Clinical Pediatrics: Open Access

Marciano et al., Clin Pediatr 2016, 1:3

Review Article Open Access

A Review of Head Trauma at Columbus Childrens Hospital: Perspectives from Pre- and Post-level 1 Trauma Center Certification

Dong Yeun Sun[1,2], **Rudy Marciano**[1*], **Edward J Kosnik**[3,4] **and Chris Karas**[1,2,4]

[1]*Department of Neurosurgery, Ohio Health, Grant Medical Center, Columbus, USA*

[2]*Brainkor, 8026 Balmoral Ct, Dublin, USA*

[3]*Department of Neurosurgery, Nationwide Children's Hospital, Columbus, USA*

[4]*Department of Neurosurgery, The Ohio State University Medical Center, Columbus, USA*

***Corresponding author:** Rudy Marciano, Department of Neurosurgery, OhioHealth, Grant Medical Center, USA, Tel: 1-484-221-1670; E-mail: rudy.marciano@ohiohealth.com

Received date: April 19, 2015; **Accepted date:** June 21, 2016; **Published date:** June 30, 2016

Abstract

Introduction: Historically, head trauma has accounted for a significant portion of trauma admissions to both neurosurgical services and hospitals in general. This study compares pediatric head trauma mortality at a single institution over six decades and through the transition from Level II to Level I pediatric trauma center status.

Methods: Retrospective chart review of the Columbus Children's Hospital Trauma Registry compared pediatric head trauma data at Columbus Children's Hospital from the following three five-year blocks, defined as periods 1, 2, and 3 respectively: 1958-1962, 1978-1982, and 2000-2004. Analysis of the data is made within each period and trends are defined with respect to diagnoses, mortality, and vulnerability of gender.

Results: The following trends were noted: (1) a significant increase in major traumatic head injury admissions in Period 3 after obtaining Level I trauma center designation, (2) a significant decrease in mortality rate of major head trauma between periods 1 and 2, but no change between periods 2 and 3 and (3) early parity in head injury incidence between genders in Periods 1 and 2, with development of a significant male predominance in Period 3.

Conclusion: Transitioning from Level II to Level I pediatric trauma center status correlated with a significant increase in pediatric head trauma admissions in this particular market. Although there have been significant decreases in mortality secondary to head trauma for various reasons between 1958 and 1978, there has been little change between 1978 and 2004 at the facility being studied despite transitioning from a Level II to Level I pediatric trauma center during that time period. There was a significant male predominance to sustain head trauma as compared to females in the most recent time period.

Keywords: Pediatric; Traumatic brain injury; Trauma; Head trauma; Level 1; Subdural hematoma; Epidural hematoma; Skull fracture

Introduction

Traumatic brain injury is the leading cause of death and disability among children >1 year old [1]. The most efficacious pre-hospital care, acute in-hospital care, and long term rehabilitation methodologies for pediatric patients suffering from traumatic brain injury is an area of research interest. While the trauma center designation process is developed at either the state or local level, The American College of Surgeons (ACS) has created a set of guidelines, which includes recommendations pertaining to both adult and pediatric in-hospital trauma resources, that assists in assigning the various trauma center level designations. Hospitals interested in pursuing advanced trauma center designations will typically undergo ACS site visits in which the presence of the recommended resources commensurate with the desired trauma level designation will be verified [2,3].

According to the ACS, Level I is the most advanced trauma center, as it designates a tertiary care facility providing total care ranging from prevention to rehabilitation of patients. Level I Trauma Center designation includes "24-hour in-house coverage by general surgeons, and prompt availability of care in specialties" such as orthopedic surgery, neurosurgery, anesthesiology, emergency medicine, radiology, critical care, internal medicine, plastic surgery, oral and maxillofacial care, and pediatric care as well as "helicopter landing capabilities approved by state and federal authorities" to accept incoming trauma transfers [2,3]. Besides availability of medical expertise and resources, the Level 1 trauma designation also involves continuous trauma care and awareness focused education of staff, residents, and the surrounding communities along with persistent trauma focused research efforts. Level I trauma centers subject themselves to frequent and comprehensive quality assessment programs, directed to ensure the usage of updated technology and resources, as well as the maintenance of surgeon competence. Trauma surgeons at this particular level are required to receive continuous medical education, in addition to initial certifications by the medical board.

