Risk factors of nosocomial infection after cardiac surgery in children with congenital heart disease

CURRENT STATUS: ACCEPTED

BMC Infectious Diseases  ▪  BMC Series

Xindi Yu
Shanghai Children's medical Center, School of Medicine, Shanghai Jiaotong University

Maolin Chen
Shanghai Children's Medical Center, School of Medicine, Shanghai Jiao Tong University

Xu Liu
Shanghai Children's Medical Center, School of Medicine, Shanghai Jiaotong University

Yiwei Chen
Shanghai Synyi Medical Technology Co., Ltd

Zedong Hao
Shanghai Synyi Medical Technology Co., Ltd

Haibo Zhang
Shanghai Children's Medical Center, School of Medicine, Shanghai Jiaotong University

Wei Wang
Shanghai children's Medical center, School of Medicine, Shanghai Jiaotong University

wangwei@scmc.com.cn  Corresponding Author

DOI:
10.21203/rs.2.13787/v3

SUBJECT AREAS
Infectious Diseases

KEYWORDS
Nosocomial infection, Cardiac surgery, Children
Abstract
Background: The aim of our study was to analyze the risk factors of nosocomial infection after cardiac surgery in children with congenital heart disease (CHD). Methods: We performed a retrospective cohort study, and children with CHD who underwent open-heart surgeries at Shanghai Children’s Medical Center from January 1, 2012 to December 31, 2018 were included. The baseline characteristics of these patients of different ages, including neonates (0-1 months old), infants (1-12 months old) and children (1-10 years old), were analyzed, and the association of risk factors with postoperative nosocomial infection were assessed. Results: A total of 11651 subjects were included in the study. The overall nosocomial infection rate was 10.8%. Nosocomial infection rates in neonates, infants, and children with congenital heart disease were 32.9%, 15.4%, and 5.2%, respectively. Multivariate logistic regression analysis found age (OR 0.798, 95%CI: 0.769-0.829; P<0.001), STS risk grade (OR 1.267, 95%CI: 1.159-1.385; P<0.001), body mass index (BMI) <5th percentile (OR 1.295, 95%CI: 1.023-1.639; P=0.032), BMI ≥95th percentile (OR 0.792, 95%CI: 0.647-0.969; P=0.023), cardiopulmonary bypass (CPB) time (OR 1.008, 95%CI: 1.003-1.012; P<0.001) and aortic clamping time (OR 1.009, 1.002-1.015; P = 0.008) were significantly associated with nosocomial infection in CHD infants. After adjusted for confounding factors, we found STS risk grade (OR 1.38, 95%CI: 1.167-1.633; P<0.001), BMI<5th percentile (OR 1.934, 95%CI: 1.377-2.715; P<0.001), CPB time (OR 1.018, 95%CI: 1.015-1.022; P<0.001), lymphocyte/WBC ratio cut off value (OR 3.818, 95%CI: 1.529-9.533; P=0.004) and AST cut off value (OR 1.546, 95%CI: 1.119-2.136; P=0.008) were significantly associated with nosocomial infection in CHD children.

Conclusion: Our study suggested STS risk grade, BMI, CPB duration, low lymphocyte/WBC or high neutrophil/WBC ratio were independently associated with nosocomial infection in CHD infant and children after cardiac surgery.

Background
In-hospital infections have an adverse effect on the clinical outcomes of pediatric patients after thoracotomy, which can cause morbidity, mortality, prolonged hospital stay[1-4]. The prevalence of nosocomial infections in children with open-heart surgery remains high. Among patients who admitted
into the ICU, 50% or more of the patients were affected by nosocomial infections, compared with about 5% to 15% of inpatients in the conventional ward[5]. In developing countries, the severity of nosocomial infections is still underestimated, mainly due to lack of good surveillance system which requires expertise and resources[6].

In-hospital infections after cardiac surgery in patients with congenital heart disease are affected by many factors. A prospective cohort study found that diabetes mellitus and obesity are associated with surgical site infection in valve surgery, and diabetes mellitus and reoperation for bleeding are associated with surgical site infection in coronary revascularization[7]. Younger age and ventilator or ECMO use at time of heart transplant are attribute to bacterial infections of pediatric patients[8]. A 4-year survey found that age <2 months, congenital malformations, post-operative complications, and open-chest procedure are associated with nosocomial infections in pediatric cardiovascular surgery patients[9]. Surgery-related risk factors include age, longer preoperative hospitalizations, higher American Society of Anesthesiologist (ASA) score, preoperative ventilation, longer duration of surgical procedures, blood transfusions, continuation of antimicrobial prophylaxis more than 48 hours, longer ICU time and longer hospitalization time, open chest, surgical risk grade, and duration of central line placement are associated with hospital-acquired infections in pediatric cardiac surgical patients[10]. The study founded that risk factors for nosocomial infection after neonatal cardiac surgery include lower Apgar score, higher incidence of other congenital malformations, longer hospital stay, central venous catheter indwelling time > 14 days, mechanical ventilation time > 7 days, blood product transfusion > 5 times[11].

Previous studies on risk factors for nosocomial infection in children with CHD have often focused on a specific age group, and few studies have detailed analysis of risk factors for nosocomial infections after CHD in children of different ages, especially in China. Therefore, the aim of this study was to explore the risk factors of post-operative in-hospital infection in children with CHD classified according to age. The study also used nomogram to analyze the discrimination ability of these risk factors for the post-operative infection. The discrimination ability of the nomograms was evaluated through the area under the (ROC) curve (AUC).
Methods

Patient and study design

Children with CHD who underwent cardiac surgery at Shanghai Children’s Medical Center from January 1, 2012 to December 31, 2018 were included in this retrospective cohort study. For patients with multiple surgery records within 30 days, only the last open-heart surgery was included and the previous surgery records were considered as operation history. The inclusion criteria include patient with CHD, age ≤10 years old. The exclusion criteria include surgery without CPB, infection within preoperative 30 days, preoperative ventilator support, and no complete blood count (CBC) within 48 hours before CPB, deaths of uninfected patients after surgery, postoperative infection occurred within 2 days of admission. Demographic characteristics and pre-operation test data were extracted from a clinical database. The study was approved by the Ethical Committee of Shanghai Children’s Medical Center. All children with congenital heart disease were divided into neonates (0-1 months old), infants (1-12 months old) and children (1-10 years old) according to age. We analyzed the in-hospital infection rate of all CHD children after cardiac surgery. The baseline characteristics of these patients of different ages were analyzed, and the association of risk factors with postoperative nosocomial infection were assessed.

