Incidence and characteristics of heart block after heart surgery in pediatric patients: A multicenter study

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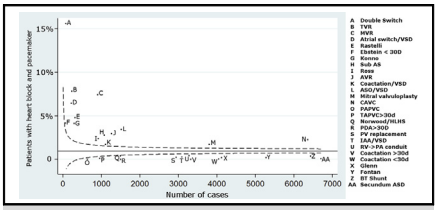
ABSTRACT

Background: Advanced second- or third-degree heart block has been reported with variable incidence after surgery for congenital heart disease in children. We report the incidence of heart block requiring a pacemaker and describe the risk factors for this complication in a large multicenter study.

Methods: We performed a retrospective cohort study, using the Pediatric Health Information System database from 45 hospitals in the United States, for all children aged 18 years, discharged between January 1, 2004, and December 31, 2013, who underwent open surgery for congenital heart disease. Patients who had heart block and placement of a pacemaker during the same hospitalization were identified. Demographic characteristics, procedure and diagnostic codes, length of stay, and mortality were analyzed. Univariable and multivariable analyses were performed.

Results: There were 101,006 surgeries performed. The median age of patients was 0.5 years (interquartile range, 26 days to 3.2 years), and 1% of patients (n = 990) had heart block and placement of a pacemaker. Surgeries associated with the highest incidences of heart block and placement of a pacemaker included the double switch operation (15.6%), tricuspid valve (7.8%) and mitral valve (7.4%) replacement, atrial switch with ventricular septal defect repair (6.4%), and Rastelli operation (4.8%). On multivariable analysis, after controlling for surgical complexity, other comorbidities, age at surgery, admission year, and clustering by institution, patients with heart block and placement of a pacemaker had higher odds of mortality (odds ratio, 1.67; 95% confidence interval, 1.24-2.26; $P < .001$).

Conclusions: The incidence of postoperative heart block requiring permanent pacemaker placement immediately after congenital heart surgery is low (1%). However, these patients have higher mortality even after adjusting for heart surgery complexity. (J Thorac Cardiovasc Surg 2016;■:1-6)



Funnel plot shows the incidence of heart block for each operation as a function of number of cases.

Central Message

We report the incidence of heart block requiring a pacemaker implant after surgery for congenital heart disease.

Perspective

The incidence of postoperative heart block requiring permanent pacemaker placement immediately after congenital heart surgery is low (1% on average). However, certain lesions are associated with significantly higher incidences, and the patients in whom heart block develops have significantly higher mortality and length of stay, even after adjusting for heart surgery complexity.

CONG

Complete heart block has been reported as a complication of open surgery in patients with congenital heart disease since these procedures were first performed.[1,2] Over the years, as surgical techniques improved, the incidence of postoperative chronic complete heart block decreased, and by the late 1960s, Fryda and colleagues[3] reported an incidence of permanent postoperative heart block of 2%. However, mortality for these patients was still high, with a range between 30% and 67%.[1,3,4] To address this issue, surgeons started to place permanent pacemakers in all patients with postoperative complete heart block.[5,6] Hofschire and colleagues[6] reported a significant reduction in the episodes of Stokes-Adams attacks and sudden death in patients who underwent placement of a permanent pacemaker. In 1984, the first guidelines for permanent cardiac

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Abbreviations and Acronyms

CI = confidence interval
ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification
IQR = interquartile range
OR = odds ratio
RACHS-1 = Risk Adjusted Classification for Congenital Heart Surgery, version 1
VSD = ventricular septal defect

pacemaker implantation were published,[7] and it was recommended that children with advanced second- or third-degree atrioventricular block persisting 10 to 14 days after surgery receive a permanent pacemaker implant. In the subsequent revision of the guidelines, the recommended waiting period was shortened to 7 days.[8] Over the last 2 decades, reports from single or few institutions have been published describing the incidence of postoperative heart block.[9-11] However, the true incidence of this complication in a large cohort of patients is unknown. We report a multicenter study of tertiary care institutions to determine the incidence of surgical heart block in the current era and to identify surgical risk factors for this complication.

CONG

MATERIALS AND METHODS

Study Design

A retrospective cohort study was performed, using the Pediatric Health Information System database, to determine the incidence of complete heart block undergoing permanent pacemaker placement in pediatric patients after open surgery for congenital or acquired heart disease and to determine the effects of this outcome on mortality. This study was classified by the Columbia University Medical Center Institutional Review Board as nonhuman subjects research and was exempted from further review.

