Big children or little adults? A statewide analysis of adolescent isolated severe traumatic brain injury outcomes at pediatric versus adult trauma centers

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BACKGROUND: The appropriate managing center for adolescent trauma patients is debated. We sought to determine whether outcome differences existed for adolescent severe traumatic brain injury (sTBI) patients treated at pediatric versus adult trauma centers. We hypothesized that no difference in mortality, functional status at discharge (FSD), or overall complication rate would be observed between center types.

METHODS: All adolescent trauma patients (aged 15–17 years) presenting with isolated sTBI (head Abbreviated Injury Scale [AIS] score ≥3; all other AIS body region scores ≤2) to accredited Levels I to II trauma centers in Pennsylvania from 2003 to 2015 were extracted from the Pennsylvania Trauma Outcome Study database. Dead on arrival, transfer, and penetrating trauma patients were excluded from analysis. Adult trauma centers were defined as non-pediatirc (PED) (n = 24), whereas standalone pediatric hospitals and adult centers with pediatric affiliation were considered Pediatric (n = 9). Multilevel mixed effects logistic regression models and a generalized linear mixed models assessed the adjusted impact of center type on mortality, overall complications, and FSD. Significance was defined as a *p* value less than 0.05.

RESULTS: A total of 1,109 isolated sTBI patients aged 15 to 17 years presented over the 13-year study period (non-PED, 685; PED, 424). In adjusted analysis controlling for age, shock index, head AIS, Glasgow Coma Scale motor, trauma center level of managing facility, case volume of managing facility, and injury year, no significant difference in mortality (adjusted odds ratio, 0.82; 95% confidence interval [CI], 0.23–2.86; $p = 0.754$), FSD (coefficient, −0.85; 95% CI, −2.03 to 0.28; $p = 0.136$), or total complication rate (adjusted odds ratio, 1.21; 95% CI, 0.43–3.39; $p = 0.714$) was observed between center types.

CONCLUSION: Although the optimal treatment facility for adolescent patients is frequently debated, patients aged 15 to 17 years presenting with isolated sTBI may experience similar outcomes when managed at pediatric and adult trauma centers. (*J Trauma Acute Care Surg.* 2017;82: 368–373. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiologic study, level III; therapeutic study, level IV.

KEY WORDS: Adolescent; traumatic brain injury; mortality; pediatric trauma center; adult trauma center.

Traumatic brain injury (TBI) is a major source of mortality and morbidity among children and adolescents.[1] According to the Centers for Disease Control and Prevention, children aged 0 to 4 years (1,451 per 100,000) and adolescents aged 15 to 19 years (896 per 100,000) account for two of the three most TBI-prone populations in the United States, accruing significant rates of TBI-related emergency department visits, hospitalizations, and deaths.[1] When health care providers (both prehospital and inhospital) are tasked with managing severely injured pediatric and adolescent TBI patients, they must often decide whether these patients can be effectively managed at adult trauma centers (TCs) or if they should be triaged to pediatric facilities. Although previous research has firmly supported the association between the establishment of regionalized trauma systems and improved survival for various forms of trauma[2–7] including TBI,[2,3] controversy exists regarding which TC designation (pediatric or adult) is most adept at managing pediatric[8–17] and adolescent patients.[13,14]

Although some literature suggests pediatric trauma patients experience better outcomes at pediatric-accredited centers,[8–12] other studies report no difference in survival between adult and pediatric facilities.[13–17] In review of available literature, only two investigations were identified which analyzed the impact of pediatric versus adult TC affiliation on outcome in adolescent-specific populations.[13,14] Unlike the conflicting findings reported when analyzing total pediatric populations,[8–12,15–17] these adolescent-specific investigations yielded similar results. Both Matsushima et al.[13] and Walther et al.[14] found no difference in risk-adjusted outcomes for adolescent patients aged 13 to 18 years and 15 to 19 years, respectively, when managed at pediatric and adult TCs. Although both of these studies reported congruent findings when analyzing adolescent outcomes for all trauma categories, no subanalyses comparing specific injury

