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Academic-community partnerships improve outcomes in pediatric trauma care☆,☆☆

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ABSTRACT

Background: To address the specialized needs of injured children, pediatric trauma centers (PTCs) were established at many large, academic hospitals. This study explores clinical outcomes observed for injured children treated at an academic-sponsored community facility.
Methods: In partnership with an academic medical center in a major metropolitan area, a not-for-profit community hospital became a designated Level II PTC in October 2010. Data for injured children <15 years old treated prior to PTC designation from January 2000 to September 2010 were prospectively collected using the Trauma and Emergency Medicine Information System and compared to data collected after PTC designation from January 2011 to December 2013.
Results: Overall, 681 injured children were treated at the community hospital from January 2011 to December 2013. Children treated after PTC designation were less likely to undergo computed tomography (CT) (50.9% vs. 81.3%, $p < 0.01$), even when controlling for age, gender, injury type, injury severity, and year (OR 0.18, 95%CI 0.08–0.37). Specifically, fewer head (45.7% vs. 68.7%, $p < 0.01$) and abdominal CTs (13.2% vs. 26.5%, $p < 0.01$) were performed. Hospital length of stay was significantly shorter (2.8 ± 3.7 days vs. 3.7 ± 5.9 days, $p < 0.01$). Mortality was low overall, but also decreased after PTC designation (0.4% vs. 2.0%, $p = 0.02$).
Conclusions: These results indicate that academic-community partnerships in pediatric trauma care are a feasible alternative and may lead to improved outcomes for injured children.

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The delivery of high quality, timely trauma care for acutely injured children is paramount. Consequently, pediatric trauma centers (PTCs) have been established to address the specialized needs of injured children. Receiving care at a PTC is associated with lower mortality rates, successful nonoperative management of blunt injury and improved functional recovery [1–5]. However, the vast majority of injured children do not receive care at a PTC, with up to 90% receiving care at a non-children's hospital [6,7]. This is primarily due to limited distribution of specialized care and lack of pediatric surgeons and specialists in a given region [2,8].

As pediatric trauma resource distribution varies widely, many question whether trauma centers with additional qualifications for children may be just as effective as free standing PTCs. For example, injured children treated at an adult hospital with a pediatric trauma unit may have similarly improved outcomes compared to those treated at a free-standing PTC [9–11]. Thus, broader definitions of alternative pediatric-specific trauma systems could bridge disparities in pediatric trauma care delivery in the United States.

Grown from a local desire for increased access to pediatric trauma care followed by public policy endorsement, a not-for-profit, community hospital and adult trauma center became a Level II PTC for a region of Los Angeles County with a population of 1.8 million. Historically, injured children in the area accessed pediatric trauma care at the regional level. After PTC designation, injured children immediately had access to specialty care at the local level. This study describes the unique

Abbreviations: PTC, pediatric trauma center; ISS, Injury Severity Score; TEMIS, Trauma and Emergency Medicine Information System; CT, computed tomography; LOS, length of stay.

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partnership between an academic medical center and community hospital and explores the improved clinical outcomes observed after PTC designation.

1. Methods

1.1. Data source

A retrospective cohort study was performed after obtaining IRB approvals from the University of California, Los Angeles and Northridge Hospital Medical Center. Data were obtained from the Trauma and Emergency Medicine Information System (TEMIS) utilized by the Northridge Hospital trauma department and other Los Angeles County trauma centers to prospectively record injury specific data points for each activated trauma treated. This dataset includes emergency medical system pre-hospital information as well as demographic, injury specific and clinical information for each injured person and activated trauma treated in the emergency department. In order for a patient's clinical information to be collected in TEMIS, they must have at least one *International Classification of Disease, Ninth Revision, Clinical Modification* (*ICD-9-CM*) injury diagnostic code within the range of 800–959.9. Exclusions include all diagnostic codes within the following ranges, unless an additional injury that meets criteria exists: 905–909.9 (late effects of injury), 910–924.9 (superficial injuries/insect bites), 930–939.9 (foreign bodies). V-codes for patients involved in trauma but without injury were not included.

