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Trauma medicine is both one of the oldest and the most recent medical specialties. Egyptian hieroglyphs and ancient Greek texts record a history of wound management, including fractures, amputations, dislocations, lacerations, and penetrating trauma [1]. Worldwide, the care of the wounded has advanced as a consequence of military conflicts throughout history. However, formal Trauma Surgery fellowship training and guidelines for civilian trauma systems have only been established since the 1970s in the United States, and even more recently elsewhere.

Wide disparities exist in the availability of high-level civilian trauma care, especially between rural and populated areas [2]. Average field-to-hospital transport times can range from several hours in remote locations, to 10 min in urban centers [3]. Additional disparities in trauma care in the United States have been associated with racial background and insurance coverage [4]. Despite the influx of experienced military physicians and nurses into the civilian trauma system [5], recent reports describe an impending critical shortage of adequately trained trauma personnel [6].

Different regions manage trauma patients differently, particularly with respect to pre-hospital care, but also with in-hospital organization. In some systems, primarily European, the initial

strategy is to bring the hospital to the patient [7]. Specially trained physicians staff ambulances and endeavor to stabilize trauma victims in the field utilizing advanced medications, monitoring, and procedures, and then accompany patients during transport to the most appropriate hospital.

In other locales, typically in North America and the UK, the goal is to bring the patient to the hospital as quickly as possible. Emergency medical technicians perform basic first-aid only and paramedics are ACLS trained, but the primary goal for both is to expedite transport to the nearest trauma-designated hospital for definitive care, the so-called scoop and run directive.

The debate regarding which pre-hospital strategy is superior may be unnecessary. Although direct comparisons are difficult due to the complex nature of comprehensive trauma care, either system appears to yield similar outcomes when applied capably [8]. Given the chaotic nature of trauma, any system is better than an improvised and disorganized approach. Patients benefit from a well-planned and competently implemented trauma system [9], which clearly will always perform better than a poorly planned, ineffectively implemented system.

In regions where “scoop and run” is the prevailing strategy of pre-hospital trauma management, urban trauma victims are able to be transported more quickly than rural victims [10]. For equivalent injury severity, mortality increases as transport times become longer. However, if a rural trauma victim survives an

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extended transport and arrives alive at a designated trauma center, subsequent survival is nearly equivalent to those transported rapidly from an urban area [3].

Once at the hospital, there may be differences in the prevailing system and organization of services. In some systems, patients are admitted to a specialty Trauma Service whose surgeons are trained to perform nearly every relevant procedure from orthopedic repairs to simple neurosurgical decompression. Other systems admit patients to a dedicated Trauma Service [11] where they are managed by trauma-fellowship trained general surgeons who manage and coordinate overall care, and perform most intra-abdominal procedures, simple amputations, and wound debridements, but consult specialists (who often operate concurrently) for neurosurgery, complex orthopedic, thoracic, ENT, vascular, and plastic surgical procedures. In yet other systems, patients are admitted to an established non-trauma surgical or even a medical service, depending on the patient's primary issue (e.g., orthopedics or neurosurgery), and the trauma service provides consultant advice. Outcomes appear to favor a trauma service being an admitting, rather than consultative service [12].

The American College of Surgeons (ACS) Committee on Fractures and Other Trauma was established in 1939 by merging two existing committees: the Committee on Fractures, which was notable for standardizing emergency splinting in the field, and the Committee on Industrial Medicine and Traumatic Surgery. In 1950 the name was changed to the Committee on Trauma (COT). In 1954, with the emphasis still on managing fractures, the committee published the manual *Early Care of Soft Tissue Injuries*, which was maintained with revisions until 1972, when it was replaced with the manual *Early Care of the Injured Patient*. The first version specifically directed at hospital trauma centers was *Optimal Hospital Resources for Care of the Injured Patient*, which was released in 1976. In 1980 the "Advanced Trauma Life Support[®]" course was introduced, with revisions every 4 years to date. Trauma Center verification was

first offered in 1987, and the National Trauma Data Bank[®] was initiated in 1989.

As originally formulated, the focus of the ACS/COT was training physicians to manage acute trauma, and specifying for hospitals the resources necessary for managing trauma patients. Over time the emphasis has broadened, with the objectives of developing comprehensive, inclusive trauma systems and coordinating resources and training to encompass pre-hospital treatment, transport, triage, acute and subacute in-patient management, and rehabilitation. Community education, injury prevention, research, and quality improvement are also important.

Over 60 countries utilize guidelines and specifications set out by the ACS/COT for the acute management of trauma patients, certification of trauma centers, and organization of trauma systems. ACS/COT publishes and revises a manual of standards for trauma care, *Resources for Optimal Care of the Trauma Patient*. In the United States, ACS/COT verifies regional hospitals in most states for trauma center designation and certification. In some regions, state or local officials verify trauma centers. Typically, their requirements are similar to those specified by the ACS/COT [13].

Adherence to the outlined standards appears to affect survival. In a retrospective study evaluating trauma care compliance at a Level-I center using 25 evidence-based or expert consensus panel recommendations, for each 10 % increase in compliance a 14 % reduction in risk-adjusted in-hospital mortality was observed [14].

The ACS/COT describes four levels of adult and pediatric trauma centers: Level I—most resources to Level IV—least resources. There are separate requirements for burn centers. In the most recent revision of standards, with emphasis placed on trauma systems organization, separate considerations are given for rural and urban systems. In an urban region with adequate Level I capacity, numerous Level II centers may not be necessary.

A Level IV hospital is always located in a rural or remote area. It must provide 24 h physician coverage and initial resuscitation and assessment prior to transfer to a higher-level facility.

