COCA Call: Bombings: Injury Patterns and Care
Date/Time: August 3, 2010 (2:00 PM- 3:00 PM ET)
Speaker: Dr. Scott Sasser, Consultant, National Center for Injury Prevention and Control (CDC)

Coordinator: Welcome and thank you for standing by. At this time all participants are in a listen-only mode. To ask a question during the question and answer session please press star then 1 on your touchtone phone. Today's conference is being recorded, if you have any objections you may disconnect.

And now I'd like to turn the meeting over to your host Miss Loretta Jackson-Brown. Ma'am, you may begin when ready.

Loretta Jackson-Brown: Thank you (Fran). Good afternoon. I'm Loretta Jackson-Brown and I am representing the Clinician Outreach and Communication Activity, COCA, with the Emergency Communications System at the Centers for Disease Control and Prevention.

I am delighted to welcome you to today's COCA conference call, Bombings: Injury Patterns and Care. We are pleased to have with us today Dr. Scott Sasser, Consultant, National Center for Injury Prevention at Centers for Disease Control and Prevention to discuss clinical information regarding blast-related injuries from terrorism and appropriate management and care of blast casualties.

During today's call you will hear the presenter referring to slides in his PowerPoint presentation. The PowerPoint slide set is available from our COCA Website at emergency.cdc.gov/coca. Click on conference calls; the slide set can be found under the call-in number and call passcode.

The objectives for today's call are that participants will be able to discuss current global context of bombings, describe the four categories of blast injury and discuss the management and care of blast casualties.

Following the presentation you will have an opportunity to ask our presenter questions. Dialing star 1 will put you into the queue for questions.

In compliance with Continuing Education requirements all presenters must disclose any financial or other relationships with the manufacturers of commercial products, suppliers of commercial services or commercial supporters as well as any use of an unlabeled product or products under the investigational use.

This presentation will not include the discussion of the unlabeled use of a product or products under investigational use. CDC, our planners and our presenter wish to disclose that they have no financial interest or other relationships with the manufacturers of commercial products, suppliers of commercial services or commercial supporters. There is no commercial support for this presentation.

Today's presenter, Dr. Sasser, is a consultant in the Division of Injury Response at CDC's National Center for Injury Prevention and Control. He is an Associate Professor in the Department of Emergency Medicine at Emory University's School of Medicine and in the Hubert Department of Global Health Rollins School of Public Health.

As a consultant, Dr. Sasser has been instrumental in enhancing CDC's emergency preparedness activities related to disaster and terrorism response as well as contributing to the advancement of acute injury care.

Dr. Sasser was lead editor on the World Health Organizations Pre-Hospital Trauma Care Systems Monograph. And as an extension of this project he currently sits on the World Health Organization's Trauma and Emergency Care Advisory Committee.

Dr. Sasser is currently involved in projects in Kenya, Rwanda and India and is the recipient of funding from the National Institutes of Health to provide injury-focused public health training to physicians in Mozambique. And the recipient of funding from the United States Agency for International Development to develop emergency medicine and emergency medical services in the Republic of Georgia.

If you're following along on the slides you should be on Slide 6. Again the PowerPoint slide set is available from our COCA Website at emergency.cdc.gov/coca. Please note that there are a few graphic slides in this presentation.

At this time please welcome today's presenter Dr. Sasser.

Scott Sasser: Good afternoon and thank you for joining for this call. It's certainly a pleasure and an honor to present this topic today.

On Slide 2 and 3 you will notice a reference to the TIIDE partners. And I just want to start by recognizing that this presentation today is the result of this cooperative agreement between the organizations that are listed on Slide 2 and

3. TIIDE stands for Terrorism Injuries, Information, Dissemination and Exchange.

It's a cooperative agreement that is coordinated by the CDC and involves the partners that you see listed on these two slides. And the goal of the partnership is really to ascertain, develop and disseminate information on terrorist bombing events and the management of casualties associated with those events.

So this course, Bombings: Injury Patterns and Care, represents the efforts of all these organizations over the course of the past several years to develop initially a first version of this course and this revision that was finalized last fall.

The partners themselves are very active engaging not only membership in their own organizations but other organizations and groups as well and involving them in this process.

And although most of the - if not all of the partners listed on these two slides are national organizations the TIIDE partnership has grown and expanded and there's an increasing international, as you might imagine, component to this work as the group draws heavily on the experience of the international community in preparing for and responding to terrorist bombings.

On Slide 4 really hints at the first section of this talk and that is the contextual component of bombings. The next few slides will give us an overview of the current international and national context for terrorist bombing preparedness and provide information on the most common form of terrorist attacks, specific international bombing events, the U.S. experience with terrorist

bombings, the risk and predictability, if you will, of future events, the United States' own level of preparedness for terrorist bombings and a comparison of severity of injury between terrorist bombing casualties and injuries sustained in quote/unquote routine trauma.

