

## The Emerging Crisis in Trauma Care: A History and Definition of the Problem

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The history of trauma care is inextricably linked to wars and wounds. Trauma antedates recorded history and there are examples of anthropological findings showing trepanation of the cranium dated to 10,000 BC. These craniums have been found in the Tigris-Euphrates Valley, along the shores of the Mediterranean, and in meso-America. It is most likely these operations were performed for depressed cranial fractures and possibly epidural hematomas. The surgery was most likely performed by priests or shamans within the various cultures. Some of these craniums show that the operation was performed more than once; and there is ample evidence that there was success because there was healing of the man-made hole. There is also evidence that they were able to treat fractures and dislocations with success and knitting of the bones.

The first solid evidence of war wounds came from a mass grave found in Egypt and dated to approximately 2000 BC.<sup>9</sup> The bodies of 60 soldiers were found in a sufficiently well-preserved state to show mace wounds, gaping wounds, and arrows still in the body. The Smith Papyrus records the clinical treatment of 48 cases of war wounds and is primarily a textbook on how to treat wounds, most of which were penetrating. According to Majno, there were 147 recorded wounds in Homer's *Iliad*, with an overall mortality of 77.6%. Thirty-one soldiers sustained wounds to the head, all of which were lethal. The surgical care for a wounded Greek soldier was crude at best. However, the Greeks did recognize the need for a system of trauma care and provide one of the first examples of a trauma system. The wounded were given care in special barracks (*klisiai*) or in nearby ships. Drugs, usually derived from plants, were applied to wounds.

The Romans perfected the delivery of combat care and set up a system of trauma centers surrounding the Roman Empire. These trauma centers were called "valetudinaria" and were built during the 1st and 2nd centuries AD. The remains of 25 such centers have been found, but, significantly, none were found in Rome or other large cities. It is noteworthy that there were 11 found in Roman Britannica,

more than currently exist. Some of the valetudinaria were designed to handle a combat casualty rate of up to 10%. There was a regular medical corps within the Roman legions, and at least 85 army physicians are recorded, mainly because they died and earned an epitaph.

From elsewhere in the world came other evidence that trauma systems were provided for the military. India may well have had a system of trauma care that rivaled that of the Romans. Their *Artasastra*, a book written during the reign of Ashoka, documented that the Indian army had an ambulance service, with well-equipped surgeons, and women to prepare food and beverages and bandage wounds. Indian medicine was specialized, and it was the "shalyarara" (surgeon) who would be called on to treat wounds. "Shalyarara" literally means "arrow-remover," because the bow and arrow was the traditional weapon for Indians.

The concept of shock could not be appreciated during the rise of surgery in Europe and Asia. In fact, it was not until the late 19th and early 20th century that shock was described. The Greeks understood that hemorrhage could lead to death, and they also empirically treated this with herbs, specifically, ephedra *nebrodensis*, which came from Sardinia. The same treatment was used in China, where it was called Ma-Huang, and it also was ephedra. It is most likely that these two distant cultures shared the discovery of ephedra via the "Silk Road." Hippocrates and Galen did not use the tourniquet. This was partially based on the evidence of Largus, who stated that if you took a skin bag and filled it with liquid and then wrapped a rope around it, tightening the rope would increase expulsion of the fluid out of the bag orifice. So much for the early scientific method.

During the first millennium, military trauma care did not make any major advances until midway in the second millennium, just before the Renaissance. Arabic surgery did thrive for two to three centuries, but it was up to two French military surgeons, who lived 250 years apart, to bring trauma care into the age of enlightenment.

Ambrose Paré (1510–1590) served four French kings during the time of the French-Spanish civil and religious wars.<sup>13</sup> His major contributions to treating penetrating trauma included his treatment of gunshot wounds, the use of ligature

instead of cauterization, and the use of nutrition during the postinjury period. Paré was also much interested in prosthetic devices and designed a number of them for amputees.