1.2. PTC designation

PTC designation occurred after establishing a working partnership between Northridge Hospital Medical Center and Mattel Children's Hospital at UCLA. Northridge Hospital is a not-for-profit community hospital and Level II adult trauma center serving a potential catchment area of approximately 500,000 children. Mattel Children's Hospital at UCLA is a tertiary-quaternary care, pediatric academic medical center and Level 1 PTC serving the greater Los Angeles area. Level I and Level II PTC designations are defined according to California and Los Angeles County Department of Health Services [12]. Prior to Level II PTC designation, injured children treated at Northridge Hospital were cared for by adult trauma surgeons entirely or subsequently transferred to regional PTCs, with potential delay in definitive treatment. Due to a local, high-profile infant death after a motor vehicle collision requiring transport to a regional PTC, legislation to assist funding a new PTC to serve the area was introduced in 2005 by a bill sponsored for general trauma care needs. Northridge Hospital was the only active adult trauma center of several in the area that also had pediatric intensive care unit capabilities and pediatric services infrastructure.

Table 1 outlines the Los Angeles County requirements for Level II PTC designation. At Northridge Hospital, the pediatric trauma program medical director was a pediatric surgeon with dual appointments at Mattel Children's Hospital and Northridge Hospital, along with five other pediatric surgeons. The trauma nurse coordinator already employed for the adult trauma service functioned as the pediatric trauma nurse coordinator. The pediatric trauma director and coordinator provide for the implementation of the trauma level requirements and coordinate with the local county emergency medical system agency. The pediatric trauma team is a multidisciplinary group of immediate responders responsible for the initial resuscitation and management of the pediatric trauma patient. Back up call schedules for the pediatric and adult trauma surgeons are activated when needed for operative cases. For sub-specialty services requiring transfer outside of Northridge Hospital, contracts were made with UCLA some pediatric surgical and medical specialty services who took part in a call pool sharing coverage of Northridge Hospital and Mattel Children's Hospital at UCLA.

Table 1
Northridge Hospital Medical Center responders to pediatric trauma activation and level II PTC designation requirements.

Pediatric Trauma Response Team:	Pediatric Surgeon and Adult Trauma Surgeon Pediatric Intensivist, Anesthesiologist Emergency Medicine Physician Pediatric Critical Care Nurse, Emergency Trauma Nurses x 2 Operating Room Charge Nurse, Emergency Technician, Respiratory Therapist, Blood Bank Technician, Radiology Technologist
PTC Designation Requirements:	
Pediatric Trauma Program Medical Director	Board-certified surgeon with experience in pediatric trauma care
Pediatric Trauma Nurse Coordinator	Registered nurse with qualification and may also be the trauma nurse coordinator/manager for an adult trauma service
Pediatric Specialty Departments and Services	Surgical: Neurologic, obstetric/gynecologic**, ophthalmologic, oral or maxillofacial or head and neck, orthopedic, plastic, urologic, microsurgery/reimplantation** Non-Surgical: Anesthesiology, cardiology, critical care, emergency medicine, gastroenterology, general pediatrics, hematology/oncology, infectious disease, neonatology, nephrology, neurology, pathology, psychiatry, pulmonology, radiology, rehabilitation/physical medicine**, adolescent medicine**, child development**, genetics**, neuroradiology**, psychiatry**, allergy/immunology**, dentistry**, endocrinology** Facility capabilities: PICU, Pediatric service, ER, Operating room, Burn center**, Physical therapy, Rehabilitation**, Clinical lab and blood bank, Acute hemodialysis, Respiratory therapy, Occupational therapy, Speech therapy, Social service, Acute spinal cord management, Potential organ donor protocol, Community outreach program, Continuing education program, SCAN (suspect child abuse and neglect) team, Aeromedical transport plan, Child life program
Pediatric Emergency Response	Available with qualified pediatric surgical and nonsurgical specialists in-house, immediately available, and/or promptly available on-call as directed.

