of evidence that such persons can effectively recognize the need for a tourniquet and properly apply such a device — especially given the likely need to improvise under such circumstances.[9,62] This last point is illustrated by a case of femoral artery transection by broadhead arrow as the result of a deer hunting accident to which the author responded as an emergency medical technician. The victim's nephew had attempted to place a tourniquet made from the victim's belt prior to going for help. The patient was deceased due to blood loss at the time of the arrival of the author and his coworkers. It was determined that the bystander had improperly placed tourniquet distal to the injury and with insufficient force to be of any utility even if it were in a proper position.

Probably the strongest argument towards the broader use of tourniquets in the field is the experience of the United States military,[63-65] such as in Iraq where the combination of aggressive hemorrhage control and rapid transport has produced minimal complications associated to tourniquet use.[66-69] A few anecdotal reports of deaths that may have been preventable by the timely application of tourniquets for control of bleeding have also emerged from the battlefields of the Middle East and serve to point out that while improvements in care have been made, there are still cases that can be learned from.[70] While the tourniquets can not be given sole credit, their ability to allow those who would have otherwise bled out to receive the full benefit of modern trauma care as was described by the Balad vascular team and other — early thrombectomy and heparin administration along with vascular reconstruction or shunting and fasciotomy when necessary — can not be denied.

The use of tourniquet as a "stopgap" measure in combat[56] — with reassessment of the necessity of the tourniquet as soon as situational conditions allow — is part of the Tactical Combat Casualty Care course the United States Army conducts.[71,72] This emphasis on conversion to less aggressive means of hemorrhage control whenever possible may be one reason that reports from the Iraq theater of operations describe the presence of unnecessary tourniquets upon arrival at medical facilities as infrequent. This attitude has been incorporated into the military version of the Prehospital Trauma Life Support (PHTLS) manual,[73] which is widely used in the education not only of military personnel, but also in the education of tactical medics in the law enforcement community as well. Even some staunch opponents of the widespread use of tourniquets admit that the temporary use of tourniquets under tactical conditions or similar circumstances is acceptable to effect the safe extraction of the wounded party.[40,41]

The rapid employment of tourniquets may also provide an opportunity to improve the prognosis for those who might otherwise not receive care due to the severity of their injuries in a mass casualty situation where triage principles are applied. The expedient control of extremity hemorrhage may allow a few of these patients to survive long enough for them to be evacuated even when a medic may be forced to move on to another patient due to prioritization.[74] This is similar to techniques employed in damage control surgery- in both combat and civilian settings — where pneumatic tourniquets have been used in place of vascular clamps to allow the control of more immediately life threatening thoracic and abdominal injuries, as well as in isolated orthopedic cases prior to reconstruction or shunting.[66,67,75,76] It has also been utilized for the control of hemorrhage during ongoing emergency department resuscitation of combat casualties.[77] While the possibility of such a technique being utilized outside of a medical facility is speculative at this point, it might be worthy of further investigation to determine the feasibility and utility of such a recommendation.

The use of tourniquets, while beneficial to many of those wounded in combat or with otherwise uncontrollable bleeding, is not without its hazards and potential complications. Any use of a tourniquet must be with full awareness of the risks involved and to brush these aside would be to abandon one of the basic tenets of evidence based medical practice.

Most of the complications stemming from tourniquet use are either the result of direct pressure on underlying tissues or the byproducts of ischemia distal to the site of application. While most of the complications that have been reported in association with their use (both for control of hemorrhage and as an adjunct to surgery) have been localized, there are systemic complications that can result including thromboembolic events,[78] most notably pulmonary embolism, renal failure due to rhabdomyolysis,[79-84] lactic and respiratory acidosis, hyperkalemia, arrhythmias, and shock.[85]

The use of tourniquets during elective surgery has led to reports of cardiac arrest secondary to circulatory overload in patients with poor cardiac reserve resulting from a functional increase in the circulating blood volume. This is likely to not be a factor in a hypovolemic trauma patient but may play a role in the case of a patient with underlying heart disease who is being fluid resuscitated with a tourniquet in place. Tourniquet removal postoperatively has produced transient increases in end-tidal carbon dioxide levels, and transient decreases in central venous pressure and blood pressure. The former may be of significance in a patient with head trauma, but the effect can be minimized through hyperventilation of the patient. Release of a tourniquet has also been described to induce brief systemic thrombolysis

as a result of the stimulation of various anticoagulation mechanisms by ischemia.[86]