Despite the strict protocol of trauma centers to preserve their Level I designations, there is debate as to whether there is a marked difference in outcomes between Level I and Level II trauma designations in regards to general trauma and traumatic brain injury in particular [4-8]. While there are many similarities between Level I and II trauma center designations, including in-house general surgery presence with prompt availability of sub-specialists, there are also some key differences mainly in trauma volume, teaching institution status, community outreach, and research requirements [9].

DuBose et al noted that trauma patients admitted to a Level II trauma center had a mortality rate of 13.9%, whereas those admitted to a Level I Trauma Center had a mortality rate of 9.6%, which remained statistically significant after controlling for other variables [6]. Based on a retrospective review of the National Trauma Data Bank encompassing 130,154 patients, those with an Injury Severity Score (ISS) >15 that were treated at Level 1 trauma centers had significantly lower mortality when compared to those treated at Level 2 trauma centers [5]. A retrospective review of 208, 866 patients from the Pennsylvania Trauma Outcomes Registry admitted to Level I and Level II trauma centers supported the tiered designation system for trauma centers given the 15% lower risk for mortality of those admitted to Level I centers [4].

It should be noted that the difference in mortality risk between Level I and II centers was insignificant in those with lesser traumatic injuries (ISS < 15) [8]. This trend of improved outcomes at Level I trauma centers is not completely consistent across the literature. A retrospective review of the North Carolina Trauma Registry compared the outcomes of patients at Level I and II trauma centers treated for four specifically morbid traumatic injuries (thoracic aortic disruption, liver lacerations, pulmonary contusions, and pelvic fractures) and found no significant difference in mortality rates between the two facilities. A separate retrospective review of 140, 691 trauma patients in Pennsylvania showed no significant difference in mortality rates between Level I and II trauma centers and noted variability between facilities suggesting that factors other than those required to obtain Level I status, including age of the trauma system, play a part in mortality outcomes [9]. Future contributions to the literature will continue to investigate the effects of trauma center designation status on outcomes and mortality.

The ACS has separate trauma center level designations for adult and pediatric pediatric trauma centers given the different expertise and resources required for optimal care of the pediatric population [2]. As with adult trauma center level designation, there are strong requirements for neurosurgical expertise and availability in the ACS guidelines for pediatric trauma level designations given the acuity and significance of pediatric neurotrauma in general, and traumatic brain injury in particular [3]. As with adult trauma, there is also some debate as to the outcome of pediatric brain injury based on the trauma level designation of the admitting institution. Given that the major difference between Level 1 and 2 trauma designations are based on volume, teaching institution status, and research but the sub-specialties required by the ACS are available at both Level 1 and 2 centers, it is prudent to investigate differences in outcomes between centers[2]. Given the fact that 25% of the U.S. population lives in a county without a neurosurgeon and 44% of practicing neurosurgeons are over age 55, this question is especially pertinent from a public health perspective as clinical equipoise between neurotrauma outcomes at Level 1 and 2 trauma centers would provide a great logistical advantage for distributing the burden of trauma care, especially in less populated areas of the country [10]. In an attempt to provide clarification on this issue, this retrospective case review of patients at Columbus Children's Hospital (now Nationwide Children's Hospital) investigates mortality rates in pediatric head injury compared across several decades and the transition from Level I to Level II pediatric trauma center designations.

Methods

A review of the Columbus Children's Hospital was conducted and all traumatic brain injuries including intraparenchymal hemorrhage, subdural hematoma, epidural hematoma, diffuse axonal injury and depressed skull fractures were identified and recorded in an Excel spreadsheet. The data was divided into three periods of five-year blocks (Period 1: 1958-1962; Period 2: 1978-1982; and Period 3: 2000-2004), with Period 3 representing the post-Level I trauma certification era. Analysis of the data collected by the Columbus Children's Hospital Trauma Registry was done with respect to diagnoses, mechanisms of injury, mortality, gender predilection. All patients meeting study criteria within the specified time frame were included in the data set; thereby, extending the study's external validity. The population included all patients less than 18 years old. Frequency distributions and summary statistics were used to describe mortality. Comparisons between groups were performed using simple graphic representations.

Results

There was a predilection for males to suffer head trauma more frequently than females in period 3, while there was near parity in earlier periods. From period 1 to period 2, there was an almost 50% decrease in the incidence of brain injury followed by an almost 5x increase in period 3. There was a significant increase in mortality per diagnosis from period 2 to period 3 for subdural hematoma, intracerebral hemorrhage, diffuse axonal injury, and depressed skull fracture, while mortality from epidural hematoma remained relatively stable. There was a decrease in mortality rate from period 1 (16%) to period 2 (9.3) and virtually no change in period 3 (9.4%).