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types, such as TBI, between TC designations, were conducted. Although adult and pediatric TCs may have similar outcomes when managing generalized injuries, it is unclear whether this holds true for more specialized, severe injuries. The purpose of this investigation was to elaborate on this question by comparing risk-adjusted outcomes at pediatric and adult TCs for adolescent patients presenting with severe TBI (sTBI). Although the two previous investigations analyzing adolescent-specific outcomes between center types found no difference between designations,[13,14] we hypothesized that adolescent sTBI patients (a more severe injury category) would experience improved adjusted mortality when managed at pediatric versus adult TCs in the Commonwealth of Pennsylvania. In addition, in an analysis of secondary endpoints, we hypothesized that adjusted overall complication rate would be significantly lower and functional status at discharge (FSD) significantly higher for adolescent sTBI patients managed at pediatric compared with adult facilities.

PATIENTS AND METHODS

After institutional review board approval, the Pennsylvania Trauma Outcome Study database, a statewide trauma registry of the Pennsylvania Trauma Systems Foundation (PTSF) (Digital Innovations, Forest Hill, MD), was retrospectively queried for all adolescent trauma patients (aged 15–17 years) treated at accredited Levels I to II adult and pediatric TCs from 2003 to 2015. The specific population of interest included all adolescent patients presenting with isolated sTBI (head Abbreviated Injury Scale [AIS] score ≥3, all other AIS body region scores ≤2). Dead on arrival, transfer, and penetrating trauma patients were excluded from analysis as to compare only patients with manageable injuries treated exclusively at one facility type. The adolescent designation of 15 to 17 years old was selected based on the fact that general practice guidelines in Pennsylvania suggest severely injured patients below the age of 15 years should be managed at TCs with pediatric affiliation, whereas patients 18 and older are considered adult cases and as such are effectively managed at adult centers.

Since its establishment in 1984 as part of the Emergency Medical Services Act, the PTSF has served as the accrediting body for all TCs in the Commonwealth of Pennsylvania. Verifying both pediatric and adult centers, the PTSF accredits institutions in accordance with standards established by the American College of Surgeons Committee on Trauma Resources for Optimal Care of the Injured Patient.[18] From 2003 to 2015, there were 33 Levels I to II TCs in Pennsylvania, of which 24 were adult centers, 6 were adult/pediatric centers, and 3 were standalone pediatric centers. To evaluate the impact of TC designation on adolescent sTBI outcomes, the study facilities were separated into two groups, pediatric TCs (n = 9; pediatirc [PED]) and adult TCs (n = 24; non-PED). For the purpose of this investigation, pediatric TCs were classified as all adult/pediatric affiliated centers (n = 6) as well as all standalone pediatric centers (n = 3). Over the course of the study period, no relevant changes in accreditation status were reported for any of the 33 Levels I to II centers under investigation. Univariate analysis in the form of Kruskal-Wallis tests for continuous variables and Fisher's exact tests for categorical variables was used to determine baseline demographic differences between PED and non-PED centers, including rates of neurosurgical intervention (craniotomy, craniectomy, bolt [intracranial pressure monitor/ventriculostomy]) and complications (total complication rate, pneumonia, pulmonary embolism, deep vein thrombosis, wound infection).

A multilevel mixed-effects logistic regression modeling approach was implemented to determine the adjusted impact of facility type (PED vs. non-PED) on mortality and total complication rate for the total study population as well as a more severely injured subset (all sTBI patients with an Injury Severity Score ≥16). Similarly, a generalized linear mixed model assessed the adjusted impact of facility type on FSD score within these two groups. Functional status at discharge is a functional status measure composed of five parts (feeding, locomotion, expression, transfer mobility, and social interaction) scored on a scale from 1 to 4 (1, complete dependence; 4, complete independence). Each item is required to be assessed by a member of the patient care team as close to discharge as possible, but not earlier than 48 hours before discharge. Patients who die in hospital are not given an FSD score, and as such, were excluded from the FSD model. All adjusted analyses controlled for age, shock index, head AIS score, Glasgow Coma Scale (GCS) motor score, TC level of managing facility, case volume of managing facility, injury year, and clustering within state TCs. To determine the discrimination of the multilevel models, the area under the receiver operating characteristic was calculated and graphed (total study population mortality model). All data manipulation and statistical analysis were performed using Stata/MP, version 14.1. A p value less than 0.05 was considered statistically significant.

