SHOCK TRAUMA!

TEXT BY JOANN RODGERS PHOTOGRAPHY BY ERIC POGGENPOHL

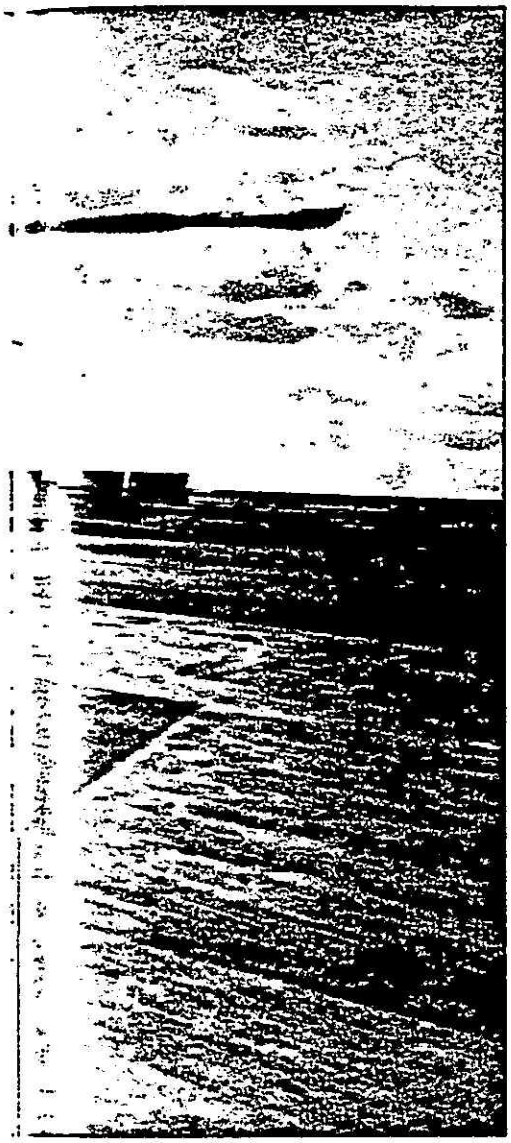
Why is this emergency center called the world's best? And, since its lifesaving surgical techniques are being widely adopted, why is it still so controversial?

The emergency broadcast system announces that a head injury is on its way. The waiting team of nurses and doctors races to the helipad on a nearby garage roof. Within minutes, the 20-year-old motorcycle-accident victim is in the admitting area, crowded as it is most weekends when cars, speed, cycles, alcohol and youth all collide.

There is no time to waste. Seven medics begin applying long-memorized procedures. Within minutes, the patient is connected to six IV (intravenous) lines, drugs have been administered, an endotrachial tube has been inserted into his throat. A cardiograph and other electronic monitoring devices continuously measure his vital signs; blood samples and X-rays are taken, and the lab data is teleprinted to the team.

Several hours later, the youth, now stabilized, is moved into an operating room for surgery that includes a delicate brain operation that will keep him a functioning human being. Five surgeons and an anesthesiologist work on different parts of his body simultaneously.

This trauma victim will make it. He is lucky. As a result of his critical, near-death condition, he has been taken to



(Left) A policeman and nurse rush an accident victim from a rooftop helipad to an ambulance that will speedily transport him to the Shock Trauma center. (Right) To revive a man whose heart just stopped, a nurse straddles the body and pumps the chest.