Discussion

This retrospective review was conducted with the goal of examining changes in pediatric head trauma mortality over time at this institution. A secondary aim was determining the effect of transitioning from Level II to Level I pediatric trauma center status on mortality secondary to pediatric head trauma. This review encompassed patients over a wide time period ranging from 1958 through 2004, which undoubtedly includes many improvements in the management of traumatic brain injury. There was a significant decrease in mortality from pediatric head injury between 1958 and 1982. That being said, the mortality between 1982 and 2004 due to head injury changed very little. This is an interesting finding, as the Columbus Children's Hospital transitioned from a Level II to Level I pediatric trauma center during this period. It can be hypothesized that the decreased mortality rates Between Period 1 and Period 2 are partly due to a series of technological advances and widespread introduction of advanced imaging techniques allowing more accurate and prompt diagnosis/monitoring, rather than administrative changes. While some of the literature cites increased exposure to specific trauma pathologies as a likely reason for the improved outcomes at Level I trauma centers, the results of this study show that despite increases in major head trauma admissions under the Level I designation in Period 3, head injury mortality rates remained relatively stable at the institution.

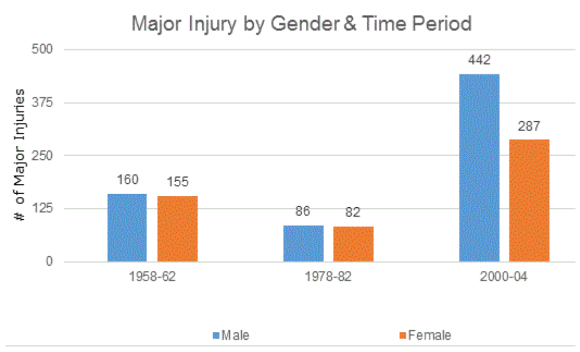

Figure 1: Major injury by gender & time period.

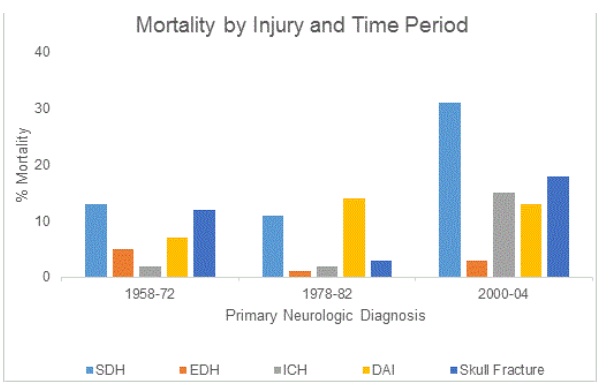

Figure 2: Mortality by injury and time period.

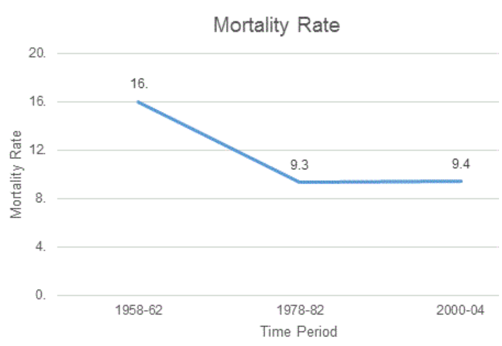

Figure 3: Mortality rate.

There was a marked increase in mortality secondary to subdural hematoma, intracerebral hemorrhage, and skull fracture between Period 2 and Period 3. The most likely explanation for this finding is an increase in the acuity and injury severity of patients as the facility transitioned from a Level II to a Level I pediatric trauma center. The increased severity of injuries is supported by the marked increase in patients presenting with skull fractures, signifying an increase in higher energy mechanisms of trauma [Haider et al]. Similar findings after a change to higher level trauma status were reported by Berney et al where TBI related mortality increased from 6.5% to 14% between 1979 and 1990, while there was a marked decrease in mortality in previous time periods [11].

Independent of institutional variations, the national epidemiology of trauma has also changed over time, with a decrease in hospital admissions from mild TBI, likely due to increased awareness and widespread addition of safety features to automobiles, while admissions for severe TBI have remained stable from 1991-2005 [12].

