Surgical site infections and bloodstream infections in infants after cardiac surgery

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Objective: Few recent studies have assessed the epidemiology of and risk factors for surgical site infections (SSIs) and bloodstream infections (BSIs) in infants after cardiac surgery. We hypothesized that infants younger than 30 days old and those with higher Risk Adjustment in Congenital Heart Surgery-1 scores would have an increased risk of SSIs, but not an increased risk of BSIs after surgery.

Methods: We performed a retrospective cohort study of infants younger than 1 year of age undergoing cardiac surgery from January 2010 to December 2011 to determine the rates of SSIs and BSIs occurring within 3 months of surgery, risk factors associated with these infections, and causative pathogens. Multivariable associations using Cox proportional hazard modeling assessed potential risk factors for BSIs or SSIs.

Results: Overall, 8.7% (48 of 552) of surgical procedures were complicated by SSIs (n = 19) or BSIs (n = 29). Thus, SSIs and BSIs occurred after 3.4% and 5.3% of procedures, respectively. Multivariate models found age younger than 30 days, incorrect timing of preoperative antibiotics, and excessive bleeding within 24 hours of surgery to be significant predictors for SSIs, and duration of use of arterial lines to be a significant predictor for BSIs. Gram-positive bacteria caused 75% of SSIs and BSIs and methicillin-susceptible *Staphylococcus aureus* caused 63% of SSIs.

Discussion: We identified some potential strategies to reduce risk, including closer monitoring of timing of preoperative antimicrobial prophylaxis and enhanced efforts to achieve intraoperative hemostasis and earlier removal of arterial lines.

Conclusions: SSIs and BSIs remain important complications after cardiac surgery in infants. (J Thorac Cardiovasc Surg 2014;148:259-65)

Approximately 20,000 pediatric patients, of whom 50% are infants younger than 1 year of age, undergo reparative and palliative procedures for structural heart defects in the United States each year.[1] Surgical site infections (SSIs) and postoperative bloodstream infections (BSIs) are well-described complications of cardiac surgery and can occur in 3% to 8% and 6% to 10% of children, respectively.[2-6] Furthermore, the mortality rate can increase 2-fold after SSIs and 3-fold after BSIs and both infections are associated with an increased length of hospital stay, readmissions, and higher health care expenditures.[7,8]

When compared with older children, infants younger than 1 year of age are at increased risk of postoperative infections after cardiac surgery.[4,9,10] However, to our knowledge, no recent studies have described the epidemiology of these health care–associated infections (HAIs) in this age group or identified potentially modifiable risk factors to prevent such infections. The objectives of this study were to determine the incidence of SSIs and BSIs after cardiac surgery in infants, risk factors for such infections, the causative pathogens, and their susceptibility to antimicrobial agents. Potential preoperative, intraoperative, and postoperative risk factors including adherence to selected perioperative prophylaxis recommendations used at our institution were assessed. We hypothesized that infants younger than 30 days of age and those with higher Risk Adjustment in Congenital Heart Surgery 1 (RACHS-1) scores[11] would be at increased risk of SSIs, but not at increased risk of BSIs.

METHODS

Study Design, Site, and Subjects

We performed a retrospective cohort study of infants younger than 1 year of age who underwent cardiac surgery at our tertiary care, academic children's hospital in New York City from January 2010 to December 2011. At our hospital, children older than a month of age generally receive postoperative care in the pediatric cardiac intensive care unit (14 beds) and neonates 1 month or younger generally receive care in the cardiac area of the neonatal intensive care unit (12 beds). Eligible infants were those undergoing either palliative or definitive repair of complex congenital

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Abbreviations and Acronyms

BSI = bloodstream infection
CI = confidence interval
CLABSI = central line–associated bloodstream infection
HAI = health care–associated infection
RACHS-1 = Risk Adjustment in Congenital Heart Surgery 1
RBC = red blood cell
SSI = surgical site infection

cardiac lesions. Excluded infants were those undergoing cardiac transplantation or pacemaker implantation only, or premature infants undergoing ligation of a patent ductus arteriosus. The Columbia University Medical Center Institutional Review Board granted a waiver of informed consent for this study.