** May be provided through a written transfer agreement with a hospital that has a department, division, service, or section that provides this service.

1.3. Study cohort

Northridge Hospital became a designated Level II PTC on October 4, 2010. Demographic, clinical and injury specific data points for each injured child <15 years old treated from January 2000–September 2010 were retrospectively collected (pre-PTC) and compared to prospective data collected from January 2011 to December 2013 (post-PTC). One patient who was initially admitted as an activated trauma in the post-PTC group ultimately did not have an *ICD-9-CM* injury code that qualified for inclusion in the TEMIS dataset and therefore was excluded from this analysis. Patient age, injury severity score (ISS) and hospital length of stay (LOS) were analyzed as continuous variables. ISS was further categorized into mild, moderate and severe categories. A score of 0–9 was considered mild injury, 10–14 moderate and ≥15 severe. If a patient was admitted as an activated trauma but discharged from the Emergency Department the same day, their LOS was counted as one day. Mortality was defined as any trauma related in hospital death. All other analyzed outcomes were evaluated as dichotomous, categorical variables. Type of CT scan performed was determined based on the type of radiologic study performed and the anatomical body part studied as recorded in TEMIS. Discharge destination was defined as the level of post-hospital care received after discharge from Northridge Hospital. Transfer to an acute care facility after PTC designation typically occurred due to patient insurance preferences after patient stabilization, and rarely occurred for need of higher level pediatric trauma care. Transfer to another trauma center

occurred if there was a need for long term rehabilitation after traumatic brain or spinal cord injury.

1.4. Statistical analysis

Longitudinal analysis of annual admission rates for injured children from 2000 to 2013 was performed. Annual percentage of children undergoing any CT scan was also evaluated. Unadjusted bivariate analysis using chi-squared and Fisher's exact test was conducted to determine demographic and clinical differences between injured children before and after PTC designation. CT usage and type of CT performed was also compared between pre- and post-PTC groups. Multivariate logistic regression was utilized to identify factors associated with likelihood to undergo CT scan. No statistically significant interactions between ISS and the other covariates in the regression model were identified. Statistical analyses were performed using SAS version 9.4 (SAS Inc., Cary, NC). A p-value <0.05 was considered significant.

2. Results

Annual pediatric trauma admissions from 2000 to 2013 are depicted in Fig. 1A. Prior to PTC designation, 13 to 40 injured children were treated at the community hospital per year. After designation, annual pediatric trauma admissions ranged from 211 to 247 injured children per year. The annual percentage of children who received a CT scan before and after PTC designation is illustrated in Fig. 1B. Prior to PTC designation, percentages of injured children per year receiving a CT scan ranged from 63–100% per year. Following PTC designation, the percentages dropped to 42–57%.

Cohort demographics, hospitalization and discharge information were compared between pre- and post-PTC groups in Table 2. Significantly more children in the post-PTC group suffered blunt injury (97.6% vs. 91.2%, $p < 0.01$). Mortality was lower in the post-PTC group (0.4% vs. 2.0%, $p = 0.02$) and more children were discharged home (92.8% vs. 86.1%, $p < 0.01$). Compared with children treated in the decade prior, injured children treated after PTC designation were younger (6.6 ± 4.6 years vs. 9.5 ± 4.2 years, $p < 0.01$) and had a slightly lower injury severity score (ISS) (6.0 ± 6.0 vs 7.1 ± 8.2, $p = 0.02$). Moreover, after PTC designation, injured children exhibited a significantly shorter hospital LOS (2.8 ± 3.7 days vs. 3.7 ± 5.9 days, $p < 0.01$) and significant decline in the rate of transfers to other acute care facilities (2.5% vs 8.5%, $p < 0.01$).

Injured children treated after PTC designation experienced fewer CT scans (50.9% vs 81.3%, $p < 0.01$) overall. The majority of CT scans performed in both groups included head imaging. Fewer head CT's (45.7% vs. 68.7%, $p < 0.01$), fewer spine CT's (0.06% vs. 2.0%, $p = 0.04$) and fewer abdominal CT's (13.2% vs. 26.5%, $p < 0.01$) were performed after PTC designation. CT's of the orbit, face, neck, chest, pelvis and extremity did not significantly differ between groups.