Data Source

Data for this study were obtained from the Pediatric Health Information System, an administrative database that contains inpatient observation data from 45 not-for-profit, tertiary care pediatric hospitals in the United States. These hospitals are affiliated with the Children's Hospital Association (Overland Park, Kan). Data quality and reliability are ensured through a joint effort between the Children's Hospital Association and participating hospitals. Participating hospitals provide discharge and encounter data, including demographics, diagnoses, and procedures. All data are de-identified at the time of data submission, and data are subjected to a number of reliability and validity checks before being included in the database.

Study Population

The database was queried for all children aged 18 years or less, discharged between January 1, 2004, and December 31, 2013, who underwent open surgery based on a Risk Adjusted Classification for Congenital Heart Surgery, version 1 (RACHS-1) score.[12] Data collected included diagnosis of congenital heart diseased based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes, age at surgery, gender, and major comorbidities (genetic abnormalities and other chronic hematologic, renal, gastroenterologic, or neurologic conditions, as previously defined by Feudtner and colleagues[13]). Procedure codes were queried for all the surgical procedures based on the RACHS-1 classification and all the surgical procedures for placement of a pacemaker and implantable defibrillator. Death during the hospitalization, length of stay, and costs per day were recorded. Patients with multiple surgical admissions were treated as if each admission was independent.

The information was analyzed for missing data. Missing data were defined as absence of age, cardiac diagnosis, or RACHS-1 procedure. Hospitals with less than 30 patients were excluded from analysis (3 centers, n = 22 patients).

Predictors and Outcomes

The primary outcome of interest was advanced second-degree (ICD-9-CM: 426.12), third-degree (ICD-9-CM: 426.0), or unspecified heart block (ICD-9-CM: 426.10) in patients who underwent placement of a permanent ventricular or dual-chamber pacemaker or defibrillator. Patients who underwent a permanent pacemaker or defibrillator on the same date or before their RACHS-1 operation were excluded from further analysis.

The primary predictor of interest was the procedure done during the hospitalization that had the highest RACHS-1 score. Other variables considered included age at surgery, gender, RACHS-1 scoring, comorbidities (including genetic abnormalities and other chronic hematologic, renal, gastroenterologic, or neurologic conditions), year of operation, and admitting hospital.

The effects of the primary outcome on mortality, total hospital length of stay, and inpatient standardized costs per day were analyzed. Mortality was defined as in-hospital death. Standardized costs are adjusted for costs of living by hospital location, using the Centers for Medicare & Medicaid Services Wage Index (http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Wage-Index-Files.html) to allow comparison of resource use across institutions. All costs were further adjusted for inflation (to 2014 dollars), using the Medical Consumer Price Index (http://www.bls.gov/cpi/#tables).

Data Analysis

Statistical analyses were conducted in Stata software, version 13 (StataCorp LP, College Station, Tex). Standard summary statistics were used, including means with standard deviations or medians with interquartile ranges (IQRs) for continuous variables, and frequencies with proportions for categoric variables. For each of 57 operation types (defined by RACHS-1 coding), rates of heart block and pacemaker placement were calculated. These rates were compared with the overall incidence in the rest of the cohort by chi-square with Bonferroni correction. These rates were then graphically depicted for each procedure as a function of the number of cases in our cohort. Lines depicting the 5th and 95th binomial prediction limits were superimposed to create a funnel plot. Procedure types falling above or below these prediction limits were said to be associated with significantly high or low incidences, respectively.

To assess the association between predictor variables and mortality, we used chi-square, *t* tests, and Wilcoxon rank-sum tests. To assess the association between predictor variables and length of stay and costs per day, we used Wilcoxon rank-sum tests and Spearman correlation. Variables with *P* values of .10 or less in univariable analyses were evaluated together in multivariable analyses using logistic regression in the assessment of mortality and linear regression in the assessment of length of stay and costs per day. We clustered standard errors on institution to account for possible correlation between children treated within each center.

RESULTS

Patient Characteristics

A total of 102,271 hospitalizations (75,094 patients) from 42 hospitals were identified during the study period. Of