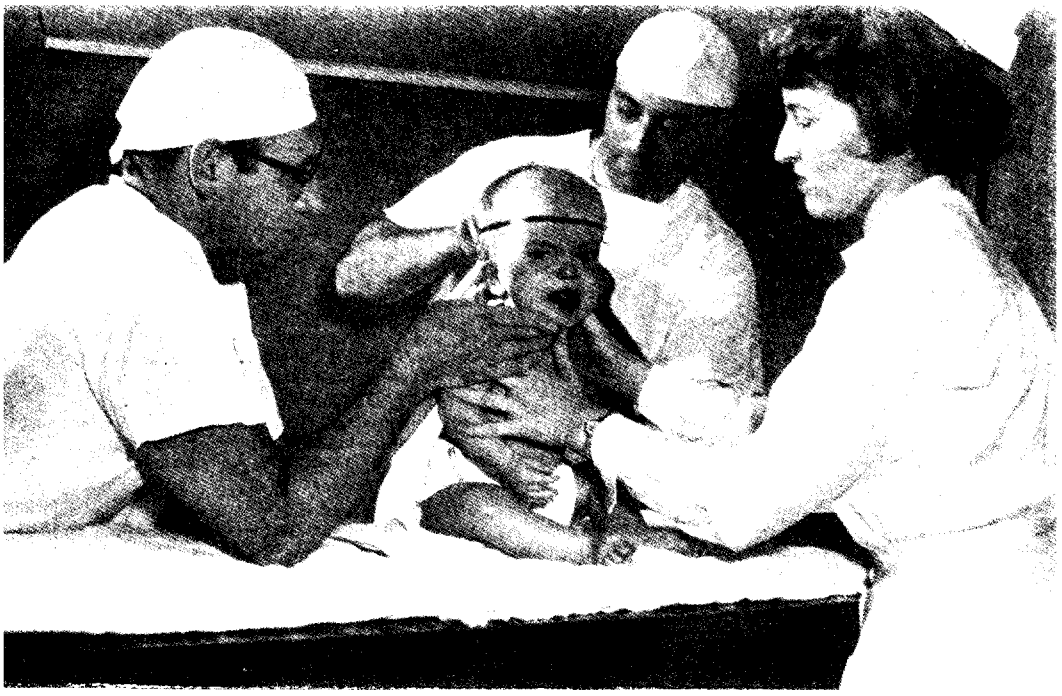


At the Philadelphia Children's Hospital, Dr. Everett Koop and Dr. Eugene Spitz examine Kenneth Waltz. An abnormal accumulation of spinal fluid distorts the heads of victims of "water on the brain."

Surgery Saved the Day

By STEVEN M. SPENCER

The doctors call it hydrocephalus—"water on the brain"—and, in the past, it has killed ninety per cent of its tiny victims before they were two years old. Now a dramatic new surgical idea is making well children of a majority of such cases.

Prompt action by her parents saved Barbara Ann Scheel (center) from death or mental retardation. An operation that will help a three-month-old baby may be useless if put off until he is a year old.

THE clock on the green-tiled wall, registering 8:15 on a humid Philadelphia morning, ticked off the details of a familiar scene, the quiet, systematic bustle that marks the beginning of every operating-room drama. Nurses whisked in and out with carts and trays. An attendant adjusted the big overhead lights. There was the click of instruments as they were unwrapped and laid in precise array on sterile cloths.

But the cast of performers on this day was an unusually large one. Crowded into the fifteen-foot arena were five surgeons, three nurses, an anesthetist and a general-purpose technician—ten persons in all—and each with a specific assigned task. By contrast, the focus of their organized activity was unbelievably small, a baby girl three weeks old and no longer than a doctor's forearm. She lay on a special operating table the size of a footstool, which had been placed on top of the regular table. Already in an anesthetic sleep, the tiny patient, whom we'll call Nancy, had been propped on her right side, with strips of adhesive tape across her left shoulder and thigh to keep her from rolling. The position was important. For this was to be no ordinary operation. The baby was on her side so that two major operations could proceed at one time upon her small body.