It was Dominique Larrey, Napoleon’s surgeon, who addressed trauma from a systematic and organizational standpoint.<sup>5</sup> Larrey introduced the concept of the “flying ambulance,” the sole purpose of which was to provide rapid removal of the wounded from the battlefield. Larrey also introduced the concept of putting the hospital as close to the frontlines as feasible to permit wound surgery as soon as possible. His primary intent was to operate during the period of “wound shock” when there was an element of analgesia, most likely because of endorphins, but also to reduce infection in the postamputation period.

Larrey had an understanding of problems that were unique to military surgery and system development. Some of his contributions can best be appreciated by his efforts before Napoleon’s Russian campaign. Larrey did not know which country Napoleon was planning to attack, and there was even conjecture of an invasion of England. He left Paris on February 24, 1812, and was ordered to Mentz, Germany. Shortly thereafter, he went to Magdeberg and then on to Berlin, where he began preparation for the campaign, still not knowing precisely where the French Army was headed. In his own words, “Previous to my departure from this capital, I organized six divisions of flying ambulances, each one consisting of eight surgeons. The surgeon-major exercised their divisions daily, according to my instructions, in the performance of operations and the application of bandages. The greatest degree of emulation and the strictest discipline were prevalent, among all the surgeons.”

The 19th and 20th centuries were notable in the improvement of surgical care in combat. Antisepsis was introduced during our Civil War, and there was a gradual decline in patients who died from their wounds (*Table 32.1*). The surgical mortality for head, chest, and abdominal wounds also decreased after the First World War (WWI) (*Table 32.2*). Between WWI and WWII, the first civilian trauma system was created in Austria by Böhler. Although initially designed

**TABLE 32.2.** Surgical mortality for head, chest, and abdominal wounds (United States Army)

War	Head	Thorax	Abdomen
World War I			
<i>Cases</i>	189	104	1816
<i>% Mortality</i>	40	37	67
World War II			
<i>Cases</i>	2051	1364	2315
<i>% Mortality</i>	14	10	23
Korean War			
<i>Cases</i>	673	158	384
<i>% Mortality</i>	10	8	9
Vietnam War			
<i>Cases</i>	1171	1176	1209
<i>% Mortality</i>	10	7	9

for industrial accidents, by the time of WWII, it also included motor traffic accidents.

The most remarkable development of a statewide trauma system occurred early in the 1970s in Germany.<sup>17</sup> At that time, road traffic accidents accounted for 18,000 deaths annually. Since 1975, this has been reduced to approximately 7,000. In 1966, two trauma centers were started in the United States: one in Chicago at Cook County (Robert Freeark) and one in San Francisco (F. William Blaisdell). The first statewide trauma system was initiated in 1969 by R. A. Cowley in the State of Maryland. It was at approximately the same time that the American College of Surgeons Committee on Trauma (ACSCOT) started to develop criteria for trauma systems. In 1976, the first Optimal Criteria document was published, followed shortly thereafter by the Advanced Trauma Life Support (ATLS) course, which was designed for emergency physicians and surgeons, and defined criteria for resuscitation during the first hour after injury. Subsequently, there were two other significant developments by the AC-

**TABLE 32.1.** Percentage of wounded dying of wounds (United States Army)

War	Year	No.wounded	Percentage of wounded who died of wounds
Mexican War	1846–1848	3400	15
American Civil War	1861–1865	318,200	14
Spanish-American War	1898	1600	7
World War I (excluding gas)	1918	153,000	8
World War II	1942–1945	599,724	4.5
Korean War	1950–1953	77,788	2.5
Vietnam War	1965–1972	96,811	3.6