Definition and variables

Nosocomial infection was defined according to draft version of the hospital infection diagnosis standard of Chinese Ministry of Health[12]. The variables of interest in the study included preoperative demographic data of the patient, laboratory test data after admission, surgical related variables. All these study data were obtained from the hospital’s electronic medical record. All laboratory testing was done at Shanghai Children’s Medical Center. The cut-offs and selection criteria for laboratory tests were listed in supplementary Table 2. Moreover, the STS risk grade was defined as ordinal data; an increase in the STS risk grade can indicate the risk of nosocomial infection[13].

Statistical analysis
Continuous variables were described as Mean ± SD or Median (Range) according to their distributions and categorical data were presented as frequency (%). For between group comparison, T tests or Mann-Whitney U tests were used for continuous variables and Chi-squared tests or Fisher’s exact tests for categorical data, as appropriate.

To identify risk factors for nosocomial infection, univariate logistic regression was used first and multiple logistic regression were applied for significant variables (i.e. P<0.05) in the univariate analysis to select the significant risk factors.

Then, nomograms were established for the risk predictive models for nosocomial infection, taking the whole samples for infant subgroup and child subgroup as derivation cohorts, respectively. Finally, cross validation was conducted as internal validation.

All tests were two-sided and p<0.05 were regarded as statistically significant.

Results
A total of 11651 subjects were included in the study. Among them, there are 85 newborns, 6183 infants, and 5383 children. Nosocomial infection rates in neonates, infants, and children with congenital heart disease were 32.9%, 15.4%, and 5.2%, respectively. The overall nosocomial infection rate was 10.8%. There were 3739 patients who underwent surgery between 2012 and 2014, and the incidence of nosocomial infection was 12%. There were 7912 patients who underwent surgery between 2015 and 2018, the hospital infection rate was 10.3%. Among 1259 cases of nosocomial infection, there were 989 ventilator-associated pneumonia, 188 urinary system infections, 71 systemic infections, 10 catheter-related bacteremia, and 1 upper respiratory tract infection (Table 1). The interval from the end of surgery to infection of catheter-related bacteremia was 193.3h (137.9, 267.0), the time interval for ventilator-associated pneumonia, urinary tract infection, upper respiratory infection and systemic Infection were 24.5h (21.0, 48.8), 96.2h (87.2, 120.7), 21.9h (21.9, 21.9) and 46.6h (14.0, 98.5). The deaths were found in ventilator-associated pneumonia patients (3.03%), urinary tract infection patients (1.06%), and systemic infection (4.23). Postoperative length of stays was 8-17.5 d in all infection patients (Table 1).
Newborns

Baseline characteristics and postoperative outcomes of newborns with and without nosocomial infection

Of all 85 neonatal CHD patients, there were 28 nosocomial infections and 91 controls. There were no significant differences in length of hospital stay and mortality after operation between nosocomial infection patients and control (P=0.124, P=0.329) (Table 2). General characteristics were similar for nosocomial infection and control in CHD newborns. Significant differences were found in age (19.5d vs. 14d, P=0.039), Neutrophil count (P=0.026) between of nosocomial infection and control (Supplemental table).

Infants

Baseline characteristics and postoperative outcomes of infants with and without nosocomial infection

Among 6183 CHD infants (median age 188d, range: 122-250d), there were 952 nosocomial infections, and 5231controls. Among baseline characteristics, CPB time (69 min vs. 51 min, P<0.001) and aortic clamping time (42min vs. 31min, P<0.001)of nosocomial infections infant was significantly higher than control group, but age (138d vs. 196d, P<0.001) was significantly younger. BMI, STS risk grade, delayed sternal closure, serum creatinine level, lymphocyte count, neutrophil count, lymphocyte/white blood cell (WBC) ratio and neutrophil/WBC ratio were all significantly different between nosocomial infection and control in CHD newborns (Table 3). The length of hospital stay and mortality were significantly different between nosocomial infection and control after cardiac surgery (both P<0.001) (Table 2).

Univariate and multivariate analysis of risk factors for nosocomial infection in CHD infants

Significant risk factors in the univariate analysis associated with nosocomial infection were age, STS risk grade, delayed sternal closure, BMI < 5th percentile, CPB time, aortic clamping time, lymphocyte count [cut off value, lymphocyte/WBC ratio, neutrophil count [cut off value, neutrophil/WBC ratio and serum creatinine [cut off value (Table 4).
After adjusted confounding factors, the study found age (OR 0.798, 95%CI: 0.769-0.829; P<0.001), STS risk grade (OR 1.267, 95%CI: 1.159-1.385; P<0.001), BMI <5th percentile (OR 1295, 95%CI: 1.023-1.639; P=0.032), BMI >95th percentile (OR 0.792, 95%CI: 0.647-0.969; P=0.023), CPB time (OR 1.008, 95%CI: 1.003-1.012; P<0.001), aortic clamping time (OR 1.009, 95%CI: 1.002-1.015; P=0.008) were significantly associated with nosocomial infection in CHD infants (Table 4).

**Nomograms predicting nosocomial infection risk of CHD infant after cardiac surgery**

Nosocomial infection probability can be estimated with the nomograms (Figure 1). In order to calculate the probability of nosocomial infection after heart surgery in infants with congenital heart disease, each parameter has a corresponding score on the point axis, and the sum of the scores is plotted on the “total point” axis. The probability of nosocomial infection is the value at a vertical line from corresponding total points. The area under the curve (AUC) of nomograms predicting nosocomial infection risk of CHD infant after cardiac surgery was 0.738 (95% CI: 0.721-0.755, P<0.001). After cross validation, AUC of nomograms was 0.730 (Figure 2).