RESULTS

A total of 17,050 adolescent trauma patients presented over the 13-year study period, of which 1,934 presented with isolated sTBI. Within this population, 29 patients were pronounced dead on arrival/died in the emergency department, 139 presented with penetrating trauma, and 657 patients were transferred, producing a final study population of 1,109 sTBI patients. The adolescent sTBI population under investigation was predominantly composed of 17-year-old (39.7%), male (74.3%) trauma patients. Further demographic data for the total study population is detailed in Table 1.

Of the 1,109 patients analyzed, 685 (61.8%) were managed at adult TCs and 424 (38.2%) at pediatric centers. No significant difference in sex distribution (non-PED, 73.9% male; PED, 75.0% male; p = 0.675), Injury Severity Score (ISS) (non-PED, 17.5 ± 7.90; PED, 19.9 ± 6.33; p = 0.325), GCS (non-PED, 11.6 ± 4.74; PED, 11.7 ± 4.76; p = 0.819), head AIS (non-PED, 3.78 ± 0.79; PED, 3.84 ± 0.72; p = 0.179), or shock index score (non-PED, 0.72 ± 0.22; PED, 0.71 ± 0.22; p = 0.611) was found for adolescents treated at the two center types. Age was the only demographic variable found to elicit small, yet statistically significant, differences between designations, with non-PED centers treating slightly older patients than PED counterparts (non-PED, 16.2 ± 0.79; PED, 16.1 ± 0.81; p = 0.034).

