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Understanding readmissions in children undergoing surgery: A pediatric NSQIP analysis☆,☆☆

Afif N. Kulaylat [a,*], Dorothy V. Rocourt [a], Anthony Y. Tsai [a], Kathryn L. Martin [a], Brett W. Engbrecht [a], Mary C. Santos [a], Robert E. Cilley [a], Christopher S. Hollenbeak [a,b], Peter W. Dillon [a]

[a] Division of Pediatric Surgery, Penn State Children's Hospital, Penn State Health, Hershey, PA, USA
[b] Department of Public Health Sciences, The Pennsylvania State University, College of Medicine, Hershey, PA, USA

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ABSTRACT

Background: Readmission is increasingly being utilized as an important clinical outcome and measure of hospital quality. Our aim was to delineate rates, risk factors, and reasons for unplanned readmission in pediatric surgery.
Materials and methods: Retrospective review of pediatric patients (n = 130,274) undergoing surgery (2013–2014) at hospitals enrolled in the Pediatric National Surgical Quality Improvement Program (NSQIP-P) was performed. Logistic regression was used to model factors associated with unplanned 30-day readmission. Reasons for readmission were reviewed to determine the most common causes of readmission.
Results: There were 6059 (n = 4.7%) readmitted children within 30 days of the index operation. Of these, 5041 (n = 3.9%) were unplanned, with readmission rates ranging from 1.3% in plastic surgery to 5.2% in general pediatric surgery, and 10.8% in neurosurgery. Unplanned readmissions were associated with emergent status, comorbidities, and the occurrence of pre- or postdischarge postoperative complications. Overall, the most common causes for readmission were surgical site infections (23.9%), ileus/obstruction/gastrointestinal (16.8%), respiratory (8.6%), graft/implant/device-related (8.1%), neurologic (7.0%), or pain (5.8%). Median time from discharge to readmission was 8 days (IQR: 3–14 days). Reasons for readmission, time until readmission, and need for reoperative procedure (overall 28%, n = 1414) varied between surgical specialties.
Conclusion: The reasons for readmission in children undergoing surgery are complex, varied, and influenced by patient characteristics and postoperative complications. These data inform risk-stratification for readmission in pediatric surgical populations, and help to identify potential areas for targeted interventions to improve quality. They also highlight the importance of accounting for case-mix in the interpretation of hospital readmission rates.
Level of evidence: 3.

Growing attention is being paid to hospital readmissions, particularly in the era of the Affordable Care Act (ACA). As part of the concurrently established Hospital Readmissions Reduction Program (HRRP) in adults, provisions exist to reduce payment from the Centers of Medicare and Medicaid (CMS) to hospitals with excess readmissions [1]. Presently, readmission rates are tracked nationally by CMS on a hospital-wide all-cause basis, as well as for a limited number of conditions and surgeries [1]. Given these implications on healthcare costs and patient outcomes, readmissions are increasingly being utilized as a measure of hospital and surgeon performance and quality. As part of the Pediatric Quality Measures Program, established by the Children's Health Insurance Program Reauthorization Act, pediatric readmissions are expected to be a core quality measure with several states already implementing readmission penalties [2–4].

Surgical readmissions are a complex phenomenon that may be characterized as planned or unplanned and related or unrelated to the index surgery. More importantly, readmission may be preventable or unpreventable. Numerous studies in adults have attempted to delineate the factors associated with readmission across a wide spectrum of surgeries [1,5–14]. From these studies has emerged an understanding of the importance and necessity of risk-adjustment in readmission rates. Given these inherent complexities, the interpretation of hospital readmission as a reliable, valid, and meaningful quality metric remains challenging and controversial [2–4,15–19].

While the majority of work on hospital readmissions has focused on adult populations, research in children has been largely limited to

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* Corresponding author at: The Pennsylvania State University, College of Medicine, Department of Surgery, 500 University Drive, H066, P.O. Box 850, Hershey, PA 17033-0850, USA. Tel.: +1 717 531 8521; fax: +1 717 531 3618.
E-mail address: akulaylat@pennstatehealth.psu.edu (A.N. Kulaylat).

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single-institution series or general pediatric conditions [19–24]. The development of the Pediatric National Surgical Quality Improvement Program (NSQIP-P) provides the opportunity to assess surgical readmissions in children on a national level using a clinical database. Our aim was to evaluate readmission rates across different specialties captured in NSQIP-P, identify factors associated with unplanned readmissions, and characterize the underlying reasons for unplanned readmissions in children undergoing surgery.

1. Methods

This study was reviewed by the Penn State College of Medicine Institutional Review Board and determined to be exempt from formal review.

1.1. Data and population

Data were obtained from the 2013 and 2014 NSQIP-P participant use data files, encompassing data from 64 participating hospitals. NSQIP-P was formed in 2005 through a partnership between the American College of Surgeons and the American Pediatric Surgical Association to record and monitor patient outcomes in a risk-adjusted fashion in the pediatric surgical population [25,26]. Data are prospectively abstracted and collected by trained clinical reviewers, and details regarding the sampling method, abstraction process, and variables have been described in detail in previous work [27–30].

