

## Chapter 2: Trauma systems, pediatric trauma centers, and the neurosurgeon

### I. RECOMMENDATIONS

*A. Standards.* There are insufficient data to support a treatment standard for this topic.

*B. Guidelines.* In a metropolitan area, pediatric patients with severe traumatic brain injury (TBI) should be transported directly to a pediatric trauma center if available.

*C. Options.* Pediatric patients with severe TBI should be treated in a pediatric trauma center or in an adult trauma center with added qualifications to treat children in preference to a level I or II adult trauma center without added qualifications for pediatric treatment.

*D. Indications from Adult Guidelines.* The adult guidelines (1) recommend organized trauma systems as a guideline and the services of a neurosurgeon as an option in the treatment of brain trauma. They cite studies that demonstrate overall reduction in mortality rate after implementation of trauma systems, and they use the *Resources for Optimal Care of the Injured Patient* of the American College of Surgeons Committee on Trauma (2) as a foundation for their recommendations.

### II. OVERVIEW

Although a number of studies report decreased mortality rate with implementation of trauma systems and use of pediatric trauma centers (3–6), recent research suggests that survival in certain subgroups may not be improved. Mann et al. (7) found a significant increase in deaths due to TBI from pre- to postimplementation of Oregon's trauma system for patients who were injured in rural areas and transferred to a higher level of care. For patients who died, transfer time from level 3 and level 4 rural hospitals increased after the trauma system was established. The number of patients with TBI who were transferred for neurologic examination also increased. Authors suggest that trauma system protocols for ex-

peditious transfer may have the unintended result of subjecting unstable patients to premature transfer.

Trauma systems, pediatric trauma centers, and caregivers who are specifically trained to treat children are all components of a system of care designed to provide better outcomes for patients. For this section, studies were identified that address isolated components of this system of care and present the findings. It must be emphasized that, ultimately, outcome is a function of the system and not of its isolated components.

### III. PROCESS

We searched Medline and Healthstar from 1966 to 2001 by using the search strategy for this question (see Appendix A) and supplemented the results with literature recommended by peers or identified from reference lists. Of 24 potentially relevant studies, three were used as evidence for this question (Table 1).

### IV. SCIENTIFIC FOUNDATION

Three studies, two retrospective (4, 6) and one prospective (5), provide limited evidence of the influence of trauma systems and pediatric trauma centers on mortality rates for children who sustain moderate to severe TBI. One of the three (6) also evaluates the effect of being a pediatric trauma center on the number of neurosurgical procedures provided to patients. The number of procedures could be considered a surrogate indicator of intensity of treatment and therefore an indirect link to outcome.

#### Pediatric Trauma Centers

Potoka et al. (6) conducted a retrospective review of medical records of patients 0–16 yrs old treated at pediatric or adult trauma centers in the state of Pennsylvania between 1993 and 1997. Four patient groups were specified, according

to the type of trauma center in which they were treated:

- PTC: pediatric trauma center (n = 1,077)
- ATC AQ: adult trauma center with added qualifications to treat children (n = 909)
- ATC I: level I adult trauma center (n = 344)
- ATC II: level II adult trauma center (n = 726)

Whereas the study included patients with mild and moderate TBI, this evaluation is based on the patients with severe TBI (Glasgow Coma Scale score 3–8). Dependent variables were mortality rate, number of neurosurgical procedures, and mortality rate for patients who received neurosurgical procedures.

Method of and criteria for referral and transfer within the statewide system are not discussed in this publication. Distributions for injury severity based on injury severity score are presented for the parent group of all traumas but not for the subgroup of TBI.

This class III study suggests the following:

1. Pediatric patients with severe TBI are more likely to survive if treated in PTCs, or ATC Aqs, than in level I or level II ATCs.
2. The pediatric patient with severe TBI who requires neurosurgical procedures has a lower chance of survival in level II ATCs vs. the other centers.

Johnson and Krishnamurthy (5) conducted a prospective, nonrandomized comparison of mortality rate among admitted patients, some of whom were transported directly to Children's Hospital in Washington, DC, a level I PTC, and some of whom were first transported to other hospitals and then transferred to Children's Hospital in Washington, DC.

