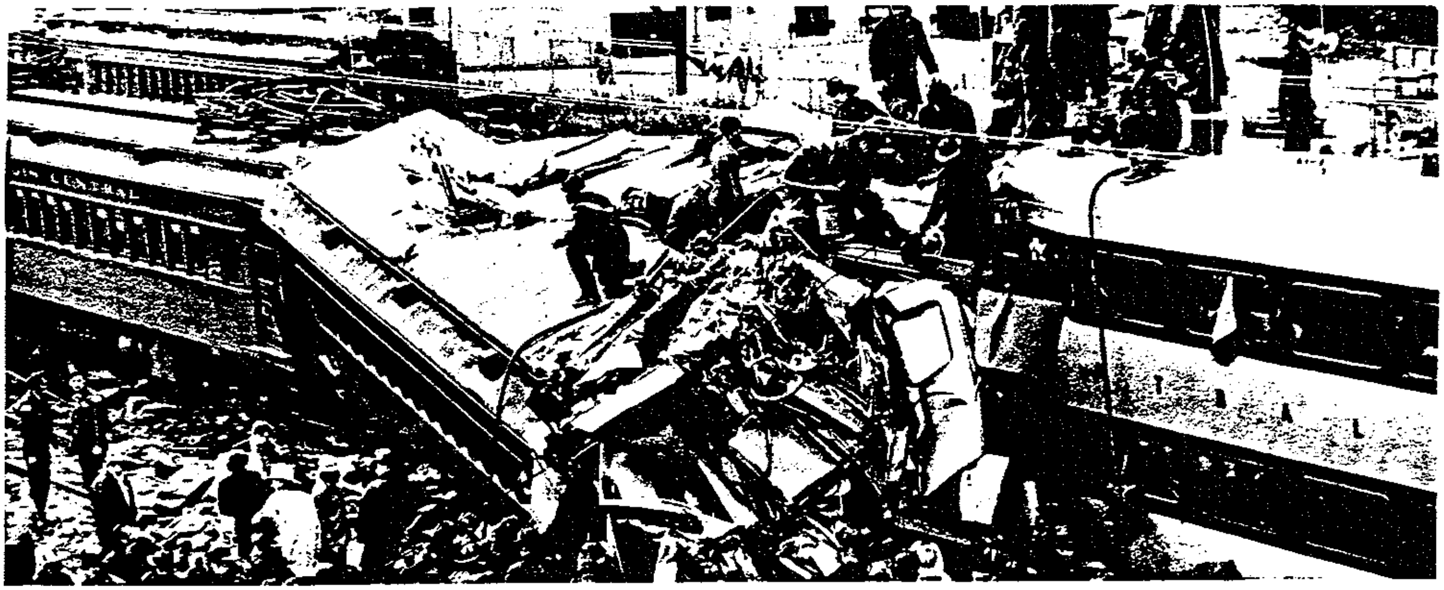
1972

# Care of the injured—



Chicago Sun-Times photo by Pete Peters

# *the surgeon's responsibility*

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**In brief . . .**

*This is the tenth annual Scudder Oration on Trauma, delivered by Dr. Shires October 4, 1972, in San Francisco.*

*Many advances have been made in treating the injured patient but much more needs to be done, is the major theme of Dr. Shires' presentation. Transportation is one of the first priorities and, while the nation has responded in time of war, what is appalling, he points out, is the relative inaction in the organization of emergency services for the seriously ill in civilian life. Another pressing need is for more surgeons interested in management of the severely injured patient.*

*Dr. Shires calls for combining care and research in a single setting, and more rapid dissemination of research results so that the time lag after accumulation of new knowledge is reduced.*

*Calling attention to gains from recent surgical research, Dr. Shires states that more patients are surviving severe injuries than ever before.*

It is a genuine honor to be asked to deliver the 10th annual Scudder Oration on Trauma for the American College of Surgeons. My initial reaction to the invitation to give this oration was similar to that expressed by previous Scudder orators—that is, why me?

Upon reflection, I suppose it was principally because the majority of my professional life has been spent in teaching, practicing, and doing research related to the care of the injured. Several events combined to set me upon this course.

My former chief, mentor, and good friend, the late Dr. Carl A. Moyer, was the one individual primarily responsible for my entering the field of surgery. This brilliant surgical educator was fascinated by the immense challenge presented by the injured patient. His stimulus to work in the fields of injury, burns, and homeostatic responses to injury is well known. At the time Dr. Moyer was my professor of surgery, he was chief of surgery at a large metropolitan, city-county hospital—Parkland Memorial Hospital in Dallas. The

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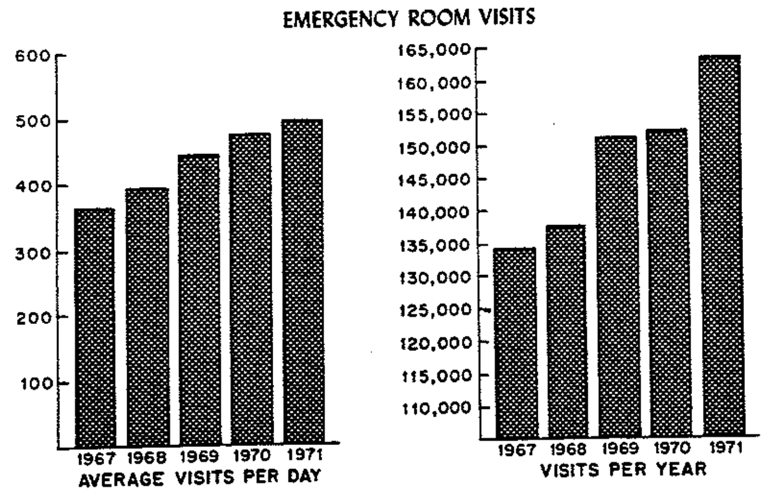


**Figure 1:** average daily and annual emergency department visits at Parkland Hospital, Dallas, Texas

continuing clinical stimulus from training in and, subsequently, as surgical director of a hospital such as this is a very powerful one.

With an abundance of severely injured patients such as is seen at an institution like Parkland, (*see figure 1*), one cannot help but be impressed with the tremendous need for improvements in all phases of care of the injured patient, including transportation, initial care, definitive care, and research toward even better care. The constant increase in the number and severity of serious injuries is truly awesome.

Parkland also affords a unique opportunity by having direct contiguity with the University of Texas Southwestern Medical School. Working with a group of surgeons and surgical specialists interested in rendering better care, including training and research for care of the injured patient, has been a real inspiration. Early dedication to a unified approach to the injured patient resulted in this care being documented by the team of individuals caring for the patient. This experience has been documented in "*Care of the Trauma Patient*" as well as in numerous papers and chapters.[1,5] It has served to promote interdisciplinary cohesion among general surgeons and specialty surgeons.

From this kind of background, training, responsibility, and experience, several impressions have emerged. Severely injured patients present a challenge requiring all of the resources surgeons can command. Because transportation and initial care are critical steps in the management of the seriously injured, expertise must begin as close to the time of injury as possible. Total clinical care of the highest order must be delivered, requiring a really "compleat" physician. All of the skills and knowledge so well developed by surgeons and surgical specialists are not only desirable but necessary to deliver adequate total patient care. More research, research in the broadest sense in relation to all aspects of trauma, is needed. Research should include studies in the delivery of emergency medical services, clinical research for better operative and non-operative care of injured patients, and basic biological research for a better understanding of the mechanisms of response to injury. This, of course, includes both basic as well as "basic applied" research.