Localized complications have included pain, erythema or localized bullous skin lesions, nerve damage[78,87] from paresthesias to paralysis of the affected limb, vascular spasm, fracture of atheromatous plaque, muscle injury,[88] gangrene and other infectious complications, edema, to compartment syndrome.[78] The nerve and muscle injuries may be transient or permanent in nature,[89] although the latter is exceedingly uncommon in most settings today where tourniquets are utilized for hemorrhage control. This is due to a strong positive correlation between the length of time the tourniquet is in place and the rate and severity of complications that result.[39,90] A similar correlation exists with the amount of pressure produced by the tourniquet,[91,92] but this is mainly an issue with improvised tourniquets and those with a width of one inch or less. It should also be noted that patients with preexisting neuropathies, such as those associated with diabetes or alcohol abuse, appear to be at an increased risk of nerve injury,[93] and other factors may also serve to predispose patients to nerve related complications.

Complications of questionable association, due to a lack of corroborating clinical evidence in injured human subjects to support such claims, include the possible affects of inflammatory mediators on the gut mucosa following ischemia of a limb. This assertion was made by persons with a stated distrust of the use of tourniquets and was accompanied by an unsubstantiated claim that the use of a tourniquet in the hypotensive patient places the patient at a "considerable risk" of loss of life.[41] Such contentions are largely refuted by the volume of cases that have been recently entered into the literature as a result of current military operations without any indication that serious complications of a systemic or localized nature have been frequently associated with the short term (< 2 hrs) use of tourniquets for hemorrhage control. It is for this reason that until evidence supporting such claims of negative systemic outcomes stemming directly and without question from the use of tourniquets by properly trained and equipped medical professionals, the assertions to that effect must be viewed with a certain degree of skepticism.

Failure of a tourniquet is usually the result of insufficient pressure, but this can easily be prevented by reinforcing during the training of those who will be employing such devices that total arterial occlusion is the goal. There have been isolated cases reported among surgical patients where extreme calcification of the arteries prevented effective use of tourniquets for the establishment of a bloodless field.[94-96] This is unlikely however to be a significant factor in the use of tourniquets for hemorrhage control.

There are still several unanswered or only partially answered question regarding the use of tourniquets and the attendant complications, infrequent as they may be in current practice. These include the role of hypothermia[31,97-101] and agents such as antioxidants in minimizing muscle and nerve damage from ischemia. The former has already been demonstrated to be of benefit on a limited basis, with even a marginal (2 to 3 degrees Celsius) decrease in muscle temperature has been shown to be beneficial.[32] Further research into these aspects of trauma care, and others, are still needed and therefore should be encouraged.

The use of the tourniquet in hemorrhage control is likely to remain controversial for the near future; however, given the best evidence available mandates serious reconsideration of the attitudes that we as a profession hold toward this practice. While there are potential risks involved in the utilization of tourniquets should not be overlooked, expeditious and clinically and/or situation appropriate application in the presence of potentially life threatening hemorrhage is in keeping not only with the standards of the medical professions, but accordingly so with the best interests of the patient.

Based upon the best evidence available from the literature, the following conclusions are drawn:

- Emergency medical personnel, both civilian and military, should be trained in and equipped for the proper use of tourniquets; the focus of first aid training for civilian populations should continue to deemphasize their use and focus instead on early medical assistance an the use of direct pressure to control hemorrhage.
- No patient should exsanguinate from an extremity wound because of the hesitance of a medical professional to utilize a tourniquet to control bleeding due to fear of potential complications.
- In circumstances such as combat (or the civilian equivalent thereof), high risk of building collapse, fire, or explosions where expedient movement of the patient is necessary for the safety of the patient and the caregivers, the use of a tourniquet is appropriate to gain control of life threatening hemorrhage.
- The existence of a mass casualty incident may be an indication for the use of tourniquets for temporary control of hemorrhage while the situation is brought under control.
- The need for a tourniquet applied to allow movement of a wounded person or during a mass casualty incident should be reevaluated at the earliest possible time.
- The mere presence of an amputation with hemorrhage does not necessitate the use of a tourniquet; most bleeding from such injuries are controllable through use of direct pressure, elevation, and packing of the wound. If these actions do not achieve

hemostasis, then the use of a tourniquet is indicated.