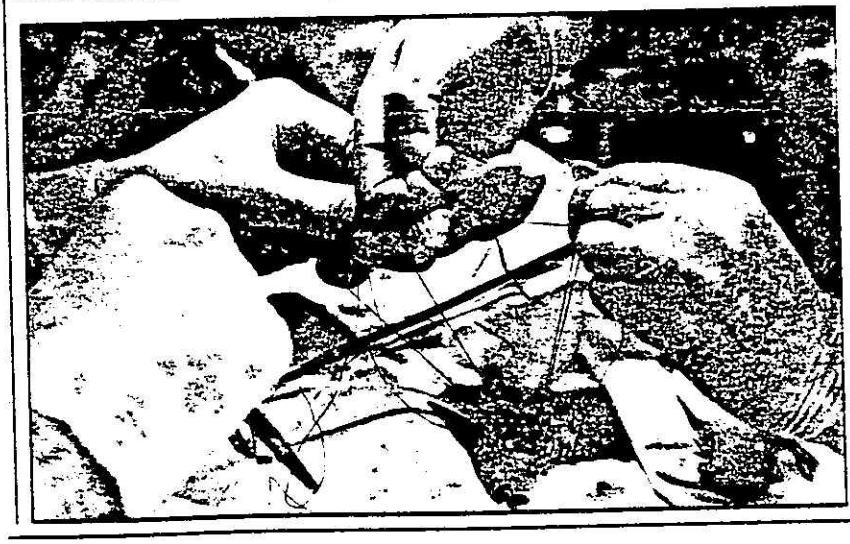
Shock Trauma, not a condition but what is considered the best emergency room in the world, at the Maryland Institute for Emergency Medical Services Systems (MIEMSS) in downtown Baltimore. By applying a scientific approach, this national model for critical care is doing something unique in emergency medicine and doing it best. With a combination of a MASH-style field unit and a computerized control center, the $17-million-a-year Shock Trauma center treats the 1,200 *worst* accident victims in Maryland each year and consistently saves four out of five of them. Forty percent of those discharged would have been pronounced dead on arrival in most *good* hospitals. Since 1968, Shock Trauma has cut the death rate from severe head injuries from 80 percent to 22 percent. Overall mortality in the unit is a fifth of that in the best intensive care units in the nation. In this institute, complications of trauma that still kill thousands—such as shock lung and ruptured aortas—have been virtually eliminated as causes of death. Only 4 percent of the trauma victims die in the operating room.

Trauma-related deaths are a serious health threat, an epidemic among the young. For people between the ages of 1 and 39, accidental injury is the leading cause of death. Every year, more than 100,000 Americans die of trauma received in crashes, drownings, fires, poisonings and falls. Another 400,000 are permanently disabled.

Victims of auto accidents, gunshot and knife wounds, suicide attempts, scuba-diving accidents and industrial and farm accidents are all candidates for Shock Trauma care. Whatever the cause of their injuries, these are patients who hang onto life by a thread. They may have lockjaw, gas gangrene oozing from wounds or spinal-cord injuries and broken and protruding bones. They are patients with raging systemic infections and carbon monoxide poisoning. Half are under the influence of alcohol or some other drug. They are overdosed, half drowned or burned. Their major blood vessels may be ruptured or sliced. They need everything fast.

Usually they are single, male, white,

(Above) The moment someone is admitted, a team of doctors and nurses springs into action right in the receiving area. Already, a doctor is making an incision to reach the heart, while others check vital signs. (Below) For speed, two doctors sew up a wound.



(Below) A nurse jots down data about a patient directly on her scrubs so she has ready reference during the operation.

young—16 to 25—and healthy. Typically, they are students, blue-collar workers or unemployed. "Half a million out of eighty million accident cases a year need Shock Trauma's services," says one veteran traumatologist. "And we aim to get it to them."

BENEFICIARIES OF RESEARCH

The crushed bodies that come through Shock Trauma's doors never see how the system works nor what went into developing it. They simply live, beneficiaries of applied research on trauma at every level: the whole body, the organs, the cells, the molecules within the cells.

"We have put science into the art of delivering care to the most neglected patients in our health-care system," says Dr. R Adams Cowley, the jowly, feisty heart surgeon who pioneered and still directs MIEMSS. "Dr. Shock Trauma" to a growing band of grateful families and guru to a generation of emergency-medicine specialists, Cowley is sharply critical of conventional approaches to trauma. "Severe trauma is an unchecked killer that cannot be controlled in traditional emergency rooms," he maintains.

A child facing a tonsillectomy, Cowley notes, generally gets more measured, prepared medical attention than the most critically ill patient to come to the hospital—the trauma victim. "The nonsystem we have of treating these injury patients is grossly inadequate," Cowley complains.