Recent Scudder orators have dealt in great detail with some segments of the overall and the specific management of the problems of seriously injured patients. Examples include: Dr. William T. Fitts, who in 1970 discussed delivery of emergency medical services, and "men for the care of the injured".[21] Dr. Rudolf J. Noer in 1968 dealt with a specific and severe injury, that is, injuries to the liver.[35] Last year, Dr. William A. Altemeier dealt with the potent problem of infections and, more specifically, with the needs for continuing biological research into the mysteries of infections in injured patients.[3]

In this presentation I will discuss the challenge presented by the injured patient; the response of the surgeon, including the role and responsibility which is uniquely the surgeons', to the challenge presented by the injured patient; and the emerging needs and opportunities to surgeons of all persuasions to respond to the challenge presented by serious injury.

The problems presented by care of the injured patients might well be expressed as the challenge. This challenge to surgeons may be viewed in double perspective: the historical perspective, which demonstrates that recognition of the problem of proper care of the injured dates back to antiquity; and the enormity of the challenge which has emerged as an unparalleled demand, to the extent that a national environmental health problem is presented today.

The problem associated with providing care of the severely injured is documented well back into antiquity.[34] The contemporary surgical historian, Meade, states, "It is hardly surprising that surgery of a number of parts of the human body had its origin in the treatment of wounds, for in many respects man's environment is a hostile one, threatening him on all sides with insults to the body that is ill-adapted to resist force. Aside from the mute testimony of the remains of our forebears, however, the first actual account of the treatment of wounds is to be found in the Edwin Smith Papyrus.[15] According to Breasted, it was written about 1700 BC, but composed of texts dating back as far as 3000 BC."

The fascinating Smith Papyrus which is now translated and in print, includes the records of 48 cases with discussions of diagnosis, treatment, and prognosis. It is interesting that the earliest scientific document ever brought to life is a treatise on surgery. In his *Great Ideas in the History of Surgery,*[52] Zimmerman states, "This remarkable book was compiled by an unknown author at a time when medicine was magical-religious, when the vocabulary of science had not yet been created, and when the first groping steps in inductive reasoning were being taken. This volume is as logical as a modern textbook in surgery. The text of the Smith Papyrus differs in part only from the other medical papyri so far discovered. It is the oldest in date of origin, and is the only one that deals primarily with surgery. The work describes a series of cases logically arranged, beginning at the head and progressing downward. The more superficial injuries are described first, followed by the progressively more severe ones."

**IN HOMER'S ILIAD,** supposed to have been composed around 1000 BC, an account is given of surgeons extracting arrows and washing the wounds with warm water. According to the late Dr. A. O. Whipple, Frolich claimed to have found records of no fewer than 147 war wounds in the Iliad, and Homer "records each stab with anatomical precision".[34] According to Susruta, who wrote about 600 BC, the ancient Hindus treated wounds of the intestine by applying black ants and exercised scrupulous cleanliness in their operations. Hippocrates, two centuries later, stated that wounds should ordinarily be kept dry, and if they had to be irrigated, the irrigation should be done with pure or boiled water. He gave the first description of primary and secondary healing of wounds as well as signs of suppuration.[34]

With the dawning of the Christian era, Celsus produced his remarkable book *De re medica.*[52] In it he gave instruction for the treatment of extrusion and perforation of the bowel. He advocated suturing the opening and covering it with omentum when the bowel was replaced in the abdomen. In his opinion only wounds of the large intestine could be so treated successfully. He also spoke of ligation of the blood vessels but advised that the ligatures be left long so that they might be brought out of the wound.

Galen also advocated cleaning wounds of blood clots and foreign material. He, too, sutured wounds but he applied an ointment to favor the production of suppuration which he considered necessary to wound healing. Many other physicians of old wrote prolifically on the treatment of wounds, including such respected names as Theodoric and Guy de Chauliac in the 13th and 14th centuries.

**AFTER THE ADVENT** of gunpowder in 1400 AD, one begins to see treatises on treatment of gunshot wounds such as those by von Pfolspeundt and Brunschwig in 1460 and 1490. For all practical purposes the burning oil treatment of wounds was given the quietus by Ambrose Pare in the middle 1500's.[52] Pare's discovery came when he treated large numbers of gunshot wounds in wartime and simply ran out of oil. He applied a bland mixture of his own consisting of egg yolks, turpentine and oil of roses and then coupled such therapy with ligature of vessels. Following the Renaissance many surgeons including Weismann, Purmann, and the great John Hunter introduced many modifications into the handling of wounds. Hunter differentiated between primary and secondary healing; he did not bleed wounds. He believed that bullet wounds should not be explored since suppuration would extrude the bullet or make its location apparent. Hunter's work brought this aspect of surgery really as far as it could go until the introduction of bacteriology in the 19th century.

The development of surgery as it is known today basically began in the 19th century with pioneering efforts of men such as Semmelweiss, Holmes, Pasteur, and Lister.[34] Prior to that time, virtually all surgery involved relatively external trauma and wounds since almost no elective surgery could be successfully done until the development of antisepsis, asepsis, and anesthesia. Nearly all the treatises on the management of gunshot wounds of the abdomen

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advocated, until the 1880's, a conservative management of abdominal wounds. During the American civil war, abdominal wounds were almost invariably fatal. In 1882 Marion Simms began to emphasize the need for laparotomy in the case of abdominal wounds, but even in 1887 the mortality rate in abdominal wounds was still 77 percent. At the beginning of the Boer war in 1889, surgeons in the British army had orders to do laparotomies for abdominal wounds, but the results were so bad that the order was issued to use conservative methods. During the Russo-Japanese war, just 15 years later, conservative treatment was once again replaced by operative intervention. Even at the end of world war I, when operative management was again used, the mortality rate was still 50 percent for penetrating abdominal wounds. In world war II, the mortality rate for abdominal wounds began to fall and ultimately reached approximately 25 percent.[52]

Thus, it can be seen that the story of surgery for trauma, while a lengthy one, has been successful only in relatively recent times. The surgery for trauma has paralleled modern day surgery in that the success of surgical treatment of serious injury did not appear until the 19th century with the advent of antisepsis, asepsis, anesthesia, and subsequently the availability of blood transfusions shortly after the turn of the century.

**SINCE SUCCESSFUL TREATMENT** of the injured patient is a contemporary phenomenon, it is no surprise that the importance of transportation of the wounded is also a relatively recent innovation. For example, the organization of an ambulance corps in the US and the management of ambulance-trains was first ordered by McClellan in 1862, issued, according to the surgeon-general's report, at the insistance of surgeon Jonathan Letterman, medical director of the Army of the Potomac.[16] In world war II, the transport of the injured to battalion aid stations by ambulance or jeep, by ambulance to the clearing company, and finally by propeller-driven aircraft to a railroad hospital, is a remarkable advance. The Korean and Vietnam conflicts have seen further advances in the transport of the wounded through the use of helicopter and jet aircraft.[24]

It is further remarkable that the challenge presented by the severely injured patient has been translated into clinical or basic research of any magnitude only in the 20th century.