Table 1. Evidence table

Reference	Description of Study	Data Class	Conclusion
Potoka (6) 2000	Retrospective medical record review of children treated for head injury (GCS score range, 3–15; age, 0–16 yrs) at accredited trauma centers in Pennsylvania with data entered in the Pennsylvania Trauma Outcome Study registry between 1993 and 1997. Data for this review include moderate (GCS, 9–12; n = 588) and severe (GCS, 3 to 8; n = 2,468) patients, n = 3,056. GCS score is not specified. Independent variable: level of pediatric accommodation in trauma center (PTC, ATC AQ, ATC I, ATC II). Dependent variables: mortality, neurosurgical procedures, mortality for patients receiving neurosurgical procedures. Analysis: Student's <i>t</i> -test, Mann-Whitney <i>U</i> , $\chi^2$ , Fisher's exact. No use of multivariate statistics. Results were not stratified by age. Baseline differences in ages between groups are not accounted for.	III	Survival higher in PTC or ATC AQ than level I or II ATCs for severe TBI. Equal chance of survival for severe TBI requiring neurosurgery in PTC, ATC AQ, or level I ATC, but not level II ATC. Equal chance of survival for moderate TBI, regardless of facility. For moderate TBI, more likely to have neurosurgery in PTC or level I ATC, and if they do, less likely to die; less likely to have neurosurgery in ATC AQ or level II ATC, and if they do, more likely to die.
Johnson et al. (5) 1996	Prospective, nonrandomized comparison of direct (n = 135) vs. indirect (n = 90) transports to level I PTC. Children (n = 225; age, 1–12 yrs) seen by neurosurgical services at Children's Hospital in Washington, DC, between 1985 and 1988. Severity stratified by admission GCS (moderate, 9–12; severe, $\leq 8$ ). Independent variable: direct vs. indirect transport. Dependent variable: mortality. Analysis: $\chi^2$ , Mann-Whitney <i>U</i> , Fisher's exact. No use of multivariate statistics. Baseline differences: for entire sample (including milds), LOS in PICU was significantly shorter for direct transport group; percent intubated at arrival was greater for indirect transport group; significantly greater child abuse and child abuse as cause of death in indirect transport group; for patients with GCS 3–8, trauma score was significantly higher in direct transport group (score = 9) than indirect transport group (score = 7).	II	For severe TBI, survival higher for direct transport patients than indirect transport patients. Equal chance of survival for moderate TBI, regardless of transport method.
Hulka et al. (4) 1997	Population-based (Washington and Oregon) retrospective medical record review of children <19 yrs old, hospitalized with at least one discharge diagnostic code between 800 and 959 (excluding 905–909, late effects of injury; 930–939, foreign bodies; 958–trauma complications. Severity stratified by ISS (minor, 1–15; serious, >15). Independent variable: presence or absence of trauma system. Dependent variable: mortality. Compared mortality between Oregon and Washington before (1985–1987) and after (1991–1993) Oregon implemented its statewide trauma system. All traumas/Oregon/before: 14,082 All traumas/Washington/before: 18,525 All traumas/Oregon/after: 8,981 All traumas/Washington/after: 12,991 Numbers for head injury not reported per group. Analysis: Multiple logistic regression model to calculate risk adjusted odds of death. IVs in model: trauma system, age, gender, severity, AIS scores, and multiple injuries (AIS score of 2 or more in more than one AIS region).	III	For all severity levels and all injuries, no significant difference between states in mortality before or after trauma system. For severe traumas and all injuries, no significant difference between states in mortality before trauma system; mortality significantly higher in Washington than Oregon after trauma system. Before trauma system, decreasing age, and maximum AIS head, chest, and abdomen associated with risk of death. After trauma system, maximum AIS head and abdomen remained.

GCS, Glasgow Coma Scale; PTC, pediatric trauma center; ATC, adult trauma center; AQ, with added qualifications; TBI, traumatic brain injury; LOS, length of stay; PICU, pediatric intensive care unit; IV, independent variables; AIS, Abbreviated Injury Score.

Table 2. Pediatric mortality after acute trauma in Oregon and Washington, before and after implementation of a statewide trauma system in Oregon

Interval	State	
	Oregon	Washington
1985–1987	No trauma system (n = 14,082)	No trauma system (n = 18,525)
1991–1993	Statewide trauma system (n = 8,981)	No trauma system (n = 12,991)

Patients included children 1–12 yrs of age treated in neurosurgical services between 1985 and 1988.