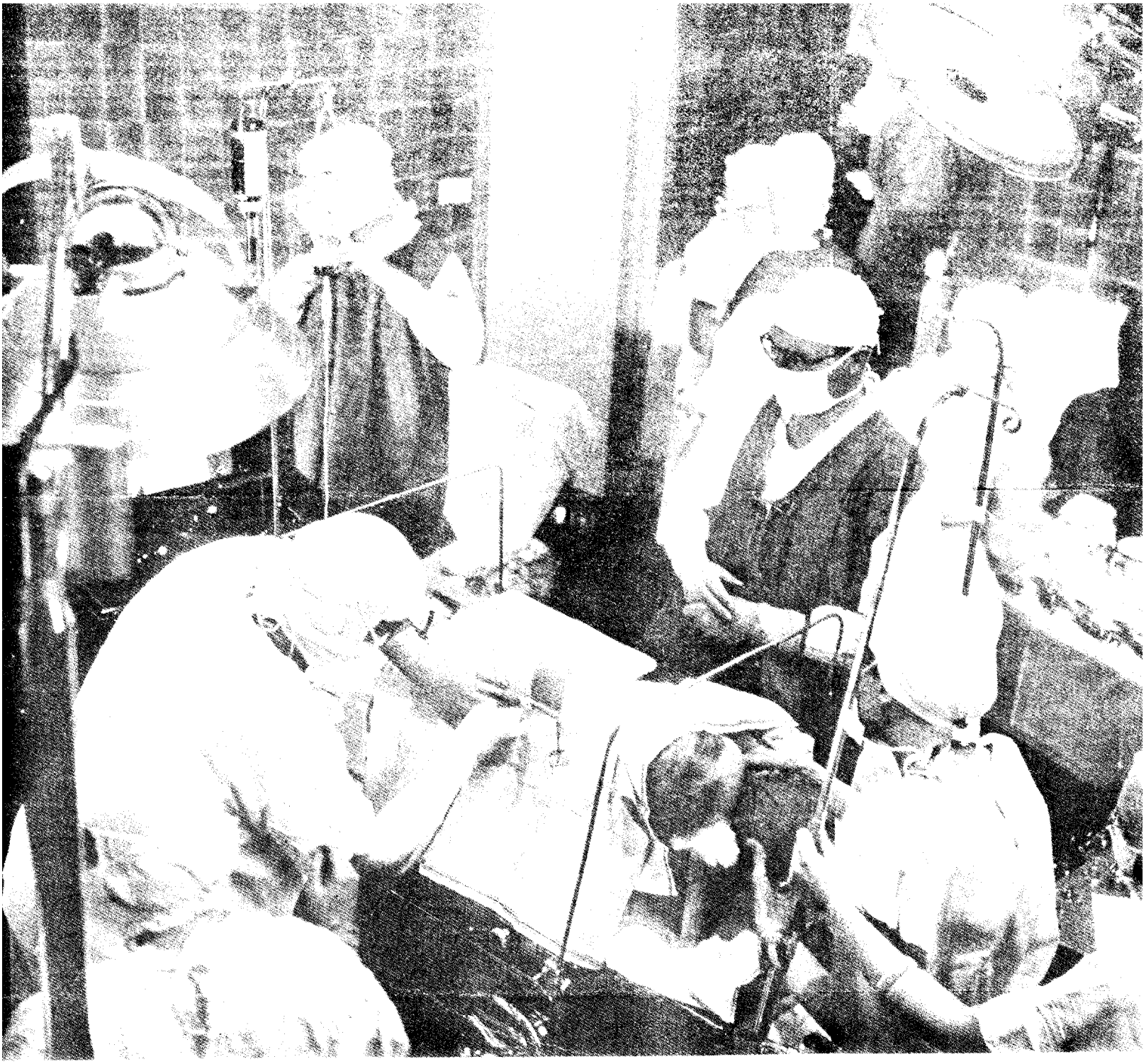
What had brought Nancy here to the Children's Hospital of Philadelphia was one of several inborn defects which, if not corrected, usually result in mental retardation, blindness, crippling or death. Her particular condition had been diagnosed as hydrocephalus, often called "water on the brain." It consists of an abnormal accumulation of spinal fluid, the increased pressure of which squeezes the brain and distorts the head. Fortunately, hydrocephalus is not too common, but neither is it very rare. And to the parents of a baby so afflicted it has nearly always been a heartbreaking tragedy. Until very recently almost 90 per cent of the infants born with hydrocephalus died before they were two years old. Most of those who survived were seriously handicapped, mentally or physically or both. Usually their heads were greatly enlarged.