The emergence of large series of patients with severe injury managed in a unified fashion has also been a contemporary phenomenon, basically coming only during the latter part of this century. Similarly, the application of basic research methodology to surgical problems has been even a more recent event. Money for basic research, and particularly basic applied research, to the injured patient has become available only in the last 30 years. This is especially interesting in that the appreciation of the problems of the seriously injured patient has roughly paralleled the development of the automobile.

**IN A RECENT APPRAISAL** Dr. Sam Seeley from the National Academy of Sciences—National Research Council brought to the forefront the magnitude of the problem of trauma in a 1966 monograph entitled "Accidental Death and Disability—The Neglected Disease of Modern Society". In this monograph, trauma was termed not only "the neglected disease of modern society", but also "the nation's most important environmental health problem". The magnitude of the problem is staggering. There are currently at least 50 million injuries each year in the United States alone, resulting in 120,000 deaths and almost one-half million permanent disabilities. Serious injury has become the leading cause of death through the age of 36. For every person killed by trauma, 10 to 15 others require hospitalization with the result that accident patients occupy 22,000,000 bed-days per year or approximately one-eighth of the United States total. This number of bed-days is greater than the number required for delivery of all babies born annually, more than needed by all heart patients annually, and four times more than needed for all cancer patients annually.[4]

As pointed out earlier in this past decade by Dr. Robert Kennedy, then director of the field program on trauma of the American College of Surgeons, trauma continues to be looked upon as an unnecessary but permissive killer. It is interesting that the public has held such a fatalistic view of accidents. There are probably many reasons for this view, but not the least of which is the relatively acute or short-term illness frequently produced by trauma as compared with lingering illness from cancer, heart disease, stroke, or other morbid diseases. This is particularly impressive since two thirds of all trauma occurs in young, healthy people in the most productive period of their lives, many of whom suffer or die as a result of accidental injury.

The challenge, then, presented by patients with traumatic injury represents the challenge that is representative of the ultimate aim of all medicine: the challenge is *improvement in patient care.*

Toward this end, improvement in patient care, we might examine the response of surgeons to three distinct challenges: transportation and initial care, definitive care of injuries, and research, both basic and applied.

It is apparent that all responses to the challenge imposed by the severely injured patient cannot be recounted here, or one would be recounting in detail the history of medicine, including the history of surgery as we have sketched it, and the numerous contributions of surgeons.

I have chosen rather to use examples of primary responses and advances by surgeons. It will be obvious that we have drawn primarily from our personal experience since these are the ones we are most familiar with. We also welcome the opportunity to express appreciation to a group of surgeons of all persuasions who are dedicated to better care of the severely injured patient. This includes their work toward improvement of transportation, direct care of the patient beginning with initial care, research related to patient care, and basic biologic research.

**SINCE SURGERY** for wounded patients was grossly ineffectual until the 19th century, the major recorded organized efforts at transport developed shortly after the major advances in surgery, including anesthesia and asepsis. As recounted previously, the US military advances in transportation began during the civil war and received major emphasis during subsequent periods of conflict.

The lag in efforts at better transportation of the injured in civilian life is difficult to understand. Today, more young men die in accidents annually than died annually in any national conflict. It is rather surprising that no unified or coordinated effort to improve transportation of injured in civilian life has been made until just recently. Within the last few years concerted efforts have been started by several groups. One of the pioneers in this effort has been the Committee on Trauma of the American College of Surgeons through Drs. Curtis P. Artz, Oscar P. Hampton, Jr., and others. Sincere and dedicated effort has occurred in other groups, including the National Academy of Sciences, The American Academy of Orthopaedic Surgeons, the Department of Health, Education, and Welfare (Public Health Service), The American Medical Association, and even more recently, the United States Department of Transportation. Several excellent guidelines have recently been published by the American College of Surgeons and the National Academy of Sciences—National Research Council.[2, 3, 16] These are guidelines primarily for improving the delivery of emergency medical service.

This increased effort on the part of many has now culminated in pending legislation which would provide funds for improving emergency medical services nationally. Hopefully, such legislation will be passed allowing communities to be able to implement better emergency services. Some cities, such as Jacksonville, Florida, have established effective systems of emergency medical services on their own initiative,[50] stimulated by the chaotic and unsatisfactory delivery of existing services. These have served as models for other cities, such as Dallas, where ambulance service will soon be delivered by the fire department, with personnel receiving advanced and continuing training by surgeons. As this and other experiences have shown, improvement of delivery starts with an effective ground transportation ambulance operation. The use of helicopters in civilian transportation will probably be limited to transportation of victims who are more than 20 minutes away from treatment centers by ambulance. This, of course, is occasioned by the lack of landing sites in central city, and the need for transportation to heliports even in urban communities. However, as pointed out in 1969 by the Emergency Medical Services Conference at the Airlie Conference, sponsored by the American College of Surgeons and the American Academy of Orthopaedic Surgeons, "much remains to be done in the delivery of emergency medical services".

In our own hospital system, we have concentrated on improving initial care of the patient upon his arrival at the hospital. To this end we have instituted a triage system for initial sorting and management.[44]

The triage system has proved to be a useful technique and involves several component systems. The need for inter-communication, including direct communication between ambulance and emergency department, giving advance warning of the arrival of a seriously injured patient, soon became quite obvious. In

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addition, it became obvious that communication between major hospitals in the city was needed in the event of a large scale disaster, such as a tornado or aircraft crash, which might involve hundreds of casualties. Short-wave communication was established in order to avoid the convergence of multiple patients with serious injuries into one single hospital, particularly one ill-equipped to handle a large volume of major injuries. Direct inter-communicating telephones within the administration of the hospital were installed independent of the switchboard, since switchboard lines frequently become overloaded in time of crisis. In addition, the triage nurse has direct communication into the triage area so that advance notice can be given to specific management areas when necessary.

The triage officers are trained emergency room nurses, who serve in 8-hour shifts, on duty 24 hours per day. The triage nurse has the communications mentioned within the emergency department as well as with the police, ambulance, and with other hospitals.

The Parkland emergency department was divided into five areas for immediate sorting for initial care: surgery, medicine, obstetrics, pediatrics, and minor medicine and surgery, where patients are seen whose initial injuries or illness appear to be ones which will not require hospital admission.

**IN ADDITION** to five areas, other specialty areas are provided for, such as otolaryngology, ophthalmology, urology, and oral, orthopaedic, and plastic surgery. Once injured patients have been dispatched to the surgery section of the emergency department, severely injured patients are placed in trauma resuscitation rooms, which are reserved for initial care and resuscitation of the severely injured patient. All necessary items–such as catheters, tubes, blood sampling tubes, and equipment for suction, oxygen, establishment of assistant ventilation as well as methods for cardiac defibrillation and airway resuscitation are always available so there is no need to send to distant points for supplies. It is also helpful to have available ancillary services, including x-ray, laboratory, and blood bank close to the emergency department.

Upon arrival, patients are immediately categorized by injury into one of three groups: (1) those whose injuries interfere with vital physiologic function, (2) those who have serious injury, but in whom there are no immediate threats to life, or (3) those whose injuries may produce occult damage.

