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Variability in the structure and care processes for critically injured children: A multicenter survey of trauma bay and intensive care units☆

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ABSTRACT

Purpose: Evaluate national variation in structure and care processes for critically injured children.
Methods: Institutions with pediatric intensive care units (PICUs) that treat trauma patients were identified through the Virtual Pediatric Systems (n = 72). Prospective survey data were obtained from PICU and Trauma Directors (n = 69, 96% response). Inquiries related to structure and care processes in the PICU and emergency department included infrastructure, physician staffing, team composition, decision making, and protocol/checklist use.
Results: About one-third of the 69 institutions were ACS-verified Level-1 Pediatric Trauma Centers (32%); 36 (52%) were state-designated Level 1. The surgeon was the primary decision maker in the trauma bay at 88% of sites, and in the PICU at 44%. The intensivist was primary in the PICU at 30% of sites and intensivist consultation was elective at 11%. Free-standing pediatric centers used checklists more often than adult/pediatric centers for DVT prophylaxis (75% vs. 50%, p = 0.039), cervical spine clearance (75% vs. 44%, p = 0.011), and pain control (63% vs. 34%, p = 0.024). Otherwise, protocols/checklists were infrequently utilized by either center type.
Conclusion: Variability exists in structure and care processes for critically injured children. Further investigation of variation and its causal relationship to outcomes is warranted to provide optimal care.

Unintentional injury is the leading cause of fatal and nonfatal injury in children nationwide [1]. Integrated trauma systems are essential to providing quality emergency care. Despite mature adult trauma systems throughout the majority of the United States, trauma management for children remains fragmented. Ninety percent of injured children in the United States are treated in general emergency departments (EDs) at either adult or combined adult/pediatric centers rather than at trauma centers [2]. Fifty percent of EDs in the nation treat fewer than 10 pediatric patients per year [3], and only 6% of EDs in the US have the requisite supplies deemed essential for management of pediatric emergencies [4,5]. Lack of resources, organization, and centralization underlie the variability in emergency care provided to injured children throughout the nation. The Institute of Medicine's 2007 report, *Emergency Care for Children Growing Pains*, highlighted the need for coordination, regionalization, and systems of accountability to improve emergency care for injured children [6].

The distribution of pediatric injury nationwide challenges the integration of pediatric and trauma care. However, it has been shown that younger, more critically injured children derive the most benefit from treatment at verified trauma centers [7]. In addition to primary emergency and trauma services, triage and inter-facility transfer guidelines are necessary to cohort severely injured children at centers with specialized services and intensive care units (ICUs) for pediatric patients or that have designated pediatric beds. Once a child reaches the ICU, however, what constitutes optimal care remains unclear. While more

Abbreviations: ACS, American College of Surgeons; REDCap, Research Electronic Data Capture'; ICU, intensive care unit; PICU, pediatric intensive care unit; TC, trauma center; PTC, pediatric trauma center; VPS, Virtual PICU Systems, LLC; COT, Committee on Trauma; ED, emergency department.

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elucidated in adult medical and surgical critical care and trauma management [8–12], there is currently no consensus regarding unit infrastructure (open vs. closed units), physician staffing models, team composition, continuity of care, and protocol and checklist utilization in pediatric trauma management.

Additionally, the impact of latent processes of care, such as the nuances in decision making between intensivists and surgeons and the subjective "degree" of involvement by each healthcare team member, remains unknown in the setting of critically injured children. Similar questions – related to both salient and latent features of care – exist for pediatric trauma management in the emergency department.

How do we measure quality of care in this multimodal, multifaceted care environment? Quality of healthcare is often conceptualized using Donabedian's framework, highlighting structure, process, and outcome [13]. Structure includes the setting in which medical care occurs, and describes material resources and organization. Process describes provision and receipt of care. Outcome defines the impact of providing care on the health status of the patient and/or population. "This three-part approach to quality assessment is possible only because good structure increases the likelihood of good process, and good process increases the likelihood of good outcome." [13]

The objective of this study was to describe the variability in Donabedian's first two domains, the structure and processes of care, for critically injured children in a national sample that included both free-standing pediatric and combined adult/pediatric centers.

1. Materials and methods

1.1. Survey creation and dissemination

A survey was created using consensus input from experts in the fields of pediatric trauma, pediatric critical care, pediatric traumatic brain injury, and pediatric injury prevention. A pilot questionnaire was distributed to four American College of Surgeons (ACS)-verified Level 1 Pediatric Trauma Centers (PTCs) and one ACS-verified Level 2 PTC to test the validity of the survey tool. After aggregating the pilot data and soliciting feedback from respondents, questions were refined to target content of interest more effectively. Based on pilot data feedback, the questions pertaining to the trauma bay and ICU were split into two separate surveys. This division enabled a targeted query to the individual(s) who would be most knowledgeable in the structure and processes of care in each area (trauma bay vs. ICU). Trauma bay and PICU surveys are provided in Supplementary Files A and B, respectively.