In the typical nonsystem approach to emergency medicine, the victim lies mangled in the road while someone hunts for a phone booth. The ambulance takes 15 minutes to find the crash scene and then rushes him to the nearest hospital, which is ready or not. The nurse on duty, amid a typical crowd of drunks and crying kids, looks at the carnage coming off the ambulance and pages the intern. (Senior staff doctors don't usually work at peak accident times: nights, weekends, summer vacations, holidays.) The intern orders a lot of tests and X-rays from a lab with a skeleton crew. It will take the orthopedic surgeon half an hour to get to the hospital, and the neurosurgeon is operating in another hospital 30 miles away. In an hour, the patient has bled to death, which may be just as well. Had he lived, he would have been a crippled vegetable.

Taking their cue from battlefield medicine in Korea and Vietnam, Cowley and Shock Trauma's other developers found that when people need sophisticated care for multiple trauma, the chances of their getting it range from slim to none unless there is a *standardized, mechanized, organized,* on-line system in place at all times, supported by tested protocols, endless practice, teamwork, a fetish for speed and aggressive treatment.

"At Shock Trauma, we treat accident victims as if they had standing appointments," Cowley explains. "No one waits for anything."

In fact, they can't wait. The reason is shock, the true villain in the trauma story. Marked by a slowdown in circulation of the blood through vital tissues and organs, shock, according to Cowley, is a "momentary pause in the act of death."

When he analyzed shock in detail, a task that has consumed his professional career, Cowley found that during this state the body engages in a fierce struggle for survival at the cellular level, where shock upsets the delicate balance of the defense network that cells need to destroy infection-causing bacteria. Shock also destroys the fragile checks and balances of the blood's chemistry.

If people stay in shock too long, they'll die, Cowley learned, even if every medical and surgical procedure is successful. And "too long" is a very short time.

"They may die in five minutes or a week later. But they will die. At most, there are only sixty minutes, one golden hour, to get inside, stop bleeding, restore normal blood pressure and oxygenation of the tissues and begin to systematically reverse the process and damage of shock. If I can get to you within that time, I can probably save you, no matter how serious your injuries."

Speed, then, is of the essence. When, in a typical case, one man with a stab wound in his chest was brought to Shock Trauma, he was immediately evaluated, had lines for fluids placed in his veins and arteries, had heart function checked, had a chest tube and a urinary catheter inserted, had his blood typed and crossmatched for seven units of blood and had four of them in him by the time he came through the operating room door—all within 40 minutes of his arrival.

In one nonstop six-and-a-half-hour operation, another accident victim had his spleen removed, a lacerated liver repaired, a rod inserted into his fractured thighbone, his tibia reduced, a broken kneecap repaired and a mangled right ear restored by plastic surgery.

Everything happens so fast in this unit that procedures might seem less rehearsed than they are. "We can't do our jobs without putting numbers and protocols in place of hunches and personal experiences," Cowley explains. "We have to measure, profile and set down step-by-step procedures to deal with the imperatives of trauma in order of priority."

These protocols, known as "Cowley's Cookbook," are the very foundation of Shock Trauma's precision care. For more than 10 years, Cowley and MIEMSS collected hundreds of bits of data on each of thousands of patients, sifted them for patterns of what worked best and uncov-

Joann Rodgers, Hearst science writer, has spent hundreds of hours observing procedures at the Shock Trauma center in Baltimore.

THE DEATH LAB

They called it the "death lab." Patients were brought there only when all hope was gone. In this room at the University of Maryland Hospital, heart surgeon R Adams Cowley and his team of traumatologists learned what minute, insidious changes occurred in a human body dying of shock.

In the death lab, doctors and nurses clustered around the single dying patient, recording every available vital sign and metabolic variable.