SSIs and BSIs

To determine the rate of SSIs or BSIs, the clinical courses of eligible infants were followed up for 90 days after each cardiac procedure. If an eligible infant had more than one cardiac procedure during the study period, all procedures were included to determine these rates. The Centers for Disease Control and Prevention's National Healthcare Safety Network case definitions were used for SSIs, primary and secondary BSIs, and central line–associated bloodstream infections (CLABSIs).[12] In addition, the causative pathogens and their susceptibility to cefazolin were assessed using the Clinical and Laboratory Standards Institute guidance.[13]

Risk Factors for SSIs and BSIs

The electronic health records of eligible infants were reviewed for potential risk factors for BSIs or SSIs. If an infant had more than one surgical procedure during their first year of life, risk factors were assessed only after the first procedure. Potential risk factors included demographic characteristics (eg, age at the time of surgery, sex), comorbid conditions (eg, chromosomal anomalies or lack of splenic function), as well as preoperative factors (eg, duration of preoperative hospitalization, American Society of Anesthesiologists, and RACHS-1 category). The American Society of Anesthesiologists score correlates physical status with surgical mortality[14]; a score of 1 indicates an otherwise healthy patient and a score of 5 indicates a patient not expected to live more than 24 hours independent of a surgical intervention. The RACHS-1 categories combine cardiac surgical procedures that have similar surgical mortality rates; group 1 procedures carry the lowest risk of mortality and group 6 procedures carry the highest risk of mortality.[11] In addition, intraoperative factors (eg, skin disinfection with povidone-iodine vs chlorhexidine; duration of cardiopulmonary bypass, aortic cross-clamp, and deep hypothermic circulatory arrest), and postoperative factors (eg, excessive bleeding defined as receiving red blood cells (RBCs) plus 2 or more of the following products: platelets, fresh-frozen plasma, and/or factor VII within 24 hours of surgery end time; and duration of device use such as central venous catheters and chest tubes) were assessed.

Furthermore, failure to provide the correct perioperative prophylactic antibiotic (ie, cefazolin, or vancomycin if allergic to β-lactam agents or history of infection or colonization with methicillin-resistant *Staphylococcus aureus*) or incorrect timing (ie, failure to administer cefazolin within 60 minutes or vancomycin within 120 minutes before incision) was assessed.

Statistical Methods

The incidence of postoperative BSIs and SSIs was determined. Bivariate associations between potential risk factors and BSIs or SSIs after the first surgical procedure were examined using Cox proportional hazard modeling (version 9.2 for Windows; SAS Institute, Inc, Cary, NC). Kaplan-Meier survival curves were plotted to test the proportionality assumption of the models. Infants were censored for HAIs, death, or 90 days after their last surgical procedure. The hazard ratio, 95% confidence interval (CI), and *P* value were reported for each potential risk factor.

Significant variables ($P < .05$) from the bivariate analysis were included in the multivariable Cox proportional hazards saturated model. In addition, the RACHS-1 score was included in the multivariable model to test the hypothesis that a higher RACHS-1 score was a risk factor for SSI. Infants with missing values for one or more of the significant bivariate variables were excluded from the multivariable analysis. The final model for each outcome was determined by backward elimination. Variables in the final model were selected based on the stability of the model (lower Akaike information criterion) and either remained significant predictors ($P < .05$) or potential confounders (>10% difference in the parameter estimate). Colinearity and multilinearity were tested when appropriate. If variables were found to be collinear or multilinear, then the potentially more biologically relevant parameter was selected for the multivariable model (eg, because weight and age were found to be collinear [$r = 0.81$; $n = 470$; $P < .0001$], age was selected). If both continuous and categoric parameters were significant for a given variable (eg, age and neonate), the categoric parameter (ie, neonate defined as age <30 days at the time of surgery) was included in the multivariate analysis.

RESULTS

During the study period, 504 infants underwent 602 cardiac procedures, of whom 470 infants (552 procedures) were included in this study. The following infants were excluded: those undergoing patent ductus arteriorus ligation procedures (n = 26), heart transplantation (n = 12), or pacemaker implantation (N = 11), and 1 infant who died within 24 hours of surgery. Among the 470 included infants, 401, 58, 10, and 1 infant had 1, 2, 3, and 4 cardiac procedures, respectively, performed during their first year of life.

Incidence of BSI and SSI

After the 552 included surgical procedures, 19 SSIs occurred (1 deep and 18 superficial SSIs) and 29 BSIs (6 CLABSIs) occurred. Thus, the rates of SSIs and BSIs in the study population were 3.4% and 5.3%, respectively. No subject had both a BSI and SSI. After the 207 procedures performed in neonates younger than 30 days of age, the rates of SSIs and BSIs were 6.8% (n = 14) and 3.9% (n = 8), respectively. SSIs presented a mean of 27 days after surgery (median, 19 days; range, 9-49 days) and BSIs presented a mean of 17 days after surgery (median, 9 days; range, 1-76 days).

Risk Factors Associated With HAIs

All SSIs and 69% (20 of 29) of BSIs occurred after the first surgical procedure and thus were included in the risk factor analyses shown in Table 1 (SSIs) and in Table 2 (BSIs). Bivariate analysis identified 6 potential risk factors for SSIs and 4 potential risk factors for BSIs. Younger age, non-white race, lower weight, higher intraoperative glucose level, excessive bleeding, and incorrect timing of preoperative antibiotics were associated positively with SSIs.