**Children**

**Baseline characteristics and postoperative outcomes of children with and without nosocomial infection**

Among 5383 CHD children (median age 929 d, range: 545-1458 d), there were 279 nosocomial infections and 5104 controls. Few characteristics were similar for nosocomial infection and control patients. Nosocomial infection CHD children had longer CPB time (88min vs. 48min, P<0.001) and aortic clamping time (52min vs. 28min, P<0.001). Characteristics of nosocomial infection CHD children including proportion of patients with a history of cardiac surgery, BMI, STS risk grade, proportion of patients with delayed sternal closure, abnormal ALT, AST, WBC counts, lymphocyte counts, neutrophil count, lymphocyte/WBC ratio and neutrophil/WBC ratio were all significantly different with those of control in CHD children (Table 5). The length of hospital stay and mortality were significantly different between nosocomial infection and control after cardiac surgery (both
Univariate and multivariate analysis of risk factors for nosocomial infection in CHD children

Univariate analysis found that history of cardiac surgery, STS risk grade, delayed sternal closure, BMI < 5th percentile, CPB time, aortic clamping time, lymphocyte counts, lymphocyte/WBC ratio, neutrophil count cut-off value, neutrophil/WBC ratio cut-off value, ALT cut-off value and AST cut-off value of nosocomial infection CHD children were all significantly different with control CHD children. Multivariate analysis found that STS risk grade (OR 1.38, 95%CI: 1.167-1.633; P<0.001), BMI < 5th percentile (OR 1.934, 95%CI: 1.377-2.715; P<0.001), CPB time (OR 1.018, 95%CI: 1.015-1.022; P<0.001), lymphocyte/WBC ratio cut-off value (OR 3.818, 95%CI: 1.529-9.533; P=0.004) and AST cut-off value (OR 1.546, 95%CI: 1.119-2.136; P=0.008) were significantly associated with nosocomial infection in CHD children (Table 6).

Nomograms predicting nosocomial infection risk of CHD children after cardiac surgery

Nosocomial infection probability of CHD children after cardiac surgery can also be estimated with the nomograms, and calculation method is similar with that of CHD infant (Figure 3). The AUC of nomograms predicting nosocomial infection risk of CHD children after cardiac surgery was 0.818 (95% CI: 0.792-0.844, P<0.001). After cross validation, AUC of nomograms was 0.808 (Figure 4).

Discussion

CHD has become the most common congenital defect in China. Due to China’s large population base, the number of new cases of CHD per year is huge. Surgery is the main treatment for most heart defects[14]. But pediatric cardiac surgery reduces the patient’s immunity and increases the risk of postoperative infection[15]. The study found that nosocomial infection was one of the main complications in the postoperative period in children with CHD, and are major causes of morbidity and mortality after cardiac surgery[16]. Nosocomial infections are also associated with longer intensive care unit (ICU) stay and greater antibiotic usage[17-19]. Analysis and identification of risk factors for nosocomial infections is important for identifying the highest risk population and developing
strategies to prevent nosocomial infections. There have been few previous studies on the risk of nosocomial infection after cardiac surgery in children with congenital heart disease, and most of the studies were small size studies. This study investigated the risk factors for infection in 11937 CHD children after cardiac surgery, the results have important clinical significance for the prevention and treatment of nosocomial infection in CHD children.

In present study, nosocomial infection rate was 10.8%, and nosocomial infection rates of newborns, infant and child were 32.9%, 15.4%, and 5.2%, respectively. Overall nosocomial infection rate is slightly lower than previous studies[20, 21].

Nosocomial infection rate of CHD newborn was higher than infant and child in our study, age may be one of the main reasons for this difference. We also found that age was significantly associated with nosocomial infection of infant and child after cardiac surgery. Previous studies found that younger age was associated with higher incidence of postoperative infectious complications[22, 23]. Younger age was independently associated with acquisition of bacterial infection post-heart transplantation in children[8]. A matched case-control study found that age younger than 1 year was an independent risk factors for any type of SSI after cardiac surgery in children[24]. Sen et al. assessed the risk factors for postoperative infection after congenital heart surgery using data from the International Quality Improvement Collaborative for Congenital Heart Surgery in Developing World Countries, they found younger age was one of independent risk factors for infection[16].

Surgery itself is the risk of postoperative infection[25]. In our study, STS risk grade and history of cardiac surgery were significantly associated with post-operative nosocomial infection in CHD infant and child. The complexity of surgery is related to the operation time. The more complicated the operation, the longer the operation time, and the worse the outcome of the patient[26]. Duration of surgery and surgical complexity score are all risk factors of nosocomial infections in infants and children undergoing open heart surgery[20, 27]. The possible cause is that the risk of bacterial contamination and cell damage increases at the surgical site as the operation time increases.

Retrospective study confirmed high complexity and previous cardiothoracic operation were associated with major infection after pediatric cardiac surgery[25, 28]. A cross-sectional prospective study found
that duration of operation ≥ 3 hours significantly predicted surgical site infection[29]. Previous case-control studies showed longer duration of surgery were independently associated with hospitalized surgical site infections after cardiovascular surgery in children[24, 30]. Higher surgical complexity was an independent risk factor for nosocomial infection after congenital heart surgery[16].

Obesity and BMI is associated with an increased number of ventilator days, as well as increased ICU and hospital lengths of stay, which increase the risk of nosocomial infections[31, 32]. Previous study showed that a higher BMI is directly related to longer hospital and ICU stay[33], which increases the risk of nosocomial infections[11, 34]. In a two-center prospective randomized controlled study, multiple regression analysis demonstrated a preoperative BMI of >30 kg/m2 was an independent predictor for an increased surgical site infection rate after cardiac surgery in adult patients[35]. Higher BMI patients have a higher risk of community acquired and nosocomial infections in the ICU[33, 36, 37]. However, in this study, BMI <5th percentile was significantly associated with increased odds of nosocomial infection after cardiac surgery in CHD infant and child. But BMI ≥95th percentile was a protective factor for postoperative infection in CHD infant. This correlation is different from that of adults. The possible reason is that the BMI of children with CHD in our study is smaller than general population, and the patients with BMI >95th percentile have not reached the standard of obesity. And BMI <5th percentile may result from CHD and bad nutrition. It also suggested that the better nutrition condition may be helpful to prevent nosocomial infection after cardiac surgery in children. In addition, among the adult population, people with high BMI are prone to diabetes, high blood pressure and other diseases, which are risk factors for postoperative infection[38, 39]. However, children with high BMI have a low risk of developing these diseases. This may also be one of the reasons why higher BMI was associated with decreased odds of postoperative infection risk in CHD children.