TABLE 1. Total Adolescent sTBI Study Population Demographics

Variable	Total Population (n = 1,109)	Adult (n = 685)	Pediatric (n = 424)	*p*
Age, y, mean ± SD	16.1 ± 0.80	16.2 ± 0.79	16.1 ± 0.81	0.034
Median (IQR)	16.0 (15.0–17.0)	16.0 (16.0–17.0)	16.0 (15.0–17.0)	
15, n (%)	292 (26.3)	166 (24.2)	126 (29.7)	0.047
16, n (%)	377 (34.0)	234 (34.2)	143 (33.7)	0.882
17, n (%)	440 (39.7)	285 (41.6)	155 (36.6)	0.093
Sex, male, n (%)	824 (74.3)	506 (73.9)	318 (75.0)	0.675
Shock Index, mean ± SD	0.71 ± 0.22	0.72 ± 0.22	0.71 ± 0.22	0.611
ISS, mean ± SD	17.6 ± 7.34	17.5 ± 7.90	17.9 ± 6.33	0.325
Median (IQR)	17.0 (11–21)	17.0 (10–21)	17.0 (14–21)	
GCS, mean ± SD	11.6 ± 4.75	11.6 ± 4.74	11.6 ± 4.78	0.819
Median (IQR)	15.0 (8.00–15.0)	15.0 (8.00–15.0)	15.0 (8.00–15.0)	
AIS scores, mean ± SD				
Median (IQR)				
Head	3.80 ± 0.76	3.78 ± 0.79	3.84 ± 0.72	0.179
	4.00 (3.00–4.00)	4.00 (3.00–4.00)	4.00 (3.00–4.00)	
Face	0.67 ± 0.77	0.61 ± 0.76	0.76 ± 0.78	0.002
	0.00 (0.00–1.00)	0.00 (0.00–1.00)	1.00 (0.00–1.00)	
Neck	0.02 ± 0.16	0.02 ± 0.17	0.02 ± 0.14	0.812
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Thorax	0.11 ± 0.40	0.11 ± 0.41	0.11 ± 0.40	0.807
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Abdomen	0.17 ± 0.45	0.16 ± 0.44	0.19 ± 0.46	0.203
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Spine	0.19 ± 0.57	0.19 ± 0.58	0.18 ± 0.54	0.715
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Upper extremity	0.38 ± 0.64	0.35 ± 0.63	0.42 ± 0.66	0.082
	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.00 (0.00–1.00)	
Lower extremity	0.36 ± 0.63	0.32 ± 0.61	0.43 ± 0.65	0.006
	0.00 (0.00–1.00)	0.00 (0.00–0.00)	0.00 (0.00–1.00)	
Neurosurgical intervention, n (%)	159 (14.3)	90 (13.1)	69 (16.3)	0.157
Craniotomy	87 (7.84)	45 (6.57)	42 (9.91)	0.555
Craniectomy	31 (2.80)	11 (1.61)	20 (4.72)	0.006
Intracranial pressure monitor	83 (7.48)	51 (7.45)	32 (7.55)	0.950
Complication rate, n (%)	37 (3.34)	21 (3.07)	16 (3.77)	0.534
Pneumonia	40 (3.61)	25 (3.65)	15 (3.54)	0.922
Pulmonary embolism	3 (0.27)	1 (0.15)	2 (0.47)	0.371
Deep vein thrombosis	9 (0.81)	5 (0.73)	4 (0.94)	0.709
Wound infection	4 (0.36)	3 (0.44)	1 (0.24)	0.559
ICU LOS, d, mean ± SD	2.53 ± 5.11	2.38 ± 4.29	2.76 ± 6.20	0.264
Median (IQR)	1.00 (0.00–2.00)	1.00 (0.00–2.00)	1.00 (0.00–2.00)	
Mortality, n (%)	37 (3.34)	25 (3.65)	12 (2.83)	0.448
	Nonfatal (n = 1,072)	**Adult (n = 660)**	**Pediatric (n = 412)**	***p***
FSD scores, mean ± SD	17.9 ± 4.47	18.3 ± 3.69	17.3 ± 5.29	0.003
Median (IQR)	20.0 (18.0–20.0)	20.0 (19.0–20.0)	20.0 (18.0-20.0)	
Feeding	3.63 ± 0.93	3.71 ± 0.78	3.53 ± 1.09	0.010
	4.00 (4.00–4.00)	4.00 (4.00–4.00)	4.00 (4.00–4.00)	
Locomotion	3.48 ± 1.00	3.57 ± 0.86	3.36 ± 1.17	0.004
	4.00 (3.00–4.00)	4.00 (4.00–4.00)	4.00 (3.00–4.00)	
Expression	3.64 ± 0.91	3.73 ± 0.74	3.52 ± 1.08	0.002
	4.00 (4.00–4.00)	4.00 (4.00–4.00)	4.00 (4.00–4.00)	
Transfer mobility	3.49 ± 1.00	3.57 ± 0.88	3.39 ± 1.14	0.017
	4.00 (4.00–4.00)	4.00 (4.00–4.00)	4.00 (3.00–4.00)	
Social interaction	3.61 ± 0.93	3.70 ± 0.78	3.51 ± 1.09	0.005
<	4.00 (4.00–4.00)	4.00 (4.00–4.00)	4.00 (4.00–4.00)	

In terms of management approaches and outcomes, no significant difference in neurosurgical intervention rates were found between PED and non-PED facilities for craniotomy (non-PED, 6.57%; PED, 9.91%; $p = 0.555$) and bolt (non-PED, 7.45%; PED, 7.55%; $p = 0.950$); however, rates of craniectomy were significantly higher at PED centers (non-PED, 1.61%; PED, 4.72%; $p = 0.006$). Patients undergoing neurosurgical intervention were found to have significantly lower FSD scores compared to nonsurgical counterparts. No statistical differences in overall complication rate, or individual complications including pneumonia, pulmonary embolism, deep vein thrombosis, or wound infection were found between center types. Overall unadjusted FSD score (non-PED, 18.3 ± 3.69; PED, 17.3 ± 5.29; $p = 0.003$), as well as individual FSD subcomponents, were found to be significantly higher at non-PED centers; however, no significant difference in mortality rate was observed between center types in univariate analysis (non-PED, 3.65%; PED, 2.83%; $p = 0.448$) (Table 1).

