

Increasing use of endovascular therapy in pediatric arterial trauma

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ABSTRACT

Background: Endovascular therapy has been increasingly used for critically injured adults. However, little is known about the epidemiology and outcomes of endovascularly managed arterial injuries in children. We therefore aimed to evaluate recent trends in the endovascular management of pediatric arterial injuries and its association with early survival.

Methods: An 8-year analysis of the National Trauma Databank (2007-2014) was performed to extract all pediatric trauma patients (aged ≤ 16 years) with arterial injuries. Demographics, clinical data, interventions (endovascular vs open), and outcomes (in-hospital mortality and length of stay) were extracted. Patients undergoing endovascular or open procedures were compared for differences in clinical characteristics using bivariate analysis. Multivariable logistic regression analysis quantified the association between endovascular therapy and survival in the context of other variables predictive of survival on univariate analysis, with $\alpha \leq .05$.

Results: There were 35,771 pediatric patients available for analysis. Overall, there was a significant increase in the use of endovascular procedures (from 7.8% in 2007 to 12.9% in 2014; $P < .001$), particularly among blunt trauma patients (5.8% in 2007 to 15.7% in 2014; $P < .001$). Conversely, a significant decrease was noted for open procedures ($P < .001$). There was a stepwise increase in the proportion of patients managed endovascularly as the Injury Severity Score (ISS) increased (highest in the ISS spectrum of 31-50). Angioembolization of internal iliac injury and thoracic aortic endograft placement were the two most common endovascular procedures ($n = 88$ [33.4%] and $n = 60$ [22.9%], respectively). There were 331 decedents (9.1% vascular injured children), 242 (73.1%) of whom were dead on arrival. After controlling for differences in demographics and clinical data, when outcomes were compared between patients who underwent endovascular and open procedures, there were no significant differences regarding in-hospital mortality (3.0% vs 3.6%; odds ratio, 0.7; 95% confidence interval, 0.1-6.1; $P = .778$). A logistic regression model identified Glasgow Coma Scale score ≤ 8 , ISS ≥ 16 , positive result of ethanol or drug screen, and systolic blood pressure < 90 mm Hg on admission as independent risk factors for death.

Conclusions: The use of endovascular therapy in pediatric vascular arterial trauma has significantly increased, especially among severely injured blunt trauma patients. Despite this successful integration into care, there was no in-hospital survival advantage conferred by endovascular therapy compared with traditional open therapy. Approximately 10% of children with arterial injuries died during initial trauma assessment before therapy could be offered. Glasgow Coma Scale score ≤ 8 , ISS ≥ 16 , positive result of ethanol or drug screen, and systolic blood pressure < 90 mm Hg on admission were identified as independent risk factors for death. As children are a population of vulnerable patients, long-term, multi-center studies are required to determine the most appropriate use of and indications for endovascular therapy in pediatric arterial trauma. (*J Vasc Surg* 2017;■:1-9.)

Endovascular techniques, whether to gain temporary hemorrhage control or to provide definitive treatment of an injured vessel, have revolutionized management of adult arterial trauma. Reports of endovascular therapy continue to emerge for virtually every single named

major artery.¹⁻⁴ Unfortunately, reports of the use of endovascular technologies in arterial trauma are restricted largely to adult populations. Moreover, the reports lack long-term follow-up, with variable rates of patency of endovascular interventions. Regardless of unclear long-term efficacy, reported rates of endovascular therapy in adult arterial trauma appear to be increasing,⁵⁻⁷ with early survival benefits noted with endovascular therapy.⁶

Although uncommon among children, traumatic arterial injuries remain a significant cause of morbidity and mortality in the civilian setting, with 30-day amputation and death rates exceeding 10% in contemporary studies.⁸⁻¹¹ The appropriateness of endovascular therapies in children is unknown. Concerns about the durability and efficacy of endovascularly managed arterial injuries are particularly prescient in the pediatric population. Unfortunately, the published experience regarding the endovascular management of pediatric arterial trauma has been largely confined to case reports.¹²⁻¹⁵ The magnitude of the problem is currently unknown as the epidemiology

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Author conflict of interest: none.

Additional material for this article may be found online at www.jvascsurg.org.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

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<http://dx.doi.org/10.1016/j.jvs.2017.04.072>

of endovascularly managed pediatric vascular injuries has never been described.

