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Advances in the Care of the Multiple Trauma Patient—Introduction

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Twenty years ago, one of the great fears of the surgeon managing the patient with multiple trauma was the development of the fat emboli syndrome and subsequent death of the patient. An alternate set of fears was the development of pulmonary thromboemboli, undiagnosed hidden bleeding, or intracranial hematoma with sudden death. Many patients who did not develop these problems lingered on for prolonged periods having complication after complication, to die completely emaciated 2 to 3 months after their accident. No one who lived through that period can forget the complete hopelessness that evolved day after day in the management of a multiple trauma patient who did not quickly get well and developed "complications."

The history of the development of improved care for the multiple trauma patient may be briefly recapitulated as follows. In the early 1800's, Napoleon's surgeon, Larrey, introduced the concepts of ambulances and progressive levels of care that are now generally utilized. Billroth, from his experiences in Zürich (1860–1887), stated, "Of 93 patients with open tibia fractures, 57 healed and 36 died. Of 16 patients with open femur fractures, 6 healed and 10 died. Of the 93 tibial fractures, 28 were amputated and 65 were treated in plaster with minimal débridement. Of these 65, 15 died of wound infection. In the 28 amputations, there were 20 deaths and only 8 healed." In the First World War, an open femur fracture was associated with an 80% mortality rate until the Thomas splint was introduced, at which time the mortality rate promptly dropped to 10%, probably because of better control of blood loss. Shock research began during the First World War and gave convincing evidence of the importance of blood volume deficit as a main causative factor in post-traumatic shock. However, various concerns about toxins kept this from being generally accepted. In World War II, Grant and Reeve and the group of Beecher and Simeone again stressed the importance of blood volume deficit in shock. At this time, a few units of plasma-derived protein, a little whole blood, and some saline were usually given for volume resuscitation.

During the Korean War, there was once again a vigorous shock research team at work under John Howard's direction. Nonetheless, the major problem in the Korean War was oliguric renal failure from delayed and inadequate volume resuscitation due in major part to delayed transport. It was not until the Vietnam War that the volume requirements for circulatory resuscitation were properly understood and a rapid helicopter transport system was developed. This understanding was greatly facilitated by the work of Shires. The consequent reduction in the duration of the physiologic insult was probably of equal importance to survival, as is emphasized by Messmer elsewhere in this symposium.

The problems with the lungs in the post-traumatic period were largely known only from post-mortem studies until the early 1960's, because it was clinically impractical to obtain blood gases. The blood gas machine utilized today was not described until 1957, and was not in common clinical use until the end of the 1960's. Positive end expiratory pressure (PEEP) (as a therapeutic manoeuver as soon as any signs of impending pulmonary failure become detectable) was not described until 1968 by Ashbaugh et al. Until the mid-1960's, the only ventilators in

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volume and cycle time that largely required general anesthesia for use. The use of a ventilator at that time was so reliably associated with death that there were many papers on the damage done to the lung by the ventilator. It was in the late 1960's that dependable volume cycled ventilators with versatile control systems became available.

In 1968, intravenous hyperalimentation was first described by Dudrick et al. There were then many years of argument as to whether nutritional support in the surgical patient was important or not. The work of Border and associates on multiple systems organ failure suggests that many of the patients who died of "complications" in fact died of protein malnutrition.

Basic attributes of the wound infection problem were not generally appreciated until the 1970's. Even now such a discussion usually revolves around how the bacteria got into the wound, and there is little discussion concerning the deterioration of host defense (MacLean, this symposium) and of the retained necrotic tissue that supports the bacterial growth. Clearly, the problem with Billroth's open tibia fractures was his minimal "débridement." A much better descriptive term is *wound excision.*

The modern operative treatment of fractures began in the early 1960's as a systematic endeavor, but required several years of incubation to become accepted on a widespread basis (Tscherne and Allgöwer, this symposium). No real "invasion" of the United States and Canada began until the 1970's. Even then, it was necessary to train a whole new generation of surgeons who truly appreciated soft tissue as well as fracture management, before the principles of operative fracture management could be properly applied.

Evaluation of the multiple trauma patient in any organized way was quite impossible until the advent of the various injury severity scores, which began in 1971 and which did not become generally useful until the late 1970's (Champion, this symposium).

Until the mid-1970's it was generally thought that, on the night of admission, the multiple trauma patient should have only the surgery that was required to save life and limb. The patient was thought to be "too sick" to undergo any further surgery. There was only slight appreciation that fracture management had anything to do with the cardiopulmonary metabolic failures of which the patient later died. As a consequence, the fractures were managed by plaster and traction in almost complete isolation from the rest of the problems of the patient.

In addition to all of the preceding problems, there was a lack of appreciation of the need for organization in the care of the multiple trauma patient. As a result, such patients were—and in many cases still are—delivered to the nearest hospital. Whenever such a patient was delivered, the medical facilities of the receiving hospital were often overwhelmed and the delivery of good organized care was a rarity. A few ideally located hospitals received a sufficient volume of multiple trauma cases to be able to dedicate the resources in hospital personnel, equipment, and money required to provide organized care to the multiple trauma patient. In the early 1970's, Boyd and Cowley began to cry out that the care of the multiple trauma patient could be vastly improved simply by organizing the delivery system so that selected hospitals received a sufficient volume of multiple trauma cases in order that a proficient trauma care team could be developed and supported (see their article in this symposium).