Bivariate analysis of CT usage showed that older children (8.4 ± 4.5 years vs. 6.1 ± 4.5 years, $p < 0.01$) and children with a higher ISS (7.1 ± 7.1 vs. 5.9 ± 6.0, $p = 0.01$) underwent more CT scans. CT usage did not vary by male gender (64.3% vs. 66.7%, $p = 0.45$) or blunt injury (96.4% vs. 94.6%, $p = 0.17$). PTC designation was the most important independent factor predicting decreased likelihood of receiving a CT scan (OR 0.18, 95% CI 0.08–0.37; Table 3). Older children (OR 1.09, 95% CI 1.06–1.13) and children who sustained a blunt injury (OR 2.97, 95% CI 1.49–5.93) were more likely to have a CT scan performed. Finally, increased ISS was also significantly associated with increased likelihood to undergo a CT scan (OR 1.03, 95% CI 1.01–1.05).

Table 2
Cohort demographics and hospitalization.

	Pre-PTC N = 294 (%)	Post-PTC N = 681 (%)	p-Value
Male Gender	192 (65.3)	445 (65.3)	0.99
Blunt Injury	268 (91.2)	659 (97.6)	<0.01
ICU Admissions	126 (42.9)	277 (40.7)	0.53
Mortality	6 (2.0)	3 (0.4)	0.02
Discharge Destination			
Home	253 (86.1)	632 (92.8)	<0.01
Home with Home Health	0 (0)	8 (1.2)	0.06
Acute Care Facility	25 (8.5)	17 (2.5)	<0.01
Subacute Care	0 (0)	1 (0.2)	0.51
Rehabilitation Center	6 (2.0)	12 (1.8)	0.77
Skilled Nursing Facility	2 (0.7)	0 (0)	0.03
Trauma Center	1 (0.34)	6 (0.9)	0.36
Eloped	1 (0.34)	1 (0.2)	0.54
ISS			
Mild ISS	223 (75.9)	528 (77.5)	0.57
Moderate ISS	32 (10.9)	100 (14.7)	0.11
Severe ISS	39 (13.3)	53 (7.8)	<0.01
	Mean ± SD	Mean ± SD	
Age (years)	9.5 ± 4.2	6.6 ± 4.6	<0.01
ISS	7.1 ± 8.2	6.0 ± 6.0	0.02
Length of Stay (days)	3.7 ± 5.9	2.8 ± 3.7	<0.01

ISS = Injury Severity Score, SD = standard deviation.

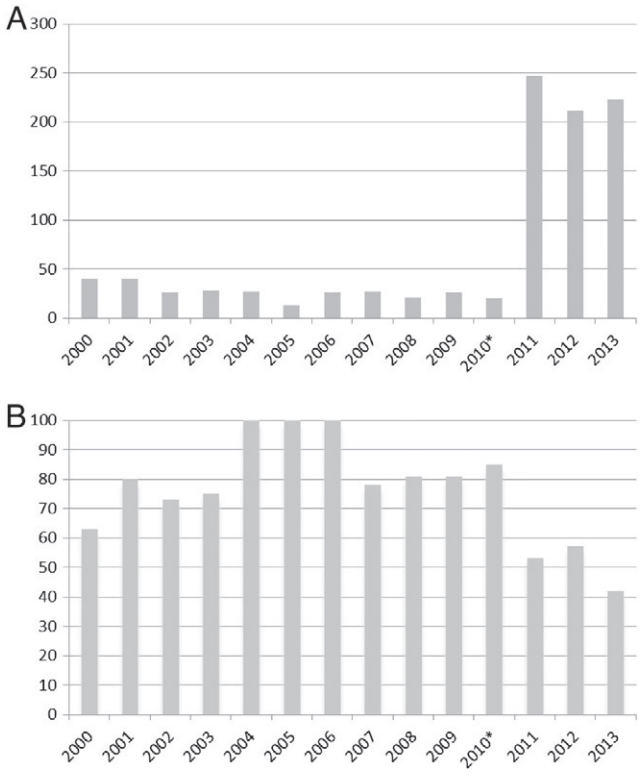

Fig. 1. A. Annual Pediatric Trauma Admissions. Total number of injured children admitted each year both before and after PTC designation. B. Percent CT Usage by Year. Percent per year of injured children receiving a CT scan before and after PTC designation.