SCOT, including the Multiple Trauma Outcome Study, which has now gone on to be the National Trauma Data Bank, and a verification program for existing trauma centers. The College recognized early on that the designation of trauma centers was a political and legal process, and the verification program simply examined patient medical records and program improvement documents to verify whether or not the hospital met the designation criteria. By 1995, a report in the *Journal of the American Medical Association* showed that five states had statewide trauma systems.<sup>1</sup> This was followed in 1998 by a nationwide report published in the *Journal of Trauma* documenting that five states continued to meet all eight previously described criteria for trauma systems<sup>10</sup> and 28 states met at least six or seven criteria, whereas an additional four states met at least four criteria. Finally, in 2006, another study evaluating the efficacy of trauma center care on mortality showed that the mortality from trauma was 7.6% in designated trauma centers compared with 9.5% in hospitals that were not designated.<sup>11</sup> One year after discharge, the significance continued, with a mortality of 10.4% versus 13.8%. Another study<sup>14</sup> published in 2006 from Florida showed that in counties with a trauma center, the mean fatality rate was 50% less than in counties without a trauma center. It can be seen from this data that the effectiveness of a trauma center is irrefutable as shown by these two recent studies and the data from Germany.

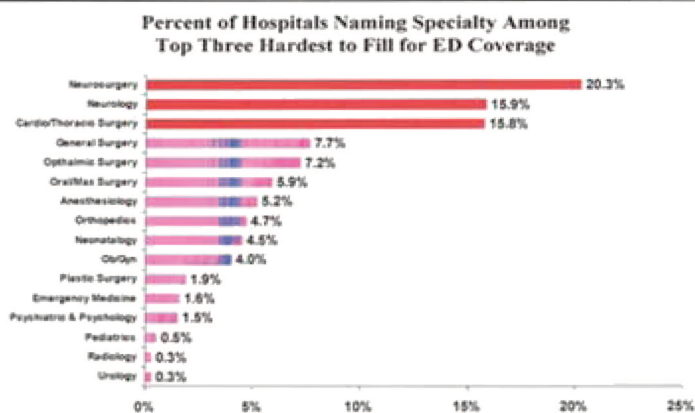
### THE CRISIS IN PATIENT ACCESS TO EMERGENCY SURGICAL CARE

The Division of Advocacy and Health Policy of the American College of Surgeons has recently come out with a very timely white paper with the same title as this section.<sup>7</sup> In the introduction of this article, it was pointed out that:

- “A majority of surgeons take ED call 5–10 days a month; some surgical specialists take call far more often.”
- “Many surgeons provide on-call services simultaneously at two or more hospitals, and a significant number say they have difficulty negotiating their on-call schedules.”
- “Hospital bylaws typically require surgeons to participate in on-call panels, although older individuals are often allowed to ‘opt out,’ and they are more frequently taking advantage of this option.”
- “A significant number of surgeons have been sued by patients first seen in the ED, and some physicians are offered discounts on their liability coverage if they limit or eliminate ED call.”

The Advocacy and Health Policy Division goes on to point out the importance of emergency rooms as a safety net for patients and its role in trauma care. A study by the Lewin group in 2002 showed that neurosurgeons, orthopedic surgeons, general surgeons, and plastic surgeons were among the specialists in short supply for emergency department (ED) on-call panels. (Fig. 32.1).<sup>15</sup> The Lewin study was confirmed by the Schumacher Group in 2003, reporting that one-third of EDs lacked surgeon specialty coverage, causing 76% of those responding to go on divert status.<sup>16</sup> More recently, similar surveys were conducted by the American College of Emergency Physicians in 2006, and they showed that nearly three-quarters of ED medical directors think that they have inadequate on-call specialist coverage, compared with two-thirds in 2004.<sup>12</sup> In the most recent survey, orthopedic, plastic, and neurological surgeons, as well as otolaryngologists and hand surgeons, were reported as most often being in short supply. The American College of Surgeons Bulletin white paper also points out that surgeons are older, with a

