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Variability in noncardiac surgical procedures in children with congenital heart disease

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ABSTRACT

Background: The purpose of this study was to examine the volume and variability of noncardiac surgeries performed in children with congenital heart disease (CHD) requiring cardiac surgery in the first year of life.
Methods: Patients who underwent cardiac surgery by 1 year of age and had a minimum 5-year follow-up at 22 of the hospitals contributing to the Pediatric Health Information System database between 2004 and 2012 were included. Frequencies of noncardiac surgical procedures by age 5 years were determined and categorized by subspecialty. Patients were stratified according to their maximum RACHS-1 (Risk Adjustment in Congenital Heart Surgery) category. The proportions of patients across hospitals who had a noncardiac surgical procedure for each subspecialty were compared using logistic mixed effects models.
Results: 8857 patients underwent congenital heart surgery during the first year of life, 3621 (41%) of whom had 13,894 noncardiac surgical procedures by 5 years. Over half of all procedures were in general surgery (4432; 31.9%) or otolaryngology (4002; 28.8%). There was significant variation among hospitals in the proportion of CHD patients having noncardiac surgical procedures. Compared to children in the low risk group (RACHS-1 categories 1–3), children in the high-risk group (categories 4–6) were more likely to have general, dental, orthopedic, and thoracic procedures.
Conclusions: Children with CHD requiring cardiac surgery frequently also undergo noncardiac surgical procedures; however, considerable variability in the frequency of these procedures exists across hospitals. This suggests a lack of uniformity in indications used for surgical intervention. Further research should aim to better standardize care for this complex patient population.

Congenital heart disease (CHD) is the most common type of congenital anomaly, occurring in up to 1% of all live births. CHD is characterized by a wide range of clinical presentations, anatomic variations, and expected outcomes [1]. Within this population, some anatomic anomalies are more severe than others, and children who require intervention by one year of age have been defined as having critical CHD [2,3]. These patients frequently also undergo noncardiac surgical procedures for the management of both comorbid conditions and additional noncardiac congenital anomalies [4]. The need for multiple major operative procedures in this population is of particular concern owing to the more complicated anesthetic management and increased risk for perioperative complications [5–12].

There is little information regarding the types and frequencies of noncardiac procedures that are commonly performed in patients with CHD. Most studies present a single institutional experience, which limits generalizability and is inadequate to assess variability in practice across institutions. Obtaining a better understanding of the noncardiac surgical procedures performed in patients with CHD at tertiary children's hospitals can be informative for family counseling and setting expectations. In addition, examining procedure types and frequencies across institutions can allow us to identify variation in practice and to determine factors that may account for such variation [13].

The objectives of this study were (1) to characterize the types and frequencies of noncardiac procedures performed in patients with CHD undergoing cardiac surgery within the first year of life across a multi-institutional cohort of freestanding children's hospitals, and (2) to examine variability in practice across institutions.

1. Methods

1.1. Data source and cohort development

A multi-institutional cohort of patients with critical CHD undergoing cardiac surgery by one year of age was developed using the

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Pediatric Health Information System (PHIS), an administrative database that contains inpatient, observation, emergency department, and ambulatory surgery discharge/encounter data from 44 freestanding children's hospitals that are part of the Children's Hospital Association. The PHIS contains International Classification of Diseases 9th Revision, Clinical Modification (ICD-9-CM) diagnostic and procedure codes, date-stamped billing data, and other administrative data from 44 free-standing children's hospitals [13–15].

Patients born between January 2004 and June 2007 who had an ICD-9-CM diagnosis code for CHD (745.0–747.49, except 746.86 "congenital heart block") and a cardiac surgical procedure code by one year of age were included (Fig. 1) [16]. Pediatric cardiac surgical procedures were defined by adapting the algorithm utilized by The Agency for Healthcare Research and Quality pediatric heart surgery quality indicators [17]. Catheter-based interventions for CHD are not included in this algorithm. Patients who were premature or under the age of 30 days and underwent patent ductus arteriosus (PDA) ligation only, and patients who underwent cardiac transplantation as their only cardiac procedure were excluded. In order to capture noncardiac surgical procedures performed in a variety of settings, only hospitals that submitted data from all encounter types during the entire time period of study were included.

The frequencies of all procedures other than cardiac surgeries performed prior to age 5 were examined. A noncardiac procedure was defined as a procedure performed in an operating room that was not part of palliating the cardiac lesion. These procedures were manually reviewed to exclude therapeutic interventions that have ICD-9-CM procedure codes, but do not represent surgical procedures (e.g. 38.93 venous catheter not elsewhere classifiable, 99.04 packed cell transfusion). In addition, thoracotomy and thymus resection/excision procedure codes were excluded if they occurred on the same day as any cardiac procedure, as these were likely part of the cardiac operation. The remaining procedures were classified into one of nine subspecialty divisions by the authors: general surgery, otolaryngology, dental or oral and maxillofacial surgery (OMFS), urology, noncardiac thoracic surgery, plastic surgery, ophthalmology, orthopedic surgery, and neurosurgery. A table of the included procedures can be viewed at https://sharedoc.nchri.org/CSOR/Pages/ProcedureTable.aspx.