Similar to the results obtained in univariate analysis, adjusted mortality modeling controlling for age, shock index, head AIS, GCS motor score, TC level (I), case volume, and injury year, found no difference in mortality between PED and non-PED centers for the total study population (adjusted odds ratio [AOR], 0.82; 95% confidence interval [CI], 0.23–2.86; $p = 0.754$), or a more severely injured (ISS ≥ 16; n = 705) subgroup (AOR, 1.06; 95% CI, 0.28–3.94; $p = 0.934$) (Table 2). Overall, both morality models were found to have good discrimination with area under the receiver operating characteristics of 0.96 for the total study population (Fig. 1), and 0.93 for the more severely injured subgroup. Similarly, in terms of complications, no significant difference in adjusted total complication rate was found between PED and non-PED centers for the total study population (AOR, 1.21; 95% CI, 0.43–3.39; $p = 0.714$), or the severely injured subset (AOR, 1.18; 95% CI, 0.42–3.33; $p = 0.757$) (Table 3). Contrary to univariate findings, adjusted analysis of functional outcomes for the nonfatal study population (n = 1,072) found no difference in FSD between PED and non-PED subgroups for the total study population (coefficient, −0.65; 95% CI, −1.44 to 0.15; $p = 0.113$), or the more severely injured (ISS ≥ 16; n = 670) subset (coefficient, −0.85; 95% CI, −2.03 to 0.28; $p = 0.136$) (Table 4).

DISCUSSION

Traumatic brain injury is a major public health issue afflicting an estimated 1.7 million people annually in the United States.[1] Although TBI affects people across all age categories, a disproportionate percentage of TBI-related emergency department visits, hospitalizations, and deaths occur in adolescents, making research into this specific age segment crucial.[1] As adolescents fall between pediatric and adult classifications, determining the optimal treatment facility for managing these patients can be challenging. Although some studies investigating pediatric populations, including adolescents, suggest these patients have better outcomes at pediatric-designated TCs,[8–12] other analyses report no difference in adjusted outcomes between pediatric and adult facilities.[13–17] Additionally, although a few of these studies examined adolescent-specific populations,[13,14] the literature on this age segment is scarce,

TABLE 2. Multilevel Mixed-Effects Logistic Regression Mortality Models for the Total Study Population and a Severely Injured (ISS ≥ 16) Subgroup

	Mortality Model (Total Study Population; n = 1,109)		Mortality Model (ISS ≥16 Population; n = 705)	
Variable	AOR (95% CI)	p	AOR (95% CI)	p
Pediatric center	0.82 (0.23–2.86)	0.754	1.06 (0.28–3.94)	0.934
Age	1.28 (0.70–2.34)	0.414	1.20 (0.65–2.21)	0.566
Shock Index	10.2 (1.98–52.9)	0.006	13.2 (2.27–76.8)	0.004
Head AIS	3.71 (1.73–7.96)	0.001	3.97 (1.49–10.6)	0.006
GCS motor	0.35 (0.20–0.61)	<0.001	0.36 (0.21–0.63)	<0.001
TC level (Level I)	1.88 (0.56–6.33)	0.308	1.61 (0.46–5.73)	0.458
Case volume	1.01 (0.99–1.03)	0.328	1.01 (0.99–1.03)	0.415
Injury year	1.18 (1.03–1.33)	0.013	1.17 (1.03–1.34)	0.017
	AUROC, 0.96 (0.93–0.98)		AUROC, 0.93 (0.88–0.97)	

AUROC, area under the receiver operating characteristic.

TABLE 3. Multilevel Mixed-Effects Logistic Regression Complication Models for the Total Study Population and a Severely Injured (ISS ≥ 16) Subgroup

	Complication Model (Total Study Population; n = 1,109)		Complication Model (ISS ≥16 Population; n = 705)	
Variable	AOR (95% CI)	p	AOR (95% CI)	p
Pediatric center	1.21 (0.43–3.39)	0.714	1.18 (0.42–3.33)	0.757
Age	1.13 (0.70–1.83)	0.620	1.24 (0.75–2.04)	0.401
Shock Index	2.22 (0.44–11.1)	0.332	2.38 (0.46–12.2)	0.300
Head AIS	2.89 (1.62–5.18)	<0.001	2.02 (0.96–4.29)	0.066
GCS motor	0.81 (0.68–0.97)	0.022	0.82 (0.68–0.99)	0.034
TC level (Level I)	1.16 (0.42–3.19)	0.782	1.32 (0.47–3.73)	0.605
Case volume	1.00 (0.98–1.02)	0.802	1.00 (0.98–1.02)	0.783
Injury year	0.65 (0.56–0.76)	<0.001	0.66 (0.55–0.79)	<0.001
	AUROC, 0.91 (0.88–0.92)		AUROC, 0.87 (0.82–0.93)	

and fails to investigate the impact of TC designation on specific injury types, such as TBI.