In 2006 the Institute of Medicine published a three-volume series of the future of emergency care in the United States. And despite justifiable concerns about the dangers of chemical, biologic or nuclear attack bombings with conventional explosives were recognized in those reports as remaining the terrorist's method of choice.

Similarly - excuse me - in the next slide labeled Threat Assessment 2007 in his 2000 - in his January 2007 briefing to the Senate Select Committee on Intelligence, John Negroponte highlighted his concern over the most likely al-Qa'ida attack scenario noting that use of a conventional explosive continues to be the most probably al-Qa'ida attack scenario.

In 2008, in a similar briefing to the Senate Select Committee, J. Michael McConnell continued to emphasize concern over the possibility of al-Qa'ida using conventional explosives giving their proficiency at producing improvised explosive devices and their ability to overcome security obstacles.

One year later the same briefing to the same committee, Dennis Blair highlighted the fact that conventional explosives continue to be the most often used instrument of destruction in terrorist attacks.

So over the course of three years, two administrations, two political parties and three different Directors of National Intelligence and three separate threat

assessments all had a consistent similar message, conventional terrorism remains the most probable form of terrorist attack in the United States.

The next slide, Global Perspective, terrorist attacks remain an ever-present threat. They continue to occur globally and on an alarming scale. Bombings, the perpetrator's method of choice, remain a real and constant threat with an average of approximately two terrorist attacks per day worldwide during 2005.

In the past 30 years terrorism has evolved from mostly secular national organizations to diverse, multinational, global organizations. These organizations have different motivations and tactics and their bombings are increasingly lethal as witnessed in Madrid in 2004, in London in 2005 and Mumbai in 2006 terrorist efforts reveal an ever increasing degree of sophistication, coordination and capacity for harm.

There are six events listed on this slide and I'm sure we could update them even again now with more current events. But each of these reflects a different tactic and motive. Perhaps the one to highlight the most is some of the bombings in Jaipur, India in 2008 which there were nine synchronized bombs with 63 persons dead and over 200 injured.

These were well synchronized backpack bombs that drove a crowd from place to place while targeting their movements. Subsequent bombing on July 26, 2008 in India also targeted hospitals.

We certainly are familiar with the bombings that have occurred in Israel and the United Kingdom in 2005 and Spain in 2004 again showing an increasing

degree of sophistication as the perpetrators targets multiple targets at once for simultaneous explosions.

Over the past 20 years, or actually over the 20 year period 1983-2002, there were over 36,000 bombing incidents recorded in the United States alone resulting in over 5900 injured and almost 700 dead. These numbers are actually for actual and attempted bombing events during the period.

The photograph there I think is probably familiar to many people; it's a picture of the Murrah building in Oklahoma City in April of 1995 in which a truck bomb with 2500 kilograms of fertilizer mixed with fuel resulted in 168 dead and over 800 injured.

The next slide is entitled Predictable Surprise and it's simply meant to recognize that the reality of persistent, complex, global terrorist bombings make terrorist bombings in the United States and predictable surprise.

What do we mean by that? Well there's several characteristics highlighted on this slide. The first is a tendency to maintain the status quo. We assume often that we can provide the same level of care for large numbers of casualties from terrorist bombings as we do for victims of a bus crash or a smaller event that may occur on a daily basis. And we often fail to deceiver ourself in a natural reaction to maintain the status quo.

There's also a problem that exists that will not solve itself, reports of bombings occur almost daily; it's really a matter of when not if terrorism will return to the United States and our emergency medical systems and hospital systems may be ill equipped to manage the consequences.

As we've highlighted in the prior slides it's clearly a problem that is getting worse; terrorist events show no sign of abating. They happen almost daily and reveal an ever increasing level of coordination and sophistication.

And finally solving the problem will incur present costs with delayed benefits. A central issue in preparing for terrorist bombings in the United States is to proactively educate and prepare our providers, our responders and our administrators. However this is often - this is an expensive endeavor and the benefits are not fully recognized until they have to be used in a response to a terrorist attack or similar disaster.

So the next logical question is in the context of global terrorist bombing events that are increasingly tactically sophisticated, in the context of the risk as highlighted from the Institute of Medicine through the threat assessments of the Directors of National Intelligence, the risk to the United States and the fact that this represents a predictable surprise, how prepared are we?

Well in 2008 a study was commissioned by the US House of Representatives Committee on Oversight and Government Reform that sought to see what the capability of hospitals in seven U.S. cities would be to handle a surge similar to that seen after the Madrid 2004 bombings.

And essentially what the committee did was they conducted a survey of Level 1 trauma centers in seven major U.S. cities to assess their capacity and see if they felt they could respond to the number of casualties experienced in Madrid. It was conducted in the afternoon across these seven cities.