Patients who have interference with vital physiologic function, by and large, have priorities established for airway patency, control of hemorrhage and assessment of neurologic and other body functions. Immediate endotracheal intubation has virtually replaced emergency tracheostomy as the first essential in the management of the severely injured.[44]

One of the lessons learned from the initial care of the injured patient both in civilian and military life has been the multiple advantages to a team approach to the injured patient. One physician must be in overall control of the care of the patient at all times, from the time of his arrival in the hospital. However, with constant use of consultative surgical and other disciplines, the patient can have multiple serious injuries managed simultaneously.

Many advances have been made in the surgical treatment of specific injuries in the last few years. Obviously space will not permit detailed description of all these techniques. However, certain examples serve as a useful description of the increase in awareness, interest, and thoughtful productivity with which surgeons have responded to the seriously injured patient in recent time.

The diagnosis of abdominal injury is an example of recent advances in diagnostic accuracy. While all gunshot wounds and proven penetrating wounds of the abdomen are explored, blunt trauma remains one of the major causes of death from injury. Even when external wounds may be insignificant or absent, the internal injury is often a potentially lethal one. Consequently, techniques are evolving to aid in the diagnosis of serious, blunt abdominal injury. Two such techniques which have been useful have included abdominal paracentesis and abdominal peritoneal lavage.

Diagnosis in the patient with blunt abdominal trauma is frequently complicated by associated multiple system injuries. These may mask signs and symptoms of serious abdominal injury. Diagnostic needle paracentesis has been advocated by numerous authors for many years.[19] If non-clotting blood is recovered from the peritoneal cavity following two or four quadrant taps, the accuracy of the adjunctive procedure has been reported as high as 95 percent in predicting intra-abdominal injury. The chance of obtaining a positive tap seems to be directly related to the amount of blood in the peritoneal cavity. Paracentesis is a simple, quick procedure that has relatively few complications. Whereas abdominal paracentesis is accurate if positive, no information is gained if the tap is negative. The major objection to the use of this test is the high percentage of false negative results.

Because of the lack of reliability attached to negative paracentesis, other procedures have been sought to detect intra-abdominal injury. Canizaro, Fitts, and Sawyer described the use of intraperitoneal saline infusions in animals in 1964.[14] Consistently they recovered blood stained fluid in animals who had had blood injected into the peritoneal cavity and subsequently had negative abdominal paracentesis. Root described the technique of peritoneal lavage in patients in 1965.[40] A follow-up published in 1970 reported 304 patients with a 96 percent accuracy rate. This stimulated an introduction of peritoneal lavage as a supplementary diagnostic technique in the evaluation of patients with blunt abdominal trauma at our institution.[47]

From November, 1970 through May, 1972, 267 patients had peritoneal lavage at Parkland. Peritoneal lavage was not performed routinely on all patients seen with abdominal trauma. A diagnosis and decision as to surgery was usually made by history and physical examination. Patients thought to have unreliable physical findings were further evaluated by two quadrant needle paracentesis. If the paracentesis was negative, peritoneal lavage was performed. Other indications for lavage as outlined in *Table 1* included patients with mild to severe closed head injury or patients with an altered state of consciousness, caused by acute alcoholism, shock, or drug abuse. Patients with spinal cord injuries in whom physical findings were felt to be unreliable, or patients with equivocal abdominal findings, were also lavaged.

Contraindications for peritoneal lavage are outlined in *Table 2*. Patients with a history of multiple abdominal operative procedures were not lavaged for two reasons: adhesions increase the likelihood of penetrating large or small bowel, and lavage fluid occasionally becomes trapped in loculated areas, walled off by adhesions, thus making return of the fluid difficult. The gravid uterus is also a contraindication because of the danger of injury to the fetus. In addition, if the lavage is performed in the upper abdomen, with displacement of the viscera, there is a greater chance of penetrating the stomach, small bowel, or transverse colon. If needle paracentesis was positive, or obvious indications for surgery existed, time was not wasted attempting to further document the diagnosis.

Sixty-four and eight tenths percent of the patients were observed on the basis of negative lavage, and 35.2 percent of the group had exploratory laparotomy. Specific indications for the use of lavage have emerged, and it appears the test should not routinely be used for every injured patient suspected of having intra-abdominal trauma. It is not recommended for gunshot wounds and stab wounds of the abdomen, and gives very little information about retroperitoneal injuries. There were 3.5 percent false positives, 3.1 percent false negatives, and a complication rate of 4.5 percent. This study further demonstrates the reliability of peritoneal lavage as an adjunct in evaluating patients with blunt abdominal trauma.

**Table 1:** indications for peritoneal lavage
- Closed head injuries
- Altered consciousness
- Spinal cord injuries
- Equivocal abdominal findings
- Negative paracentesis

**Table 2:** contraindications to peritoneal lavage
- Gunshot and stab wounds of the abdomen
- Multiple abdominal procedures
- Presence of dilated bowel
- Pregnancy
- Positive needle paracentesis

Pancreatic injury has remained a serious surgical problem since its original description in 1827. Our own experience with modification of surgical management has been interesting.[27] The mortality for penetrating injuries to the pancreas has remained at approximately 20 percent because of associated major vessel injuries. Due to more aggressive management of pancreatic injuries, the mortality for blunt trauma of the pancreas has decreased from a previously reported 37 percent to an overall 16 percent, and to 8 percent during the past five years. Mortality for the pancreatic injury is less than 5 percent. Distal pancreatectomy has been useful for transections of the body of the pancreas, but a Roux-en-Y anastomosis to both ends of the pancreas has been a preferred and satisfactory method of management of the completely transected pancreas in the region of the neck, (*see figure 2*). This has been done to preserve pancreatic tissue and prevent pancreatic insufficiency. It has also been useful in saving time looking for an injured duct in a hemorrhagic pancreas, as well as avoiding injury to adjacent vessels such as superior mesenteric or splenic vessels. Pancreaticoduodenectomy has only been performed for combined pancreaticoduodenal injuries. On rare occasions a Whipple

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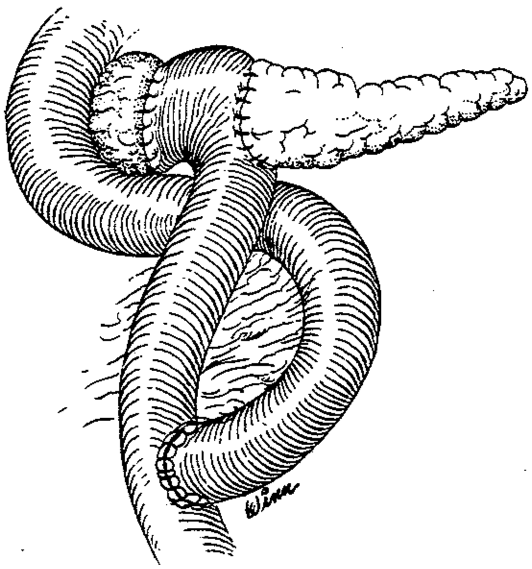

**Figure 2:** Roux-en-Y pancreatico jejunostomy for trans-sectional proximal pancreatic injury

procedure may be necessary for combined common bile duct and pancreatic injury. When the procedure has been necessary, it has been technically quite easy because the extensive damage has already produced hemostasis and most of the dissection.