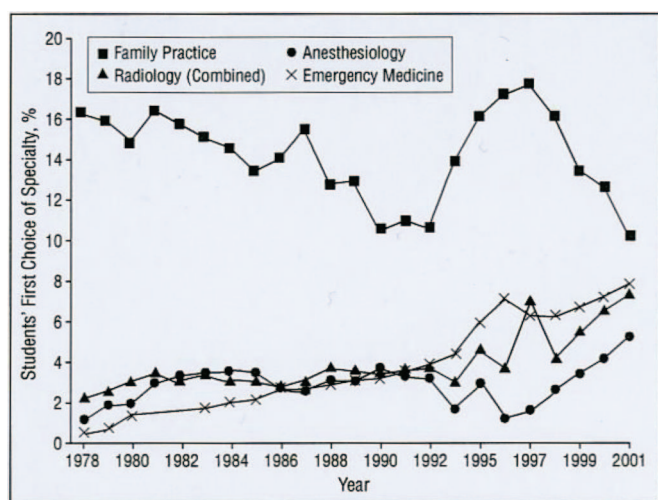
### Neurosurgery, neurology, and cardio/thoracic surgery were the hardest physician coverage slots to fill



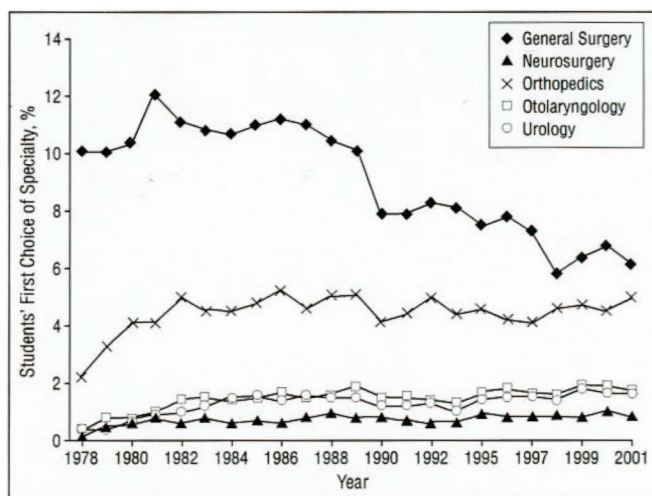
**FIGURE 32.1.** Neurosurgery, neurology, and cardiothoracic surgery were the hardest physician coverage slots to fill. Percent of hospitals naming specialty among top three hardest to fill for ED coverage (from, The Lewin Group Analysis of AHA ED Hospital Capacity Survey, 2002, April 2002, 7–18. <http://www.aha.org/ahapolicyforum/resources/EDdiversionsurvey0404.html>. Accessed April 4, 2006 [15]).

significant number taking emergency call as 55 years or older. Furthermore, there is a decrease in surgeons providing charity care. The Emergency Medical Treatment and Active Labor Act (EMTALA), which was originally designed as an “antidumping” federal measure, has become a “dumping” problem. Finally, malpractice continues to be a problem to any surgeon who provides emergency care.

The crisis in emergency surgery care is further compounded by two studies published by R. A. Cooper, who states, “The physician shortage is here now and will become worse by 2020, when the deficit may be as great as 200,000 physicians.<sup>3,4</sup> Many of these will be surgeons, gastroenterologists, and cardiologists.” There is a particular crisis in general surgery. Of the approximately 1000 surgeons who successfully pass their boards, only 200 to 250 remain in general surgery. Most are getting subspecialty training, and very few of these want to take trauma call. There is also a decline in interest in surgery because of lifestyle issues, sex, and mentorship. A particularly poignant study by Bland and Isaacs showed a trend toward lifestyle medical specialties rather than surgical specialties (Figs. 32.2 and 32.3).<sup>2</sup> There is a fairly dramatic fall from 1978 to 2001 in the interest of fourth-year medical students in general surgery. Orthopedics may have slightly increased, but neurosurgery, otolaryngology, and urology have stayed relatively flat. There is a particular issue as it relates to sex. Graduating medical students are at least 50% female, and very few apply to general surgery (7% or a little more than 500 applicants). Part of this disinterest in general surgery is the hours during the surgical residency, part of it is lifestyle, part of it is a desire to combine a professional career with a traditional role as a



**FIGURE 32.2.** The so-called “lifestyle” specialties have continued to attract medical students (from, Bland KI, Isaacs G. Contemporary trends in student selection of medical specialties: The potential impact on general surgery. *Arch Surg* 137:259–267, 2002 [2]).