Periods of stability as well as periodic uptrends in mortality have also been reported by others. A large study described a 50% decrease in mortality secondary to severe TBI over 150 years with multiple periodic fluctuations [13]. From 1930-1970, Stein et al showed no change in severe TBI mortality, which was attributed to improved hospital care and neurosurgery services countered by a national increase in motor vehicle collisions (MVC). This was followed by a decrease in TBI mortality from 1970-1990 attributed to widespread introduction of CT scanning and intracranial pressure monitoring followed by a slight increase in mortality from 1990-2006 that was postulated due to increased elderly population and subsequent deaths from falls, more effective and widespread EMS services, more aggressive in-hospital treatment, and publication bias with more studies released from level 2 trauma centers, low volume centers, and developing countries [13].

Supporting the stable mortality rate overall despite increased acuity of patients between Periods 2 and 3 is the increase in trauma patients presenting to the institution via helicopter between those two periods. Recent data on transportation modalities for trauma patients showed that helicopter transportation, when compared to ground transport, is associated with a lower mortality rate despite transporting severe TBI patients with GCS scores that are 2.5 points lower on average[14]. Since most patients with severe TBI that die do so within 2 hours of injury, an increase in helicopter transport results in institutions receiving a larger number of those with likely grave prognoses [15,16].

The mortality from DAI (diffuse axonal injury) decreased slightly and overall TBI related mortality remained stable between Period 2 and Period 3, despite treating patients with more severe injuries. This is most likely due to improvements in pediatric neurocritical care. Others studies have shown that implementation of a pediatric neurocritical care program and a standardized TBI management protocol resulted in 8% and 10% decreases in overall mortality rate secondary to severe TBI respectively [17,18].

While there is wide variability in the design parameters of neurotrauma studies in general and pediatric TBI studies in particular, including the definition of severe TBI, a common theme is to exclude from the data patients presenting with either fixed and dilated pupils or a GCS score of 3 due to the believed poor prognosis. In a 1978 study describing the critical care management of TBI, Bruce et al noted that children recover more favorably from severe TBI than adults and that even the most severely head injured patients have a good prognosis for survival. A more recent study found that when comparing pediatric patients presenting with a GCS of 3 and fixed-dilated pupils to a similar adult group, the mortality rates were 80.9% and 85% respectively [19]. The mortality rates were 50.7% and 53.4%, respectively, for pediatric and adult patients presenting with a GCS3 and pupils reactive to light. The conclusion was that children presenting with fixed-dilated pupils and GCS3 should be treated aggressively. Individual case reports have also reported good outcomes with similar presentations[20]. These findings may warrant further verification to ensure prudent utilization of trauma resources.

At this point, it is unclear if a Level I trauma center designation correlates with improved pediatric head trauma outcomes as compared to Level II facilities. Generalizations in pediatric neurotrauma research are difficult given the geographic and socioeconomic variations in management and outcomes. A study of 7140 pediatric severe TBI patients at 156 different facilities showed that infants were less likely to receive intracranial pressure monitoring after severe TBI while pediatric trauma centers were less likely to utilize intracranial pressure monitoring or decompressive craniectomy than combined pediatric-adult trauma centers [21]. The same study noted that, as of 2013, only 38% of surveyed physicians practiced at an institution with a TBI management protocol [21]. Regional geographic variability has been demonstrated with the midwestern and southern United States having 1.3 and 1.7 times higher relative risks for severe TBI mortality than the northeast United states [16]. Statewide variation has been demonstrated with inpatient TBI mortality rates ranging from 6% to 2.2% in Arkansas and New Jersey respectively [22]. There is likely local variation as well between cities and even single neighborhoods. The same study showed a 1.9% mortality difference between the insured and uninsured suffering TBI [22]. Given the paucity of both Level I trauma centers and neurosurgeons that treat pediatric neurotrauma across large portions of the country, further investigation into this subject may be warranted. Given that some studies have found parity in general trauma outcomes between certain Level I and II trauma centers, further investigation into the factors that improve outcomes, other than those required to obtain Level I status, is warranted. Many factors, including volume of trauma, type of trauma, experience of staff physicians and nursing staff, quality of local EMS services, hospital infrastructure, local socioeconomic factors and access to government and community services may all play a part in the final outcomes of trauma patients, regardless of the specific facilities trauma center designation. Despite the evolution of large scale administrative changes to trauma centers around the world, further study is warranted as to the impact of these changes on mortality in patients, both pediatric and adult, presenting with traumatic brain injury.