This small patient on the miniature operating table was, however, to have a much better chance at normal life and health than is indicated by the above statistics. For the two teams of surgeons, one working on the spine and the other on the abdomen, would carry out the two phases of a remarkable new procedure, designed to pipe off the excess spinal fluid and prevent the damaging rise in pressure within the skull and spinal canal.

The operation, developed in its present form by Dr. Eugene B. Spitz, neurosurgeon, and Dr. C. Everett Koop, chief surgeon, both of the Children's Hospital staff, is one of the most effective solutions yet offered for a problem that has challenged the best surgical efforts for more than fifty years. And it is part of a concentrated preventive attack which the Philadelphia Children's Hospital doctors and other teams, notably Dr. Franc D. Ingraham and his associates in Boston, are making against certain anatomical causes of mental retardation.

These causes have long technical names. In addition to hydrocephalus, the main ones under consideration here are subdural hematoma and craniostenosis. They differ from one another in many details. But they have one thing in common. All of them are "brain crowders." They place a constricting barrier, of fluid, membrane or bone, around or against the infant's brain. And as the brain at this age is growing with amazing rapidity—doubling in volume during the first nine months of life and attaining 80 per cent of full adult development by the end of the second year—it is obvious that any physical restraint upon such growth will have serious consequences, in some cases squeezing the brain into a layer of tissue only a fraction of an inch in thickness.

From this it follows that the restraining shackles must be cut away early in life if the brain is to have adequate room in which to grow. Neurosurgery for the affected infants can almost be regarded, therefore, as an emergency procedure. An operation that will help a baby at three weeks or three months of age may be useless if put off until he is a year or a year and a half old.



Dr. Spitz and Dr. Koop operate on Kenneth Waltz. Surgery relieves the deadly pressure on the baby's brain by piping off excess spinal fluid.

In Nancy's case the first signs of trouble had been feeding difficulties and a fever when she was only five days old. Her doctor at the Northern New Jersey hospital where she was born immediately began a search for the cause. First he found blood in the spinal fluid. Then he noticed the baby's head was beginning to enlarge, an observation he confirmed with a tape measure. Finally, when a needle puncture revealed intracranial pressure and a thinning of the brain, the doctor suspected hydrocephalus and sent Nancy to Philadelphia.

Following the operation, which involved inserting a plastic drainage tube between the spinal canal and the abdominal cavity, she began almost at once to improve. The "soft spot," or fontanel, where the bones of the forehead are joined, had previously been taut and bulging. As soon as drainage was established it flattened out. The head lost its swollen appearance and slowed down to a normal rate of growth, so that over a period of months the rest of Nancy's body was able to catch up with it and eliminate any disproportion in size. She began to eat normally, and to laugh and smile like any well and happy baby. Her mental development, by all tests, is proceeding at a good pace, showing that the operation was done in time to prevent any serious brain damage.

The urgent necessity for prompt action is a point which all physicians working on this problem feel has not been fully understood or strongly enough emphasized. Errors of two types have been made, both resulting in tragic loss of precious time. Some parents, although recognizing an abnormality, have done nothing about it because they have been advised the situation was hopeless and nothing could be done. Others have been told that the odd shape of the baby's head or some slowness in sitting up, walking or talking was "nothing to worry about" and that the child would "grow out of it."

PHOTOGRAPHY BY GUS PASQUARELLA

It is a doctor's business to worry about these things, asserts Doctor Spitz; it takes only a few minutes for a physician to determine, by feeling the bones of a baby's head, whether there is really anything to worry about and whether a more detailed and extensive examination is called for. It is also a mistake to assume that convulsions or other neurological disturbances are simply due to psychological factors or to a fever. Convulsions aren't normal, whether the child has a fever or not, and they should always be investigated to determine the underlying cause.