And their conclusion was that none of the hospitals surveyed in the seven cities had sufficient emergency care capacity to respond to an attack generating the number of casualties that occurred in 2004 in Madrid.

Next slide. How sick - perhaps that should be in quotes - are bombing - are the bombing injured? Are they similar to patients who are injured in quote/unquote routine or daily trauma?

This slide in the highlighted red box simply points out that casualties of terrorist bombings are more critically injured than their counterparts from routine trauma and more bombing casualties have a higher ISS, a lower GCS, a lower admission blood pressure, a higher incidence of admissions to the ICU, a higher incidence of multiple body injuries injured - body areas injured and they are more likely to have a surgical procedure or to die in the hospital.

So what are the injury patters? Well if you remember that bombings represent an ongoing threat, a predictable surprise, a complexity of attacks, a present lack of preparedness and an increased severity of injuries let's discuss some specific injury patterns.

On the next slide entitled Explosives I think it's important that as we get into the discussion of injury patterns we must first talk some about the physics of explosions. I think it helps us understand some of the terminology in the literature, understand injury patterns, predict the likelihood of certain types of injuries and assist with the protection and prevention of injuries.

As highlighted on this slide explosives are categorized as either high order explosives or low order explosives. High order explosives produce a defining

supersonic over-pressurization shock wave. The examples of high order explosives include TNT, C4, Semtex, nitroglycerin and others.

Low order explosives create a sub-sonic explosion and they lack high order explosives' over-pressurization wave. Low order explosives essentially release their energy slowly in a process called deflagration which is essentially a burn.

Example of low order explosives include pipe bombs, gun powder, petroleum-based bombs such as Molotov cocktails or aircraft improvised as guided missiles. High order and low order explosives may cause or do cause different injury patterns.

High energy explosions, an explosion of the phenomena that result from a sudden release of energy and that involves the instantaneous, near instantaneous transformation of a solid or a liquid into a gas which occupies the same space but at a higher pressure.

That gas rapidly expands outward from an epicenter at supersonic speeds and compresses the surrounding medium driving it outward in a pressure pulse or blast wave.

The next slide is a graphic of the ideal blast wave form also known as a Friedlander curve; the graphic illustration of the time course of pressure changes following explosions. The energy from the blast wave is expressed in terms of the peak and the duration of over pressure.

The peak over pressure is primarily determined by the magnitude of the blast. The dissipation time interval and speed of the blast wave is often determined

by the medium; more dissipation than air and more prolonged and intense in water. The negative pressure phase may explain some of the findings - implosive findings and effects after major blasts.

Another key component in discussing the physics is to recognize that solid surfaces such as external or internal walls, floors, ceilings may reflect or do reflect and may amplify blast wave. A high pressure gas may impact a barrier and reflect off of it in upwards of 2-20 times as powerful as the incident wave.

As an example of that the next slide is a graphic of the Russell Square bombing in London in 2005 which in many ways reflects the ultimate reflection or closed space environment for bombings.

Most deaths in the London bombings in 2005 occurred at this location, 26 of the 52 people who died, died in the Russell Square attack. Notice that the Russell Square tube is a tube tunnel very far below the surface not a sub-surface tunnel.

And the graphic is a little hard to see but in the lower right hand side you see the measurement or the size differential in the two tunnels the top one being a tube tunnel with a diameter of approximately 3.5 meters so there's not much room outside of the train before you hit the walls.

So the bomb goes off as you can see in the top of the graphic almost midway between the Kings Cross and Russell Square Station in this tube tunnel deep below the surface creating a severe enclosed space environment resulting in reflection of the blast wave off of multiple walls and barriers.

How do we classify or categorize blast injuries? There are four primary categories, primary blast injury is due to the blast wave that we discussed earlier passing through the body and causing damage. It's a unique pattern of injury only seen with high explosive detonations and is a pattern of injury that may be unfamiliar to most civilian providers and responders.

Secondary blast injury is blunt or penetrating injury due to flying debris that strikes the body. Tertiary blast injury refers to blunt or penetrating injury that occurs as a result of the body being displaced and thrown into objects. Quaternary, formerly called miscellaneous blast injury, refers to all other forms of injury including burns, crush, contamination, exacerbations of existing disease and so forth.

A fifth category of injury, quinary, has been proposed and is being discussed in the literature and refers to the hyper inflammatory state that may occur in casualties of terrorist bombings.

It's nice to divide these up into these categories but in reality most bombing casualties have a combination of the above injury patterns and thus their injuries are best categorized as complex.

Primary blast injures. Primary blast injuries are unique to high order explosive detonations. They are not seen in low order explosive detonations. Primary blast injuries are due to tissue injury as the pressure wave passes through the body.

They are characterized by anatomical and physiologic changes that result from the direct or reflected over-pressurization force generated by the blast wave

impacting the body's surface and affect primary gas containing structures, lungs, gastrointestinal tract and ears.