Survey data were collected and managed using Research Electronic Data Capture (REDCap), a secure web-based application designed to support validated data capture, hosted at the University of Washington [14]. This study was deemed exempt from review by the University of Washington Institutional Review Board.

1.2. Sample

The survey was sent to all Virtual Pediatric Systems-affiliated institutions in the United States. Virtual Pediatric Systems, LLC ("VPS") is co-owned by two not-for-profit entities, Children's Hospital Los Angeles (CHLA) and the Children's Hospital Association's NACHRI. Since inception in 1997, VPS has grown to include over 130 active ICU units representing nearly one-million cases making it the largest pediatric collaborative for quality improvement based on detailed patient records in critical care. VPS's specialties include risk adjustment and comparative analysis, each aimed to enhance the quality of pediatric critical care [15]. All VPS-affiliated PICUs indicating in the site-specific VPS Participant Profile that their institution cared for trauma patients were considered eligible and were sent a cover letter and electronic access to the survey form(s) on May 6, 2014 ($n = 79$). Sites were contacted by phone and email between June 1 and August 4, 2014 to encourage participation. VPS site coordinators at each institution and/or the PICU Medical Director were the targeted respondents for the PICU-focused survey. The Trauma Program Manager and/or the Trauma Program Director were the targeted respondents for the trauma bay-focused survey.

1.3. Decision rules

If more than one survey was started per site, the most complete survey was chosen for analysis. If two surveys were completed, field values were blindly compared through the RedCAP software for concordance. If discrepant field values were identified, the position of the respondent was considered. The answer from the targeted respondent most immediately involved in the operations of the ICU or trauma bay was used for data analysis. If discrepant field values existed in two different surveys completed by the same individual at an institution, the most recent answer was used for analysis. This occurred rarely and appeared to be isolated to situations in which the survey respondent did not immediately know the answer to a question, consulted a colleague for input, and then started a new survey through Redcap instead of completing their original form. Surveys were considered complete if >90% of the questions were answered. Response rates were calculated based on established guidelines [16].

1.4. Definitions utilized in the survey

An academic health center was defined as an accredited, degree-granting institution of higher education that consists of a medical school (allopathic or osteopathic) or health professional school and/or is affiliated with a teaching hospital or health system [17].

Trauma center level was captured for each participating institution using both state and American College of Surgeons (ACS) definitions [18]. Hospitals self-reported their state and ACS designation; the latter was cross referenced with the most up-to-date and available data from the Committee on Trauma (COT, August 11, 2014). The ACS verifies centers for adult trauma (Levels I–III Trauma Center, TC) and pediatric trauma (Level I or II Pediatric Trauma Center, PTC). ACS also qualifies adult trauma centers that demonstrate capacity to care for the injured child. These centers must see at least 100 children under the age of 15 per year and have the following resources: trauma surgeons credentialed by the hospital for pediatric trauma management, a pediatric emergency department area, a pediatric ICU area, pediatric resuscitation equipment, and a pediatric performance improvement and patient safety (PIPS) program [18]. State certification of trauma capabilities varies by state (or county) and was captured from survey results alone.

An intensivist was defined as a physician with board certification in Medicine, Anesthesia, Surgery, or Pediatrics, and also certified in critical care medicine. Emergency Medicine physicians who completed a critical care fellowship in an ACEP accredited program were also included [19].

A "closed ICU" was defined as an "ICU where patients are cared for primarily by a critical care team," with other specialties acting as consulting services. In this case, the critical care team is the primary decision making service. Usually only the ICU team writes admission, discharge, and daily orders on the patients. ICUs that did not meet the survey's definition of 'closed' were defined as 'open.'

Unit intensity classification was defined to be consistent with Pronovost et al. [8]. High intensity units included closed ICUs, ICUs where the intensivist was considered the primary physician, and ICUs where critical care consultation was mandatory. Low intensity units included open ICUs and ICUs where there was no intensivist or consultation was elective. To target unit intensity while maintaining the granularity related to unit structure and decision making, respondents were first asked who was considered the primary physician for pediatric trauma patients admitted to the ICU. If a non-intensivist (e.g. a surgical attending without critical care board certification) was reported to be the patient's "primary" physician, the survey respondent was asked if critical care consultation was mandatory or elective. Respondents