During cardiac surgery, CBP induces a systemic inflammatory response that causes immune disorders and significant pulmonary dysfunction[40, 41]. CPB time is closely related to aortic clamping time. Interestingly, we found through multivariate analysis that CPB time was significantly associated with the risk of nosocomial infection after cardiac surgery in children, but there was no significant
association with the risk of postoperative infection in infants. The aortic clamping time is just the opposite, and there is only a significant correlation with the risk of postoperative nosocomial infection in infants. Aortic cross-clamp time greater than 85 minutes was an independent risk factor for surgical site infections in children undergoing cardiac surgery[24]. Lomtadze et al. confirmed that long CPB and cross-clamp time are major risk factors for nosocomial infection after cardiac surgery in a retrospective case study[42].

Neutrophils, the most abundant human immune cells, are rapidly recruited to sites of infection, where they fulfill their life-saving antimicrobial functions[43]. Neutrophils are responsible for nonspecific inflammation through secretion of many inflammatory mediators[44]. This study found neutrophils are involved in the activation of non-specific inflammation, and lymphopenia is associated with adverse outcomes[44]. In our study, high neutrophils/WBC ratio was significantly associated with nosocomial infection in CHD infants, low lymphocyte/WBC ratio was significantly associated with nosocomial infection in child after surgery.

AST is one of the commonly used enzyme indicators for clinical evaluation of myocardial injury, and myocardial damage leads to an increase in AST levels[45]. The patients included in this study were children with congenital heart disease and had varying degrees of myocardial cell damage. These patients have lower immunity than normal people, and the risk of inflammatory reactions and infections increases. This may explain the association between increased AST levels in CHD children and postoperative infection, but further clinical studies are needed.

Combined with the above risk factors, we can use nomogram to assess the risk of nosocomial infections in infants and children with congenital heart disease after cardiac surgery. In our study, the AUC of nomograms predicting nosocomial infection risk of CHD infant after cardiac surgery was 0.738. After cross validation, AUC of nomograms was 0.730. The AUC of nomograms predicting nosocomial infection risk of CHD children was 0.818. After cross validation, AUC of nomograms was 0.808. Therefore, nomograms had good discrimination ability of the risk of nosocomial infection after cardiac surgery in infants and children.

Limitations
Several limitations should be considered to interpret this study. First, this is a retrospective single-center study. Second, some biomarkers of infection or inflammatory, such as CRP, as well as PCT, was not measured and analyzed. Third, the type of infection such as bacteria or virus, the grams positive of negative bacteria was not analyzed in this study. Fourth, the association between multidrug resistance and postoperative infection cannot be analyzed because of the lack of data related to multiple resistances.

Conclusions
STS risk grade, BMI, CPB duration, low lymphocyte/WBC ratio or high neutrophil/WBC ratio were independently associated with nosocomial infection in CHD infant and children after cardiac surgery. Additional preventive strategies, including controlling weight (such as nutrition support), optimizing the surgical procedure may reduce risk of postoperative infection, but further research is needed.

Abbreviations
CHD: congenital heart disease
BMI: body mass index
STS risk grade: Society of Thoracic Surgeons risk grade
ASA: American Society of Anesthesiologist
ALT: alanine transaminase
AST: aspartate aminotransferase
ALP: alkaline phosphatase
WBC: white blood cell

Declarations
Ethics approval and consent to participate
The research project is in accordance with the ethical principles of “Declaration of Helsinki” and “International Ethical Guidelines for Biomedical Research Involving Human Subjects” promulgated by the Council for International Organization of Medical Sciences. After carefully reviewing, the research was approved by the Ethical Committee of Shanghai Children’s Medical Center. All patients were free of informed consent because the study was a retrospective study. The approved number is SCMCIRB-K2016047.
**Consent to publish**

This study was a retrospective study, it did not contain any individual person’s data and all data has been desensitized. So, all patients were free of informed consent.

**Availability of data and materials**

The data and materials are not available because of hospital regulation.

**Competing interests**

The authors declare no competing interests.

**Funding**

The research was funded by National Science Foundation of China (No: 81670372).

**Authors' Contributions**

XD Y: responsible for research implementation, data collection and analysis

ML C: responsible for supervision of project execution, data quality control, final approval of the version to be published

X L: accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved, final approval of the version to be published

YW C: responsible for the statistics and analysis of research data, final approval of the version to be published

ZD H: responsible for retrieval and screening literature, drafting the article

HB Z: responsible for data collection, data quality control, final approval of the version to be published

W W: responsible for the determination of the research direction, the design of the research program, and the summary of the research questions.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

**Acknowledgements**

Thanks to all the staff of Shanghai Children’s Medical Center who have contributed to the study.

Thanks to Shanghai Synyi Medical Technology Co., Ltd for providing a data analysis and statistical
References

1. Li LY, Wang SQ: Economic effects of nosocomial infections in cardiac surgery. *The Journal of hospital infection* 1990, **16**(4):339-341.

2. Kollef MH, Sharpless L, Vlasnik J, Pasque C, Murphy D, Fraser VJ: The impact of nosocomial infections on patient outcomes following cardiac surgery. *Chest* 1997, **112**(3):666-675.

3. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton Dj: The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol* 1999, **20**(11):725-730.

4. Martone WJ, Nichols RL: Recognition, prevention, surveillance, and management of surgical site infections: introduction to the problem and symposium overview. *Clin Infect Dis* 2001, **33** Suppl 2:S67-68.

5. Vincent JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, Moreno R, Lipman J, Gomersall C, Sakr Y et al: International study of the prevalence and outcomes of infection in intensive care units. *Jama* 2009, **302**(21):2323-2329.

6. Allegranzi B, Pittet D: Preventing infections acquired during health-care delivery. *Lancet (London, England)* 2008, **372**(9651):1719-1720.

7. Figuerola-Tejerina A, Rodriguez-Caravaca G, Bustamante-Munguira J, Maria San Roman-Montero J, Duran-Poveda M: Epidemiological Surveillance of Surgical Site Infection and its Risk Factors in Cardiac Surgery: A Prospective Cohort Study. *Revista espanola de cardiologia (English ed)* 2016, **69**(9):842-848.

8. Rostad CA, Wehrheim K, Kirklin JK, Naftel D, Pruitt E, Hoffman TM, L’Ecuyer T, Berkowitz K, Mahle WT, Scheel JN: Bacterial infections after pediatric heart
transplantation: Epidemiology, risk factors and outcomes. Journal of Heart & Lung Transplantation 2016, 35(4):S21-S21.