This graphic entitled Blast overpressure wave is simply a photograph to attempt to demonstrate graphically the blast wave and blast front that imparts the brisance or shattering ability of a blast wave and is the cause of primary blast injury. If you look at the graphic you can see the distortion of the sky beyond the blast that represents the wave or the pressure propagating outward.

Primary blast injuries, as the blast wave moves through - propagates through the lungs there is a tearing of the tissues with the resultant hemorrhage and edema resulting in pulmonary injury.

Auditory injury occurs when the tympanic membrane is ruptured which is the most common primary blast injury. And signs of ear injury are often evident on initial presentation with problems such as hearing loss, tinnitus otalgia or vertigo.

Abdominal injury is when the gas-filled structures of the abdomen, those that are most vulnerable especially the colon, are injured. This results in bowel perforation, hemorrhage, mesenteric shear injuries and solid organ lacerations as well.

Finally traumatic brain injuries, although there are some controversy whether the brain is vulnerable to primary blast caused by the over pressurization wave animal models and recent literature and experience suggests that it is.

Shear and stretch waves from the over pressurization potentially cause traumatic brain injury directly through concussion, hemorrhage, edema or

diffuse axonal injury. The primary blast mechanism can also result in cerebral infarction due to blast lung injuries and consequent formation of gas emboli.

Secondary blast injury, secondary blast injury is the most common injury encountered in terrorist bombings and results in blunt or penetrating injury from flying debris and fragments that may include explosive debris, implanted foreign objects, human remains and environmental debris that has been made airborne. Patients may present with multiple secondary injuries. And these may include human remains which we'll discuss a little bit further on.

Tertiary blast injuries, tertiary blast injury as I mentioned earlier results from the body literally being thrown into an object with the resultant penetrating or blunt injury, impalement or even traumatic amputation.

Quaternary blast injuries again formerly in a lot of the literature that you'll review referred to as miscellaneous blast injuries. They reflect explosion related injuries or illnesses not due to primary, secondary or tertiary mechanism.

Examples of quaternary blast injuries may include burns, crush injuries, eye irritation from dust or superficial corneal abrasions, inhalation injuries, toxins, exacerbations of chronic disease such as asthma, COPD, angina, hypertension or hyperglycemia.

And finally as I mentioned in the overview slide, quinary blast injuries. Quinary blast affects have also been postulated especially of late in the medical literature and they refer to the clinical consequences of a - what’s thought to be post-detonation environmental contaminants including bacterial, radiation or tissue reactions to fuel and metals.

Blast injuries severity, the severity of blast injuries is affected by many factors including the type of explosives, the amount of explosives and the intensity, amplitude, rate of rise and duration of the pressure wave.

It is also dependant upon the casualty's location in relation to the blast. The intensity of an explosion pressure wave declines with the cubed root of the distance away from the actual explosion. For an example a person three meters from an explosion experiences eight times more over pressure than a person who is six meters away.

After an explosion in a confined space such as a bus or perhaps on a subway as we talked about on the previous slides, one would anticipate in addition to penetrating injuries more casualties with primary blast injuries and lung damage than you would expect from an explosion that occurred in open air say in the middle of a football field or a soccer field.

Explosions in confined spaces and structural collapse are associated with greater morbidity and mortality. And as an example of that the graphic that perhaps many of you may have seen from an article in JAMA following the Oklahoma City bombings and it's a diagram of the location of individuals at the time of the explosion, where they actually were in the building when the bomb was detonated.

It illustrates I think clearly casualty distribution from structural collapse. Those patients who are red in color are those who died. And you can see that they were either in close proximity to where the bomb went off in the front lower part of the building or most of them appear to be floating in air because they were in a part of the building that underwent structural collapse.

Next slide is entitled Bombings: Context, Injury Patterns and Care highlighted in yellow. While we understand the context of bombings and the injury patterns - we've gone over the context of bombings and the injury patterns let's now talk about some specific items related to medical care of these patients.

Blast lung injury, the term blast lung is typically used to describe severe pulmonary contusion, hemorrhage and/or edema with direct alveolar and vascular injury as a result of the blast overpressure wave.

It results in severe pulmonary contusion and is complicated by pneumothoraces, hemothoraces, bronchopleural fistulas, fat embolization and alveolar pulmonary edemous fistulas as well as air embolisms.

Blast lung injury occurs at a pressure range of approximately 50-80 psi. It occurs in roughly less than 10% of the casualties seen and has been reported in anywhere of 30% - 60% of admitted casualties. In an Israeli study 38% of admitted patients resulting from a bus bombing had blast lung injury.

In the Madrid train bombings, the hospital that saw the most patients found an incidence of blast lung at 7% of patients seen and 63% of those admitted to the intensive care unit.