Several factors have led to an improvement in survival figures for hepatic injuries:[33]

(*a*) Early exploration aided by the use of diagnostic peritoneal tap or peritoneal lavage saves many patients before fatal hemorrhage develops.

(*b*) Optimal amounts of blood and balanced electrolyte solution are used. In addition to massive loss of blood in many of these patients, there is often loss of extracellular fluid, which must be replaced.

(*c*) The use of adequate drainage in every case of hepatic injury, and the cessation of the use of gauze packs to control hemorrhage, greatly decrease the mortality and morbidity from liver injuries. Madding et al noted that the decrease in mortality from liver wounds from 60 percent in world war I to approximately 27 percent in world war II was due largely to the cessation of the use of gauze packs to control hemorrhage and the institution of adequate drainage in every case.[31]

(*d*) Antibiotics are used in all cases of hepatic trauma in order to prevent or decrease the high incidence of infectious complications occurring with this injury. This is particularly helpful when such injury is associated with other lesions of the gastrointestinal tract.

(*e*) Finally, the employment of liver resection for massive liver trauma (*see figure 3*) has reduced the mortality and morbidity from massive liver trauma for several reasons. There is a reduction in the incidence of hemorrhage and hematobilia, which occur frequently when other forms of treatment are used for massive liver trauma. There is more adequate prevention of purulent complications by the removal of necrotic hepatic tissue, better establishment of drainage, and less use of foreign material in the wounds, such as packs or Gelfoam, which tend to prevent drainage and sequester infected necrotic material with the liver. The incidence of biliary fistula, which is often high following suture repair or gauze-pack tamponade, is much lower following resection. This is due to the ligation of separate bile ducts during resection, more effective drainage of the wounds, and less retention of necrotic tissue and foreign bodies in the wound. Since we originally advocated lobar or sublobar resection, the mortality has been reduced from 70 percent to 20 percent in our experience with massive injuries.[48]

Injuries of the major hepatic veins and the intrahepatic vena cava are being encountered with increasing frequency. This increase is explained in part by a greater incidence of high speed vehicular injuries, more rapid transportation of patients to surgical facilities, and more effective resuscitation of such patients who previously almost invariably died before they could be operated upon.

Patients with major hepatic venous or intrahepatic vena cava injury who survive to reach surgery, often die on the operating table from major hemorrhagic or air embolism occurring during attempts to expose the injuries for repair. This is due to the lack of a suitable surgical technique to arrest hemorrhage safely and consistently while simultaneously exposing the injuries to permit repair. Recent experience with hepatic resection for major hepatic injuries by Ackroyd et al,[7] Aronson et al,[9] Donovan et al,[18] Foster et al,[22] and McClelland and Shires et al[32] has indicated a marked decrease in mortality, but even resection treat-

**Figure 3:** right hepatic lobectomy

ment may fail because of inability to quickly control major vessel hemorrhage.

Several surgical techniques to control hemorrhage during repair of these injuries have been suggested. Donovan et al[18] recommended clamping the inferior vena cava immediately inferior and superior to the liver while occluding the portal vein and hepatic artery. Heaney et al have suggested a similar technique by approaching the suprahepatic inferior vena cava through an incision in the diaphragm posterior to the xyphoid process, in addition to clamping the aorta just below the diaphragm to avoid leaking of blood in the lower part of the body. Emergency or elective hepatic resection was subsequently performed and required only 25–30 minutes of vascular isolation of the liver. Certainly, this experience, as well as that of Starzl's during liver transplantation, indicates that vascular arrest in the human normothermic liver may be tolerated for a maximum of about one hour. An additional margin of safety might be obtained using local hypothermia by lavaging the peritoneal cavity at surgery with several liters of saline solution at 4° C.

Prolonged occlusion of the vena cava or aorta, however, may not be tolerated hemodynamically by patients who have profound circulatory defects related to trauma and hemorrhage. A second factor making prolonged occlusion of the suprarenal vena cava or aorta inadvisable is the possibility of compounding renal injury by interfering with renal blood flow in patients with severe hemorrhagic shock.

In order to prevent these problems Schrock et al[41] have recommended opening the chest and placing a large tube through the right atrial appendage of the heart traversing the intrahepatic vena cava. Placement of occlusive tapes around the vena cava and its indwelling tube superior and inferior to the liver would thus permit vascular isolation of the injuries and allow return of venous blood to the heart from the lower body. Although effective, such a shunt has the disadvantages of requiring an immediate thoracic incision, a cardiomyotomy, and manipulation of the hepatic venous injuries before the hemorrhage is controlled.

Emergency use of standard Foley catheters inserted proximally and distally into the vena cava through an intrahepatic venotomy and then connected together to shunt blood around the intrahepatic vena cava has also been effective, in our experience, in achieving vascular isolation of the liver without preventing return of blood to the heart through the inferior vena cava. Though effective, this is somewhat cumbersome and has led us to design a single large catheter for this purpose.[32]

During the past decade, there has been a progressive increase in the incidence of both civilian and military arterial injuries.[37]

Analysis of these results has emphasized several concepts. Since normal peripheral pulses do not preclude serious arterial injury, exploration for proximity to injury has become necessary. The use of synthetic material for vascular repair in these contaminated wounds is no longer acceptable. Successful management of vascular injuries demands the precise application of meticulous surgical technique. Adequate exposure and debridement are necessary before attempting definitive repair. Every effort must be made to insure intimal coaptation and restoration of normal vessel diameter. Careful attention to proper vessel length is mandatory. A search for and removal of intravascular thrombi prior to closure of the vessel will reduce the possibility of early thrombosis. When the extremity is threatened by vascular compression, prompt fasciotomy is necessary. If normal distal flow is not immediately obtained, operative arteriography is indicated. When these concepts are observed, vascular repair can usually be successfully concluded.

The precise application of meticulous surgical techniques of wound debridement and vascular repair has been demonstrated to be essential to success. Arteriographic demonstration of adequate repair and distal flow, and the use of autogenous vein grafts have also proven to be quite useful.

**BURN INJURY** has seen remarkable advances in several areas in the past two decades, especially in initial care and control of sepsis.

An approach to early resuscitation of the burn shock victim has been derived from studies of the serial changes in plasma and extracellular fluid volumes, cardiac output, and acid-base equilibrium in experimental burns.

The results of these studies indicate that the volume of fluid required for optimal maintenance of the functional extracellular fluid volume is only slightly greater than that recommended by currently used clinical guides. However, the most rapid and optimal circulatory responses, and the most consistent prevention of acidosis, were obtained when the entire quantity was administered in the first 24 hours postburn. No additional volume requirements persisted in the patients studied by Baxter.[10]

A balanced crystalloid solution was found to be as effective as colloid solutions in maintaining these parameters in the first 18 to 24 hours postburn. Colloid given between 18 and 30 hours (mean, 24 hours) postburn proved to be more effective in the correction of residual deficits in plasma volume.

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This approach to the resuscitation of burn shock patients has permitted the clear identification of the presence of some factors that limit the effectiveness of fluid therapy. The demonstration of some substance with myocardial depressant activity in the plasma of the experimental burn patient and in the plasma of some of the larger clinical burn patients suggests a mechanism for this lack of response.[11] The persistent rheological changes, as indicated by the increased whole blood viscosity and by an increased platelet adhesiveness, must also play an important role in the residual functional derangements observed in various organs.