Appreciation of the need for earlier recognition and treatment of neurological conditions in children is what prompted the heads of several departments at the University of Pennsylvania School of Medicine—Dr. I. S. Ravdin, of surgery; Dr. Francis C. Grant, of neurosurgery;

and Dr. Joseph Stokes, Jr., of pediatrics—to set up the special pediatric-neurosurgery unit at the Children's Hospital. Doctor Spitz, assistant professor of neurological surgery, was placed in charge, and Doctor Koop, chief surgeon at the hospital and associate professor of pediatric surgery, works closely with him. Through coordinated study of the large number of cases brought to this center it is also hoped to accumulate information that may lead to improved methods of treatment.

Of course, it would be misleading to suggest that operations will prevent more than a fraction of the cases of mental deficiency. The factors responsible for a large proportion of cases have not even been identified and could not therefore be expected to yield to surgery. But "brain-crowding" conditions of the type we are discussing here occur so often that it is possible to save thousands of lives and minds through alertness and prompt follow-through on the part of parents and physicians.

One such life was that of Betty, a chubby, bright-eyed little girl who, at the time we saw her, was nine months old. What had rescued her from death or mental retardation was her parents' refusal to accept a discouraging medical prognosis as the final word.

The third child in the family, Betty had had a normal birth and had seemed all right in every way until she was three weeks old.

"Then one day, when I cuddled the baby against my cheek," her mother said, "I noticed her head was unusually soft, high up on her forehead. Of course that's where all babies have a soft spot, but Betty's head was softer than I thought it should have been."

The mother consulted a pediatrician, who looked the child over carefully, expressed concern about the condition, and referred her to a brain specialist in a small Eastern city. The brain specialist kept the baby in a hospital for five days for a series of examinations, and during this period the mother and father were sleepless with worry over the outcome of the tests.

"We tried and tried to get information about what was going on and what they thought was wrong with the baby," the mother related, "but we could never get hold of the doctor. I guess he just hated to give us the bad news. Finally I was notified to come and get the baby and take her home, but I still wasn't told what was to be done for her. Then the brain specialist sent his assistant to tell us that Betty had hydrocephalus. He explained what it was and said there was no effective treatment for it.

"We asked if there wasn't something that could be done for her, and the doctor said, 'I'm afraid not. You could take her all over the world and you wouldn't find anyone who could help your daughter.'"

This was a bitter blow, and the parents were heartsick. By now the infant's head was beginning to look abnormally large. "It was so noticeable that I was sensitive about it," the mother said, "and I would never take the baby's bonnet off when she was out in her carriage. But we did feel that surely, somewhere, something might be done for her."

Betty's parents have always believed in the power of prayer. Appropriately, it was the pastor of their church who told them about the operations being performed at Children's Hospital, of Philadelphia, to help infants with this distressing condition. They took the baby to the surgeons there, who performed the operation when she was eight weeks old. Betty's improvement since then has been remarkable. She sat up alone when she was eight months old and was able to stand on her feet when given support. Although her head is slightly wider and higher at the back than normal, there is every indication that she will develop properly in every other respect.

Sometimes it is not easy to diagnose hydrocephalus in its very early stages, but there may be other difficulties that cause the doctors to keep an eye on the child. This was the story in the case of Billy M., who was born early in 1951, after a long and difficult labor, and who had so much trouble breathing that he was placed in an incubator and given oxygen. On the second day he was transferred to the Children's Hospital, where doctors found that in addition to his respiratory troubles he was slightly spastic in his arms and legs. And there were certain abnormal reflexes. However, he improved in a few days and was sent home, with a request that the family doctor keep a close watch on him and bring him back to the hospital in three months, or sooner if his condition changed.

It was soon noticed that Billy's head was becoming larger than normal. His mother recalls that caps and bonnets didn't fit him.

"But you know how babies' heads often are," she said. "Lots of babies seem to have large heads at first. I didn't think too much about it."

Her doctor did, however. He also noticed that Billy's upper eyelids were stretched in a peculiar manner, typical of hydrocephalus. He lost no time in getting Billy back to Children's Hospital, where the diagnosis was quickly made, and the situation and the operative procedure carefully explained to the parents. They were told that without an operation the baby's chances of life were not good, and that if he did live there was a strong likelihood that he would be impaired mentally.

"There was never any hesitation in our minds about having the operation," Billy's mother said.

"And just look at him now," his father added.