Again going back to our prior discussion on physics and proximity to the blast and enclosed spaces a higher incidence of blast lung is reported in enclosed space bombings than those that are reported to be out of doors.

Blast lung injuries, the next slide is a chest radiograph that depicts typical patterns seen in blast lung injury, bilateral patchy infiltrates in a butterfly pattern - a quote/unquote butterfly pattern is what you'll see it referred to in the literature.

The lung closest to the blast typically has more severe findings. X-ray findings are reported to develop and progress over several hours with clearance of the chest x-ray in five to seven days.

So how do we actually manage it? Blast lung injuries should be managed as a major pulmonary contusion. High flow oxygen, chest decompression for pneumothoraces or hemothoraces, balanced fluid resuscitation administered judiciously recognizing that potentially to make the edema and lung injury worse, and intubation and mechanical ventilation if required.

I say if required because if a positive pressure oxygen is needed to maintain oxygen saturation then we have to proceed with intubation and mechanical ventilation but proceeding with caution and recognizing the complex nature of blast lung injuries and the potential to exacerbate the injury by providing positive pressure ventilation.

Ways to manage that include limiting our peak inspiratory pressures to avoid the potential for air emboli, permissive hypercapnia and in some severe cases of pulmonary hemorrhage selected bronchus intubation for independent lung ventilation. Disposition of patients that are diagnosed with blast lung injuries should be to an intensive care unit setting.

Most casualties with blast lung injury die at the scene. The survival rate of critically injured patients with blast lung who actually make it to the hospital is greater than 70%.

In Madrid 17 patients at one hospital were diagnosed with blast lung injury of which five died. Three of these deaths were due however to non-pulmonary injuries.

One year later in a study done in Israel of survivors of blast lung injury at one year most survivors demonstrated normal lung function test and complete resolution of their chest radiographic findings - chest radiograph findings, I'm sorry.

The next slide is entitled Blast Auditory Injury. External ear amputation has been reported as a marker for mortality reflecting a close proximity to the blast. External ear injury is typically the result otherwise of secondary or tertiary injuries of flying debris resulting in lacerations and contusions.

The most common injury to the ear - we made reference to this earlier - is a ruptured tympanic membrane. The inner ear - excuse me - may also be injured through receptor stunning and sensorineural hearing loss and presenting symptoms may include hearing loss, tinnitus, vertigo.

Next slide, tympanic membrane rupture, again the most common primary blast injury, occurring at approximately 5 PSI. And if you'll recall blast lung injury was in the order of 50-80 so it takes much less to rupture the tympanic membrane and results in acute hearing loss, as we said tinnitus otalgia.

It is a marker for primary blast exposure. It was once thought to be correlated with more significant blast injuries, but in the increasing body of literature there appears to be an imperfect correlation. So I think the best way to say it is a marker that somebody was exposed to a primary blast or was - has a primary blast injury but it is not necessarily indicative of a more severe primary blast injury.

The next slide just reveals a diagram that on the left shows a normal tympanic membrane, the middle one shows a tympanic membrane rupture and at the right it shows a healing perforation.

Managing tympanic membrane rupture, first and foremost, keeping it clean and dry. Second, referring to ear, nose and throat surgery, especially where there is indication for careful suctioning of debris, blood and cerumen.

Antibiotic ear drops may be indicated in the context of tympanic membrane perforations or ear canal lacerations. Patients clearly should avoid probing or irrigating the auditory canal and avoid immersing the head underwater. Typically small perforations heal spontaneously over the course of several weeks. Extensive perforations may require further intervention and surgery.

Gastrointestinal injury; I mentioned early on in one of the overview slides for this section the colon is the most commonly injured organ. Usually as a result of acute perforation or mesenteric avulsion with delayed perforation.

Other abdominal injuries reported include (subcasular) hematomas, lacerations to solid organs, testicular rupture and tension pneumoperitoneum. As with many things in the abdomen there may be a delayed presentation for hours or even days.

And once the presentation is clear these are typically managed as an acute abdomen caused by other etiology as well. One note is blast abdominal injury is actually increased in underwater explosions due to the enhanced propagation of the blast wave in water.

And finally in primary blast injury traumatic blast or traumatic brain injury, this slide simply states if blast casualties can sustain traumatic brain injury without a direct blow to the head due to exposure of the blast overpressure wave.

Symptoms may include headache, fatigue, poor concentration. Symptoms may often be delayed. And it is often linked to or misdiagnosed as a post traumatic stress disorder.

Moving onto secondary and tertiary injuries. Bomb fragments, dispersives added to the bomb and debris, as we noted, can all impact the body. Fragments follow unpredictable paths and liberal use of radiography should be considered.

All wounds are considered dirty and wounds should therefore be left open with administration of broad spectrum antibiotics considered. Entry wounds may be deceivingly unimpressive.

