Pediatric Trauma Systems: Critical Distinctions

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Background: Injured children represent 25% of all injured patients in the United States and have unique needs that may require treatment at a pediatric trauma center or a trauma center with pediatric commitment. This work attempts to determine if there is existing evidence that pediatric trauma centers, trauma centers with pediatric commitment, or trauma systems have improved the care of injured children.

Methods: Published literature evaluating the impact on injured children of pediatric trauma centers, trauma centers with pediatric commitment, or trauma systems was reviewed. The studies were divided by the methodology used for evaluation: panel studies, trauma registry studies, and population-based studies.

Results: Of the 18 studies reviewed, only 2 population-based studies evaluated the impact of trauma centers or systems on children. One found that a trauma center did not improve the injured child's risk of death. The other found that a statewide trauma system improved the risk of death in seriously injured children. A third population-based study found improved risk of death if the child was treated at an urban trauma center.

Conclusion: Further analysis is necessary to demonstrate whether trauma systems make a difference in pediatric outcome. Injury prevention will have the greatest impact on future pediatric injury outcomes.

Injured children represent 25% of all injured patients in the United States. Injured children have unique needs that distinguish them from injured adults, and specific principles and guidelines have been developed for the treatment of injured children. It has been hypothesized that regional pediatric trauma centers or trauma centers with pediatric commitment provide superior survival advantages for injured children. Specific advantages of pediatric trauma centers include the availability of comprehensive pediatric specialty services and a demonstrated institutional commitment to pediatric trauma research, education, and injury prevention. In 1997, 34 hospitals in 20 states were self-reported pediatric trauma centers, and it was estimated that only 2 to 3% of injured children nationwide were treated at those pediatric trauma centers. Injured children treated at trauma centers with pediatric commitment appear to have outcomes comparable to injured patients defined in large, multi-institutional reference populations.

A trauma system coordinates the timely care of an injured patient from the onset of injury through
prehospital triage and care, hospital care, and rehabilitation. In 1988, using eight specific criteria, West determined that only two states had complete trauma systems. An update to this national evaluation in 1995 found that only five states met all eight criteria. No comment was made in either study regarding the unique characteristics of pediatric trauma centers or what role pediatric trauma centers play in a complete trauma system. Designation of pediatric trauma centers may constitute the essential element of a pediatric trauma system. However, a pediatric trauma center does not solely define the systematic care of pediatric trauma patients. Pediatric trauma centers must work within the structure of a larger trauma system to maximize the care of injured children.

An essential part of a trauma system is the ability to assess whether care of injured patients is adequate. To this end, the published literature evaluating pediatric trauma centers and trauma centers with pediatric commitment and studies evaluating the impact of trauma systems on children was reviewed in an evidence-based fashion to determine if trauma systems have improved the care of injured children. The methods used to systematically review the available literature have been described by others. Three analytical methods are commonly used to determine if trauma centers or systems impact the care of injured patients: panel studies, trauma registry studies, and population-based studies. These methodologies are discussed as they relate to pediatric trauma care, and associated tables are provided.

**PATIENTS AND METHODS**

**Panel Studies**

The purpose of a panel study is to evaluate, on the basis of the assessments of an expert panel, the preventability of trauma deaths. Information provided to panel members should ideally include all aspects of the patient's care, including prehospital, in-hospital, and autopsy data. The panel renders a decision regarding preventability of death. Published pediatric panel studies evaluating trauma care are outlined in Table 1.

Panel study methodology provides a specific evaluation of various aspects of patient care that can be obtained with relative ease and minimal cost. Expert panel members can pinpoint errors made in patient management; this, in turn, can lead to improved quality control. However, bias in determining preventability can occur if panel members are not blinded. Most panel series are based on a relatively small sample, and no statistical analysis can be performed. All pediatric panel studies published to date evaluate hospital and autopsy data, and most evaluate prehospital data. Specific errors in management were implicated as potential reasons for mortality. All panels consisted of a small group of experts, usually the authors. Although all studies demonstrated a number of preventable pediatric deaths, no follow-up studies using the same methodology have been published showing improvement of preventable death rates following trauma center or system implementation.

**Registry Studies**

Registry-based studies provide information on a group of patients taken from a trauma registry that
has been maintained by trauma centers or various governmental authorities. Statistical comparisons are made between the study group and a reference group to determine if care is appropriate. This analysis technique assumes that the study and reference groups are similar in demographics, type and severity of injuries, and physiologic parameters.

Two reference populations used in pediatric trauma literature are the Major Trauma Outcome Study (MTOS) and the National Pediatric Trauma Registry (NPTR). The MTOS references approximately 160,000 injured patients treated at 140 hospitals between 1982 and 1989. Seventeen of the 140 hospitals were designated as pediatric specialty centers, and children under 15 years of age constitute only 10.8% of the total MTOS population. The Revised Trauma Score was used as the physiologic index of injury and the Injury Severity Score (ISS) was used as the anatomic measure of injury. Trauma and Injury Severity Score (TRISS) methodology is used for MTOS analyses. All MTOS norms were calculated from the adult (age ≥ 15 years) patients.