- Tourniquets may be placed proximal to the site of uncontrollable bleeding around an impaled object; under no circumstances should the tourniquet be applied over the impaled object.
- Tourniquets should not be applied over joints, or over clothing. It should also be at least 3–5 centimeters from the wound margins. The rule of the thumb the author used when teaching was to place it the width of the palm of a hand proximal to the wound whenever possible, as this provides an easy frame of reference.
- Any limb with an applied tourniquet should be fully exposed with removal of all clothing, and the tourniquet should never be covered with an form of bandage. The patient should be clearly marked so as the presence of a tourniquet will be know, along with the time it was placed. It may also be advisable to instruct a conscious patient to tell every medical provider they come in contact with about the presence of a tourniquet.
- Continued bleeding (other than medullary oozing from fracture bones) distal to the site of the tourniquet is a sign of insufficient pressure and a need to tighten the tourniquet further.
- A tourniquet should not be loosened in any patient with obvious signs of shock, amputation that necessitated use of such a device to control bleeding, recurrent hemorrhage upon release of the tourniquet, or any case where the hemorrhage associated with the wound would be expected to be uncontrollable by any other means.
- Any tourniquet that has been in place for more than six hours should be left in place until arrival at a facility capable of definitive care.

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UNCONVENTIONAL WARFARE

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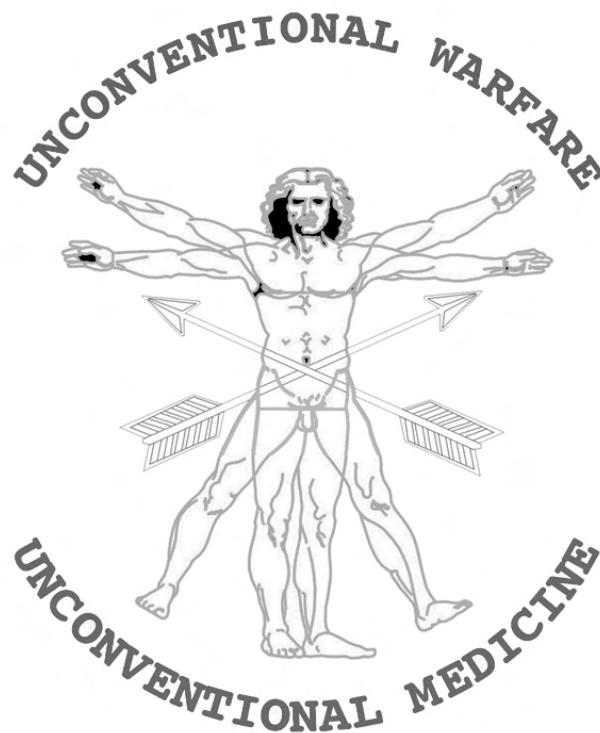
Three-Step Emergency Cricothyroidotomy

Allan MacIntyre, DO; Mark K. Markarian, MD; Dale Carrison, DO; Jay Coates, DO; Deborah Kuhls, MD; JohnJ. Fildes, MD

ABSTRACT

Objective: Surgical cricothyroidotomy is the airway of choice in combat. It is too dangerous for combat medics to perform orotracheal intubation, because of the time needed to complete the procedure and the light signature from the intubation equipment, which provides an easy target for the enemy. The purpose of this article was to provide a modified approach for obtaining a surgical airway in complete darkness, with night-vision goggles. **Methods:** At our desert surgical skills training location at Nellis Air Force Base (Las Vegas, Nevada), Air Force para-rescue personnel received training in this technique using human cadavers. This training was provided during the fall and winter months of 2003-2006. **Results:** Through trial and error, we developed a "quick and easy" method of obtaining a surgical airway in complete darkness, using three steps. The steps involve the traditional skin and cricothyroid membrane incisions but add the use of an elastic bougie as a guide for endotracheal tube placement. We have discovered that the bougie not only provides an excellent guide for tube placement but also eliminates the use of additional equipment, such as tracheal hooks or dilators. Furthermore, the bevel of the enaotracheal tube displaces the cricothyroid membrane laterally, which allows placement of larger tubes and yields a better tracheal seal. **Conclusions:** Combat medics can perform the three-step surgical cricothyroidotomy quickly and efficiently in complete darkness. An elastic bougie is required to place a larger endotracheal tube. No additional surgical equipment is needed.