At the time of Moyer's first presentation of reduction in sepsis by topical silver nitrate[35], Moncrief[29] had treated almost 200 patients with sulfamylon and neither was aware of the results seen by the other. According to Moncrief, "The study was closely controlled and later limited to a small number of investigators in order to be certain of the results and to preclude an overenthusiastic response. In the light of the success of the technique, and the absence of any serious unknown problems appearing, it would seem that this close scrutiny was well justified. Other workers rapidly confirmed the success of the topical sulfamylon in controlling burn wound sepsis, and the search for additional topical antibacterial agents was widened. Among the earliest to come later on the scene was gentamicin, which was designed specifically against the dominant *Pseudomonas aeruginosa.* Its unrestricted use in such instances has led to the development of resistant strains predominating in the hospital environment, and points up the inadvisability of banking exclusively on a single agent. Other substances are still being investigated, including the silver sulfadiazine complex of Fox and the technique of subeschar installation of antibiotics as practiced so successfully by Baxter."

**MOST HISTORIANS** point out that until the 20th century all surgeons were either wound or barber surgeons, from the 14th through the 18th centuries; or later, general surgeons. At the beginning of the 20th century surgical specialties began to develop. A review of examples of the surgical response to the challenge presented by the seriously injured would be in error if this review did not include examples of contributions by the now well developed surgical specialties. One such example can be seen in a recent quotation from Dr. Charles Gregory[23]: "The general acceptance of open reduction and internal fixation with metallic devices, in appropriate closed fractures, stands in curious distinction to the rejection of the same technique if the fracture is an open one—i.e., compound. In the latter circumstances, internal fixation is viewed with abhorrence by many surgeons. Metal in an open fracture, they argue, is fraught with disaster.

"It can hardly be the metal since present day alloys are virtually inert with respect to inciting a tissue response. And certainly no significant tissue response is anticipated when such metal is used in a closed fracture, which is opened and fixed electively. The difference, then, must rest with the wounded soft tissues, and how they are managed.

"**IF AN ADEQUATE** debridement is done, and if the wound is left open (as it may be even with metallic fixation), or closed primarily without suture line tension or underlying dead space, our present experience indicates there is no greater incidence of infection (perhaps even less) than in open fractures treated without internal fixation. Certainly judgment is necessary but it is a judgment about the wounded tissues, how they should be managed, and how they may be expected to respond."

Walker and Clark have shown that a delay in reduction of facial fractures associated with cerebrospinal fluid rhinorrhea until the rhinorrhea ceases has been a long perpetuated myth.[49] Such delays can last many, many days, make reductions difficult, and cause resumption of the rhinorrhea. Early reduction and secure fixation of facial fractures with an associated CSF rhinorrhea have resulted in a meaningful relief from a prolonged CSF drip and/or the severe complication of meningitis. In management of over 300 patients with multiple middle face fractures and concomitant CSF rhinorrhea since 1956, each of whom had the earliest possible reduction and fixation of his facial fractures, only two developed meningitis. One patient contracted meningitis during the initial hospitalization and treatment of his facial fractures. The other patient recovered from the original injuries and treatment with an early cessation of his CSF rhinorrhea, only to have the rhinorrhea recur a year later followed shortly by meningitis. Both patients survived their infections via appropriate antibiotic and supportive therapy. No patient developed a cerebral aerocele. A less than 1 percent morbidity in occurrence of this severe complication supports the premise that early reduction and fixation of facial fractures associated with CSF rhinorrhea hastens stoppage of the leak and markedly reduces morbidity associated with it.

It is not surprising that basic surgical biological research is a twentieth century phenomenon. This is particularly clear when it is realized again that modern surgery basically had its origin in the 19th century. Many of the pioneers in biological research and surgery have worked almost entirely in the 20th century and include some who have only recently expired. This would include the names of men such as Drs. Alfred Blalock and Carl A. Moyer. Further, some of the pioneers in biological research in surgery are very much contemporaries in modern surgery. This list would have to include such names as Drs. Lester R. Dragstedt and Francis D. Moore.

As in previous discussions of transportation and definitive care, any discussion of surgical research will of necessity have to include only examples rather than a chronological listing or even a collative attempt at advances in surgical research. Consequently, I would like to once again use our experience at Parkland as an example of the type of surgical biological research that is being done by surgeons to meet the challenge presented by the severely injured patient. Some adjunctive or related research will of necessity be included; I apologize for not being able to include many others.

**WE BECAME INTERESTED** in studying body fluid volumes to try to delineate changes in response to the low flow state. During a long series of experiments it has been shown that in severe untreated hemorrhagic shock the response to reduction in blood volume is multifaceted.[43] A reduction in extracellular fluid volume is pronounced in untreated sustained hemorrhagic shock in lower animals and in primates. Subsequent studies demonstrated that the 80 percent mortality of a standard Wiggers shock preparation was reduced to 30 percent when an extracellular mimic was supplied in addition to replacement of shed blood.

A working hypothesis was then necessary to explain the reduction in available interstitial fluid in response to hemorrhagic shock. There is no question that some plasma, or transcapillary, refilling does occur in response to hemorrhage and to hemorrhagic shock. This response, however, is initially rather limited and, in severe hemorrhagic shock, grossly inadequate to explain the reduction seen in interstitial fluid. Since there is no source for external loss, the question arose as to whether interstitial fluid might move into the cell mass in an isotonic fashion.

More recently, we have been studying ion transport across cell membranes in order to determine the possibility of intracellular swelling in skeletal muscle in response to hemorrhagic shock.[13] Using a Ling-Gerard Ultramicroelectrode, intracellular transmembrane potential recording has been done using glass tips with diameters of less than one micron. This electrode has been modified to record intracellular transmembrane potential *in vivo* before, during, and after shock.

Skeletal muscle measurements in acute hemorrhagic shock demonstrate a constant and sustained fall in the normally negative intracellular transmembrane potential. Additional studies show that change in variables such as pH, $pCO_2$, and bicarbonate do not influence the transmembrane potential in shock. Even with progressive metabolic acidosis and its subsequent correction, the potential still follows the blood pressure and the shock state.[13]

The analysis of changes occurring on a cellular level in association with hemorrhagic shock has previously been limited by the lack of techniques for directly assessing the regulatory function of the cell membrane. Current studies utilize the direct measurement of skeletal muscle transmembrane potential and an analysis of fluid and electrolyte content of muscle and directly aspirated interstitial fluid[17] to detect reversible alterations in cell membrane transport occurring in hemorrhagic shock. The data obtained indicate a marked diminution in extracellular water (both total ECW and muscle ECW) and a significant increase in intracellular sodium concentration in association with prolonged and sustained muscle membrane depolarization. These changes are reversible *in vivo* following the institution of adequate resuscitative measures.[45]

**PRESENT STUDIES** indicate the existence of major alteration in cell membrane function in skeletal muscle cells following hemorrhagic shock in animals and in man. Transmembrane potential difference appears to be the most significant indicator of such alterations in membrane function, while changes in intracellular sodium as well as intra-extracellular potassium ratios occur after a period of sustained membrane depolarizations.