**FIGURE 32.3.** In contrast to the “lifestyle” specialties, general surgery has declining attraction to medical students; orthopedics has increased slightly, and other surgical specialties tend to be flat (from, Bland KI, Isaacs G. Contemporary trends in student selection of medical specialties: The potential impact on general surgery. *Arch Surg* 137:259–267, 2002 [2]).

mother, and it also reflects that the programs have not provided protected time so that they can do both. There seems to be some positive change in application to surgical programs since institution of the 80-hour work week.

Recently, the American Association for the Surgery of Trauma, working in concert with the American Board of Surgery, has proposed a solution to attracting medical students into trauma and critical care surgery and retaining them once they pass their boards. The proposed solution essentially expands trauma and surgical critical care to also include emergency general surgery. To accomplish this, it is most likely surgeons would have to rotate in shifts to cover the hospital 24 hours a day. This might be particularly attractive to women and single parents who would have more control of their time.

Another potentially damaging feature of the surgical crisis in emergency rooms is the “on-call pay.” This is highly variable in various geographic regions of the United States. General surgeons are requesting \$1000 to \$2000 a night for on-call; orthopedic surgeons are requesting \$2000 to \$4000 a night for on-call; and neurosurgeons are requesting \$3000 to \$7000 per night for on-call. Hospitals are currently willing to pay some of these stipends in an effort to correct deficiencies in on-call schedules as documented by the American College of Emergency Physicians. It is highly unlikely that Congress and/or the public will understand or be sympathetic with such payments, particularly with the increasing annual costs in healthcare and the median total compensation for surgeons (Table 32.3). The public might be more sympathetic if hospitals reimburse the surgeons for uncompensated patient care



**TABLE 32.3.** Median total compensation for surgeons, 2005<sup>a</sup>

	Academic	Private practice
General	235,482	282,504
Trauma	254,214	365,854
Orthopedic	227,000	383,697
Orthopedic trauma	318,400	420,845
Neurosurgeon	365,828	524,894

<sup>a</sup>From, MGMA, 2006.

services or assisted specialty groups in recruitment to fulfill trauma care need and obligations.

A major problem by 2010 will be the 30% increase in the elderly population.<sup>20</sup> It used to be that the peak in death rate from injury was in the 16- to 24-year age group. We are now seeing a bimodal distribution, with an increased death rate in the elderly. The elderly are more active, and unfortunately, the mortality rate for Injury Severity Score greater than 15 is 3.5 times those of their younger counterparts. These patients spend more time in the intensive care unit, and, unfortunately, do not have a good return to independent living status or quality of life after their trauma episode.

The lack of general surgeons also impacts negatively on the Department of Defense (DOD) and their need for surgeons (18, 21–23). Approximately 20% of DOD surgeons are active-duty surgeons; 80% must come from the reserve. Unfortunately, young surgeons do not join the reserve. Studies after Desert Storm by the General Accounting Office showed that surgeons were not being trained properly for trauma, particularly the active-duty surgeons; however, the DOD has recently improved this during the past 4 years. Another negative impact on trauma care is that many trauma centers are closing or downgrading their level of care. Since 2003, “dumping” has become an increasing problem for Level I and II trauma centers. This phenomenon is characterized by community hospitals calling the trauma centers and speaking to an emergency physician or surgeon, telling them they have a trauma case that they cannot provide care for; either because of lack of personnel or because the patient’s case is too complex. Many of these patients, once they reach the trauma center, are observed and then discharged the following morning.