INTRODUCTION

Military medics need to treat many different types of life threatening injuries quickly and efficiently while in a combat zone. To increase survival rates, they attend Tactical Combat Casualty Care courses taught months before their deployment.[1,2] There they learn how to treat the most common preventable causes of death seen on the battlefield, while engaging the enemy. For example, if the medic is being fired upon, he or she must first suppress enemy fire by returning fire. After the shooting ceases, the medic takes the casualty to cover and follows the triage mnemonic MARCH (Table 1).[3] (1) Massive compressible hemorrhage is controlled with the use of pressure dressings, tourniquets, and hemostatic dressings. (2) The airway is assessed; if compromised, it is maintained through placement of a nasopharyngeal airway with a jaw-thrust maneuver. If the airway remains compromised, then the medic can place a Combitube (Tyco-Kendall, Mansfield, Massachusetts) or perform a cricothyroidotomy.[4] (3) Respiratory emergencies such as tension pneumothorax can be decompressed with needle thoracostomy using a 10 to 14-gauge BD Angiocath Autoguard angiocatheter (BD Biociences, San Jose, California). A casualty with a sucking chest wound is covered with an Asherman chest seal or Vaseline gauze, and respiratory effort is monitored closely. (4) If the patient displays palpable radial pulses and normal mentation, then no intravenous fluids are given; if these features are diminished, then a controlled fluid bolus is infused.[5,6] (5) Hypothermia must be prevented. If necessary, the casualty may be placed in a body bag to prevent evaporative heat loss and given warm intravenous fluids. Once the casualties can

be safely removed from the battlefield, they are transported to a forward surgical team if they are in unstable condition or are transported to a combat support hospital if they are in stable condition. If the medic has to perform these lifesaving procedures in complete darkness; however, then considerable challenges can exist. Over the past three years at our desert medical training site at Nellis Air Force Base, we have developed and modified a technique for establishing a surgical airway while in complete darkness, with the use of night-vision goggles and an elastic bougie, as a guide for proper endotracheal tube placement.

METHODS

The recommended equipment consists of a size 10 scalpel, an elastic bougie, a cuffed endotracheal tube (ranging in size from 6 to 8), and night-vision goggles (Fig. 1A). The three-step surgical airway procedure is outlined as follows.

Step 1: Skin Incision

Quickly cleanse the neck, and grasp the larynx with the nondominant hand. Use the index finger of the nondominant hand to identify the thyroid cartilage, cricothyroid membrane, and cricoid ring. Once the underlying structures have been identified, use the dominant hand to make a vertical incision over the cricothyroid membrane (Fig. 1B). Place the nondominant index finger into the vertical incision and move it side to side to clearly feel the cricothyroid membrane (Fig. 1C).

Fig. 1. (A) Surgical airway procedure being performed with night-vision goggles. (B)Vertical skin incision superficial to the cricothyroid membrane. (C)Nondominant index finger placed into the vertical skin incision, to palpate the cricothyroid membrane.

