

The value of trauma centers

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This year, in the United States alone, there will be approximately 164,000 deaths due to trauma. And for every death there will be at least two permanent disabilities. Trauma affects primarily young people and accounts for more years of lost life than cancer and heart disease combined. Among 15 to 24 year olds, trauma accounts for 50 percent more deaths in the United States than in any other industrialized society. Not only does trauma cause death and disability, but the cost to society is staggering: \$83.5-billion per year or \$228-million per day. Trauma is clearly a major health and social problem.

Trauma-care studies

Since trauma is a major health-care issue, we physicians must ask if there is anything wrong with our current system of trauma care, and if there is any evidence that trauma centers improve trauma care. A number of studies have documented poor results from our current system, which is not really a system since it is not integrated nor organized. A study done by Van Wagoner in 1960 showed that of 606 injured male soldiers treated in community hospitals in Texas, 96 patients would have survived had adequate treatment been instituted, and an additional 103 patients would probably have been saved if their treatment had been appropriate.

In another study, C. F. Frey et al showed that 28 out of 159 patients died in Michigan as a result of injuries because they were inappropriately treated. In 1972, Gertner et al showed that one-third of motor-vehicle accidents involving abdominal trauma in the Baltimore area resulted in preventable deaths.

Various colleagues and I have conducted studies in the San Francisco Bay Area to examine trauma deaths. The first study, published in 1974, compared trauma-related deaths that occurred in a trauma center with those that occurred in community hospitals. This study showed that patients from motor-vehicle accidents who were treated in hospitals that were not trauma centers had a significantly higher chance of dying than those treated in a trauma center.

Similar results were found in a study conducted in conjunction with Dr. John West of Orange County.

This study compared deaths caused by motor-vehicle accidents in one region where there were no trauma centers with those in a region that had a single designated trauma center. Outcome was significantly better in the region with a trauma center. Another Bay Area study was done in 1977 and further documented poor outcome when patients were taken to a hospital that was not a trauma center. Recently, I studied trauma care in eight Bay Area counties and concluded that 40 percent of motor-vehicle accident victims may have been saved if there had not been delays in diagnosis or if appropriate care had been rendered. A number of other studies have been done in Wisconsin, Vermont, Salt Lake City, and New York, which have shown that the number of preventable deaths related to an inadequate trauma-care system varies from 30 to 40 percent. I am aware of at least four additional studies currently under way or recently completed that support the previous studies.

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One inescapable conclusion emerges from these studies: There is a major problem in the delivery of trauma care in the United States. This literature also suggests that implementation of an integrated and organized trauma-center system can improve the results of trauma care in the United States.

The roots of trauma care

Organized, regional trauma care has its roots in armed conflict. According to Majno, the first mention in recorded history of organized battlefield care is in

the *Iliad*. Specifically, the wounded were carried off the battlefield and cared for in barracks (*Klisiai*) or in nearby ships. One-hundred and forty-seven wounds are specifically mentioned in the *Iliad*, and the mortality was 77 percent. The Romans also had considerable experience with care of the wounded, and as early as 480 BC, the wounded were assigned to the care of the patricians.

In the first and second centuries AD, the Romans established hospitals along the borders of the Roman Empire to care for the wounded. Archaeologists have identified at least 25 of these hospitals, or *valetudinaria*, which were fairly sophisticated in design and concept.

Baron Larrey, Napoleon's chief surgeon, developed two concepts to improve the care of the wounded that have persisted through to modern times. The first was the flying ambulance, which reduced the time it took to provide definitive care to the injured. Prior to the invention of these ambulances, the injured often remained on the battlefield for periods of 24 to 36 hours. Larrey's second innovation was to concentrate the casualties in one area and to operate on them as close to the front lines as possible.

During World War I, the time lag from injury to surgery was still 12 to 18 hours. This was reduced during World War II to six to 12 hours. One of the most dramatic reductions in the time lag from injury to definitive care occurred during the Korean conflict. The United States Army Medical Corps decided to bypass the battalion aid station and take the injured soldiers directly from the field to the Mobile Army Surgical Hospital (MASH). The average time lag from injury to definitive care during the Korean conflict was two to four hours, and overall mortality was 2.4 percent.