No parents were ever prouder. And it would be hard to find a cuter two-and-a-half-year-old than Billy. He is a completely charming little fellow, with blue eyes, an engaging smile and a bright, alert manner. The perfect host, he dashed into the bedroom to get his toy dog, which he pulled out through the slats of his crib and brought to show the visitors. He gave the right answers to the standard questions about what the dog and cat and cow say, and he made an amusingly realistic "eek" for the bird. He had recently visited the Philadelphia Zoo, where he said he had seen "tigers, wots of tigers, and wions—and how about the hippopotamus?" His father chuckled. "He always says it that way—'How about the hippopotamus?'"

Billy could count up to six and could pick out and identify the pennies, quarters, nickels and dimes in a handful of change—and without asking for any. In brief, Billy showed that he is a perfectly normal little boy, better behaved than many. No one would suspect that his brain had ever been threatened by a treacherous rise of spinal-fluid pressure. All Billy knows about "my opewation" is the incisions in his abdomen and back.

To understand how operations in the vicinity of the waistline can reduce brain-squeezing pressure in the head it is necessary to consider a few points of anatomy, specifically the distribution of the spinal fluid. This clear, watery liquid occupies the ventricles, or hollow spaces, inside the brain. It also bathes the outside surface of the brain and it surrounds the spinal cord within its bony vertebral canal. In the normal individual and in those with hydrocephalus of the type with which we are concerned, these chambers and channels connect with one another to form a continuous but closed system. Therefore, withdrawing fluid from a lower level of the spine will decrease the pressure of the whole system, including the brain.

The increased pressure in hydrocephalus is usually brought about by an excess of spinal fluid. Whether the excess in turn is due to an overproduction of fluid, an underabsorption of it, or both, is not always clear. In some cases of hydrocephalus the situation is complicated by—or even caused by—blockage somewhere in the cerebro-spinal-fluid system, and in most of these cases tapping the spine would not lower pressure in the brain. To obtain relief through the procedure we are discussing here it is necessary that the patient's hydrocephalus be of the so-called communicating type, in which there is free flow of fluid between the brain ventricles and the spinal canal. Other techniques may eventually be worked out for the obstructive cases, but to date only communicating hydrocephalus has been corrected by the new operation. Between 1948 and 1952 a little less than half of the hydrocephalus patients coming to Children's Hospital—87 out of 184—had the communicating type, but of the first fourteen seen in 1953, all but two were of this variety.

Most of the surgical efforts in hydrocephalus have been aimed at providing an overflow through which to drain off the excess spinal fluid and keep the pressure down. Various ways of doing this have been attempted over the course of the past half century, but most of them met with failure or indifferent success. Dr. Harvey Cushing, the famous brain surgeon, placed a silver tube between the spinal canal and the abdominal cavity in fifteen patients. This was in the early 1900's, and though his results were promising, they were not consistently good and the method was discontinued. A German surgeon, Dr. B. Heile, developed several techniques, one of which, in 1925, involved removing a kidney and hooking up a rubber tube from the spinal canal to the kidney end of the ureter, thus draining off the excess spinal fluid through the urinary tract.

In 1948 Doctor Ingraham and his associates, and Doctor Spitz, independently, tried this procedure, with newer plastic tubing; and a number of patients so operated on are still doing well. This method may still be used under certain circumstances, but it has had two drawbacks. First, there was the danger of a urinary-tract infection spreading upward to the membranes around the spinal cord or brain and producing a meningitis. Second, because a kidney had been removed and a direct hookup made between the spinal fluid channels and the bladder, a great deal of body salt was lost which would normally have been conserved by that kidney. It became difficult to maintain adequate salt levels in these patients.

Doctor Spitz and Doctor Koop therefore returned to the older principle of draining the spinal fluid into the abdominal cavity, where it would be absorbed into the general circulation of blood and lymph. They used a plastic tubing for this purpose, as we have already mentioned, inserting one end into a small incision in the spinal canal and placing the other end in the abdominal area—or peritoneal space, to use a more specific term.

But in several cases the tubing became plugged by the omentum, a fatty tissue which hangs between the loops of large intestine. That the omentum should get in the way was only natural. For, as Doctor Koop remarked, "Older surgeons used to call the omentum the policeman of the belly because of the way it would wrap itself around a foreign body or an infected area and wall it off." In the hydrocephalus cases, however, it was a nuisance and a serious obstacle to the success of the operation.