Another major problem in trauma care is that rehabilitation beds are not available after a severe injury. The General Accounting Office performed a study showing that only one in eight patients with traumatic brain injury receive appropriate rehabilitation after their acute care.<sup>24</sup> Rehabilitation is particularly a problem in patients who have no insurance. I had a patient approximately 8 months ago who was 36 years old, married, and had four children—all boys. He

started his own construction company, but unfortunately, he did not have enough money to buy health insurance, which would have cost \$6000 per year for a family of six. He fell while constructing a building and became paralyzed. As a result of the accident, his acute care was provided by my hospital free of charge, but we could not find a rehabilitation facility that would take him. We taught his wife the bare necessities of care for a paraplegic, but, obviously, he is high risk for complications, and home care with his wife performing most of the care will not allow her to work and provide for the family.

There are other issues as well. Of some concern to acute care hospitals is the recent growth in free-standing ambulatory surgery centers. In many instances, these centers are owned by specialty surgeons, and the advantage to them is that they do not have to take night call. Another issue is the importation of surgeons from developing countries.<sup>19</sup> The obvious downside of importation of surgeons from developing countries is that this represents a serious “brain drain.” It is also a short-term solution. Of equal concern is the issue of competence. According to the Institute for International Medical Education, India has 205 medical schools.<sup>6</sup> A recent study in the *British Medical Journal* stated that the quality of graduates is highly variable, particularly from the 20 private medical schools.<sup>8</sup> Most of the state run medical schools (60%) have inadequate infrastructure, staff, and facilities. A surgeon trained in a developing country only need pass the United States Medical Licensing Examination (USMLE) and serve 1 year of internship to practice surgery in the United States. Suburban and rural hospitals do not necessarily require board certification on their medical staff. It is my opinion that general surgeons and specialty surgeons who are foreign medical graduates should undergo the same rigorous tests for competence that surgical residents in the United States must pass.

Finally, we must address the issue of specialty surgical coverage to EDs, and specifically those that are designated trauma centers. The lack of consistent coverage, obviously, adversely affects outcomes, and when a hospital diverts, it puts more stress on other parts of the trauma system. Optimally, the solutions would come from professional societies that represent the surgical subspecialties. Not only does this problem apply to trauma centers in this country, but it also has an impact on our ability to deliver trauma care to the military. If a solution is not forthcoming, it has been proposed that those subspecialty emergencies required primarily at night when coverage is not available, could be performed by the “emergency general surgeon.” This would obviously require a definition of what constitutes a true emergency and a further description on the skills and normative standards that would be included in the curriculum of an emergency general surgeon. It should be noted that some of these emergency procedures are already performed by the general

surgeon in Europe, Malaysia, Australia, New Zealand, and, in some instances, in rural United States. Alternatively, the surgical subspecialty shortage could be met by importing surgeons from other countries, but, as noted above, this is suboptimal.

### SUMMARY

The crisis in patient access to emergency surgical care as articulated by the Division of Advocacy and Health Policy of the American College of Surgeons is real. It is most likely that in the next 10 years this crisis will only get worse. At last count, there were 190 Level I trauma centers in the United States, of which, 48 have been verified by the American College of Surgeons. There are 263 Level II centers, of which, 51 have been verified. These centers provide approximately 50% of tertiary trauma care in the United States. The data is overwhelming that they do make a difference in outcome.

Neurosurgical professional societies participated with the American College of Surgeons in developing the recent white paper from the Division of Advocacy and Health Policy. It is now time to solve the crisis, and neurosurgery should step up to the plate and provide coverage for Level I and Level II trauma centers at a reasonable cost. Furthermore, neurosurgery should be involved in continuing to help to solve the crisis that currently exists. If neurosurgery cannot or does not want to provide coverage, they should let other surgeons provide coverage.