Table 3
Multivariate analysis of CT usage after PTC designation.

	OR	95% CI	p-Value
Post-PTC	0.18	0.08–0.37	<0.01
Male Gender	0.79	0.59–1.07	0.12
Blunt Injury	2.97	1.49–5.93	<0.01
Age in years	1.09	1.06–1.13	<0.01
ISS	1.03	1.01–1.05	0.02
Year of Injury	1.06	0.97–1.15	0.17

CT = computed tomography, PTC = pediatric trauma center, ISS = Injury Severity Score, OR = odds ratio, CI = confidence interval.

3. Discussion

This study describes a novel partnership between a not-for-profit community hospital and a pediatric academic medical center. Shared goals between institutions resulted in improved outcomes for injured children in an area previously without local access to specialized pediatric trauma care. Community-academic partnerships have been previously described in the adult literature to improve clinical care for vulnerable populations such as cancer survivors [13] and at-risk elders [14–16]. However, community-academic partnerships have been rarely described in pediatric trauma care delivery [17]. This particular partnership was exceptional, growing from a community desire for improved access to pediatric trauma care, legislation and subsequent funding for a pediatric trauma center followed by an academic collaboration to augment institutional development. For many trauma centers, community engagement frequently aims at primary and secondary injury prevention. This study highlights a community-academic partnership resulting in tertiary prevention, maximizing injury care and minimizing injury sequelae [18].

As overall mortality is very low for injured children, meaningful outcomes in pediatric trauma are controversial. The most prominent finding in this study was the dramatic decrease in CT use for injured children treated after PTC designation, even when controlling for patient and injury specific variables. Current literature underscores the overuse of CT scans for injured children [19–21] and the link between CT use in the pediatric population and overall increased lifetime risk of cancer [22,23]. In response, multiple triage algorithms emphasizing monitored observation, plain radiography and decreased CT usage have been developed [24–26]. For example, clinical algorithms such as CATCH [26], a Canadian decision tool stratifying mildly injured children into high and medium risk for head injury, predicts optimal head CT scan rates of 30% and 52% respectively. However, this decision tool has yet to be validated prospectively. In the present study, usage of head CTs decreased considerably after PTC designation (45.7% vs. 68.7%, $p < 0.01$), likely reflecting endorsement of current recommendations for head injured children stressing close observation in lieu of CT imaging. Adult trauma surgeons may benefit from increased education on appropriate imaging utilization in children as CT usage may be a surrogate for inexperience in pediatric trauma care. Ultimately, targeted use of CT in pediatric trauma may be a future measure of improved quality in care and warrants further discussion, investigation and consensus at the policy level.

In addition to decreased CT use, injured children admitted after PTC designation were more often discharged home, stayed a shorter time in the hospital and exhibited decreased overall mortality. These results agree with prior reports of decreased hospitalization and mortality associated with pediatric trauma center designation [6,11,27]. These effects may be due to a more focused initial trauma assessment, resuscitation and recovery for injured children. Availability of pediatric-specific trauma specialists within a hospital system could facilitate improved resource utilization and therefore translate to more expedited care, improved quality, and decreased healthcare expenditure. However, the post-PTC group did exhibit a slightly lower ISS which could also contribute to the improved outcomes observed. The rarity of mortality in this study and the relatively short hospital LOS observed between groups precluded further regression analysis controlling for ISS. As most children survive after injury and have shorter hospital stays compared to their adult counterparts, this study's findings again highlight the need to develop meaningful quality indicators in pediatric trauma care.