Multidimensional injury, casualties, as I noted again on an earlier slide, a victim may have numerous injuries from different mechanisms of blast injuries. Patients often need complex medical management and a result in exponential increase in resource utilization. Each casualty may have some component of primary, secondary, tertiary and quaternary injury.

The next slide is simply a graphic presentation of multiple injuries in a casualty with numerous simultaneous injuries making the management of this patient extremely challenging.

We are fortunate enough in the TIIDE partnership to have many members of the military involved through the national organizations and to help us learn some of the lessons from the United States military experience.

And some of those are I'm sure very familiar to many of you but are highlighted here as some of the early lessons that have come out if you will. And those include that maintaining existing blood volume may require aggressive hemorrhage control.

With proper training responders may achieve hemorrhage control with tourniquets in the setting of traumatic amputation and crushed or mangled extremities. New hemostatic dressings may stop or minimize hemorrhage especially in areas that are not amenable to a tourniquet such as the torso, neck, head.

As we know in our experience with trauma body temperature begins to decrease at the time of severe injury and avoiding heat loss is essential to avoiding metabolic acidosis and coagulopathy.

And damage control surgeries not only to stop the bleeding and remove contaminants but - or to stop the bleeding and remove contaminants followed by resuscitation optimized in the ICU and returning to the operating room for definitive procedures.

Again not everything on this slide is new as a result of the lessons of the U.S. military but I think it's, if you will, becoming more prominent and refined as it comes out of the military experience.

Special considerations, the next section will cover aspects of blast injury in certain populations, groups and special situations. Pregnant patients, the pediatric population and older adults will be addressed as well as communications difficulties, mental health consequences of explosions and post-exposure prophylaxis issues and blast casualties.

Pregnancy, in pregnancy the placenta is at risk of abruption from the primary blast wave due to its different density relative to the uterine wall and the amniotic fluid sac.

Pregnant casualties of blast events warrant continuous fetal monitoring and screening for fetal maternal hemorrhage in the second and third trimesters. First trimester pregnancy is managed expectantly. OB/GYN consultation is essential for managing the pregnant patients in this uncommon context.

When a blast occurs in a community all demographics may be injured; young children and infants pose challenges with communication that may be compounded by an injury to the ear.

All children may have issues with separation from parents and families that may occur in the context of these blast events. And our planning must include a strategy for identification and reunification.

While injury management principals are the same across demographics there are anatomic and physiologic differences among children that must be understood when applying management principals.

Neonates have a head that is larger relative to the rest of the body. Bones have growth plates and tend to be more pliable permitting energy distribution into soft tissues and viscera.

Normal vital signs in children reflect higher heart rates and lower blood pressures than in adults. The experience of the 1995 Oklahoma City bombing with involved a daycare center demonstrated that children sustained a large number of multidimensional injuries reflecting anatomic exposure and large energy absorption. There was significant mortality associated with these injuries.

Pediatric casualties from blasts have higher injury severity scores than non-blast trauma and are more resource-intensive to manage. Integration with regional pediatric trauma centers is an important part of this plan yet every hospital initially must be ready to manage pediatric casualties.

Older adults have reduced bone density and muscle mass which increase their risk for traumatic orthopedic injuries. They are particularly intolerant of rib fractures and pulmonary contusions from blunt chest trauma.

Older adults often have antecedent mobility limitations which challenge evacuation, rehabilitation and recovery. Furthermore they may have chronic medical conditions such as cardiovascular and pulmonary disease which can be exacerbated by the event. These quaternary injuries can include myocardial infarction and chronic obstructive disease exacerbation.

Communication barriers, significant barriers to communications may exist in the context of blast events. In a multicultural population multiple languages will make risk communication and casualty care more difficult. The affected population includes those with antecedent deafness and chronic hearing loss limits the effectiveness of verbal techniques.

The blast itself may also cause ear injury and acute hearing impairment. This can make casualty disposition more challenging. An anecdotal report - actually we had the opportunity to travel to Madrid and meet with a lot of the individuals involved in the bombing response there. And one of the things that arose in the hospitals was a inability to communicate with patients due to blast injury of their ear resulting in more CT scans of the injured population because the providers were unsure if their inability to communicate was simply due to the ear injury or was due to some type of head injury that made them have difficult - made the patient have difficulty in communicating.

Next slide - mental health consequences. Mental health continues to be an underappreciated need in response and recovery to blast events. The risk factors associated with mental health consequences are well known and surround the central point of uncertainty.

There is little or no warning or unknown duration of the event. There is the threat to personal safety. There are unknown health risks and lingering concerns about residual health risk. Will there be dust that causes a pulmonary disease and so forth.

Mental health consequences may apply to the entire community and this includes first responders of the event to receivers of the casualties; no one is

immune. Psychological first aid provides contact and engagement while ensuring safety and security to the patients.