Now the best way to combat a nuisance that has no compensating virtues is to remove it. That is precisely what Doctor Koop decided to do with the troublesome omentum. And while he was working out that modification of the hydrocephalus operation, Doctor Spitz was designing a little plastic tip, or nozzle, further to improve the drainage from the end of the flexible plastic tubing.

Simple as these innovations sound, to employ them successfully against the brain-destroying pressure of hydrocephalus requires much careful preliminary study of the patient, a high degree of surgical judgment and skill, and smooth teamwork on the part of every one of those ten people in the operating room—the surgeons, anesthesiologists, nurses and technicians. The surgeons feel that credit for an important assist should also go to the chemical companies which developed the nonirritating plastic tubing and which co-operated with the doctors in finding the proper type and size for the delicate job in hand.

In the preoperative examination the doctor pays close attention to the baby's head, noting whether or not the fontanels—soft spots at the junctions of the skull segments—are bulging. He asks the mother about the child's general physical development and its behavior, and makes his own observations concerning these matters. He then inserts a needle through one of the soft parts of the skull to determine the thickness of the brain and thus obtain an indication of how much the fluid pressure has already compressed the brain tissue. Finally, a dye is injected into one of the ventricles of the brain and a few minutes later a small amount of fluid is removed through a spinal puncture. If dye appears in the sample of spinal fluid, this is evidence that there is free communication between the brain and the spinal canal, and that the baby has a good chance of being helped by surgery, other factors being favorable.

For a close-up look at what takes place during the operation itself, let's go back to the scene with which this article opened, the green-tiled operating room in Philadelphia Children's Hospital, where the three-week-old baby, Nancy, was the patient. We were sitting in the small gallery as Nancy was carried into the room in the arms of an attendant. A nurse was holding the bottles of blood and glucose which had already been connected by plastic transfusion tubing to veins in the baby's foot. She was placed on her

side, as we have said, to permit both teams of surgeons to operate simultaneously. A surgical assistant now swabs the back and belly with bright orange antiseptic solution. As the nurses begin to drape sheets over the baby, Doctor Koop, helping in this procedure, feels the fabric between thumb and finger and shakes his head. "This one is too hot and heavy," he says, throwing it aside; and to the visitor in the operating-room gallery, "You don't realize how much these things weigh on a little body."

A flat plate in the shape of a pancake turner with a wire attached is placed between the baby's knees. This is one terminal of the electric-cautery apparatus to be used in sealing off small blood vessels. A copper chain is looped over the infant's wrist as an electrical ground to guard against sparks that might ignite anesthetic gases.

Meanwhile the anesthesiologist, Dr. Margery Deming, has inserted a tube into the child's throat and windpipe, and through this the anesthetic is now being administered. For a few moments the baby's skin becomes bluish and Doctor Deming pumps the rubber anesthetic bag to assist the breathing.

"When a child takes anesthesia poorly," Doctor Spitz explains, "it is often a sign that some brain damage has already been produced by the hydrocephalus. We hope there hasn't been too much and that we're not too late with the operation."

Now the skin is a healthy pink again, Doctor Deming nods reassuringly to the surgeons, and they begin. Doctor Spitz, having first felt the spine with his fingers and marked with purple dye the site of the proposed incision, makes a two-inch cut. This exposes the ridge of the spine, and with a bone nipper he removes parts of two vertebrae in the lumbar, or "small-of-the-back," region. He is now close to the tough membrane that forms the wall of the spinal canal. Through this membrane he makes a tiny nick and immediately inserts one end of the special plastic tubing, anchoring it in place with two stitches taken into but not through the thickness of the tubing.

Meanwhile Doctor Koop, on the other side of the operating table, has made a two-inch incision just above the infant's navel, and through it he has gently pulled the colon, or large intestine. Clinging to the colon and lying between it and the stomach is the omentum. At this age it contains very little fat. It is just a membrane, but it is as stringy as wet cheesecloth and it is easy to see how it could plug the end of a tube lying near it. The surgeon carefully strips the omentum away from the intestinal wall with the blunt end of an instrument, sometimes the handle of a scalpel. This blunt dissection technique is used, where possible, to avoid bleeding.