This tactic was improved upon in the Vietnam conflict when casualties were taken directly from the battlefield to the Corps Surgical Hospital, bypassing the battalion aid station and MASH. One study showed that the average time lag from injury to emergency care was 65 minutes, and another study

found that the time lag from injury to definitive surgical care was 81 minutes. This military experience should have been an incentive and a model for improvement in civilian trauma care. Unfortunately, this has not been the case, except in a few isolated instances.

The German system

One example of excellent regional trauma care can be found in West Germany. During the late 1960s, West Germany studied our methods and techniques of providing battlefield care in Vietnam. In 1970, the West Germans applied these methods virtually throughout the country and established trauma centers up and down the major autobahns. Integral to their trauma center concept is rapid prehospital transport, which primarily involves the use of helicopters but also includes ground transport. No patient in Germany is more than 30 minutes from a designated trauma center.

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As a consequence of this regionalized system, the mortality rate from motor-vehicle accidents since 1970 has dropped from 16,000 per year to 12,000 per year, a reduction of 25 percent. It is probably no coincidence that this reduction of 25 percent coincides remarkably closely to the preventable death data shown in most American studies (30 to 40 percent).

The German system is not only strong in prehospital and hospital care but also involves an excellent rehabilitation program. Most survivors return to productive lives. By applying some simple arithmetic and assuming that the 4,000 additional pa-

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tients who now survive each year return to work, a financial benefit to society can be shown. If one assumes that each survivor earns \$10,000 a year and pays \$2,500 in taxes, the gross national product would be increased by \$220-million and tax revenues would increase by \$55-million. The value of a trauma center, therefore, becomes not only a reduction in lost lives and disability, but a positive financial contribution to society as well.

Other countries, including Switzerland and Israel, also have excellent trauma systems. The United States has islands of excellence where trauma systems have been developed, such as Maryland, Houston, Dallas, Louisville, Seattle, and Detroit, to name a few.

One of the best examples of the value of a trauma center and system can be found in Orange County, California. After the original Orange County study documented that trauma outcome was unacceptable, five trauma centers were designated in June of 1980. A study done this year and about to be published in the *Archives of Surgery* has examined the results and impact of these designated trauma centers. To my knowledge this is the first time that data are available comparing trauma care before and after the establishment of trauma centers.

The data show that preventable deaths were reduced from 73 percent to nine percent when the patients were treated in one of the five designated trauma centers. If the patient were inappropriately triaged to a hospital that was not a trauma center, the preventable mortality remained at 67 percent. The study further documents that appropriate surgery was performed in the trauma center. In addition, patients did not die because other hospitals were passed by enroute to the trauma centers. This finding is consistent with data from Vietnam, where battalion aid stations were bypassed. These data clearly document the value of trauma centers.

Distribution of death

Data from Orange County and from Maryland, and autopsy studies done in San Francisco, tend to indi-

cate that death from trauma has trimodal distribution. The first peak of deaths is within seconds or minutes of injury. Invariably these deaths are due to lacerations in the brain, brain stem, upper spinal cord, heart, aorta, or other large vessels. Few of these patients can be saved, although in some large urban areas with rapid transport, some deaths have been avoided. This will probably never be possible in suburban and rural areas.

The second death peak occurs within the first two hours after injury, and some have referred to this period as the "golden hour" for the critically injured. These deaths are usually due to subdural and epidural hematomas, hemopneumothorax, ruptured spleen, lacerations of the liver, fractured femur, or multiple injuries associated with significant blood loss. These patients benefit most from regionalized trauma care, and their numbers are significant. If a trauma team consisting of surgeons, anesthesiologists, and nurses is either in house or promptly available, these patients can usually be saved.

The third death peak occurs days or weeks after the injury and is almost always due to sepsis and multiple organ failure. These patients also benefit from a trauma center. Concentration of the expertise of surgeons and physicians in one center allows for a rational, therapeutic approach that positively affects patient outcome. It also provides an opportunity for research into the mechanisms of sepsis after injury and new therapeutic methods.

Trauma centers have other values as well, particularly the Level I center, which can serve as an educational resource for the training of surgeons, nurses, and other specialists in the care of the injured patient. A Level I center should also take the lead in developing disaster plans and in educating the public in the region it serves. All trauma centers should provide access to rehabilitation services so that the patient who recovers from acute injuries can return to a productive life. In the final analysis, trauma centers are of value for many reasons, but their most important value is in reducing death, disability, and health-care costs.