The exact mechanism for the production of electrolyte changes, as well as the marked diminution in extracellular water which occurs following hemorrhagic shock, is not known. It appears that they may well represent a reduction in the efficiency of an active ionic pump mechanism or a selective increase in muscle cell membrane permeability to sodium or both. These possibilities seem more likely than a change in a neutral sodium-potassium pump at the present time,[45] (*see figure 4*).

In this modern day of instant travel and instant communication, surgeons have repeatedly shown that research data are often transformed into therapeutic regimens very quickly. Responses to this kind of research have led to different forms of resuscitation for injured

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THEORETICAL TRANSPORT MECHANISMS RESPONSIBLE FOR ALTERATIONS IN P.D. AND FLUID — ELECTROLYTE DISTRIBUTION IN HEMORRHAGIC SHOCK

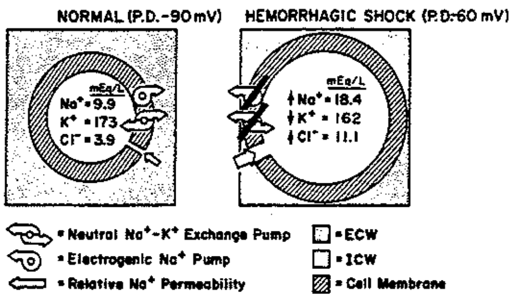


**Figure 4:** theoretical transport mechanisms responsible for alterations in P.D. and fluid-electrolyte distribution in hemorrhagic shock

patients. Detailed reviews of resuscitation in thousands of civilian injuries have been reported with excellent results.[1] Similarly, large numbers of battle casualties have been resuscitated, using newer forms of resuscitation.[30] A review of Vietnam battle casualty resuscitations has led Hardaway to write, "Intravenous blood and fluid administration is the single most important factor in the treatment of shock".[25]

Additional statistics on the mortality rate of seriously injured patients in Vietnam tend to approximate those in Korea (2.5 percent). However, the wounded to killed ratio is 6:1 in Vietnam while in Korea it was 3:1. This dramatically indicates that more patients than ever before are surviving combat injuries.[51]

Further data have shown that post-traumatic renal failure in Vietnam was approximately 1 in every 1,867 amongst all combat casualties, whereas in Korea the incidence of post-traumatic renal failure was approximately one per 200 casualties. Consequently, it is obvious that a number of factors, including rapid transportation, better resuscitation, more appropriate definitive care, and others, have substantially reduced the mortality from serious injury just in the past 20 years.

In addition to reduction in mortality and morbidity including acute renal failure, therapy has also resulted in the emergence of less severe forms of morbidity from injury.[42]

Progressive uremia occurring without a period of oliguria and accompanied by a daily urine volume of greater than 1,000 to 1,500 ml per day is now recognized as the most frequent variant of renal failure occurring in association with trauma.[42] Recognition of this has established the variable severity of renal damage, and has indicated the frequency with which some renal damage occurs as a complication of trauma and shock.

The incidence of high-output renal failure is between 5 and 10 times more frequent than classic oliguric renal failure. Twenty-seven cases severe enough to require special therapy have been observed in 6,500 patients operated for trauma. Many other cases with less severe involvement could be diagnosed, but required no special therapy.

The importance of this clinical entity lies in the fact that it is a milder form of renal insufficiency representing a spectrum of renal damage in response to trauma; and that realization of its presence by serial measurements of blood-urea nitrogen, potassium, $CO_2$ combining power, and chlorides permits intelligent chemical and fluid management with a much greater latitude because of the large daily urine-volume excretion.

The most frequently encountered complication with this type of renal failure is hyperkalemia induced by the routine postoperative administration of potassium. As little as 20 to 40 mEq of potassium per day may rapidly produce myocardial potassium intoxication requiring emergency hemodialysis. Maintenance of fluid volumes involves replacing the large volume of urine with 5 percent dextrose in water, and with accurate replacement of all other fluid losses with fluids of appropriate sodium concentration and anion composition. Acidosis is easily controlled in most cases by the anionic content of administered fluids in accordance with the fluids lost via extrarenal routes.

The mean values for the typical clinical course of these patients are shown in *figure 5*. There is mounting azotemia for a mean of 10 days with progressive decrease toward normal for the next 10 to 12 day period. The azotemia is accompanied by urine volumes which generally increase daily, reaching their height at the peak

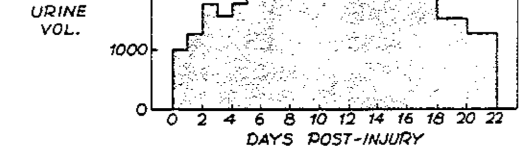


**Figure 5:** typical course of post-traumatic high output renal failure

of the azotemia, and then gradually returning to a normal range.

The spectrum varies from very mild elevations of blood urea nitrogen of 50 to 70 mg percent up to severe azotemia of 240 to 250 mg percent urea nitrogen. The wide spectrum of the severity of damage in this type of renal failure suggests that it is a less severe form of a similar process which produces oliguric renal failure.

The analysis of these cases has revealed that the syndrome is more likely to appear in association with severe injuries (with average blood losses of 5,000 cc).[42] The average recorded time in shock was 2 hours and 30 minutes, sufficient time to produce severe renal damage. A variety of anesthetic agents and techniques were employed, and there was a notable absence of detectable transfusion reactions. Regional hypothermia was employed in the severe or prolonged cases of shock. Drug administration was limited to the use of a variety of antibiotics with no consistent pattern of administration.

The mortality rate in this group of patients was 18.5 percent as opposed to the extremely high mortality for oliguric renal failure. The causes of death were thought to result from complications of the injury and were, in general, not related to the renal failure. However, deaths from infection constitute the most frequent cause of death in oliguric renal insufficiency.

**THIS TYPE** of failure is not specific for traumatic injury. It has been observed in association with elective surgical procedures, in nonelective surgical illnesses usually involving infection or shock, and with the administration of nephrotoxic agents. The increased recognition of this entity has resulted in the implication of many nephrotoxic factors which produce or occur in association with some degree of renal damage.

The occurrence of this lesion in the trauma patient, where it has replaced oliguric renal failure as one of the most common complications of injury, indicates that more complete restoration of fluid-volume and blood-volume deficits and more efficient surgical management of trauma attenuate the severity of damage inflicted upon the kidney.

The question might logically be asked, has renal failure been reduced and modified only at the expense of the production of pulmonary failure in response to injury? Initial reports indicated some pulmonary deaths following serious injury. Many investigations are now being made into the pulmonary responses seen following severe injury. Several facts have emerged: (a) There is a wide spectrum of pulmonary dysfunction seen in the patient population following injury. (b) The spectrum varies from absence of pulmonary involvement to a relentlessly progressive form of lung failure. (c) The rarity of progressive pulmonary failure has been demonstrated by studies carried out in Vietnam by several investigators.[12, 38, 39, 46] In almost all cases there is a definable cause for pulmonary dysfunction when present. The causative factors include sepsis; occult direct pulmonary injury; gastric content aspiration; head injury; and pulmonary microembolism, including fat, multiple transfusions, etc. Other causes, and specifically a direct response to shock and injury, seem to be even more remote.