"The major blood vessels enter the omentum from the stomach," Doctor Koop says, "and we'll get those by ligation." This means first clamping each vein or artery, then cutting, and finally tying off with thread. It is clamp, cut, clamp, cut, for eight or ten vessels. "Sometimes as many as twenty vessels must be tied," the surgeon remarks, "and you have to do them all carefully, because you don't want any of them to leak blood into the peritoneal space. It would promote adhesions. In fact, we do this omentum removal outside of the abdominal cavity so that any blood escaping during surgery will fall outside and not in."

After he has finished this part of the operation and has tucked the loops of colon back into place, Doctor Koop tunnels through the side of the infant's body with a long, blunt-nosed clamp, passing it between layers of muscle and fat, to grasp the plastic drainage tube. Doctor Spitz has already connected one end of the tube to the spinal canal. Doctor Koop draws the free end back through to the front of the body, fastens the special plastic screw tip onto the end and drops it into the abdominal cavity. Before closing up the two incisions the surgeons irrigate the tissues with fluid containing the enzymes, streptokinase and streptodornase, which discourage clots and adhesions. They also squirt some of the fluid directly into the plastic tubing, having found that otherwise a long clot may form in the tube itself and defeat the very purpose of the operation.

"This is one of the places in surgery where small details of technique really make a tremendous difference in the final result," one of the doctors says as he completes the enzyme irrigation.

During the past three and a half years at Children's Hospital forty-five babies with congenital communicating hydrocephalus have had the spine-to-abdomen drainage tube installed in the manner just described. Thirty-eight have survived, with apparent relief of the condition, and the surgeons at the hospital believe they can continue to expect success in approximately 80 per cent of the patients with this type of abnormality. In a number of other babies examined, the hydrocephalus had already caused such serious brain damage that surgery could not have helped and was therefore not attempted.

Even today, however, subdural hematomas may at first be mistaken for something else. There was the child of a bomber pilot and his wife, born in the hospital at an air base. The baby looked normal, but something was obviously wrong, for he screamed almost twenty-four hours a day. The doctors, not used to seeing such cases in an Army hospital, told the mother it was "only colic," and suggested she bring the baby back every week or two. When, at the age of three months, the baby was still extremely fretful, could take only a little food without crying and seemed a little dull, his mother took him back home to Pennsylvania, where her pediatrician referred her to the Children's Hospital, of Philadelphia. There the condition was found to be a hematoma, and two operations were performed during the baby's fourth month, in September, 1952.

There was little change in the baby's behavior until Christmas. Then the effects of the operation suddenly began to be apparent. "He blossomed out wonderfully," his mother related, "and on New Year's Day he pulled himself up in his play pen for the first time. When my husband, who had gone to Korea in November, came home in March, the baby's improvement was so great he could hardly believe it." On the day I saw the child, then thirteen months old, he was as bright as a new toy, with sparkling brown eyes and plenty of well-directed energy. He was scrambling about the doctor's waiting room, toddling a few steps and then dropping to hands and knees for faster locomotion, as many babies do while learning to walk. Although he had been definitely retarded before the operation, the physicians were now certain that he will be mentally normal.

In this condition, as in hydrocephalus, the shape of the baby's head is frequently what first causes parents or friends to become concerned. A New Jersey infant was brought to the hospital at the suggestion of a neighbor who had noticed that the back of his head was quite flat. The neighbor had faced a similar problem with her own child and was therefore alert to such signs. The baby's own parents, on the other hand, had assumed the flatness was merely the result of lying so much on his back. So it was. But the Children's Hospital doctors soon found that the reason he lay on his back was that he was too dull and lethargic to roll over, and the lethargy was in turn due to brain pressure from a hematoma. He was operated upon when nine months old; and today, at three and a half, with the threat of mental retardation removed, he is talking, walking, running and riding a tricycle like any other normal child of his age. He is neither quiet nor dull.

This experience illustrates how easy it is for a parent to misinterpret an infant's behavior. It is not uncommon for a mother, upon learning that her child has a neurological condition, to protest that it can't be so because, "he's such a good baby, doctor; he never cries." The too-good baby that never cries may, like the one who cries too much, have something wrong with him.