Therefore, the objective of this study was twofold: to describe recent trends in the endovascular management of pediatric arterial injuries in the United States and to examine the outcomes of endovascular vs open therapy for the treatment of arterial injuries among civilian pediatric trauma patients. Our hypothesis was that endovascular repairs would be increasing in the United States for the management of arterial injuries and that endovascular repair would be associated with improved survival in this population of patients.

METHODS

We analyzed the National Trauma Databank (NTDB) of the American College of Surgeons (ACS) from the years 2007 to 2014 including a total of 2,504,213 medical records of injured patients admitted to 1205 trauma centers across the United States (NTDB; ACS Committee on Trauma, Chicago, Ill). All data provided by the NTDB are deidentified and subjected to quality screening for consistency and validity and apply only to the index hospitalization. Use of NTDB data is in strict compliance with the Health Insurance Portability and Accountability Act of 1996. The content reproduced from the NTDB remains the full and exclusive copyrighted property of the ACS. The ACS is not responsible for any claims arising from works based on the original data, text, tables, or figures. The study was performed in concordance with the Declaration of Helsinki, without consent because of the retrospective nature of the registry data in the NTDB, and approved by our Institutional Review Board (H-39636).

Patients who sustained arterial injuries were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes D900-904. From that cohort, pediatric trauma patients (aged ≤ 16 years) who sustained arterial injuries were extracted. Data abstracted included age, gender, ethnicity, insurance status, facility description, mechanism of injury, systolic blood pressure (SBP), Glasgow Coma Scale (GCS) score, ethanol and drug screen on admission, Injury Severity Score (ISS), associated injuries sustained, operative procedures, and outcomes. Operative data including type and number of procedures were also extracted. The primary outcome measure was in-hospital mortality. Secondary outcomes included in-hospital complications (acute respiratory distress syndrome, pneumonia, sepsis, acute renal failure, surgical site infections, and compartment syndrome), need for limb amputation, ventilation days, hospital length of stay (LOS), and intensive care unit (ICU) LOS.

We identified patients who underwent endovascular management by ICD procedure codes 00.61-65, 39.50, 39.71-74, and 39.79. This does not include codes related to diagnostic angiography. We identified patients who

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective nonrandomized multicenter analysis using registry data from the National Trauma Databank
- **Take Home Message:** The use of endovascular therapy for pediatric arterial trauma has significantly increased, paralleling the increased use of endovascular approaches in adults, with comparable results to open surgery but not improved results.
- **Recommendation:** This study suggests that prospective studies should be conducted on pediatric blunt trauma patients to identify those who benefit from endovascular techniques and those who should continue to undergo open procedures.

underwent open procedures by procedure codes 38.00-38, 38.40-48, 38.60-68, and 39.00-59. We identified patients who sustained arterial injuries without associated ICD procedure codes to capture patients who underwent nonoperative management (Table 1). Subjects who underwent simultaneous or staged endovascular and open therapeutic arterial procedures were placed in the endovascular group. Patients who underwent diagnostic angiography without intervention, in conjunction with an open procedure simultaneously or staged, were categorized as open procedures. The number of patients undergoing endovascular, open, and nonoperative management was determined for each year and for the entire time period. Patients who were operated on were assessed for the occurrence of outcomes related to their admission by type of operation (endovascular vs open).

Statistical analysis. Patients undergoing endovascular or open procedures were compared for differences in clinical characteristics and location of arterial injury using bivariate analysis. The χ^2 and Fisher exact tests were used to compare proportions, and unpaired Student *t*-test and Mann-Whitney *U* tests were performed to compare means. The χ^2 test for trend was used to quantify statistically significant trends over time. Descriptive statistics are reported as means $\pm$ standard deviation or median (range) for continuous variables and as percentage for categorical variables. Univariate logistic regression modeling was performed to identify predictors of in-hospital survival. Adjusted odds ratio (OR) and 95% confidence intervals (CIs) were calculated for each group. A stepwise logistic regression model was created to identify predictors of in-hospital mortality. The entry criterion was an $\alpha \leq .10$ from the univariate analysis, with a stay criterion of $\alpha \leq .05$. Similarly, we then performed univariate and multivariable logistic regression on the subgroup of subjects who were not deceased on arrival to determine whether endovascular vs open revascularizations had an impact on survival

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