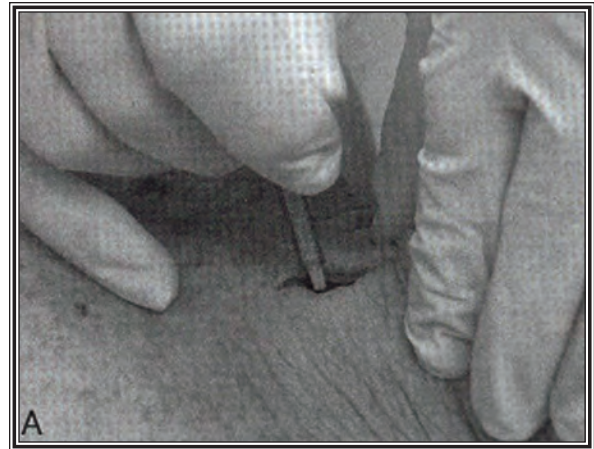Fig. 2. (A)Horizontal incision through the cricothyroid membrane. (B)Placement of an elastic bougie through the cricothyroid membrane. (C) Placement of an elastic bougie through the cricothyroid membrane with night-vision goggles.

Step 2: Incision of Cricothyroid Membrane

Remove the nondominant index finger from the cricothyroid membrane and make a 5mm horizontal incision through the cricothyroid membrane (Fig.2 A). Watch the depth of incision to avoid injury to the underlying esophagus. Place the elastic bougie into the defect and advance it until resistance is appreciated (Fig. 2, B and C). This indicates entry into the right main stem bronchus.

Step 3: Endotracheal Tube Placement

Advance the preselected cuffed endotracheal tube over the elastic bougie (Fig.3), up to the cricothyroid membrane. Ensure that the bevel of the endotracheal tube is lined up with the horizontal incision of the cricothyroid membrane before advancing further. Apply gentle pressure while advancing the endotracheal tube through the divided cricothyroid membrane. As the bevel of the endotracheal tube is passing through the membrane, it will push the cricothyroid membrane laterally. This will open the defect, allowing placement of the larger endotracheal tube. Once the endotracheal tube cuff has entered the trachea, stop advancing. Remove the elastic bougie, and inflate the endotracheal tube cuff.

DISCUSSION

There are many benefits of using the three-step approach described above to obtain a surgical airway. First, a medic can perform this procedure quickly and safely, without the burden of any additional equipment (such as a Trousseau dilator or a tracheal hook). This three-step airway procedure requires only three items, namely, a scalpel, an endotracheal tube, and an elastic bougie. Second, the cricothyroid membrane is displaced laterally as the bevel of the endotracheal tube is advanced into the trachea. This lateral dilation not only reduces the resistance involved in advancing the endotracheal tube into the trachea but also enables the medic to place a tube larger than a standard 6mm tube. The traditional teaching is to place a 6mm endotracheal tube, rather than a ≥7mm tube, because of the ease of insertion into the narrow orifice.[7] A larger endotracheal tube can form a better seal and decrease airway leaks, both critical issues when dealing with higher peak airway pressures caused by blast injuries to the lungs. Third, the lateral dilation eliminates the need to use the back end of the scalpel to increase the diameter of the opening, which could increase the chance of an inadvertent airway injury, esophageal injury, or hand injury. The potential drawbacks of the three-step airway procedure include those associated with the visual challenges of working in the dark. The use of infrared night-vision goggles enables the medic to see in complete darkness, but there is a "learning curve." For example, there is loss of normal multidimensional sight, with visual acuity confined to the color spectrum of green and black, which would make it difficult to see active bleeding or to identify the typical skin color of a hypoxic patient.

However, one can still readily visualize the neck, important landmarks, and one's hand placement throughout the procedure. This reduces the chance of injury from the most dangerous part of the procedure, that is, using the scalpel to make the skin incision and to divide the cricothyroid membrane. We recommend using a safety scalpel, to keep the blade covered when bringing the scalpel up to the patient's neck. The safety cover can then be retracted to expose the blade and to incise the skin; the same holds true for division of the cricothyroid membrane.

CONCLUSIONS

An efficient easy means of obtaining a surgical airway via cricothyroidotomy is critical in combat. We propose a modification to the traditional cricothyroidotomy with the following three-step airway procedure. Step 1 is the identification of landmark structures and skin incision. Step 2 is cricothyroid membrane incision and insertion of a bougie. Step 3 is insertion of an endotracheal tube and removal of the bougie.

The speed, ease, and efficiency of obtaining a surgical airway, in addition to the larger airway provided (compared with traditional cricothyroidotomy), have made the three-step airway procedure a key tool for combat emergency personnel. We expect it to be just as significant and useful in the civilian setting.