This investigation sought to add to the literature on this underrepresented facet of the adolescent debate by analyzing risk-adjusted outcomes for sTBI patients treated at adult and pediatric TCs in the Commonwealth of Pennsylvania. In agreement with the two previous works analyzing adolescent-specific trauma populations,[13,14] this study failed to find any significant differences in outcomes for adolescent sTBI patients between the ages of 15 and 17 years managed at pediatric and adult centers. This finding refutes our hypothesis that improved adjusted mortality, decreased overall complications, and increased FSD would be found at pediatric centers compared to adult counterparts.

Reviewing the results of this investigation in composite, it is not surprising, however, that no significant difference in unadjusted and adjusted mortality for adolescent sTBI patients was found between center types. Both center types managed patients with nonsignificant differences in age, sex, and injury severity classifications, who developed statistically similar rates of complication over the course of their hospital stay. The fact that unadjusted FSD scores were significantly higher in patients managed at PED centers may be a result of the slight variance in management approaches used between center types—although these univariate differences were eliminated when controlling for other covariates in adjusted analysis. Although the difference was nonsignificant, pediatric centers still had a 3.2% increased overall intervention rate compared with adult counterparts. In addition, rates of craniectomy were found to be significantly higher at PED centers—both factors which could have impacted the univariate FSD results.

Comparing our results to the two previous investigations by Matsushima et al.[13] and Walther et al.,[14] who analyzed similar questions in adolescent populations, it appears as though a trend toward consensus has formed regarding adjusted outcomes for these patients between center types. It is important to note, however, that differences in the age classification of "adolescents" makes it difficult to directly compare our work to that of the previously detailed authors.

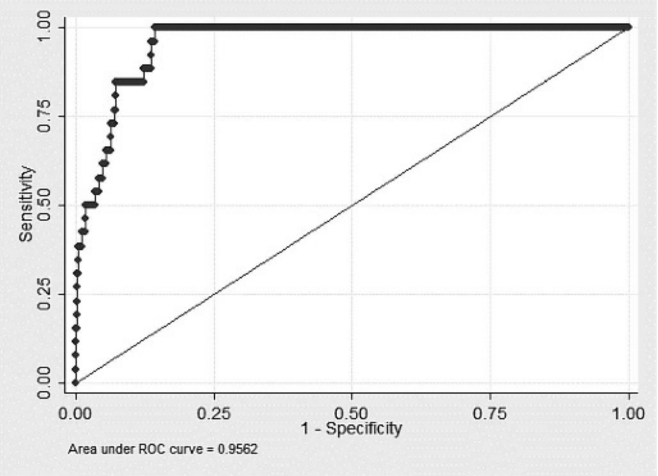

Figure 1. Area under the receiver operating characteristic curve for total study population mortality model.

TABLE 4. Generalized Linear Mixed Models for FSD for the Total Nonfatal Study Population and a Severely Injured (ISS ≥ 16) Subgroup

	FSD Model (Total Nonfatal Study Population; n = 1,072)		FSD Model (ISS ≥16 Nonfatal Population; n = 670)	
Variable	Coefficient (95% CI)	p	Coefficient (95% CI)	p
Pediatric center	−0.65 (−1.44 to 0.15)	0.113	−0.85 (−2.03 to 0.28)	0.136
Age	−0.08 (−0.38 to 0.22)	0.593	−0.12 (−0.54 to 0.32)	0.607
Shock Index	−0.01 (−1.39 to 1.37)	0.988	0.55 (−1.33 to 2.45)	0.570
Head AIS	−1.15 (−1.49 to −0.81)	<0.001	−1.00 (−1.60 to −0.36)	0.002
GCS motor	0.84 (0.71 to 0.98)	<0.001	1.01 (0.83 to 1.19)	<0.001
TC Level (Level I)	0.78 (0.03 to 1.53)	0.040	1.05 (−0.05 to 1.62)	0.063
Case volume	0.00 (−0.01 to 0.01)	0.622	0.00 (−0.02 to 0.01)	0.861
Injury year	−0.10 (−0.17 to −0.03)	0.003	−0.14 (−0.24 to −0.02)	0.007