The surgery for releasing the brain from the bonds of a subdural hematoma is carried out in the skull itself, which is first pierced with a needle to confirm the diagnosis. Preliminary drainage is then established via half-inch-diameter burr holes drilled with a stainless-steel brace-and-bit.

"You can't use much pressure on an infant's skull," Doctor Spitz remarks as he completes the boring of a burr hole, "or it will break like an eggshell."

Draining the hematoma may be all that is required. Often, however, the baby must return to the operating room, after an interval of observation, for a more extensive operation. At that time a segment of the skull is temporarily lifted off and the tough membranous hematoma sac is cut away. For this membrane alone, even when empty, can bind and hamper the development of the underlying brain tissue. The sac sometimes extends over two thirds of one hemisphere of the brain, and in many cases it partially overlies both the right and left hemispheres.

Of all the things that can interfere with the development of a baby's brain few are as strange and tragic as the premature closing of the seams of his skull, a condition known as craniostenosis. It may occur before birth and in some instances it is probably hereditary. The brain, striving to grow at a normal rate and finding certain of the cranial suture lines, or "expansion joints," firmly closed by bony fusion, pushes out in other areas, where the bone is softer. This produces a variety of bizarre skull formations, one of the commonest of which is the one called a "tower skull," with a high, flattened forehead. The eyes bulge out. Pressure on the optic nerve often causes blindness. Parts of the brain atrophy under the excessive pressure, with resulting mental retardation. The high intracranial pressure may also cause headache, vomiting and convulsive seizures.

Craniostenosis was recognized in antiquity and was mentioned by Homer and Hippocrates. Not until recent years, however, have neurosurgeons achieved consistent success in treating it. A good operative procedure was worked out in the 1890's by two surgeons named Lannelongue and Lane, but, unfortunately, it fell into disrepute because of poor results obtained by other doctors who, through wrong diagnosis, employed the operation in cases of microcephalic idiocy. In that condition the brain fails to grow, no matter how much room it has, and surgical easing of the skull bones could not be expected to improve mental development. Failure to distinguish between microcephaly, which was hopeless, and true craniostenosis, which could have been helped, thus led to the temporary abandonment of the operation.

A number of neurosurgeons have been responsible for its revival within the last two or three decades, and for improvements which have made it more effective in saving the vision and mentality of those unfortunate youngsters born with their head bones prematurely fused. The procedure is perhaps the most drastic of all skull operations performed on children. The surgeon makes several cuts clear through the skull alongside the normal suture lines and then sews strips of polyethylene-plastic film over the cut edges to delay their reunion. The bone segments eventually grow together again, leaving the plastic imbedded, but in the meantime the brain has been given a chance to reach its normal size. In some cases the cranial distortion is so extreme that it is necessary to cut an area of the skull into many small squares and remold them into a more normal contour. This technique, because of the morsels of bone involved, is called morcellation.

The amount of surgery which these small infants can tolerate never fails to astonish those not familiar with the truly phenomenal advances which have been made in this area of children's medicine. The youngest craniostenosis patient at Children's Hospital was only eighteen days old when he was operated upon. Another child, born with three deformities—craniostenosis, a pushed-in, or "funnel," chest, and a "blue-baby" heart—had all three surgically corrected during one hospitalization, when he was only two years old. An unusual aspect of his case was that even though the skull bones had fused together prematurely, they had been so poorly nourished because of the heart condition that they remained thin and allowed the head to expand with the growth of the brain. At the age of two, however, the skull had begun to tighten up and the resulting pressure was already affecting the boy's vision. The operation was just in time to restore his sight and save his brain.

It should be emphasized again that success can be achieved in all of these cases only if the affected infants are brought to the neurosurgeon as soon as an abnormality is suspected. A second factor important in the saving of these threatened lives and minds is the presence of neurosurgical teams trained in children's problems, teams that include not only surgeons but anesthetists and nurses. Unusually vigilant nursing is required by infants with brain troubles, for, as the physicians point out, "They can go from good to bad and bad to worse much faster than youngsters with other types of illness." Through the training efforts of such centers as the unit at the Children's Hospital, surgical groups capable of carrying out these brain-saving operations should soon be within reach of children everywhere.