JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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PUBLISHED BY ELSEVIER

VOL. 67, NO. 7, 2016
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.11.057

Post-Operative Outcomes in Children With and Without Congenital Heart Disease Undergoing Noncardiac Surgery

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ABSTRACT

BACKGROUND Significant advances have been made in the diagnosis and treatment of children with congenital heart disease (CHD), allowing for longer life expectancies and an increasing number who will require noncardiac surgery.

OBJECTIVES This study sought to compare the incidence of mortality and major adverse post-operative outcomes following noncardiac surgery in children with and without CHD.

METHODS Data from the 2012 pediatric database of the American College of Surgeons National Surgical Quality Improvement Program were analyzed. After propensity score matching, and stratification by severity of CHD, mortality and adverse post-operative outcomes were compared between controls and children with CHD.

RESULTS Among the 51,008 children included in the database, 4,520 children with CHD underwent noncardiac surgery. After propensity score matching, we included 2,805 children with minor CHD, 1,272 with major CHD, and 417 with severe CHD. Children in each subgroup were matched and compared with controls without CHD who underwent noncardiac surgery of comparable complexity. The incidence of overall mortality was significantly higher in children with moderate (3.9%) and severe (8.2%) CHD compared with their controls (respectively, 1.7% [$p < 0.001$] and 1.2% [$p = 0.001$]). Both 30-day and overall mortality were significantly increased in children with severe CHD (odds ratio [OR]: 8.43, 95% confidence interval [CI]: 2.52 to 28.21; $p < 0.001$; OR: 7.32, 95% CI: 2.83 to 18.90; $p < 0.001$) compared with their matched controls. Overall mortality was also significantly increased in children with major CHD compared with their controls (OR: 2.28; 95% CI: 1.37 to 3.79; $p = 0.002$), whereas no difference was observed between children with minor CHD and their matched controls.

CONCLUSIONS Children with major and severe CHD, undergoing noncardiac surgery, have an increased risk of mortality compared with children without CHD. Further studies need to identify the optimal environment for surgical procedures, develop trained multidisciplinary teams to care for children with CHD, and define management strategies for improving outcomes in this high-risk population. (J Am Coll Cardiol 2016;67:793–801)

Over the past decades, significant advances have been made in the diagnosis and treatment of children with congenital heart disease (CHD) (1). Although the overall incidence of CHD has remained stable during the last 50 years, the natural history of lesions and the overall survival rate have significantly changed (2). Advances made in surgical procedures (e.g., cardiac catheterization, systemic-to-pulmonary arterial shunts) and techniques (3,4), in concert with improvements in diagnosis, anesthesia practices, intensive care, and medical treatments, have transformed many of these fatal lesions into manageable chronic conditions (5).

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Manuscript received October 5, 2015; accepted November 3, 2015.

ABBREVIATIONS AND ACRONYMS

ACS NSQIP = American College of Surgeons National Surgical Quality Improvement Program

ASA = American Society of Anesthesiologists

CHD = congenital heart disease

CI = confidence interval

OR = odds ratio

RVU = relative value unit

As life expectancy of children with CHD has improved, this population increasingly seeks medical attention for other illnesses, and a significant number of these patients will undergo noncardiac surgeries (6-8). To date, studies addressing mortality and adverse outcomes in children with and without CHD undergoing noncardiac surgery have largely been performed at single centers and have included small patient numbers (9-11).

In this study, we compared the incidence of mortality and major adverse post-operative outcomes following noncardiac surgery in a large group of children with and without CHD, after stratification for severity of the underlying CHD.

METHODS

DATA SOURCE. This study was performed using data from the 2012 pediatric database of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP Pediatric). The ACS NSQIP Pediatric collects de-identified data on children <18 years of age undergoing noncardiac surgery, and includes 129 variables, including pre-operative risk factors, demographic characteristics, 30-day post-operative outcomes, and mortality in both the inpatient and outpatient settings (12). A systematic sampling strategy is used to avoid bias in case selection and to ensure a diverse surgical case mix. A site's trained and certified surgical clinical reviewer captures these data using a variety of methods, including medical chart review. To ensure the quality of the data collected, the ACS NSQIP Pediatric conducts inter-rater reliability audits of selected participating sites (13). The results of the audits completed to date reveal an overall disagreement rate of approximately 2% for all assessed program variables. For the 2012 database, exclusion criteria included: patients ≥18 years of age, trauma cases, solid organ transplantation, and patients undergoing multiple procedures performed by different surgical teams under the same anesthetic. In addition, cases coming from hospitals with an inter-rater reliability audit disagreement rate >5%, or a 30-day follow-up rate <80% were excluded.

STUDY POPULATION AND OUTCOME. We included all children undergoing noncardiac surgery recorded in the 2012 ACS NSQIP Pediatric database. The following demographic variables were included: sex, American Society of Anesthesiologists (ASA) physical status classification score, elective versus emergent surgery, surgical type (e.g., thoracic, neurological, orthopedic, general pediatric [including ear, nose, and throat], plastics, and urogynecology), age, body weight, and height. Children were stratified into 5 age groups: <6 months, 6 to 12 months, 1 to 6 years, 6 to 12 years, and >12 years old. Operative complexity was assessed using each procedure's relative value unit (RVU) based on current procedure terminology codes (14). RVUs have replaced the original ACS NSQIP complexity score as a measure of surgical complexity, and have been shown in database analyses to independently predict post-operative morbidity following general surgery (15-17).

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The outcomes included 30-day mortality, overall mortality (defined as any death occurring within the study interval, whether within the first 30 days or not), and the incidence of the following major post-operative outcomes occurring within 30 days after the primary surgical procedure: post-operative cardiac arrest, post-operative reintubation, infections (defined as superficial or deep surgical site, respiratory tract, and urinary tract infections), renal failure (defined as renal failure ± dialysis), neurological complication (defined as seizures, coma, cerebrovascular events, intraventricular hemorrhage), thromboembolic complication, reoperation, and any hospital readmission. Children with CHD were further classified into 3 groups, minor, major, or severe CHD, as defined in the ACS NSQIP database, based on residual lesion burden and cardiovascular functional status (**Table 1**).

STATISTICAL ANALYSIS. Continuous variables are expressed as median and interquartile range, and categorical variables are expressed as number and percentage (%). Demographic and post-operative outcomes variables were compared between CHD and controls using the Wilcoxon rank sum test for continuous variables, and chi-square for categorical variables.

We defined a priori 5 confounding variables to be used in the propensity-matched analysis: sex, age group, ASA classification, elective versus emergent surgery, and RVU. We used a saturated logit model predicting CHD status using the 5 categorical covariates (sex, age group, ASA classification, elective versus emergent surgery, and RVU) to find the exact matches for each CHD patient (18,19).

Demographic variables were compared between post-matched groups using the Wilcoxon rank sum test for continuous variables, and the Pearson chi-square test for categorical variables and proportions. Outcomes variables, including mortality and adverse post-operative complications, were compared using univariate logistic regression analysis, and results are