As trauma and critical care is highly dependent on technology, one limitation of this study is that some of the improved outcomes observed in the post-PTC group may be secondary to historical effects. Modern advances in trauma algorithms and critical care rather than a true difference in triage and management of injured children may explain part of the improvement seen over the 13 year span of this data. Additionally, over triage of injured children may explain some of the measured benefit after PTC designation. However, year of injury was included as a covariate in the regression analysis of CT usage and was not significant. This result implies that the significant decrease in CT scans observed after PTC designation is largely due to the institutional change focused on pediatric specialty care for injured children. Furthermore, injury specific data varied little between injured children in the pre- versus post-PTC groups. Before Level II PTC designation, injured children were slightly older and had an average ISS one point higher, but still remained in the mild injury category on average. Likewise blunt injury was more commonly seen in the post-PTC group, which would be anticipated in a younger cohort.

Another critique of this study is that its external applicability is uncertain. This study reflects institutional changes made within one community hospital partnering with an academic medical center to improve care delivered to injured children. It is difficult to quantify which components of the new PTC were most effective in changing clinical practice for injured children. Ultimately, it was through multidisciplinary partnerships with pediatric surgery, emergency medicine, nursing and an already established trauma surgery team, that the community hospital was brought into the realm of evidence-based pediatric trauma care. Due to budget constraints and geographic restrictions, similar partnerships among other hospital systems desiring improved pediatric trauma care delivery may face substantial logistical challenges. These concerns highlight the importance of developing alternative models for pediatric trauma care delivery tailored to the clinical needs of the local pediatric population. What makes this study especially noteworthy is that changes in local pediatric trauma care delivery occurred first because of community engagement and investment at the legislative level. In order to create novel, sustainable models for improved pediatric trauma care delivery, academic medical centers must mobilize resources, engage community members, and think creatively about addressing needs in resource-poor areas [16,28–30].

4. Conclusions

Injured children are a particularly vulnerable population whose care and resource allocation is the subject of ardent academic and political discussion. This study presents a new paradigm for pediatric trauma care delivery, highlighting improved outcomes observed for injured children after developing an academic-community partnership and PTC. Improved outcomes included fewer CTs, and thereby less radiation exposure, shorter LOS and lower mortality. Community engagement and policy-level provision is vital in order to secure continued support for this model of pediatric trauma care delivery.

Appendix A. Presented by: Lorraine Kelley-Quon, Los Angeles, CA

Discussant DR. GAIL BESNER, Columbus, OH) Thank you for an excellent presentation. In addition to the percent of CAT scans that are done at these, quote/unquote, "adult hospitals," we're very interested in dose-limiting CAT scans. Did you look at the doses that the patients were exposed to before this merger and then after this merger, and were there any differences?

Response DR. KELLEY-QUON: This is a very good question. it wasn't something that was included in this data set, but it's something that our research group has definitely discussed, being that nationally, there's been a push for decreased dosage of radiation and CT scans for children. A lot of this has been led by children's hospitals. I think this is another thing that needs to be considered, not just whether or not someone gets a CT scan, but whether or not these children are getting a CT scan with the appropriate dosage of radiation.

Discussant DR. ART COOPER, New York, NY:. Perhaps I missed it, but it seemed as though your lower mortality may have resulted from a lower overall ISS at the community hospital centers. Is that correct?

Response DR. KELLEY-QUON: What's interesting is before (—in the decade before), if you look at the average age of injured children coming into this adult trauma center, the average age was significantly higher. On average, they were about nine years old. Those children in addition to the younger teenagers, more often had penetrating injuries. That made for a little different case mix, But, even controlling for that in our multivariate analysis, the pediatric trauma center designation really drove the usage of the CT scan.

DR. COOPER Data were not risk-adjusted, though, right?

Response DR. KELLEY-QUON: The data in the multivariate logistic regression analysis were adjusted for the covariates included in the regression.

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