
Perioperative Risk Factors for Major Complications in Pediatric Surgery: A Study in Surgical Risk Assessment for Children

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BACKGROUND: There are numerous studies in the adult literature correlating comorbidities and pre- and intraoperative parameters with postoperative outcomes. However, there is a paucity of similar data in the pediatric population. Our goal was to elucidate which pre- and intraoperative patient characteristics in children undergoing surgery are associated with an increased risk of major complication within 30 days.

STUDY DESIGN: We identified 108 children who underwent surgery at our institution between June 2005 and May 2007 and had major complication or death within 30 days of surgery. Forty-two preoperative patient characteristics and 22 intraoperative variables were evaluated. The severity of the complications was graded based on the Clavien classification system, with major complications grade III or greater. We randomly selected 723 controls who had undergone surgery within a 3-month date range of the original cohort, but did not develop complications. Statistical significance was assessed by univariate and multivariate analyses.

RESULTS: Most complications were cardiovascular, occurred 1 to 3 days after surgery, and were classified as grade IIIB. We identified 5 independent risk factors on multivariate analysis: ≤ 36 weeks of gestation, American Society of Anesthesiologists score >3 , undergoing a cardiovascular or neurosurgical procedure, and receiving an intraoperative albumin transfusion. Three scoring systems (overall, preoperative, and intraoperative complication score) were developed to provide objective risk stratification.

CONCLUSIONS: We found 5 patient-specific parameters that were independent risk factors for major complications or death after pediatric surgery. Future prospective studies will help to fully stratify risk and guide interventions to improve postoperative outcomes. (J Am Coll Surg 2011;212:768–778. © 2011 by the American College of Surgeons)

Approximately 5% to 10% of patients undergoing elective surgery develop an unexpected complication.¹ Aside from their adverse effects on the patient's health, surgical complications have been shown to be associated with increased inpatient and postoperative costs.² Consequently, reducing complications has become a desirable objective, not only in

order to improve patient outcomes but also to reduce health care cost. Recently, efforts to reduce perioperative complications have been focused on eliminating risks in the operative room, most notably through use of the "universal protocol" and the "surgical safety checklist." However, these efforts do not abolish the risks for surgical complications. Consequently, it remains important to be able to identify which patients are at risk, with the premise that early identification of these patients will allow for additional care to be provided, thereby minimizing the potential for complications.

In adults, there are several risk stratification tools. The Acute Physiology and Chronic Health Evaluation (APACHE) score,³ the Physiological and Operative Severity Score for the Enumeration of Mortality (POSSUM),⁴ and the surgical APGAR score⁵ have been used to predict a patient's risk for perioperative complications. Similar tools

Disclosure information: Nothing to disclose.

Abstract presented at the American Academy of Pediatrics, Section on Surgery, Washington DC, October 2009.

Received August 19, 2010; Revised January 5, 2011; Accepted February 7, 2011.

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Abbreviations and Acronyms

ASA = American Society of Anesthesiologists
 CHB = Childrens Hospital Boston
 ROC = receiver operating characteristic curve

for the pediatric population currently do not exist. The Pediatric Risk of Mortality Score, the Clinical Risk Index for Babies, and the Score for Neonatal Acute Physiology focus on the acute care setting and rely only on physiologic variables.⁶ Although clinical factors are central to evaluating risk for these patients, the usefulness for predicting long-term morbidity is clearly limited. Alternatively, using the adult risk stratification tools on pediatric surgical complications is inappropriate because adult and pediatric physiology are quite distinct.

As a result, most pediatric surgeons rely on the American Society of Anesthesiologists (ASA) physical status classification system and previous experiences to predict a patient's perioperative course. The difficulty in using the ASA index to predict the risk of surgical complication is that the score is determined only by the presence and severity of a "systemic" disease.⁷ Therefore, discrepancy exists on the "correct" score for a given patient.⁸⁻¹⁰ In contrast, even though the surgeon's "gut-feeling" is more accurate than that of published clinical calculators,^{11,12} using previous experience to predict the risk of surgical complication is highly subjective and may be vastly different between clinicians. Our goal for this study was to develop a tool for pediatric surgeons that correctly predicts perioperative complications and death using pre- and intraoperative patient information.

METHODS

Patient selection

This study protocol, including a waiver of informed consent for individual patients, was approved by the Human Subjects Committee (Human Research Committee) at Children's Hospital Boston (CHB). The study was completed in two steps: 1) developing a scoring system using preoperative, intraoperative, and outcomes data from our patient population; and 2) evaluating the ability of the scoring system to predict the known outcomes in our population. CHB maintains a prospectively collected outcomes database of all patients who have had elective and nonelective surgery at CHB and later presented to CHB's emergency department, were readmitted from another hospital, or died within 30 days of surgery. From this database we retrospectively identified patients (cases) who underwent surgery (elective and nonelective) between June

Table 1. Clavien-Dindo Classification of Surgical Complications²⁰

Categorization in this study, grades	Definition
Minor complications	
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgetics, diuretics and electrolytes and physiotherapy. This grade also includes wound infections opened at the bedside.
Grade II	Requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included.
Major complications	
Grade III	Requiring surgical, endoscopic or radiological intervention
Grade III-a	Intervention not under general anesthesia
Grade III-b	Intervention under general anesthesia
Grade IV	Life-threatening complication (including CNS complications) requiring IC/ICU-management
Grade IV-a	Single organ dysfunction (including dialysis)
Grade IV-b	Multi-organ dysfunction
Grade V	Death of a patient
Suffix "d"	If the patient suffers from a complication at the time of discharge, the suffix "d" (for 'disability') is added to the respective grade of complication. This label indicates the need for a follow-up to fully evaluate the complication.

(Reprinted from: Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg* 2009;250:197-198, with permission.)

2005 and May 2007, developed major complications, and had complete medical records. In this study, we considered major complications as Clavien grade III or greater. Clavien grades can be found in Table 1, with examples listed in Table 2. CHB also has an electronic operating room daily log, which is prospectively collected. We then randomly and retrospectively selected "control" patients to compare with each case. These control patients were selected from the operating room database of all cases, with a goal of 6 control patients for each patient from the cohort with complications. Controls were selected randomly within 3-month time blocks corresponding to the surgery dates of the original patients, and any with a major complication within 30 days of surgery or without full

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