What about post-exposure prophylaxis? This arose following bombing in London in 2005 when the whole topic came up of who needs post-exposure prophylaxis and in what context. This resulted in the publication of a morbidity and mortality weekly report in August of 2008 by the CDC to address this issue.

And basically the report recognizes that bombings result in tissue fragments that expose casualties to blood and other bodily fluids. The CDC through this process would codify recommendations across this category for post-exposure prophylaxis to prevent infection with hepatitis B, hepatitis C or HIV.

As you can see from the graphic the greatest remains with hepatitis B in situations of penetrating injury, broken skin and mucous membrane exposure. Prophylaxis in these cases involves administration of the hep B vaccine series. There appears at this time to be very minimal risk of HIV exposure in the setting of blast events.

And finally just a few slides to review some real world scenarios if you will, the context, again. First slide, Oklahoma City, 1995, 169 dead, greater than 800 injured; more than 65% not transported by EMS; more than 60% going to hospitals within 1.5 miles of the event. And significant bystander rescue efforts.

Put this up - this slide up here just to simply highlight that we have to take these types of patterns into context when we plan to respond to these events.

Not everyone is transported by EMS, not everyone will be filtered through our EMS staging and transport mechanism.

Patient casualties will self-transport themselves often to the closest hospital, the nearest hospital not necessarily to your Level 1 trauma center. That may inundate and overwhelm those hospitals with the initial wave of casualties. And there were significant bystander rescue efforts in the initial response to Oklahoma City and in certainly many other events that I'm sure you're familiar with.

How about in Madrid in 2004, multiple train bombings, 10 detonations, nearly simultaneous explosions on four trains; 177 people dead at the scene, more than 2000 injured. Similar to the Oklahoma City experience more than half went to the two hospitals closest to the scene will 15 hospitals were available.

Over 300 casualties were managed at one hospital, 272 of those in 2.5 hours. The overwhelming majority of the casualties were not critically injured. Significant observations include lack of communication with EMS, uncontrolled casualty distribution from the scene and a casualty surge at the hospital.

Two overarching scene principals, the bombing scene is inherently unsafe. The first priority is to protect the responders. This requires intensive - requires anticipation of secondary events, appropriate PPE and activation of incident command structures.

The next priority is to protect the uninjured public so that more casualties are not created. Finally protection of the casualties; it may seen out of sequence relative to what is done everyday with putting patients first however in a

bombing event with mass casualties the essential first step is not to add more to the casualty load.

First responders with casualties not only add to the casualty load but take away from the response. The environment must also be protected to preserve forensic evidence and facilitate site recovery. The scene is not the place for the well intentioned untrained provider.

Pictured is Rebecca Anderson, a pediatric nurse who went to the scene of the Federal Building bombing in Oklahoma City because she heard that children had been injured. She was killed by falling building debris and became mortality number 169.

At the beginning of this talk we talked about the bombing of hospitals in India. In this slide is a picture of an emergency department in July 2008 when a terrorist bombing targeted a hospital in India.

Healthcare facilities may be part of the second hit strategy using sequential bombs at the scene and along the route of casualty evacuation to inflict greater injury and fear at the scene again highlighted by the movement of the crowd around in Jaipur in 2008 as well.

Mass casualty triage, triage begins at the scene with bystanders rescuing the living. The common myth of casualty evacuation by emergency medical services is dispelled by this photograph taken in Nairobi, Kenya at the embassy bombing in 1998. There is often significant initial bystander involvement.

A further look at the literature confirms the earlier findings of Oklahoma City and Madrid that casualties self-triage to the closest facility. These casualties are typically walking wounded. The next casualty surge brings the critically injured; some of whom still arrive outside of EMS transport. There is often limited EMS triage at the scene.

Mass casualty triage is different, as you know, from our daily triage in the emergency department or on the streets with our EMS system. That triage works to achieve the greatest good for the individual patient whereas mass casualty triage seeks to achieve the greatest good for the greatest number in the casualty population.

It's not a one-time decision; the system of decisions with constant reassessment across the casualty transport and casualty setting. It cannot be overstated that the vast majority of casualties from bombings are not critically injured. Bombings are lethal which accounts for the smaller number of critical injured who have complex multidimensional injuries.

Real quick on this slide in the interest of time - Are there patterns? Yeah there are - Yes there are. Casualty outcomes - this slide is basically a summary of casualty outcomes across reviews of bombings with a large number of casualties.

You can see there's typically a pattern here. More outpatient than inpatient care, over-triage with admission, high mortality relative to daily trauma outcomes. You can look at this and say, you know, 10% or 15% dead, another 20%-25% admitted and the vast majority of patients in the right hand columns treated as outpatients.

I'm going to skip the next slide and go to the slide entitled over-triage and critical mortality. And this is just a graphic reproduced from a journal article - lead author Eric Frykberg, on over-triage and critical mortality.

