Washington University School of Medicine

Digital Commons@Becker

Open Access Publications

2008

Case-control study of pediatric cardiothoracic surgical site infections

Galit Holzmamm-Pazgal

Washington University School of Medicine in St. Louis

Diane Hopkins-Broyles

BJC Healthcare

Angela Recktenwald

BJC Healthcare

Melinda Hohrein

BJC Healthcare

Patricia Kieffer

St. Louis Children's Hospital

See next page for additional authors

Follow this and additional works at: https://digitalcommons.wustl.edu/open_access_pubs

Part of the [Medicine and Health Sciences Commons](#)

Please let us know how this document benefits you.

Recommended Citation

Holzmamm-Pazgal, Galit; Hopkins-Broyles, Diane; Recktenwald, Angela; Hohrein, Melinda; Kieffer, Patricia; Huddleston, Charles; Anshuman, Sharma; and Fraser, Victoria, "Case-control study of pediatric cardiothoracic surgical site infections." *Infection Control and Hospital Epidemiology*. 20, 1. 76-79. (2008). https://digitalcommons.wustl.edu/open_access_pubs/867

This Open Access Publication is brought to you for free and open access by Digital Commons@Becker. It has been accepted for inclusion in Open Access Publications by an authorized administrator of Digital Commons@Becker. For more information, please contact vanam@wustl.edu.

Authors

Galit Holzmann-Pazgal, Diane Hopkins-Broyles, Angela Recktenwald, Melinda Hohrein, Patricia Kieffer, Charles Huddleston, Sharma Anshuman, and Victoria Fraser

CHICAGO JOURNALS

Case-Control Study of Pediatric Cardiothoracic Surgical Site Infections •

Author(s): Galit Holzman-Pazgal, MD, Diane Hopkins-Broyles, RN, MSN, CIC, Angela Recktenwald, MPH, Melinda Hohrein, Patricia Kieffer, BSN, Charles Huddleston, MD, Sharma Anshuman, MD, Victoria Fraser, MD

Reviewed work(s):

Source: *Infection Control and Hospital Epidemiology*, Vol. 29, No. 1 (January 2008), pp. 76-79

Published by: [The University of Chicago Press](http://www.press.uchicago.edu) on behalf of [The Society for Healthcare Epidemiology of America](http://www.shea-online.org)

Stable URL: <http://www.jstor.org/stable/10.1086/524323>

Accessed: 08/04/2012 19:09

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

The University of Chicago Press and The Society for Healthcare Epidemiology of America are collaborating with JSTOR to digitize, preserve and extend access to Infection Control and Hospital Epidemiology.

<http://www.jstor.org>

CONCISE COMMUNICATION

Case-Control Study of Pediatric Cardiothoracic Surgical Site Infections

Galit Holzman-Pazgal, MD;
Diane Hopkins-Broyles, RN, MSN, CIC;
Angela Recktenwald, MPH; Melinda Hohrein;
Patricia Kieffer, BSN; Charles Huddleston, MD;
Sharma Anshuman, MD; Victoria Fraser, MD

A retrospective case-control study was performed to determine the risks and outcomes associated with pediatric cardiothoracic surgical site infection. Undergoing more than 1 cardiothoracic operative procedure, having preoperative infection, and undergoing surgery on a Monday were significant risk factors. Cardiothoracic surgical site infection increased hospital and pediatric intensive care unit length of stay. Deep surgical site infection significantly increased mortality.

Infect Control Hosp Epidemiol 2008; 29:76-79

Published data regarding the incidence of cardiothoracic surgical site infection (SSI) in pediatric patients are limited. Published rates of pediatric cardiothoracic SSI range from 2.3% to 5.0%.¹⁻³ Few studies control for severity of illness or use multivariate analysis. In controlled studies, the independent risk factors identified for pediatric cardiothoracic SSI include duration of surgery, young age, presence of upper respiratory tract infection, and hypothermia.^{2,4,5}