9. Grisaru-Soen G, Paret G, D, Boyko V, Lerner-Geva L: Nosocomial infections in pediatric cardiovascular surgery patients: a 4-year survey. Pediatric Critical Care Medicine 2009, 10(10):202-206.

10. Taylor RS, Shekerdemian LS: Avoidance of Hospital-Acquired Infections in Pediatric Cardiac Surgical Patients. Pediatr Crit Care Med 2016, 17(8 Suppl 1):S279-286.

11. Shao PL: Risk factors for nosocomial infections after cardiac surgery in newborns with congenital heart disease. Pediatr Neonatol 2018, 59(4):327-328.

12. MOHC: Hospital infection diagnostic criteria. Modern Practical Medicine 2003, 15(7):460-464.

13. Cavalcante CT, de Souza NMG, Pinto VCJ, Branco KM, Pompeu RG, Teles AC, Cavalcante RC, de Andrade GV: Analysis of Surgical Mortality for Congenital Heart Defects Using RACHS-1 Risk Score in a Brazilian Single Center. Brazilian journal of cardiovascular surgery 2016, 31(3):219-225.

14. Bouma BJ, Mulder BJ: Changing Landscape of Congenital Heart Disease. Circ Res 2017, 120(6):908-922.

15. Zhang J, Yuan Y, Li P, Wang T, Gao J, Yao J, Li S: Postoperative nosocomial infections among children with congenital heart disease. Pak J Med Sci 2014, 30(3):554-557.

16. Sen AC, Morrow DF, Balachandran R, Du X, Gauvreau K, Jagannath BR, Kumar RK, Kupiec JK, Melgar ML, Chau NT et al: Postoperative Infection in Developing World Congenital Heart Surgery Programs: Data From the International Quality Improvement Collaborative. Circ Cardiovasc Qual Outcomes 2017, 10(4).
17. Sohn AH, Schwartz JM, Yang KY, Jarvis WR, Guglielmo BJ, Weinrub PS: **Risk factors and risk adjustment for surgical site infections in pediatric cardiothoracic surgery patients.** *Am J Infect Control* 2010, **38**(9):706-710.

18. Costello JM, Graham DA, Morrow DF, Potter-Bynoe G, Sandora TJ, Laussen PC: **Risk factors for central line-associated bloodstream infection in a pediatric cardiac intensive care unit.** *Pediatr Crit Care Med* 2009, **10**(4):453-459.

19. Slonim AD, Kurtines HC, Sprague BM, Singh N: **The costs associated with nosocomial bloodstream infections in the pediatric intensive care unit.** *Pediatr Crit Care Med* 2001, **2**(2):170-174.

20. Levy I, Ovadia B, Erez E, Rinat S, Ashkenazi S, Birk E, Konisberger H, Vidne B, Dagan O: **Nosocomial infections after cardiac surgery in infants and children: incidence and risk factors.** *J Hosp Infect* 2003, **53**(2):111-116.

21. Li X, Wang X, Li S, Yan J, Li D: **Diagnostic Value of Procalcitonin on Early Postoperative Infection After Pediatric Cardiac Surgery.** *Pediatr Crit Care Med* 2017, **18**(5):420-428.

22. Vaidyanathan B, Roth SJ, Rao SG, Gauvreau K, Shivaprakasha K, Kumar RK: **Outcome of ventricular septal defect repair in a developing country.** *The Journal of Pediatrics* 2002, **140**(6):736-741.

23. Ashfaq A, Zia HA, Amanullah MM: **Is early correction of congenital ventricular septal defect a better option in a developing country?** *J Pak Med Assoc* 2010, **60**(4):324-327.

24. Costello JM, Graham DA, Morrow DF, Morrow J, Potter-Bynoe G, Sandora TJ, Pigula FA, Laussen PC: **Risk factors for surgical site infection after cardiac surgery in children.** *Ann Thorac Surg* 2010, **89**(6):1833-1841; discussion 1841-1832.

25. Barker GM, O’Brien SM, Welke KF, Jacobs ML, Jacobs JP, Benjamin DK Jr, Peterson ED,
Jaggers J, Li JS: **Major Infection After Pediatric Cardiac Surgery: A Risk Estimation Model**, *Ann Thorac Surg* 2010, 89(3):843-850.

26. Hardy KL, Davis KE, Constantine RS, Chen M, Hein R, Jewell JL, Dirisala K, Lysikowski J, Reed G, Kenkel JM: **The impact of operative time on complications after plastic surgery: a multivariate regression analysis of 1753 cases.** *Aesthet Surg J* 2014, 34(4):614-622.

27. Hasija S, Makhija N, Kiran U, Choudhary S, Talwar S, Kapil A: **Nosocomial infections in infants and children after cardiac surgery**, *Indian J Thorac Cardiovasc Surg* 2008, 24(4):233-239.

28. Kansy A, Jacobs JP, Pastuszko A, Mirkowicz-Malek M, Manowska M, Jezierska E, Maruszewski P, Burczynski P, Maruszewski B: **Major infection after pediatric cardiac surgery: external validation of risk estimation model.** *Ann Thorac Surg* 2012, 94(6):2091-2095.

29. Mawalla B, Mshana SE, Chalya PL, Imirzalioglu C, Mahalu W: **Predictors of surgical site infections among patients undergoing major surgery at Bugando Medical Centre in Northwestern Tanzania.** *BMC Surg* 2011, 11:21.

30. Allpress AL, Rosenthal GL, Goodrich KM, Lupinetti FM, Zerr DM: **Risk factors for surgical site infections after pediatric cardiovascular surgery.** *Pediatr Infect Dis J* 2004, 23(3):231-234.

31. Brown CV, Neville AL, Rhee P, Salim A, Velmahos GC, Demetriades D: **The impact of obesity on the outcomes of 1,153 critically injured blunt trauma patients.** *J Trauma* 2005, 59(5):1048-1051; discussion 1051.

32. Akinnusi ME, Pineda LA, El Solh AA: **Effect of obesity on intensive care morbidity and mortality: a meta-analysis.** *Crit Care Med* 2008, 36(1):151-158.

33. Newell MA, Bard MR, Goettler CE, Toshchlog EA, Schenarts PJ, Sagraves SG, Holbert D,
Pories WJ, Rotondo MF: **Body mass index and outcomes in critically injured blunt trauma patients: weighing the impact.** *J Am Coll Surg* 2007, **204**(5):1056-1061; discussion 1062-1054.