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Med Quiz

Picture This...

Rusty Rowe, MD

During day two of a fourteen-day recon mission in the Tal-Afar region of Iraq, you notice one of your team members limping. He saw a provider on the FOB three days ago and was diagnosed with a spider bite on his left ankle. He was prescribed Keflex 500mg BID for suspected secondary cellulitis. He complains of worsening pain and swelling and notes a small amount of yellowish discharge on his sock. He states that he had a similar appearing nodule on his right thigh about three weeks ago that ruptured and then healed on its own. Otherwise, he is healthy without fever or malaise.

After he removes his boot, you see the lesion noted in the photo that is tender to palpation. Pressure on the lesion expresses only a small droplet of purulent material from the central necrotic area.

Using the primary lesion definitions outlined in your SOF medical handbook, how would you describe the morphology of this lesion?

What is your differential diagnosis for a painful, warm, erythematous nodule on the extremity of a deployed Soldier?

Photo 1

ANSWER:

Morphology: Enlarging painful erythematous nodule. May eventually develop overlying pustule, vesico-bullae, or spontaneously rupture purulent material. Surrounding erythema and induration are common.

Differential Diagnosis: Furuncle (deeper/soft tissue infections), Hidradenitis suppurativa (this typically is found in the axilla, buttock, and groin; chronic and recurrent; may need wound culture to differentiate), dissecting cellulitis of the scalp (only found on the occiput of the scalp; more common in blacks), deep fungal infections (often on leg/foot; chronic; seen in central and south America or Caribbean), brown recluse spider bite (not common; dusky erythema progressing to a necrotic expanding ulceration with pain)

COMMUNITY ACQUIRED METHICILLIN RESISTANT *STAPHYLOCOCCUS AUREUS* SKIN INFECTIONS

Staphylococcus infections of the skin, commonly caused by methicillin resistant *Staphylococcus aureus* (MRSA), are an increasing problem in the military populations. Poor hygiene, shared contaminated equipment, and close quarters living promote disease transmission in deployed personnel and military recruits. Community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA), which typically presents as a skin infection, has emerged as a highly virulent bacterium that can cause significant morbidity. Skin infections with MRSA commonly present as a painful abscess that is poorly responsive to antibiotic therapy. Incision and drainage is the treatment of choice, but patients are often additionally treated with antibiotics. Despite preventive medicine strategies such as hand washing, skin infections with CA-MRSA have increased in prevalence and represent a considerable cause of morbidity in military personnel.

MRSA infections were first described in hospitalized patients in 1961, but community-acquired strains were not reported until 1993.[1,2] Now CA-MRSA infections are increasingly reported world-wide. Hospital-acquired and community-acquired MRSA differ in genetic makeup, pathogenicity, and susceptibility to antibiotic treatment.[3] However, CA-MRSA vs HA-MRSA is more likely to affect younger patients and present with skin manifestations. Risk factors that encourage development of CA-MRSA infections include close contact, poor hygiene, sharing of contaminated equipment, breaks in the skin barrier, and/or immuno-suppresion. Populations at risk for contacting CA-MRSA infections include athletes, Native Americans, Pacific Islanders, military personnel, prisoner inmates, the homeless, IV drug users, men who

have sex with men, and children in day care centers.[4] Accurate prevalence rates for MRSA infection in the deployed Soldier are unknown at this time. Methicillin-sensitive *S aureus* (MSSA) bacteria colonize approximately 25 to 30% of the asymptomatic civilian population in the United States. Typical colonization sites include the nasal passages, fingernails, and folds of the body (axilla, groin, and perineum). Studies have also demonstrated a 1 to 3% rate of MRSA nasal colonization in pooled pediatric and adult patients visiting outpatient clinics for unrelated appointments.[3,5]

Clinically, CA-MRSA infections typically begin as an insignificant folliculitis or pustule that progresses to a painful abscess. In actuality, the strongest predictor of a CA-MRSA infection on presentation to an emergency room was the initial presentation as a furuncle in one study.[6] The individual may initially complain of an infected pimple or insect bite that enlarges and swells. In actuality, many patients and healthcare providers mistakenly diagnose a MRSA skin infection as a spider bite. The early lesion may become more painful and develop a surrounding cellulitis. Redness, warmth, and swelling are typically found at the infected site upon initial exam (see figure 1). Patients often are afebrile, but may have associated lymphadenopathy in the draining nodal basin. If treatment is delayed or if the patient is immuno-suppressed, sepsis can ensue.