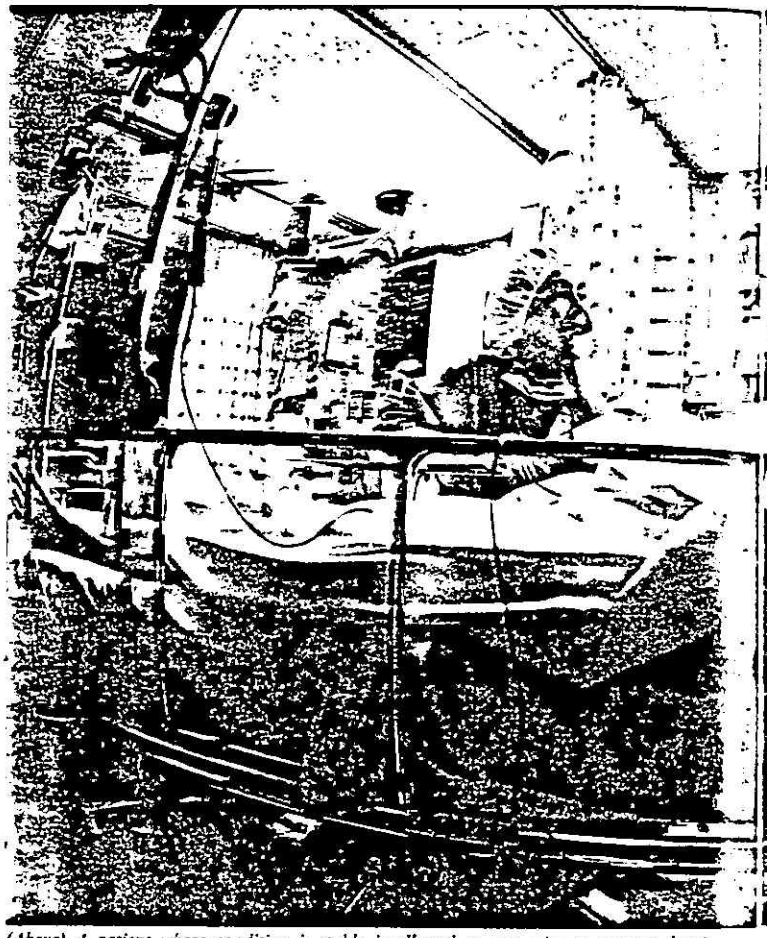
Once each hour a nurse drew a sample of blood, and a laboratory attendant spent what remained of the hour taking that sample apart, molecule by molecule. Hour by hour, Cowley and his team knew the abundance of red blood cells, the availability of oxygen-carrying hemoglobin, the breakdown rate of the liver, the contents of the urine and the cellular balance between oxygen and waste carbon dioxide.

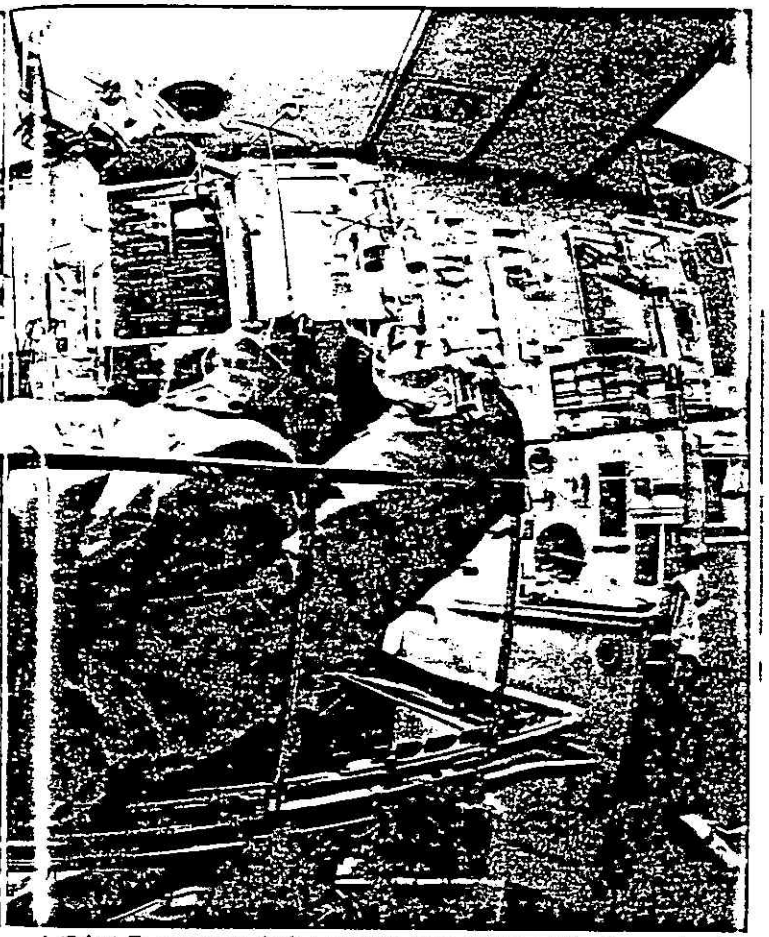
As they watched, fluctuations started to appear. The approach of death was signaled by a rise in blood pressure and then a fall, a rise and a fall. Similarly, protein levels, hormone levels and enzyme levels all began to oscillate. The metabolism seemed to be shaking itself apart; the fluctuations grew wilder and wilder. Eventually the whole colony of human cells got so out of step that chaos ruled. The heart stopped and the patient died.