Analyzing the Pennsylvania Trauma Outcome Study database, the same registry queried in our investigation, Matsushima et al.[13] compared outcomes between pediatric and adult TCs for adolescent trauma patients aged 13 to 18 years presenting with all injury types from 2005 to 2010. In addition to differences in adolescent age classification (our study analyzing patients 15–17 years old) and injury type investigated (blunt isolated sTBI vs. all blunt/penetrating trauma patients), many differences in baseline demographic/injury severity factors were found between this investigation and our own. Despite our study examining a more severely injured TBI-specific population, unadjusted mean ISS, complication rate, and mortality rate were found to be significantly higher at adult centers compared with pediatric facilities in this study. It should be noted, however, that Matsushima et al. only designated standalone pediatric TCs as "pediatric," excluding adult centers with pediatric affiliations. This could have induced substantial bias into their results because they were essentially comparing a standalone pediatric center population to a population including both patients managed at pediatric and adult TCs. Nonetheless, when analyzing these outcomes through regression analysis, both the work of Matsushima et al. and our investigation found no difference in complications or mortality for adolescent patients managed at pediatric and adult centers.

Comparing outcomes between pediatric and adult TCs for adolescent trauma patients aged 15 to 19 years with all injury types in the state of Ohio, Walther et al.[14] reported similar adjusted findings to Matsushima et al. and this study. Although unadjusted mortality rate was found to be significantly lower at pediatric centers compared with adult counterparts, when adjusting for covariates in multivariate analysis, this difference was no longer significant. It should be noted that similar to the case of Matushima et al., Walther et al. classified pediatric TCs differently than our investigation, excluding adult centers with pediatric affiliation from analysis.

Several limitations are present in this study. In addition to the inherent limitations of any retrospective analysis, the results of this investigation only encompass one state's trauma system. As such, these results may not be generalizable to the adolescent isolated severe traumatic brain injury population at large. In addition, as our study presents data from 33 TCs throughout the state of Pennsylvania, much of our data are reliant on the accuracy and completeness of this information provided from dedicated trauma registrars. Although unlikely, it is possible higher-level TCs, with a more established administration, could be providing more complete data. To maintain accreditation under the Pennsylvania Trauma Systems Foundation, however, all TCs in the state are required to submit data on all patients meeting trauma inclusion criteria within 42 days of patient discharge. Finally, as our data set lacks information pertaining to end-of-life care, specifically detailing which patients were deemed nonsalvageable by neurosurgery and which had care withdrawn, this could induce substantial bias regarding our mortality trends.

CONCLUSION

In an analysis of a unique patient population, our results failed to find any significant differences in outcomes for adolescent isolated severe traumatic brain injury patients managed at pediatric versus adult TCs in the Commonwealth of Pennsylvania. This is the first investigation, to our knowledge, that has analyzed adolescent outcomes for a specific injury type (sTBI) between centers. Future efforts should attempt to further classify other injury categories for adolescents managed at adult and pediatric center types.

AUTHORSHIP

B.W.G. participated in the study design, data collection, data analysis, interpretation of data, article preparation, and editorial oversight. M.E. participated in the study design, interpretation of data, and article preparation. A.D.C. participated in the study design, data analysis, interpretation of data, and article preparation. C.D.R. participated in the data analysis, interpretation of data, and article preparation. C.A.L. participated in the data analysis, interpretation of data, and article preparation. E.H.B. participated in the data analysis, interpretation of data, article preparation. D.W. participated in the study design and article preparation. F.B.R. participated in the study design, interpretation of data, article preparation, and editorial oversight.

DISCLOSURE

The authors declare no conflicts of interest.

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