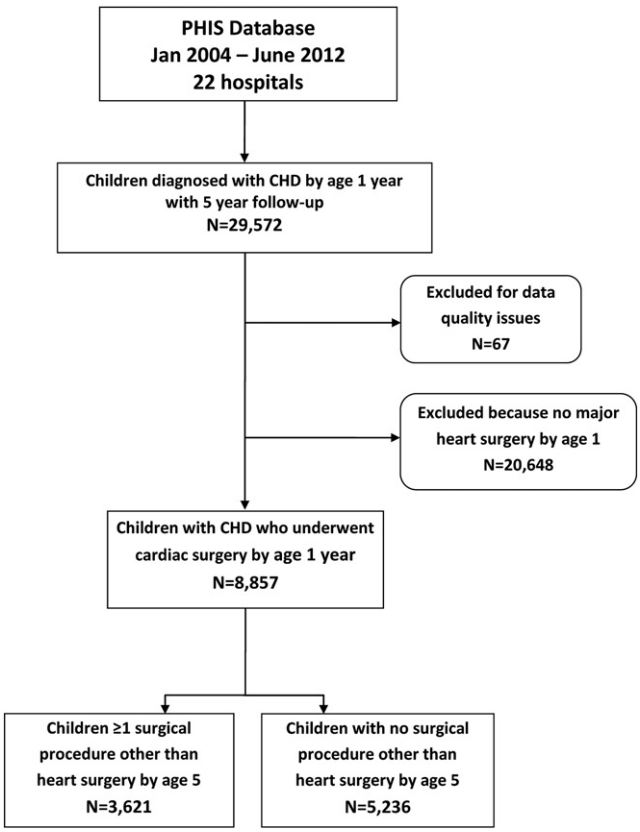

Fig. 1. Strategy used to identify the cohort of patients with critical CHD undergoing non-cardiac surgical procedures by 5 years of age within the PHIS database.

1.2. Risk stratification

CHD patients were stratified by the Risk Adjustment in Congenital Heart Surgery, version 1 (RACHS-1) method, which is a consensus-based system used widely in administrative data that stratifies congenital heart operations based on associated inhospital mortality risk [18]. For the purposes of this analysis, these categories were then combined into low risk (RACHS-1 categories 1–3) and high risk (categories 4–6) groups. Patients with no assigned RACHS-1 category were not included in these stratified analyses. For patients who underwent multiple different cardiac surgical procedures, their highest RACHS-1 category was used for classification purposes in order to capture the maximum severity of their CHD.

1.3. Statistical analysis

Patient demographic and clinical characteristics were reported as frequencies and percentages and were compared between groups with and without a noncardiac procedure using Pearson chi square tests. A logistic mixed effects model for each subspecialty was used to compare the proportion of CHD patients at each hospital who had a noncardiac surgical procedure in that specialty. The models included a random intercept for each hospital, and the significance of the between-hospital variability was tested with a likelihood ratio test for the variance of the random effect. Interhospital variability was examined before and after adjustment for RACHS-1 category, hospital volume of all noncardiac procedures in patients less than 5 years of age included for the particular specialty being evaluated, and additional patient-level characteristics that differed significantly between patients with and without a noncardiac procedure. All patients were included in the above analyses; those patients who could not be assigned a RACHS-1 category were included as another category of the RACHS-1 variable in these analyses. Analyses based on RACHS-1 category grouping into low or high groups were also performed; these stratified analyses excluded patients who could not be assigned a RACHS-1 category. To display interhospital variability, empirical Bayes estimates and confidence intervals of the random hospital-specific intercepts from the logistic mixed effects models were plotted after inverse logit transformation. Outlier hospitals were defined as those whose 95% confidence interval after adjustment did not include the overall average proportion. Finally, as a sensitivity analysis, because we expected there to be differences between patients who did and did not die inhospital by 5 years of age, and because those patients who died had no procedures afterwards, we repeated all analyses in only those patients who did not die at a PHIS hospital by age 5. All statistical analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC). Statistical significance was defined as $p < 0.05$. The conduct of this study was approved by Nationwide Children's Hospital Institutional Review Board.

2. Results

2.1. Cohort of patients with critical CHD

Twenty-two of the 44 participating PHIS hospitals submitted inpatient, observation, and ambulatory surgery data for the entirety of 2004–2012. Of the 29,505 patients with ICD-9-CM diagnosis codes for CHD treated at these hospitals, 8857 underwent a cardiac surgical procedure within the first year of life and were included in the present analysis (Fig. 1). By 5 years of age, 3621 (40.9%) of these children underwent a total of 13,894 noncardiac surgical procedures.