Other doctors had made all the same measurements before, but they'd made them once a day, not hourly. The wild oscillations were never revealed. Once Cowley and his team discovered them, they tried to treat them and often the patient recovered.

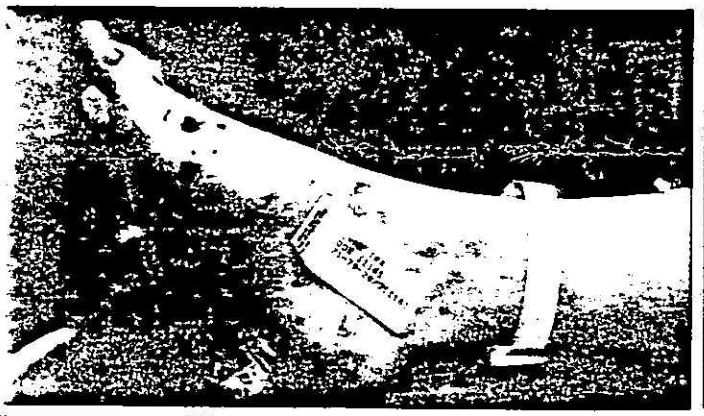
From the beginning, half the people brought to the death lab to die didn't.

SHOCK TRAUM





(Above) A patient whose condition is stable is allowed to rest prior to surgery, but he is monitored around the clock by nurses and a battery of sophisticated instruments. Before X-rays are completed, a cervical collar cradles the victim's neck, which may be broken. (Below) Each patient is tagged with his name—Doe, if unknown—and a number.



(Below) To massage or shock an arrested heart, doctors quickly slit open the chest, insert clamps and crack the ribs. Sensors (disks) monitor heartbeat and respiration.

ered treasures of emergency care. They have established a road map for trauma therapy, a script with no room for ad-libs, a guide for treatment so precise that it can be exported anywhere. Every protocol has been tested, retested and published.

Cowley himself takes trauma death as a personal affront. For those who still call his methods cold and complain that they interfere with the private practice of medicine and established ways of doing things, he reserves language that would wilt the starch in a nurse's cap. His temper is legendary, his patience measurable in microseconds and his victories considerable in the 25-year battle he has fought to win recognition for Shock Trauma's unique brand of medicine.

EXPERIMENTAL TUG-OF-WAR

With an experimental unit in 1961, Cowley began to apply to humans what he'd learned from his work with animals. For years his 12-bed unit at the University of Maryland limped along as an institutional stepchild, the object of scorn and jealousy among university and other hospitals' doctors. He had to fight for his system, sometimes engaging in a literal tug-of-war for incoming injured patients. Either outside doctors didn't want to give up their patients, or they wanted to come into the unit and deal with trauma their own way. "But if we were going to *prove* that our systems worked and establish optimal care, we had to stick to our methods the way any good researcher sticks to his. No exceptions. That upset a lot of people," Cowley recalls.

Then in 1971 a key political figure in Maryland, a close personal friend of then-governor Marvin Mandel, was seriously injured in an accident. Cowley's team saved the man, and in 1973 a grateful governor signed an order creating MIEMSS as an independent institute.

It wasn't long before the system had made dramatic inroads into Maryland's accident death rates and established Shock Trauma as a health resource.

But as a model for the rest of the country, Shock Trauma is controversial. For one thing, doctors who work there must forget a lot of their medical-school training. Surgeon David R. Boyd, who is director of the office of Emergency Medical Services (EMS) of the U.S. Department of Health and Human Services and is charged with installing a "wall-to-wall" national EMS network of more than 300 trauma units, insists that only independent emergency medical systems can produce the "kind of moxie, aggressive doctors" who can do what Shock Trauma has done. No pass-the-buck bureaucrats or medical Milquetoasts need apply. This kind of setup terrifies students and doctors who come in for the first time. It overturns everything they've learned about diagnosis and treatment.