34. Dantas SR, Kuboyama RH, Mazzali M, Moretti ML: **Nosocomial infections in renal transplant patients: risk factors and treatment implications associated with urinary tract and surgical site infections.** *J Hosp Infect* 2006, **63**(2):117-123.

35. Schimmer C, Gross J, Ramm E, Morfeld BC, Hoffmann G, Panholzer B, Hedderich J, Leyh R, Cremer J, Petzina R: **Prevention of surgical site sternal infections in cardiac surgery: a two-centre prospective randomized controlled study.** *Eur J Cardiothorac Surg* 2017, **51**(1):67-72.

36. Falagas ME, Kompoti M: **Obesity and infection.** *Lancet Infect Dis* 2006, **6**(7):438-446.

37. Dossett LA, Dageforde LA, Swenson BR, Metzger R, Bonatti H, Sawyer RG, May AK: **Obesity and site-specific nosocomial infection risk in the intensive care unit.** *Surg Infect (Larchmt)* 2009, **10**(2):137-142.

38. Dotters-Katz SK, Feldman C, Puechl A, Grotegut CA, Heine RP: **Risk factors for post-operative wound infection in the setting of chorioamnionitis and cesarean delivery.** *J Matern Fetal Neonatal Med* 2016, **29**(10):1541-1545.

39. Salt E, Wiggins AT, Rayens MK, Morris BJ, Mannino D, Hoellein A, Donegan RP, Crofford LJ: **Moderating effects of immunosuppressive medications and risk factors for post-operative joint infection following total joint arthroplasty in patients with rheumatoid arthritis or osteoarthritis.** *Semin Arthritis Rheum* 2017, **46**(4):423-429.

40. Rankin JS, Oguntonu O, Binford RS, Troichtenberg DS, Muhlbaier LH, Stratton CW: **Management of immune dysfunction after adult cardiac surgery.** *J Thorac*
Cardiovasc Surg 2011, 142(3):575-580.

41. Hadley JS, Wang JE, Michaels LC, Dempsey CM, Foster SJ, Thiemermann C, Hinds CJ: Alterations in inflammatory capacity and TLR expression on monocytes and neutrophils after cardiopulmonary bypass. Shock 2007, 27(5):466-473.

42. Lomtadze M, Chkhaidze M, Mgeladze E, Metreveli I, Tsintsadze A: Incidence and risk factors of nosocomial infections after cardiac surgery in Georgian population with congenital heart diseases. Georgian Med News 2010(178):7-11.

43. Kruger P, Saffarzadeh M, Weber AN, Rieber N, Radsak M, von Bernuth H, Benarafa C, Roos D, Skokowa J, Hartl D: Neutrophils: Between host defence, immune modulation, and tissue injury. PLoS Pathog 2015, 11(3):e1004651.

44. Azab B, Zaher M, Weiserbs KF, Torbey E, Lacossiere K, Gammad S, Gobunsuy R, Jadonath S, Baldari D, McCord D et al: Usefulness of neutrophil to lymphocyte ratio in predicting short- and long-term mortality after non-ST-elevation myocardial infarction. Am J Cardiol 2010, 106(4):470-476.

45. Bodor GS: Biochemical Markers of Myocardial Damage. Ejifcc 2016, 27(2):95-111.

Tables

Table 1. Comparison of clinical outcomes in patients with different infection types

| Infection type              | Number | Interval from the end of surgery to infection (hour) Median (IQR) |
|-----------------------------|--------|---------------------------------------------------------------|
| Catheter-related bacteremia | 10     | 193.3 (137.9, 267.0)                                          |
| Ventilator-associated pneumonia | 989   | 24.5 (21.0, 48.8)                                             |
| Urinary system infection    | 188    | 96.2 (87.2, 120.7)                                            |
| Upper respiratory tract infection | 1     | 21.9                                                          |
| Systemic infection          | 71     | 46.6 (14.0, 98.5)                                             |
| Total                       | 1259   | 40.2 (21.9, 74.9)                                             |

Table 2. Postoperative hospital stays and outcome comparison between nosocomial infection neonates and controls
### Table 3. Baseline characteristics of postoperative infection infants and control

| Parameter                          | Postoperative Infection (n=952) | Control (n=5231) |
|------------------------------------|---------------------------------|------------------|
| **Age (days)**                     | Median (IQR)                    | 138 (87.5,208)   | 196 (130,255) |
| CPB time (min)                     | Median (IQR)                    | 69 (51.98)       | 51 (40.70)    |
| Aortic clamping time (min)         | Median (IQR)                    | 42 (28.61)       | 31 (23.43)    |
| Gender                             | MALE                            | 564 (59.24%)     | 2978 (56.93%) |
| Preterm birth                      | YES                             | 7 (0.74%)        | 45 (0.86%)    |
| History of cardiac surgery         | YES                             | 13 (1.37%)       | 58 (1.11%)    |
| BMI                                | < 5th percentile                | 148 (16.95%)     | 1040 (21.24%) |
|                                    | 5th–95th percentile             | 508 (58.19%)     | 2744 (56.05%) |
|                                    | > 95th percentile               | 217 (24.86%)     | 1112 (22.71%) |
| STS risk grade                     | 1                               | 366 (38.45%)     | 3150 (60.22%) |
|                                    | 2                               | 310 (32.56%)     | 1443 (27.59%) |
|                                    | 3                               | 158 (16.6%)      | 332 (6.35%)   |
|                                    | 4                               | 116 (12.18%)     | 304 (5.81%)   |
|                                    | 5                               | 2 (0.21%)        | 2 (0.04%)     |
| Delayed sternal closure            | YES                             | 9 (0.95%)        | 8 (0.15%)     |
| ALT                                | < cut off value                  | 19 (2.3%)        | 79 (1.6%)     |
|                                    | Normal                          | 737 (89.23%)     | 4473 (90.84%) |
|                                    | cut off value                    | 70 (8.47%)       | 372 (7.55%)   |
| AST                                | Normal                          | 316 (38.16%)     | 1880 (38.03%) |
|                                    | cut off value                    | 512 (61.84%)     | 3063 (61.97%) |
| ALP                                | Normal                          | 819 (99.15%)     | 4910 (99.39%) |
|                                    | cut off value                    | 7 (0.85%)        | 30 (0.61%)    |
| Serum creatinine                   | < cut off value                  | 7 (0.85%)        | 37 (0.75%)    |
|                                    | Normal                          | 814 (98.79%)     | 4888 (99.23%) |
|                                    | cut off value                    | 3 (0.36%)        | 1 (0.02%)     |
| WBC counts                         | < cut off value                  | 18 (1.89%)       | 55 (1.05%)    |
|                                    | Normal                          | 898 (94.33%)     | 4956 (94.74%) |
|                          | cut off value | 36 (3.78%) | 220 (4.21%) |
|--------------------------|---------------|------------|-------------|
| Lymphocyte count         | < cut off value | 32 (3.36%) | 153 (2.92%) |
|                          | Normal        | 260 (27.31%) | 1166 (22.29%) |
|                          | cut off value | 660 (69.33%) | 3912 (74.78%) |
| Neutrophil count         | < cut off value | 228 (23.95%) | 1357 (25.94%) |
|                          | Normal        | 677 (71.11%) | 3703 (70.79%) |
|                          | cut off value | 47 (4.94%) | 171 (3.27%) |
| Lymphocytes/WBC          | < cut off value | 76 (7.98%) | 170 (3.25%) |
|                          | Normal        | 331 (34.77%) | 1435 (27.43%) |
|                          | cut off value | 545 (57.25%) | 3626 (69.32%) |
| Neutrophils/WBC          | < cut off value | 599 (62.92%) | 3831 (73.24%) |
|                          | Normal        | 184 (19.33%) | 902 (17.24%) |
|                          | cut off value | 169 (17.75%) | 498 (9.52%) |