Concurrent with these advances has been other progress. The computed tomographic (CT) scanner, which came into common use in the 1970's, now makes precise diagnosis of intracranial brain injuries possible (Bakay, this symposium). It also provides much more precise anatomic diagnoses for vertebral, acetabular, and even mediastinal and pancreatic injuries. The CT scanner, by largely removing concern about the undiagnosed brain injury, has been absolutely essential to modern operative treatment of the multiple trauma patient. At the same time, advances in angiography allow a much more precise diagnosis of injuries to the vessels in the extremities, pelvis, and even the retroperitoneum and aorta. The angiographer may even at times, by interventional radiology, occlude bleeding vessels for the trauma surgeon.

The simple concept of peritoneal lavage as originally proposed by Root et al. in 1965 has spared uncounted trauma patients an unnecessary operation. More importantly, it has reduced the time to surgery in those who do need surgery. Shaftan (this symposium) has made major contributions in advancing our understanding of the limitations and strengths of this diagnostic tool.

In the 1950's, the recovery room developed largely because of muscle relaxants. In surgery, the intensive care unit was an outgrowth of what became a progressively more extended recovery room. This also occurred largely in the 1960's and was essential to developing and applying the newer concepts of physiology and biochemistry to severely injured patients.

"Conservative" treatment of fractures by plaster and traction leads to a very unnatural state in which the body is largely immobilized in the enforced supine position. Because it does not really immobilize the fracture, it also becomes a continuing source of pain. Finally, such treatment leads to a state in which large hematomas, crushed muscle,

and devitalized fat are left in place to be reabsorbed by phagocytosis and endogenous body processes. Phagocytosis releases a number of factors that actively influence body temperature and metabolism. The factors are named for their bioassay and thus have different names, but physical characterization suggests that the different names apply either to the same substance or a closely related group of substances. The names utilized are endogenous pyrogen, leukocyte endogenous mediating factor, and lymphocyte activating factor (Hassett, this symposium). The most essential point is that "conservative" treatment of fractures in the multiple trauma patient has continuing bad effects upon the heart and lungs by virtue of the enforced prolonged supine position, and upon metabolism by virtue of continued pain and tissue damage and the need for large volume phagocytosis to clear the necrotic material present. The second essential point at the time (mid-1970's) was that the fractures could be stably fixed with alleviation of several of the bad effects of conservative management.

These various concerns led in the mid-1970's to a new plan for the operative management of the multiple trauma patient. It began with the traditional life and limb (includes open fractures) saving endeavors and was followed by operative repair of the fractures, provided there was continued good cardiopulmonary function and blood clotting. The operative repair of the fractures began with the femurs, because these contained the largest volume of necrotic material (blood) and their nonoperative management most interfered with pulmonary function and the nursing care of the patient. After the femur fractures, other fractures were operated upon. After surgery, the patient was supported by a ventilator with PEEP until he or she proved that it was not needed. The day after surgery the patient was begun on intravenous amino acids. The plan was that he or she would be on full nutritional support, preferably via the gastrointestinal tract, by 4 to 5 days since there was good reason to believe that this would reduce the gastrointestinal stress ulcer–hepatic failure problem and even minimize the bacteremia endotoxemic problems.

We were startled by the success achieved. In Buffalo, as well as in Basel, we saw a virtual cessation of the need for prolonged ventilatory support except for specific diagnosis such as gastric aspiration, smoke inhalation, or pneumonia. The results were so clear that controlled trials were thought to be unethical. These results have now been substantiated by the published results of Riska et al. in Helsinki, Meeks et al. in Vancouver, Wolff et al. in Basel, Rockwood in San Antonio, and Goris in Niemegen (this symposium). They have also been substantiated by many personal reports, of which the experience of Hansen in Seattle is particularly convincing. In Meeks' series of cases treated largely in the newer way discussed, the results showed 1 death in 22 cases while classical management of the fractures resulted in 14 deaths in 49 cases. These cases were largely randomly assigned to the different therapies and had equal average age management programs and injury severity scores. A study of Goris is reported in this journal. When applied to patients with an injury severity score greater than 50, this study shows similar results, in that the group of patients treated with early internal fixation of the fractures had 2 deaths in 28 cases from late sepsis, an incidence of the acute respiratory distress syndrome of 26%, and a mean duration of ventilation of 6 days, while classical treatment of the fractures was associated with 6 of 11 late sepsis deaths, an incidence of the acute respiratory distress syndrome of 82%, and a mean duration of ventilation of 26 days.

It is clear that we can no longer permit the fractures in the multiple trauma patient to be managed in isolation from the ventilatory and nutritional support since all of those factors interact. It is of top priority in the multiple trauma patient that the femur fractures be managed by stable fixation within a few hours of injury. Open fractures occur mostly in multiple trauma patients. Infection is best prevented and resisted by stable fixation while the possibility of survival is greatly enhanced. It is of great importance that open fractures be stably fixed within a few hours of admission.

The preceding changes in the care regimen clearly enhance the survival of the multiple trauma patient while also reducing pain, the cost of hospital care, and the length and degree of disability.

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