Well-defined collaborations with higher-level trauma centers, including expedited transfer protocols, are critical.

Level III facilities are typically rural and, like Level IV, must have active collaboration and transfer agreements with higher-level facilities. A Level III facility would be considered capable of assessing, stabilizing, and treating a majority of traumatic injuries. General surgeons must be available 24 h/day, and able to be at the patient's bedside within 30 min of the patient's arrival. A Level III trauma service must have a surgical director, and maintain a Performance Improvement and Patient Safety (PIPS) program. Level III centers are not required to have available advanced radiology, blood bank, laboratory, orthopedic, or neurosurgical services.

Level II and Level I centers are nearly identical in terms of the resources available to trauma patients. The main difference is in how immediately certain resources are available. In addition, Level I centers perform research, and serve a leadership role in the regional trauma system, providing organization, and education.

Despite similarly available resources, outcomes for equivalent trauma appear to be better at Level I centers, compared to Level II centers. In a multivariate-adjusted retrospective analysis of the National Trauma Data Bank[®] statistics, patients suffering the most severe injuries were more likely to survive if treated at a Level I center compared to a Level II center. Even among survivors, those treated at Level II centers had worse functional outcomes. The same study investigated the effect of trauma volume on outcomes. Interestingly, there was no survival benefit for patients brought to high-volume centers at either Level [15].

A Level II trauma center in an urban area may be a complementary facility to a nearby Level I center, transferring high-acuity patients to the Level I facility for interventional radiology, advanced orthopedic, vascular, thoracic, neurosurgical, or intensive care when these are needed, and accepting lower acuity patients from the Level I facility if the Level I capacity is overwhelmed. In a rural area without nearby Level I care, a Level II trauma center may

function as the regional leadership facility of the rural system of Level III and IV centers, providing organization and education [16].

Highlights of features common to Level II and I trauma centers include:

- A trauma surgeon on call at all times.
- All general surgeons and Emergency Medicine physicians on the trauma team are ACLS[®] certified.
- Trauma team members fulfill trauma-related Continuing Medical Education (CME).
- Neurosurgical care is promptly and continuously available.
- Orthopedic care is promptly and continuously available.
- Attending physicians involved in trauma care are board certified in their specialties.
- Radiographs and CT scans are available at all times.
- Catheter angiography and sonography are available at all times.
- Critical care services are available for trauma patients
- Intracranial pressure monitoring is available.
- Respiratory therapists are available at all times.
- Laboratory and Blood bank services are available at all times.
- Social workers, and Rehabilitation Medicine are available.
- Speech, Physical, and Occupational therapy are available.
- A trauma registry is maintained and submitted to the NTDB[®].
- The center has an active PIPS program.
- The center engages in public and professional education, including injury prevention.
- The trauma center is prepared for disasters.
- The trauma center is able to procure organs for transplant.

Additional requirements for a Level I trauma center include:

- A general surgery residency program with a trauma rotation.
- Cardiac surgery and cardiopulmonary bypass capabilities.
- Microvascular and replant capabilities.
- In-house CT technician always available.

- MRI available.
- Acute hemodialysis always available.
- Operating room and personnel immediately available at all times.
- A surgical ICU physician in-house at all times.
- A surgically directed and staffed ICU service.
- $\geq 1,200$ trauma admissions/year.
- ≥ 240 patients, or >35 patients/surgeon per year with Injury Severity Score (ISS) > 15 .
- Ongoing research with academic peer-reviewed publication.
- Extramural presentations at educational or research conferences.
- Participation in ATLS[®] training.

Separate requirements in *Resources for Optimal Care of the Trauma Patient* are specified for Pediatric trauma and Burn centers.

Requirements Specifically Related to Anesthesiologists

At all levels of trauma centers, an anesthesiologist is designated as a liaison to the trauma service. This individual should have experience in trauma anesthesia, and a commitment to education and performance improvement. The anesthesiology representative to the trauma program must attend at least 50 % of the multidisciplinary peer review meetings.

Furthermore, at all levels of trauma centers, anesthesia services must be promptly available for all emergency operations and for managing airway problems. Responsibilities assumed by anesthesiologists extend beyond the operating room and may include invasive monitoring, line placement, resuscitation, and pain management.

At Level III centers, a CRNA may be the sole on-call provider, while at Level I and II centers the anesthesiologist of record must be a board-certified attending. For Level I centers, anesthesiology providers must be in-house 24 h/day. When a senior resident or CRNA fulfills the availability requirements at Level I or II facilities, a board-certified staff anesthesiologist on-call must be immediately advised, promptly available, and present for all operations.

At Level I trauma centers, an operating room must be adequately staffed and immediately available at all times. This may be accomplished by reserving a designated operating room or by staggering A.M. starting times so that a rotating room is free at all times. If the primary operating room is occupied at a Level I or II center, there must be a mechanism for providing additional staff to open a second room.

Full operating room equipment must be available at all centers, and this must include rapid infusers, bronchoscopes, thermal control equipment, and resuscitation fluids [16].

At all Trauma center levels, the Post-Anesthesia Care Unit (PACU) must be available and staffed 24 h/day. The PACU must be capable of monitoring with pulse oximetry, end-tidal carbon dioxide detection, intra-arterial pressure monitoring, pulmonary artery pressure monitoring, patient rewarming, and intracranial pressure monitoring.

The development, implementation, verification, and continuing improvement of civilian trauma systems is an ongoing process and has been in evolution since before recorded history. Improved survival benefit to trauma victims is possible is contingent on sound evidence-based protocols and guidelines, on seamless collaboration and coordination among many disparate groups of providers, and on continuous and ongoing training, research, and education. But most of all, it is dependent on a deep and profound commitment to excellent care.

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