Note: ^ Mann-Whitney U test  ^^ T test # Chi-square test ## Fisher exact method

CPB: cardiopulmonary bypass, BMI: body mass index, STS risk grade: Society of Thoracic Surgeons risk grade, ALT: alanine transaminase, AST: aspartate aminotransferase, ALP: alkaline phosphatase, WBC: white blood cell

Table 4. Univariate and multivariate logistic regression analysis of risk factors for postoperative infection in infants with congenital heart disease
| Parameter                          | Univariate analysis                                      | OR (95% CI)                     | P-value   |
|-----------------------------------|----------------------------------------------------------|---------------------------------|-----------|
| Age (days) Unit=30                |                                                          | 0.812 (0.789,0.835)             | <0.001    |
| Gender                            |                                                          | 1.000                           |           |
| Male                              |                                                          | 1.1 (0.956,1.265)               | 0.184     |
| Preterm birth Yes                 |                                                          | 0.854 (0.384,1.899)             | 0.698     |
| History of cardiac surgery No     |                                                          | 1.000                           |           |
| Yes                               |                                                          | 1.235 (0.674,2.262)             | 0.495     |
| STS risk grade Unit=1             |                                                          | 1.625 (1.517,1.74)              | <0.001    |
| Delayed sternal closure No        |                                                          | 1.000                           |           |
| Yes                               |                                                          | 6.235 (2.4,16.203)              | <0.001    |
| BMI 5th-95th percentile           |                                                          | 1.000                           |           |
| < 5th percentile                  |                                                          | 0.769 (0.632,0.936)             | 0.009     |
| > 95th percentile                 |                                                          | 1.054 (0.886,1.254)             | 0.552     |
| CPB time Unit=1                   |                                                          | 1.017 (1.015,1.019)             | <0.001    |
| Aortic clamping time Unit=1       |                                                          | 1.023 (1.02,1.026)              | <0.001    |
| Lymphocyte count Normal           |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 0.938 (0.626,1.405)             | 0.756     |
| cut off value                     |                                                          | 0.757 (0.646,0.886)             | 0.001     |
| Lymphocytes /WBC Normal           |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 1.938 (1.442,2.605)             | <0.001    |
| cut off value                     |                                                          | 0.652 (0.561,0.757)             | <0.001    |
| Neutrophil count Normal           |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 0.919 (0.781,1.081)             | 0.308     |
| cut off value                     |                                                          | 1.503 (1.078,2.097)             | 0.016     |
| Neutrophil /WBC Normal            |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 0.766 (0.64,0.918)              | 0.004     |
| cut off value                     |                                                          | 1.664 (1.314,2.106)             | <0.001    |
| ALT Normal                        |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 1.461 (0.88,2.425)              | 0.143     |
| cut off value                     |                                                          | 1.142 (0.874,1.492)             | 0.329     |
| AST Normal                        |                                                          | 1.000                           |           |
| cut off value                     |                                                          | 0.994 (0.855,1.157)             | 0.943     |
| ALP Normal                        |                                                          | 1.000                           |           |
| cut off value                     |                                                          | 1.4 (0.613,3.196)               | 0.425     |
| Serum creatinine Normal           |                                                          | 1.000                           |           |
| < cut off value                   |                                                          | 1.136 (0.505,2.557)             | 0.758     |
| cut off value                     |                                                          | 18.008 (1.871,173.3)            | 0.012     |
Note: CPB: cardiopulmonary bypass, BMI: body mass index, STS risk grade: Society of Thoracic Surgeons risk grade, ALT: alanine transaminase, AST: aspartate aminotransferase, ALP: alkaline phosphatase, WBC: white blood cell

Table 5. Baseline characteristics of postoperative infection children and control