The primary treatment for CA-MRSA is incision and drainage (I&D) when an abscess is present. Failure to I&D skin abscesses can have catastrophic consequences even when appropriate antibiotics are prescribed. Exudates should be cultured for species identification and to determine antibiotic sensitivities. Although drainage alone will resolve most infections, antibiotic therapy is often initiated by healthcare providers despite strong evidence demonstrating little benefit. This may help prevent spread, re-infection, or clear superficial follicular infections that are not large enough for I&D.

Selection of antibiotic therapy will depend on local resistance rates, but these may not be known in the deployed setting where lab capabilities are non-existent. Most strains of CA-MRSA, although not sensitive to b-lactam antibiotics, are often susceptible to other antibiotic classes. Sulfa and tetracycline classes of antibiotics represent safe, typically effective empiric choices. CA-MRSA resistance to these antibiotic classes is uncommon at this time. Clindamycin may also be an effective treatment; however, fears of inducible resistance have made this treatment choice less favorable. Rifampin can be used in conjunction with other antibiotics, but should never be used as a solitary antibiotic therapy for MRSA infections.

Fluoroquinolone antibiotics may provide coverage for CA-MRSA, although rapid emergence of resistance in *Staphylococcal* isolates is well documented.[7] For the patient who is acutely ill, fails to respond to appropriate oral antibiotic therapy, or worsens despite I&D, evacuation to a higher level of care may be required.

PREVENTION

Preventing CA-MRSA skin and soft tissue infections is challenging; especially in patients with frequent recurrences. Colonization of the nares and skin are common reservoirs for re-infection. Close contact with other individuals colonized or infected with CA-MRSA are a common source of bacterial infections. In actuality, it is common for Soldiers who share the same combat housing unit to spread infection to their roommates. One overlooked source of re-infection is fomites. A recent study of prison inmates in Missouri showed significantly higher rates among inmates who shared personal hygiene products such as cosmetic items, lotion, bedding, toothpaste, headphones, especially nail clippers and shampoo. There was a 13% greater risk of disease spread when inmates shared shampoo or nail clippers. Furthermore, rates of infection were higher with inmates who showered and washed their hands less when compared to uninfected fellow prisoners.[8] Good personal hygiene and sanitation of equipment appears to be the best defense against re-infection or the spread of CA-MRSA. Many dermatologist advocate 4% Chlorhexidine Gluconate (Betasept® / Hibicleans®) as the deployment antiseptic surgical scrub of choice because it clears HA-MRSC and CR-MRSA carrier states.

The unique environment of the deployed Soldiers places them at increased risk of contracting CA-MRSA skin infections. Most infections present as a painful abscess that may respond to incision and drainage alone. Additionally sulfa and tetracycline antibiotics may be required to resolve or prevent recurrent skin infections. Hand washing and appropriate personal hygiene with 4% Chlorhexidine Gluconate (Betasept® / Hibi-

cleans®), sanitization of shared equipment, and improved recognition / treatment of CA-MRSA infections by healthcare providers will decrease the incidence and morbidity of CA-MRSA.

If you are DEPLOYED and have concerns about a puzzling skin condition, you can email your clinical photos, a concise morphologic description of the lesion to our Operational Teledermatology site at derm.consult@us.army.mil or to Daniel.Schissel@us.army.mil. The lesion you describe just may make its way to the next edition of **Picture This… Thanks for all you do.**

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COL Daniel Schissel originated "Picture This" for the Med Quiz. He is a 1993 graduate of the Uniformed Service University of the Health Sciences and completed his internship with the family practice department at Fort Bragg in 1994. He then served as the 2/10th Special Forces Group (Airborne) Surgeon and followed on as the 10th SFG(A) Group Surgeon. He completed his residency training in dermatology at the Brooke Army Medical Center in 1999. COL Schissel is presently stationed in Heidelberg, Germany as a staff physician and the European Regional Medical Command Dermatology Consultant. He has been selected as the U.S. Army OTSG Dermatology Consultant. COL Schissel has authored the dermatology section of the new SOF manual, serves on the USSOCOM Medical Curriculum and Examinations Board, and is the U.S. Army Aviation Dermatology Consultant.