### REFERENCES

- Bazzoli GJ, Madiera KJ, Cooper GF, McKenzie EJ, Maier RV. Progress in the development of trauma systems in the United States: Results of a national survey. *JAMA* 273:395–401, 1995.
- Bland KI, Isaacs G. Contemporary trends in student selection of medical specialties: The potential impact on general surgery. *Arch Surg* 137: 259–267, 2002.
- Cooper RA. Weighing the evidence for expanding physician supply. *Ann Intern Med* 141:705–714, 2004.
- Cooper RA, Getzen TE, McKee HJ, Laud P. Economic and demographic trends signal an impending physician shortage. *Health Aff (Millwood)* 21:140–144, 2002.
- Dible JH. *Napoleon's Surgeon*. London, William Heinemann Medical Books, 1970.
- Director of Medical Schools in India. [www.iime.org/database/asia/india.htm](http://www.iime.org/database/asia/india.htm). Accessed September 1, 2006.
- Division of Advocacy and Health Policy. A growing crisis in patient access to emergency surgical care. *Bull Am Coll Surg* 91:9–18, 2006.
- Kumar S. Report highlights shortcomings in private medical schools in India. *BMJ* 328:70, 2004.
- Maino F. *The Healing Hand*. Cambridge, MA, Harvard University Press, 1975.
- McKenzie EJ. Review of evidence regarding trauma system effectiveness resulting from panel studies. *J Trauma* 47[Suppl]:SS46–55, 1999.
- McKenzie EJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 4:366, 2006.
- On-Call Specialist Coverage in US Emergency Departments, American College of Emergency Physicians Survey of Emergency Department Directors. April 2006. [http://www.acep.org/NR/rdonlyres?DF81A858-FD39-46F6-B46A-15DF99A45806/0/RJW\\_OncallReport2006.pdf](http://www.acep.org/NR/rdonlyres?DF81A858-FD39-46F6-B46A-15DF99A45806/0/RJW_OncallReport2006.pdf).
- Packard FR. *Life and Times of Ambrose Paré*. New York, Paul B. Hoeber, 1921, ed 2.
- Papa L, Langland-Obran B, Kallanborn C, Tepas J, et al. Assessing effectiveness of a mature trauma system: Association of trauma center presence with lower injury mortality rate. *J Trauma* 61:261–267, 2006.
- The Lewin Group Analysis of AHA ED Hospital Capacity Survey, 2002, April 2002, 7–18. <http://www.aha.org/ahapolicyforum/resources/EDdiversionsurvey0404.html>. Accessed April 4, 2006.
- The Schumacher Group. 2005 hospital emergency department administration survey. <http://www.tsGED.com/survey2005.pdf>.
- Trunkey D. Trauma. *Sci Am* 249:28–35, 1983.
- Trunkey D. Lessons learned. *Arch Surg* 128:261–264, 1993.
- Trunkey D. A growing crisis in patient access to emergency care. A different interpretation and alternative solutions. *Am Coll Bull* 91:13–22, 2006.
- Trunkey D, Cahn R, Lenfesty B, Mullins R. Management of geriatric trauma patients at risk of death. *Arch Surg* 135:34–38, 2000.
- US General Accounting Office: Operation Desert Storm: Full Army medical capability not achieved. GAO/NSIAD-92-175. Washington, DC, US General Accounting Office, 1992.
- US General Accounting Office: Operation Desert Storm: Improvements required in the Navy's wartime medical care program. GAO/NSIAD-93-189. Washington, DC, US General Accounting Office, 1993.
- US General Accounting Office: Operation Desert Storm: Problems with Air Force medical readiness. GAO/NSIAD-94-58. Washington, DC, US General Accounting Office, 1993.
- US General Accounting Office: Traumatic brain injury: Programs supporting long-term services in selected states. GAO/HEHS-98-55. Washington, DC, US General Accounting Office, 1998.