| Parameter                        | Postoperative infection (n=279) | Control (n=5104) |
|----------------------------------|---------------------------------|------------------|
| Age (days)                       | Median (IQR)                    | 832 (489,1386)   | 933 (548,1386) |
| CPB time (min)                   | Median (IQR)                    | 88 (66,125)      | 48 (36,72)      |
| Aortic clamping time (min)       | Median (IQR)                    | 52 (39,76)       | 28 (19,44)      |
| Gender                           | MALE                            | 152 (54.48%)     | 2828 (55.4%)    |
| Preterm birth                    | YES                             | 2 (0.72%)        | 37 (0.72%)      |
| History of cardiac surgery       | YES                             | 82 (29.39%)      | 673 (13.19%)    |
| BMI                              | < 5th percentile                | 77 (29.84%)      | 748 (15.83%)    |
|                                 | 5th-95th percentile             | 174 (67.44%)     | 3734 (79.01%)   |
|                                 | > 95th percentile               | 7 (2.71%)        | 243 (5.14%)     |
| STS risk grade                   | 1                               | 61 (21.86%)      | 3064 (60.0%)    |
|                                 | 2                               | 144 (51.61%)     | 1497 (29.3%)    |
|                                 | 3                               | 37 (13.26%)      | 356 (6.97%)     |
|                                 | 4                               | 34 (12.19%)      | 182 (3.57%)     |
|                                 | 5                               | 3 (1.08%)        | 5 (0.1%)        |
| Delayed sternal closure          | YES                             | 4 (1.43%)        | 8 (0.16%)       |
| ALT                              | < cut off value                  | 19 (8.23%)       | 315 (6.53%)     |
|                                 | Normal                          | 200 (86.58%)     | 4435 (91.9%)    |
|                                 | cut off value                   | 12 (5.19%)       | 72 (1.49%)      |
| AST                              | Normal                          | 157 (65.15%)     | 3825 (78.1%)    |
|                                 | cut off value                   | 84 (34.85%)      | 1071 (21.8%)    |
| ALP                              | Normal                          | 240 (99.59%)     | 4860 (99.3%)    |
|                                 | cut off value                   | 1 (0.41%)        | 34 (0.69%)      |
| Serum creatinine                 | < cut off value                  | 0 (0%)           | 4 (0.08%)       |
|                                 | Normal                          | 239 (99.58%)     | 4885 (99.8%)    |
|                                 | cut off value                   | 1 (0.42%)        | 2 (0.04%)       |
| WBC counts                       | < cut off value                  | 4 (1.43%)        | 30 (0.59%)      |
|                                 | Normal                          | 263 (94.27%)     | 4970 (97.3%)    |
|                                 | cut off value                   | 12 (4.3%)        | 104 (2.04%)     |
| Lymphocyte count                 | < cut off value                  | 7 (2.51%)        | 26 (0.51%)      |
|                                 | Normal                          | 101 (36.2%)      | 1537 (30.1%)    |
### Neutrophil count

| Category        | Count | Percentage |
|-----------------|-------|------------|
| < cut off value | 22    | 7.89%      |
| Normal          | 223   | 79.93%     |
| cut off value   | 34    | 12.19%     |

### Lymphocytes/WBC

| Category        | Count | Percentage |
|-----------------|-------|------------|
| < cut off value | 11    | 3.94%      |
| Normal          | 63    | 22.58%     |
| cut off value   | 205   | 73.48%     |

### Neutrophils/WBC

| Category        | Count | Percentage |
|-----------------|-------|------------|
| < cut off value | 209   | 74.91%     |
| Normal          | 59    | 21.15%     |
| cut off value   | 11    | 3.94%      |

Note: ^ Mann-Whitney U test  ^^ T test  # Chi-square test  ## Fisher exact method

CPB: cardiopulmonary bypass, BMI: body mass index, STS risk grade: Society of Thoracic Surgeons risk grade, ALT: alanine transaminase, AST: aspartate aminotransferase, ALP: alkaline phosphatase, WBC: white blood cell

Table 6. Univariate and multivariate logistic regression analysis of risk factors for postoperative infection in children with congenital heart disease
| Parameter                         | Unit=30 | OR (95% CI)          | P-value |
|----------------------------------|---------|----------------------|---------|
| Age (days)                       |         | 0.998 (0.993,1.003)  | 0.43    |
| Gender                           |         | 1.000                |         |
| Male                             |         | 0.963 (0.756,1.227)  | 0.761   |
| Preterm birth                    |         | 1.000                |         |
| Yes                              |         | 0.989 (0.237,4.124)  | 0.988   |
| History of cardiac surgery       |         | 2.741 (2.092,3.59)   | <0.001  |
| Yes                              |         | 0.963 (0.756,1.227)  | 0.761   |
| STS risk grade                   | Unit=1  | 2.07 (1.843,2.326)   | <0.001  |
| Delayed sternal closure          |         | 1.000                |         |
| Yes                              |         | 9.268 (2.774,30.965) | <0.001  |
| BMI                              |         | 1.000                |         |
| 5th-95th percentile              |         | 1.000                |         |
| < 5th percentile                 |         | 2.209 (1.671,2.922)  | <0.001  |
| > 95th percentile                |         | 0.618 (0.287,1.331)  | 0.219   |
| CPB time                         | Unit=1  | 1.019 (1.016,1.021)  | <0.001  |
| Aortic clamping time             | Unit=1  | 1.027 (1.024,1.031)  | <0.001  |
| Lymphocyte count                 |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 4.097 (1.736,9.668)  | 0.001   |
| cut off value                    |         | 0.735 (0.571,0.947)  | 0.017   |
| Lymphocytes /WBC                 |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 3.243 (1.607,6.543)  | 0.001   |
| cut off value                    |         | 0.714 (0.534,0.956)  | 0.024   |
| Neutrophil count                 |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 0.956 (0.61,1.497)   | 0.843   |
| cut off value                    |         | 1.889 (1.296,2.754)  | 0.001   |
| Neutrophil /WBC                  |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 0.853 (0.634,1.148)  | 0.295   |
| cut off value                    |         | 2.426 (1.223,4.814)  | 0.011   |
| ALT                              |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 1.338 (0.824,2.171)  | 0.239   |
| cut off value                    |         | 3.696 (1.974,6.921)  | <0.001  |
| AST                              |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| cut off value                    |         | 1.911 (1.454,2.512)  | <0.001  |
| ALP                              |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| cut off value                    |         | 0.596 (0.081,4.369)  | 0.61    |
| Serum creatinine                 |         | 1.000                |         |
| Normal                           |         | 1.000                |         |
| < cut off value                  |         | 0 (0..)              | 0.98    |
| cut off value                    |         | 10.22 (0.923,113.101)| 0.058   |
Note: CPB: cardiopulmonary bypass, BMI: body mass index, STS risk grade: Society of Thoracic Surgeons risk grade, ALT: alanine transaminase, AST: aspartate aminotransferase, ALP: alkaline phosphatase, WBC: white blood cell

Figures

Figure 1

Nomograms predicting nosocomial infection risk of CHD infant after cardiac surgery.
Figure 2

The area under the curve of nomograms predicting nosocomial infection risk of CHD infant after cardiac surgery.
Figure 3

Nomograms predicting nosocomial infection risk of CHD children after cardiac surgery.
The area under the curve of nomograms predicting nosocomial infection risk of CHD children after cardiac surgery.

Supplementary Files
This is a list of supplementary files associated with this preprint. Click to download.
Supplemental table.pdf