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COL "Rocky" Farr was the distinguished honor graduate of his Special Forces 18D class in 1968 and completed 40 years of active service last April. He served as a recon team member with the 5th SFG(A) in SOG-Studies and Observations Group. He attended the DLI (German) and joined Detachment A, Berlin Brigade, an early special mission unit. He became the SF instructor at the ROTC Detachment, Northeast LA University and completed his BS. As a SFC, he taught in the 18D course and was selected for MSG. COL Farr was accepted to the Uniformed Services University of the Health Sciences and while a medical student, he was the medical platoon leader for the 11th SFG(A). He received his MD in l983 and has completed residencies in aerospace medicine, and anatomic and clinical pathology. He commanded Company F (ABN), 3rd BN, Academy BDE, Academy of Health Sciences as Course Director of the Special Operations Medical Sergeant's Course; and advisor to the 12th SFG(A). He was Chief, Department of Pathology, Blanchfield Army Community Hospital, and Flight Surgeon, 50th Medical Company (Air Ambulance), 101st ABN Division (Air Assault). COL Farr was the Division Surgeon of the 10th Mountain Division (Light Infantry) until becoming Deputy Commander of the U.S. Army Aeromedical Center. He attended the Air War College before becoming the Deputy Chief of Staff, Surgeon, U.S. Army Special Operations Command; Command Surgeon, U.S. Army Special Forces Command; and Command Surgeon, U.S. Army Civil Affairs and Psychological Operations Command. He became the Command Surgeon of the U.S. Special Operations Command in Tampa, FL in July 2006. He has numerous operational tours to include Bosnia, Kosovo, Kuwait, Vietnam, Cambodia, and Afghanistan.

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Special Forces Aidman's Pledge

As a Special Forces Aidman of the United States Army, I pledge my honor and my conscience to the service of my country and the art of med- icine. I recognize the responsibility which may be placed upon me for the health, and even lives, of others. I confess the limitation of my skill and knowl- edge in the caring for the sick and in- jured. I promise to follow the maxim "Primum non- nocere" ("First, thou shalt do no harm"), and to seek the assistance of more competent medical authority whenever it is available. These confidences which come to me in my attendance on the sick, I will treat as secret. I recog- nize my responsibility to impart to others who seek the service of medicine such knowledge of its art and practice as I possess, and I resolve to continue to improve my capability to this purpose. As an American Soldier, I have determined ulti- mately to place above all considerations of self the mission of my team and the cause of my nation.

Pararescue Creed

I was that which others did not want to be. I went where others feared to go, and did what others failed to do. I asked nothing from those who gave nothing, And reluctantly accepted the thought of eternal lonliess ... should I fail. I have seen the face of terror; felt the stinging cold of fear, and en- joyed the sweet taste of a moment's love. I have cried, pained and hoped...but most of all, I have lived times others would say best forgot- ten. Always I will be able to say, that I was proud of what I was: a PJ It is my duty as a Pararescueman to save a life and to aid the injured. I will perform my assigned duties quickly and efficiently, placing these duties before personal desires and comforts.

These things I do,
"That Others May Live."

A Navy Poem

I'm the one called "Doc"... I shall not walk in your footsteps, but I will walk by your side. I shall not walk in your image, I've earned my own title of pride. We've an- swered the call together, on sea and foreign land. When the cry for help was given, I've been there right at hand. Whether I am on the ocean or in the jungle wear- ing greens, Giving aid to my fellow man, be it Sailors or Marines. So the next time you see a Corpsman and you think of calling him "squid," think of the job he's doing as those before him did. And if you ever have to go out there and your life is on the block, Look at the one right next to you...

I'm the one called "Doc".

~ Harry D. Penny, Jr. USN Copyright 1975

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