And it recognizes that the goal of triage is to find the critically injured within the majority of non-critically injured. Defining a critically injured casualty as non-critically injured is under triage and is always a threat to life.

The non-critically injured patient becomes a distraction away from the critically injured. The critical mortality rate, i.e. the number of critically injured who die after arrival over the total number of critically injured goes up as over-triage rates go up.

So essentially what this graphic shows is that the critically injured often get lost in the crowd in the wave of the more numerous non-critically injured patients and their mortality goes up.

Real world challenges, there are a myriad of real world challenges that must be addressed in the context of blast events. And a lot of these challenges came from our experience in communicating with our international colleagues and visiting some of these sites that reflect - these challenges reflect real human behavior, blast physics and planning.

And untrained personnel are at risk for poor casualty outcomes. Closed spaces contain the energy of bombings better than open spaces and therefore increase morbidity and mortality. Tympanic membrane rupture results in difficult communication from the scene through the hospital.

Well intentioned blood donations greatly exceed any requirements. There's inherent surge capacity in most blood supplies. Limited resources are a recurrent, significant issue. Tracking casualty location and movement requires planning and practice.

Finally a graphic that many of you may have seen either in the publication that's listed on this slide on model uniform core criteria for mass casualty triage or are familiar from the CDC itself directly on their Website.

And essentially this was the result of an effort to forge a coherent, consistent mass casualty triage scheme for application in the field and outside of healthcare facilities.

Nine existing triage systems plus the MASS system from the National Disaster Life Supply program are reviewed regarding their effectiveness. The only evaluations found were modeled around triage of routine trauma patients and there were few comparisons between the triage systems.

So this diagram was developed by this group - this subgroup of the TIIDE partnership if you will that had representatives from all those organizations sat down and developed a - not a new triage algorithm but model core criteria that should be the part of any triage algorithm.

The diagram shows model uniform core criteria for disaster triage tools that were designed around sorting, assessing, performing life saving interventions and subsequent treatment and transport.

The scheme filters out the minimal and delayed casualties in order to find those critically injured patients and apply life saving interventions to them.

Again, not a new scheme but a model of what should be contained in a triage scheme in the mass casualty situation.

I know we're running close on time. Let me just quickly say in summary, the weapon of choice as we highlighted at the beginning of terrorists appear to be - are conventional bombings. Explosions combine the four main traumatic categories of injury, primary, secondary, tertiary and quaternary.

The injuries that result are often multidimensional and complex and beyond what is seen in the daily trauma experience. The solution - excuse me - the solution to managing these patients and addressing these system challenges will require innovative and multidisciplinary approaches that has to be undertaken given the - what we know about the global threat of terrorism, the threat as highlighted at the beginning of this lecture to the United States for terrorism to return to our shores most likely in the form of a conventional terrorist bombing.

Let me just finish by saying and highlighting the Website at the bottom of the page highlights a variety of resources for your continuing information that's updated frequently as new material is produced by the TIIDE partnership and by the CDC.

This lecture itself is available on the CDC Website as well as the American College of Emergency Physicians Website for download. And as always we welcome your questions, comments. Again this is a cooperative agreement - cooperative partnership to develop this information and get it out to the medical community nationally and internationally and then to get your feedback and move it forward.

Thank you very much for your time.

Loretta Jackson-Brown: Thank you Dr. Sasser for providing our COCA audience with such a wealth of information. I know that we are near the top of the hour but I would like to go ahead and open up the lines for a few questions.

Coordinator: Thank you. If you'd like to ask a question now please press star then 1, please record your name; that will be needed so you know when your line is open. So again star then 1. And one moment please. Another moment.

Actually I have no questions coming in at this time.

Scott Sasser: Okay.

Loretta Jackson-Brown: On behalf of COCA I would like to thank everyone for joining us today with a special thank you to our presenter, Dr. Sasser. If you have additional questions for today's presenter please email us at coca@cdc.gov. Put Dr. Sasser in the subject line of your email and we will ensure that your email is forwarded to him for a response.

Again that email address is C-O-C-A-@cdc.gov. The recording of this call and a transcript will be posted to the COCA Website at emergency.cdc.gov/coca within the next few days.

Continuing Education credits are available for this call. Those who participated in today's COCA conference call and would like to receive Continuing Education credits should complete the online evaluation by September 10, 2010 using course code EC1648 and that's E as in Echo, C as in Charlie and the numbers 1648.

For those who will complete the online evaluation between September 11, 2010 and September 20, 2011 use course code WD1648 that is W as in Walter, D as in Delta and the numbers 1648.

All Continuing Education credits and contact hours for COCA conference calls are issued online through TCE Online the CDC Training and Continuing Education Online System at www2a.cdc.gov/T as in Tango, C as in Charlie, E as in Echo - online.

Thank you again for being a part of today's COCA conference call. Have a great day.

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