The occurrence of pulmonary complications from truly non-thoracic trauma, in a recent prospective civilian injury series, indicates the incidence of pulmonary dysfunction, of any degree and from all causes associated with severe injury, to be less than 5 percent.[26] In this prospective study of over 948 severely injured patients the overall mortality was 2.5 percent. There were three deaths attributable to progressive pulmonary failure alone out of the 948 patients, an incidence of 0.3 percent.

The use of the parenteral route for nutritional supplementation when oral or tube feedings into the gastrointestinal tract cannot be given, has been tried for several decades but until recently has fallen short of expectations. Recently Dudrick, Wilmore, Vars, and Rhoads[20] have demonstrated the clinical practicability of providing complete nutritional needs for an extended period of time using high caloric parenteral feedings. Parenteral hyperalimentation involves the continuous infusion of a highly concentrated solution containing carbohydrates, proteins, and other necessary nutrients through an indwelling catheter inserted into the superior vena cava. In order to obtain the maximum benefit from parenteral therapy, the ratio of calories to nitrogen must be adequate (at least 150 kcal per gram of nitrogen) and the two materials must be infused simultaneously. When the source of calories and nitrogen are given at different times, there is a significant decrease in the utilization of nitrogen. These nutrients can be given in quantities considerably higher than the basic caloric and nitrogen requirements, and have proven to be highly successful in achieving growth and development, positive nitrogen balance, and

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weight gain in a variety of clinical situations. Unfortunately, intravenous hyperalimentation has not yet been shown to reverse the early catabolic response to surgery, trauma or sepsis, although it has proved effective in minimizing the level of negative nitrogen balance.

The principal indications for the use of parenteral hyperalimentation are found in seriously ill patients suffering from malnutrition, sepsis, surgical or accidental trauma when the use of the gastrointestinal tract for feedings is not possible. The safe and successful use of this regimen requires proper selection of patients with specific nutritional needs, experience with the technique, and an awareness of the associated complications.

In summarizing these findings arising from research by surgeons, it seems fair to say that more patients with severe injuries survive now than ever before. It also appears that as even more patients survive, a different form of body response to severe injury will be observed. Certainly, this appears to be the case with the disappearance of acute renal failure of the oliguric variety, and the appearance of a pulmonary response of multiple etiology in the severely injured patient.

Lastly, we should look at what is still needed in the management of patients with serious injury. To one who has worked in this field for many years, the challenge is quite clear. It is just as clear that this challenge is growing. The response by surgeons, and almost by surgeons alone, has been surprisingly good. However, the challenge increases and much more response is needed. To dissect what is still needed, we might reconsider the several aspects we have discussed.

It is quite apparent that transportation is a vital necessity in moving the seriously injured patient to a place of definitive care as effectively as possible. It is clear that the challenge in times of national conflict has been responded to quite well by the military as exemplified in the remarkably low morbidity and mortality rates for the seriously injured in the recent Vietnam conflict. What is appalling is the relative inaction in the transportation and organization of emergency services for the seriously injured in civilian life. As Dr. William T. Fitts pointed out in detail in his 1970 Scudder oration, the need and the challenge for improvement in transportation and care is quite clear. It is also true that many agencies are working very hard to bring about improvement in this area. Clearly outstanding in this area of need is the requirement for more and better trained persons.

One of the most pressing needs in the care of the injured is more surgeons, specifically more interested surgeons with more and better training in the management of the severely injured patient. It is no secret that care of the trauma patient is an inconvenience to the individuals concerned with his care. There is nothing elective about the time, place, or magnitude of serious injury. Many injuries occur at night, or at times which interfere with elective schedules. Consequently, the availability and concentration of talent with interest and experience to care for the injured patient becomes an even more pressing necessity.

It is apparent from the sparseness of surgical biological research so far this century that far more needs to be done in the area of basic biologic research. Surgeons are, and should continue to be, captains of the teams of biologic research directed toward response to injury. Only in the past few years has the involvement of basic scientists begun to be significant in the search for answers to the biologic response to

**Figure 6:** trauma research unit funded by the National Institutes of Health, Institute of General Medical Sciences

injury. It has not been fashionable for a basic scientist to have as his major arena an area such as surgery which is not within his basic discipline. However, with the increased use of joint appointments and continuous stimulation by the surgeon, basic scientists should be encouraged to lend their talents to the solution of biologic problems.

Research into the care of the patient is a multi-disciplined approach. Better care will result in better delivery of emergency medical services, better organization of talented and interested persons; better utilization of the emerging principles of intensive postoperative care, and more stimulation to interest surgeons in trauma as a primary discipline within surgery.

Research for care and basic research can be combined in a single setting, (*see figure 6*). A few such centers have been funded by the National Institute of General Medical Sciences of the National Institutes of Health, and it is fair to say that from the limited support and trained personnel available some success is being experienced.

Care and research combined in a single setting provide direct benefits to a given patient. One of the most unusual features is the availability of research data being gathered on a patient for immediate use in the improvement of care of the same patient. To be sure, data gathered from many patients are of value in over-all improvement of knowledge for the care of every patient. It is also apparent that research data obtained acutely in the injured patient have not been previously available in any significant volume.

It is a prerequisite to good patient research that the baseline for any studies must include the highest quality of clinical care which can be provided. In order to provide such quality care, additional specialized training must be given to all who are concerned with the patient's care. In many cases, this has already resulted in a high degree of sophistication of training for nurses, house staff, students, and staff concerned with the care of the injured patient. The setting of trauma research and care units has resulted in intimate interchange of ideas and knowledge among various disciplines. Involvement of the basic scientists, with their own expertise and knowledge of problem-solving in different disciplines, is also being accomplished.

Rapid dissemination of research results quickly follows data gathering, so that the lag time from accumulation of new knowledge to dissemination of such knowledge is greatly reduced.

It has been interesting to note that research and care delivered in such a fashion has begun to impart an awareness of and an appreciation for the complexity of the illness caused by trauma. Thus, the need for detailed study of the patient and his responses, including physiological and biochemical, at all levels, including tissue and cellular, is becoming clearer. Reduction of death and disability from trauma is beginning to achieve respectability as a major discipline involving all areas from total patient care to alterations within a single cell.

To summarize the needs, Dr. Edgar Lee, Jr.[28] has written "Surgeons cannot go it alone in this matter even though the central clinical problems are surgical. Wishful thinking and telling each other how important our work is will not make support appear. Only a dogged and clever multiple approach campaign for funds reinforced by more requests for research by well trained people will stimulate the support".

Certainly our own embryonic experience with a trauma research unit in Dallas has convinced us of the need for more general support. In the past five years we have trained more than one surgeon per year who has returned to full-time trauma care and research. The demand for positions exceeds the ability of the few trauma research units to accommodate. Additional stimuli are needed to attract more surgeons into the trauma area as a career. Such stimuli should be imaginative and include projects such as demonstration grants, contracts, construction grants, training grants, and research support. The task of convincing foundations, congress, and even the National Institutes of Health has only begun. It will only be continued by surgeons.

It should be obvious from this review that tremendous needs and unlimited opportunities for real advancement and achievement in the care of mankind are in the field of trauma. Surgery began as surgery for trauma. Surgery as a discipline may well end as surgery for trauma, and little else. To quote Isidore Cohn, Sr., "Where else save in the romance in the field of trauma is there such an example of man's humanity to man?"