"Here, the teams follow strict rules," Boyd goes on, "They treat first and ask questions later. They'll slit patients from gullet to gut just to have a look. They don't wait to see what happens. They dig right in with both hands."

Shock Trauma surgeons often look for internal injuries by making a small incision in the abdomen. Sterile solution is run in until it fills the cavity and is siphoned out by the force of gravity. If the drip is pink, there's blood—and trouble—inside.

"If the tests are positive, most patients here with multiple injuries get their abdomens opened for a look-see," Cowley says. "A third of them will need that to save their lives. In emergencies, the risk of missing something that important far outweighs the small risk of the procedures. When you look and see, you don't miss things."

As with every other unusual procedure used at Shock Trauma, there is a scientific defense for this unorthodox maneuver. A study of the results of 100 autopsies, for example, showed 18 deaths due to simple internal injuries that standard diagnostic procedures missed.

Head injuries are among the most serious. More than half of all victims of severe head injury are lost—or consigned to lives with massive brain damage—even after the best procedures have been observed: examining reflexes, keeping patients awake, avoiding sedatives. In other words, watching carefully and hoping for the best.

BRAIN-TRAUMA SWELLING

The problem in brain trauma is swelling. When a hand, leg or finger swells after an injury, it is painful but rarely dangerous. But when the brain enlarges, it is trapped inside a bony skull. Pressure builds, cutting off blood supplies to the outer edges of the brain, which are literally crushed to death.

Using traditional techniques, a neurologist will take 24 to 48 hours to detect significant brain swelling. This watchful waiting serves the patient ill, since by the time swelling is diagnosed, it is often too late to reverse it.

Today, Shock Trauma doctors continually monitor intracranial pressure in brain-trauma patients by inserting a slim tube directly through the skull, through either a wound hole or a hole deliberately drilled for that purpose. Now doctors know within half an hour if swelling is on the way—in time to give drugs and siphon fluid for further study.

Another major advance is in the treatment of shock lung, a form of respiratory

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failure that can occur even when the lungs are not directly damaged.

When shock lung strikes, the patient literally drowns in his own bodily fluids. Shock lung results from an upset or imbalance in the system whereby the lungs exchange oxygen and carbon dioxide, an exchange that occurs through membranes one cell thick. During severe trauma, fluids may spill out in the lung tissues, making it difficult for oxygen and carbon dioxide to pass back and forth freely. As the membranes thicken, fluid is forced into the lungs, and the blood cannot be oxygenated.

"POSITIVE VOLUME"

Cowley and his former colleague, Dr. C. Crawford McAslan, an anesthesiologist, had seen occasional cases of a syndrome similar to shock lung in patients placed on heart-lung machines during open-heart surgery. In those cases, respirators called "positive volume" Engstroms could be used to prevent the condition by keeping the lungs partly inflated, even during the exhalation phase of breathing, instead of letting them collapse after each inhalation.

Cowley and McAslan reasoned that an Engstrom might work for shock lung as well. But they faced two obstacles. First, the respirators were scarce and expensive—$8,000 apiece. Second, medical tradition deemed it dangerous and unethical to use mechanical breathers before real trouble had definitely set in. University of Maryland Hospital officials raged and fumed, but, in the end, the respirators were purchased and incoming patients are now hooked up routinely. By 1972, the shock-lung death rate was down to less than 1 percent.

Unconventional approaches are also applied to kidney failure. Dialysis, or artificial cleansing of the blood, is aggressively initiated very early in many trauma patients. When this practice was begun, the medical establishment "threw fits," one doctor recalls. "They were used to treating only patients with chronic kidney disease, people whose kidneys fail gradually. Shock-trauma patients need aggressive dialysis—and fast, because adrenaline and other hormones are pumping, and the body begins making enormous energy demands on its chemical plant to handle the breakdown of tissues."

The result is a huge and rapid spillage of waste products into the blood. Even if the kidneys aren't directly damaged by trauma, they can be overwhelmed by the excess wastes they are now expected to remove and so can fail. Patients at Shock Trauma can put out a whole day's waste material in an hour. Dialysis, quick and early, is the only way to bail the kidneys out, and studies so far show that it significantly reduces the death rate from kidney failure.