References

1. Quayle KS, Powell EC, Mahajan P, Hoyle JD, Nadel FM et al. (2014) Epidemiology of blunt head trauma in children in U.S. emergency departments. N Engl J Med 371: 1945-1947.
2. Joint Committee on Administrative Rules.
3. Resources for optimal care of the injured patient 2014/resources repository.
4. Clancy TV, Gary Maxwell J, Covington DL, Brinker CC, Blackman D (2001) A statewide analysis of level I and II trauma centers for patients with major injuries. J Trauma 51: 346-351.
5. Demetriades D, Martin M, Salim A, Rhee P, Brown C, et al. (2006) Relationship between American college of surgeons trauma center designation and mortality in patients with severe trauma (injury severity score > 15). J Am Coll Surg 202: 212-215.
6. DuBose JJ, Browder T, Inaba K, Teixeira PG, Chan LS, et al. (2008) Effect of trauma center designation on outcome in patients with severe traumatic brain injury. Arch Surg 143: 1213.
7. Cudnik MT, Newgard CD, Sayre MR, Steinberg SM (2009) Level I versus level II trauma centers: An outcomes-based assessment. J Trauma 66: 1321-1326.
8. Glance LG (2012) Impact of trauma center designation on outcomes: is there a difference between Level I and Level II trauma centers? J Am Coll Surg 215: 372-378.
9. Rogers FB (2014) Resources for optimal care of the injured patient 2014/ resources repository in a mature trauma system, there is no difference in outcome. J Trauma Acute Care Surg
10. Batjer H (2014) Everything You Thought You Knew About The Physician Shortage: The Specialty (Neurosurgical) Perspective.
11. Berney J, Favier J, Rilliet B (1995) Head injuries in children: a chronicle of a quarter of a century. Childs Nerv Syst 11: 256-264.
12. Bowman SM, Bird TM, Aitken ME, Tilford JM. et al. (2008) Trends in hospitalizations associated with pediatric traumatic brain injuries. Pediatrics 122: 988-993.
13. Stein SC, Georgoff P, Meghan S, Mizra K, Sonnad SS et al. (2010) 150 years of treating severe traumatic brain injury: a systematic review of progress in mortality. J Neurotrauma 27: 1343-1353.
14. Missios S and Bekelis K (2014) Transport mode to level I and II trauma centers and survival of pediatric patients with traumatic brain injury. J Neurotrauma 31: 1321-1328.
15. Tude Melo JR, Di Rocco F, Blanot S, Oliveira-Filho J, Roujeau T, et al. (2010) Mortality in children with severe head trauma: predictive factors and proposal for a new predictive scale. Neurosurgery 67:1542-1547.
16. Mills B, Rowhani-Rahbar A, Simonetti JA, Vavilala MS et al. (2015) Facility characteristics and inhospital pediatric mortality after severe traumatic brain injury. J Neurotrauma 32: 841-846.
17. Pineda JA, Leonard JR, Mazotas IG, Noetzel M, Limbrick DD et al. (2013) Effect of implementation of a paediatric neurocritical care programme on outcomes after severe traumatic brain injury: a retrospective cohort study. Lancet Neurol 12: 45-52.
18. O'Lynnger TM, Shannon CN, Le TM, Greeno A, Chung D et al. (2016) Standardizing ICU management of pediatric traumatic brain injury is associated with improved outcomes at discharge. J Neurosurg Pediatr 17: 19-26.
19. Emami P, Czorlich P, Fritzsche FS, Westphal M, Rueger JM, et al. (2016) Impact of Glasgow Coma Scale score and pupil parameters on mortality rate and outcome in pediatric and adult severe traumatic brain injury: a retrospective, multicenter cohort study. J Neurosurg 1: 1-8.
20. Pfenninger J, Santi A (2002) Severe traumatic brain injury in children--are the results improving? Swiss Med Wkly 132: 116-120.
21. Van Cleve W, Kernic MA, Ellenbogen RG, Wang J, Zatzick DF, et al. (2013) National variability in intracranial pressure monitoring and craniotomy for children with moderate to severe traumatic brain injury. Neurosurgery 73: 746-52.
22. Greene NH, Kernic MA, Vavilala MS, Rivara FP (2014) Variation in pediatric traumatic brain injury outcomes in the United States. Arch Phys Med Rehabil 95: 1148-1155.