Severity stratification included mild (Glasgow Coma Scale score 13–15), moderate (Glasgow Coma Scale score 9–12) and severe (Glasgow Coma Scale score  $\leq 8$ ) TBI. Our present interest is only the

**C**hildren with severe traumatic brain injury are more likely to survive if treated in pediatric trauma centers or in adult trauma centers specially equipped and staffed to accommodate pediatric patients.

patients in this study who sustained severe brain injury: 56 who received direct transport and 42 who received indirect transport. However, statistical significance was only reported for the overall group, which included patients with mild and moderate TBI. Mortality rate for all patients was significantly greater in the indirect transport group (4.7%) than the direct transport group (1.9%).

An important baseline difference between groups was noted for severe TBI patients. The trauma score was significantly higher in the direct transport group (n = 9) than the indirect transport group (n = 7), indicating that the patients in the latter group were less stable physiologically. Authors suggest that this is better viewed as an outcome than a baseline difference and that the physiologic deterioration occurred as a function of delays in appropriate treatment due to the transfer.

This class II study suggests that in this metropolitan area, pediatric patients with severe TBI are more likely to survive if transported immediately to a PTC than if transported first to another type of center and then transferred to a PTC.

## Trauma Systems

Hulka et al. (4) compared mortality rates between two states (Oregon and Washington) during two periods of time: before (1985–1987) and after (1991–1993) Oregon implemented a statewide trauma system (Table 2). This retrospective medical record review was an evaluation of all injured pediatric patients <19 yrs of age hospitalized with at least one discharge diagnostic code indicative of acute trauma. The sample sizes for subgroups of patients with TBI were not reported. Multiple logistic regression modeling was used to calculate the risk-adjusted odds of death. Independent variables were trauma system, age, gender, severity, Abbreviated Injury Severity Scores, and multiple injuries.

For all severe traumas, the risk of death was significantly higher in Washington than Oregon after Oregon implemented its trauma system. For TBI, maximum Abbreviated Injury Severity Score for head was the strongest predictor of risk of death both before and after implementation of the trauma system, with little change in the odds ratio (1.25 before and 1.29 after the trauma system). Thus, this class III study suggests no effect of the trauma system on risk of mortality from TBI.

## V. SUMMARY

Children with severe TBI are more likely to survive if treated in pediatric trauma centers or in adult trauma centers specially equipped and staffed to accommodate pediatric patients. In a metropolitan area, direct transport to a PTC appears to increase survival rate overall. There has been no evaluation of functional outcome for this topic.

## VI. KEY ISSUES FOR FUTURE INVESTIGATION

Large data sets have accumulated from studies evaluating trauma systems that contain sufficient sample size and variables

to allow multivariate analyses focused on specific subgroups of patients. These data sets should be used to identify pediatric patients with TBI, to stratify by age and injury severity, and to evaluate outcome based on differences in care such as trauma systems and PTCs. Unfortunately, outcome measures in existing studies are limited to mortality or very short-term morbidity. Prospective studies that link acute medical management with long-term outcome are needed to understand the effect of systems of care on children with TBI.

Novel methodological technology for evaluating systems from the discipline of systems science could be directly applied to questions about medical systems of care to provide a better understanding of both the intended and unintended results of implementation of new systems.

## REFERENCES

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See APPENDIX on Next Page

# APPENDIX: LITERATURE SEARCH STRATEGIES

## SEARCHED MEDLINE AND HEALTHSTAR FROM 1966 TO 2001

### Chapter 2. Trauma Systems, Pediatric Trauma Centers, and the Neurosurgeon

1. trauma centers/
2. trauma systems.tw.
3. 1 or 2
4. exp craniocerebral trauma/
5. head injur\$.tw.
6. brain injur\$.tw.
7. 4 or 5 or 6
8. 3 and 7
9. limit 8 to human
10. limit 9 to (newborn infant <birth to 1 month> or infant <1 to 23 months> or preschool child <2 to 5 years> or child <6 to 12 years> or adolescence <13 to 18 years>)