MIEMSS scientists sometimes find elegantly simple answers to complicated problems—preventing ruptured aortas, for instance. The aorta is the body's largest blood vessel, emerging from the heart and curving toward the spine. Even a relatively small tear in the outer layers of the vessel can eventually make it balloon in spots. When the aorta ruptures after trauma, it sometimes does so without warning. Blood literally pours out, and the patient is dead in a few minutes. Unless the condition is diagnosed in advance, sudden death is inevitable.

The question is, how to detect tears in the aorta quickly. The late Dr. Robert Ayella, an MIEMSS leader, suggested that chest X-rays of patients in a seated position would give doctors a glimpse of a swollen aorta that would be hidden by the heart when the patient was prone. Now, Shock Trauma routinely prevents deaths from ruptured aortas with this simple sit-up X-ray method.

Another problem: preventing a lack of oxygen in the tissues. It is known that gases, including oxygen, can be pushed into liquids such as blood faster when they are under pressure. Research had also established that the organisms that cause gas gangrene—a life-threatening wound infection—cannot survive under high concentrations of oxygen. Always ready to incorporate military expertise, Cowley adapted the idea of the hyperbaric (increased pressure) oxygen chamber, a cylindrical high-pressure facility first developed by the Navy to treat the bends, or decompression sickness, among deep-sea divers. In Shock Trauma's hyperbaric oxygen chamber, over 100 patients are treated each year—the vast majority successfully—for gangrene, bends, smoke inhalation and carbon monoxide poisoning.

> In the future, Cowley thinks he can eliminate the need for exploratory surgery by using data drawn from a computer.

Nothing is dearer to Cowley's heart, however, than Shock Trauma's use of high technology. "We have a full program to develop intelligent machines for patient care," says Cowley. Last year, a working prototype of an inexpensive bedside, microprocessor-based module (BeMi) was built to monitor a single critically ill patient automatically and display graph data on command to doctors and nurses. The eventual plan is to computerize nursing records, medication delivery and fluid management.

Computers are already programmed to monitor the heart, lungs and metabolic functions, make individual calculations of drug doses, acquire lab information and plot variables of patient care to determine the direction of recovery. The latter gives a "snapshot" view of patient status. Even menu lists are on the program, along with a trauma registry and an Anatomical Injury Code for evaluating the vast majority of injuries in great detail. Eventually, doctors and nurses will be able to retrieve information on patients and instantly compare them with injury profiles and outcomes of thousands of others.

"In the not-too-distant future," Cowley says, "we'll be able to bring a patient in and within minutes get all the data we need without cutting into the patient or injecting things. It will be safe, fast and accurate; then with the help of computers, we'll be able to track a patient's biological processes on many levels, the way a missile is tracked on radar. The same computer will give us a cookbook recipe for therapy with less than a tenth-of-one-percent failure rate. And on top of that, the computer will let us deliver drugs and other therapies in just the right way, in the right amount at the right time, like fuel injection on a new car."

The time has come, Cowley insists, to establish a National Institute of Trauma within the National Institutes of Health. Such a move, he says, would "recognize trauma for the killer it is, give it equal status with other killer diseases."

"PATIENT STEALING"

Cowley and Boyd's dream of a national network of emergency medical service systems is still viewed in some quarters as an expensive and questionable scheme. Charges of "patient stealing" and lawsuits over which hospital is to be the designated trauma center have polarized whole communities. "Burnout" rates are high among professionals in the emotionally charged and physically exhausting setting of the trauma unit, particularly for the nurses who are the backbone of the operation. Rescue squads are at risk of street violence. Budgets are lean, and bureaucrats in state and local health agencies are sometimes furious over what they see as loss of power to independent trauma centers. "Hell," says Cowley, "there aren't enough lifetimes to do what still has to be done."

For Cowley, the battle is no longer in the operating room but in boardrooms and legislative halls. "We spend over eight hundred million dollars a year on cancer research, four hundred million on heart research and a mere eight million on the epidemic disease of the young—trauma," Cowley says. "If we save a middle-aged or older person from cancer or heart disease, we save only a few short years—maybe. If we save a teenager from trauma, we save a whole lifetime." ■