In NSQIP-P, readmissions are captured if they occur within 30 days from the index procedure, whether they occur within the same hospital or at a different hospital. The readmission is catalogued into a planned or unplanned readmission. Additionally, the readmission may be recorded as related to the index procedure or unrelated to the index procedure. Time from the operation or discharge to the readmission may be calculated. Finally, a diagnosis must be stated for the underlying reason for readmission (ascertained by a clinical data abstractor at each hospital). This may include one of the NSQIP-P postoperative complications, or if not appropriately described by these variables, may have an International Classification of Disease, 9th Clinical Revision (ICD-9) or ICD-10 diagnosis code substituted. The validity of the NSQIP readmission variables has been previously established [31].

1.2. Outcomes and covariates

Our primary outcomes of interest were 30-day unplanned readmission rates and underlying reasons for readmission, including Current Procedural Terminology (CPT) codes most associated with unplanned readmissions across the various specialties. Our secondary outcomes of interest were evaluation of factors associated with unplanned readmission.

Thirty-day readmission in NSQIP-P was calculated in relation to the index operation. A readmission event was defined as unplanned by the hospital data abstractor if it was not part of the treatment plan at the time of the index discharge. NSQIP-P readmission categories follow the catalogue of available postoperative occurrences. In the event that the complication did not clearly meet one of these categories, the clinical abstractor applied ICD-9 code was categorized using a classification scheme generated by the Agency of Healthcare Quality Clinical Classification Software, as previously described [32]. The NSQIP-P standardized readmission categories were consolidated into this existing classification scheme (Supplemental File 1) [32].

Covariates for patient-related factors included basic demographic data (age, sex, race) available in NSQIP-P. Preoperative comorbidities and conditions were categorized into a more global organ-based comorbidity classification (Supplemental File 2). Additionally, standard American Society of Anesthesiologists (ASA) scores were included. Perioperative covariates included elective or urgent/emergent operative status, wound classification, subspecialty nature of the operation (general/thoracic pediatric surgery, neurosurgery, orthopedics, otolaryngology, urology, plastic and reconstructive surgery), and both predischarge and postdischarge postoperative complications.

1.3. Statistical analysis

Covariates were compared between patients with a 30-day unplanned readmission and those without using standard univariate statistics. Multivariable logistic regression models were used to evaluate the factors associated with unplanned readmission. In patients with both pre- and postdischarge complications (n = 416), to avoid effect modification, these patients were not included in the analysis We modeled 30-day unplanned readmission using logistic regression controlling for covariates described above. Goodness-of-fit for the models was assessed using C-statistics (the area under the receiver operation characteristics (ROC) curve). All analyses were performed using STATA software (version 10, StataCorp). Statistical significance was defined as $P < 0.05$. Figures were created using R Software (Version 3.2.1, www.R-project.org).

2. Results

There were 130,271 patients identified in the NSQIP-P for the specified study interval. There were 422 patients that were excluded for death (0.8%). Of the remaining 129,849 patients at risk for readmission, 6059 (4.7%) were readmitted. Of these 1018 (0.8%) patients had a planned readmission, while 5041 (3.9%) had an unplanned readmission. The distribution of these unplanned readmissions across surgical specialties is displayed in Fig. 1. The highest rates of readmission were observed in neurosurgery (10.8%) and general/thoracic surgery (5.2%), with lower rates of readmission observed in urology (2.6%), ENT (2.0%), orthopedics (1.9%) and plastic surgery (1.3%). The median time from discharge to an unplanned readmission was 8 days (interquartile range [IQR] 3–14 days) and differed between specialties (orthopedics 10 days [5–18], neurosurgery 9 days [IQR 4–15], urology 8 days [3–15], ENT 7 days [IQR 3–14], general/thoracic 7 days [IQR 3–13], plastics 6 days [IQR 2–16]) (Supplemental File 3).

Patient characteristics are presented in Table 1. Patient age, sex, and race were comparable between patients with unplanned readmissions and those that were not readmitted. Patients with an unplanned readmission were more likely to have at least one comorbidity (75.1% vs. 44.9%), including respiratory (23.2% vs. 13.9%), GI (34.9% vs. 17.5%), CNS (43.9% vs. 21.4), immunosuppressive (14.2% vs. 4.5%), and nutritional deficiencies (21.3% vs. 8.0%) ($P < 0.001$ for all). This was also supported by differences in the ASA scores between the two groups with higher proportions of severe or life-threatening ASA scores represented in the unplanned readmission group. The wound classification in the unplanned readmission group was also more likely to be dirty (9.5% vs. 5.4%). These surgeries also tended to be more urgent/emergent (31.8% vs. 26.6%) ($P < 0.001$ for all).

The reasons for readmission stratified by surgical specialties are presented in Supplemental File 4. This is visually presented in Fig. 2. Overall, the three most common reasons for readmission were surgical site infection (23.9%), ileus/obstruction/GI-related causes (16.8%), and pulmonary (8.6%). There were differences in the composition of the most common causes of readmission among the different surgical specialties. For example, in neurosurgery, surgical site infections (22.2%) and device/grant/implant-related complications (22.1%) predominated, followed closely by neurologic causes (19.1%) for readmission. In general pediatric surgery, GI issues predominated (25.5%), followed closely by SSI (23.9%), then pulmonary causes (10.0%).

A logistic regression model for the factors associated with unplanned readmission is presented in Table 1. Of note, the influence of comorbidities was substantial, particularly renal (OR 1.86), immunosuppressive

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