NPTR also represents a multi-institutional database accumulating data on injured children from 80 hospitals. This database contains prehospital, in-hospital, and discharge information for over 65,000 injured children from 1985 through 1995, and approximately 9,000 to 10,000 cases are added each year (NPTR, personal communication, February 1998). The institutions providing data include pediatric trauma centers and children's hospitals with pediatric trauma services. No analytic method for institutional comparison to the NPTR has been provided in the literature.

The published pediatric registry studies are demonstrated in Table 2. Many of the strengths and weaknesses associated with the registry methodology lie in the individual databases used. Both the MTOS and NPTR databases contain large numbers of patients with given levels of injury severity and determined survival. In comparing the databases, one must assume that the reference populations are similar. MTOS provides an analytical method (the Z statistic) to evaluate differences in mortality. However, to accept pediatric comparisons to the MTOS, one must accept that a child and an adult with the same Revised Trauma Score and ISS will have the same mortality rate. Eichelberger et al. demonstrated that the Trauma and Injury Severity Score can be applied as a predictive model of mortality in children with no significant differences in the Z statistic at various ages. Kaufmann et al. compared adult and pediatric injured patients treated by the same trauma surgeons and found that the Z statistics for both groups were similar to each other and to MTOS. Although these registry studies prove that investigated populations had outcomes comparable to MTOS patients, they do not indicate whether the observed outcomes were appropriate for children. Two of the four pediatric trauma centers showed significantly better outcomes when compared to the MTOS database. These findings may reflect the advantages of trauma center care or may indicate that MTOS underestimates pediatric survival.

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<th>TABLE 2. Pediatric registry studies</th>
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**Population-based Studies**
Population-based methods provide an evaluation of larger populations than are commonly included in a registry or panel study. Population-based studies obtain patient information from hospital discharge data, vital statistics data, or large regional trauma registries. Mortality rates and injury incidence rates can then be calculated on the basis of an entire population at risk in the study area. Comparisons are then made between two populations, for example, between injured patients treated at trauma centers and nontrauma centers. Variables that may influence the risk of mortality can be identified and included in regression models. A listing of published pediatric population-based studies is provided in Table 3. Limitations associated with population-based studies include a lack of defined physiological data, use of proxy measures for injury severity (i.e., ICD-9 codes), and data imprecision.

Although pediatric population-based studies have provided some insight into pediatric trauma epidemiology, only two population-based studies have evaluated the impact of a trauma center or trauma system on children. Rutledge et al. concluded that the presence of a trauma center in a county where a child was injured did not improve a child's outcome. However, Hulka found that the presence of a statewide trauma system reduced the risk of death in seriously injured children (ISS > 15).

**DISCUSSION**

It is intuitive that a trauma system should provide optimal care to all injured patients, including children. If a tertiary trauma center is the core of a regional trauma system, then a pediatric trauma center may be the core of a pediatric trauma system. Certain pediatric trauma systems with pediatric trauma centers have developed as part of a regional trauma system of care. However, because only 20 states have designated pediatric trauma centers, only a small fraction of injured children are treated at pediatric trauma centers. Trauma centers with pediatric commitment are usually regional trauma centers that function within an existing trauma system. These centers provide comparable care to pediatric trauma centers and may prove to be comparable alternatives to formal pediatric trauma systems.

The number of trauma centers functioning as pediatric trauma centers may be underestimated. There are over 400 designated trauma centers with pediatric intensive care units. These centers represent a wide spectrum and include "leaning" children's hospitals, where injured children are brought to the "adult" trauma center but are treated at associated children's hospitals. Regardless of the type of hospital, for a pediatric trauma system to function optimally, all facilities that care for injured children must be included in the structure of a trauma system.

An inclusive trauma system includes all injured patients and the hospitals that care for them. Emergency medical services are integrated into the system and are responsible for the triage of patients to appropriate institutions. Ideally, a patient's needs are matched to the appropriate facility in the system. This is especially true for children; not only the severity of injury, but also the fact they are children determines what facility should care for them.
A complete trauma system does not merely define the optimal care for injured patients but must also provide education and injury prevention to the population it serves. In no other population does prevention carry more impact than in children. Over 70% of pediatric trauma deaths occur in the field. 25-27 Although our only hope of truly impacting mortality in pediatric trauma is to prevent injuries from occurring in the first place, the influence of a trauma system on injury prevention has not been evaluated in either the adult or the pediatric population.

Evidence is scant that trauma systems have improved the outcomes of injured children. Evaluation of trauma systems is necessary to determine if improvement in outcomes of injured patients has occurred. Only two published studies have evaluated care of injured children treated at trauma centers versus nontrauma centers, and only one has examined the impact of a trauma system on pediatric outcome. 20,27 All three studies found that injured children had a reduced risk of death if treated at an urban trauma center.

Further analysis is necessary to demonstrate that trauma systems make a difference in pediatric outcome. Mortality is the major outcome measure used to evaluate trauma centers or systems. With a low average in-hospital pediatric mortality of 2 to 3%, other measures of outcome must be defined. The influence of injury prevention needs to be delineated; it will be the area of health care that will carry the greatest impact on future pediatric trauma outcomes.

REFERENCES

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