Controlling for underlying severity of illness is challenging because adequate preoperative risk stratification for pediatric patients is lacking. Several studies control for severity of illness using the American Society of Anesthesiologists (ASA) score.^{2,4} Another study matched patients by using the National Nosocomial Infections Surveillance (NNIS) system risk index score, which incorporates duration of surgery, wound class, and ASA score.¹ However, recent data in pediatrics suggest that the NNIS risk index did not adequately stratify pediatric patients who underwent median sternotomy according to their risk of developing an SSI.⁶

St. Louis Children's Hospital has performed prospective surveillance for cardiothoracic SSI since 2000. An increasing incidence of SSI was detected between 2001 and 2003. The rate increased from 1.4% (8 of 563 patients) in 2001 to 3.1% (17 of 541) in 2002, and then increased to 4.8% (23 of 476) in 2003 ($P = .002$). Most infections that occurred during 2002-2003 (26 of 40 infections [65%]) were deep SSIs. A retrospective case-control study was performed to investigate this increase.

METHODS

Case patients who underwent surgery during the period from January 1, 2002, through December 31, 2003, were

evaluated. Patients underwent procedures involving median sternotomy or posterolateral incision and were followed up for infection for up to 1 year if the procedure involved placement of an implant. Three control patients were selected per case patient. Control patients were matched on the basis of month and year of procedure. Institutional review board approval was obtained.

A standardized data collection tool was used. Data on demographic, microbiologic, preoperative, intraoperative, and postoperative variables were collected. The outcomes investigated included pediatric intensive care unit (PICU) length of stay, hospital length of stay, and mortality.

Statistical analysis was performed using SPSS statistical software, version 14.0 (SPSS). Univariate analysis using the Student t test, χ^2 test, and Fisher exact test, as appropriate, was performed to determine the risk factors for SSI. P values were 2-tailed. P of .05 or less was considered statistically significant. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were computed. The variables determined to be significant by univariate analysis and variables that had a priori clinical significance were entered into a multivariate model. Significant variables that covaried were grouped, and 1 variable from each group was chosen for entry into the model. The final model was chosen on the basis of biological plausibility and lowest $-2 \log$ likelihood function.

SSI was defined in accordance with Centers for Disease Control and Prevention and NNIS criteria.⁷ Deep SSI involved soft tissues below the subcutaneous layer, including bone and mediastinum. Clinical criteria included purulent drainage from incision, incision dehiscence or opened in a patient with fever or localized tenderness, or deep incisional SSI diagnosed by the surgeon or attending physician. SSIs were tracked for

TABLE 1. Organisms Isolated From Patients With Deep and Superficial Surgical Site Infections (SSIs)

Organism	No. (%) of infections		
	Any SSI ($n = 40$)	Deep SSI ($n = 24$)	Superficial SSI ($n = 16$)
CoNS	18 (45)	8 (33)	10 (63)
<i>Staphylococcus aureus</i>	11 (28)	5 (21)	6 (38)
MRSA	5 (13)	3 (13)	2 (13)
<i>Pseudomonas aeruginosa</i>	2 (5)	2 (8)	0
<i>Klebsiella pneumoniae</i>	2 (5)	2 (8)	0
<i>Candida albicans</i>	1 (3)	1 (4)	0
<i>Enterococcus</i> spp	2 (5)	2 (8)	0
<i>Acinetobacter</i> spp	1 (3)	1 (4)	0
<i>Haemophilus influenzae</i>	1 (3)	1 (4)	0
<i>Serratia marcescens</i>	1 (3)	0	1 (6)
Other	2 (5)	1 (4)	1 (6)
No growth	1 (3)	1 (4)	0

NOTE. Six infections were polymicrobial. CoNS, coagulase-negative staphylococci; MRSA, methicillin-resistant *S. aureus*.

30 days or for 1 year from the operative procedure when the procedure involved placement of an implant.

Superficial SSI involved the skin and subcutaneous tissue. Clinical criteria included purulent drainage from incision; organism(s) isolated from culture of incision samples; symptoms of tenderness, localized swelling or erythema; and superficial incision deliberately opened by the surgeon or diagnosis of superficial SSI made by the surgeon or attending physician. The ASA score was used to control for underlying severity of illness.⁸

The primary outcome of interest was SSI. Secondary outcomes were death and length of stay in the hospital and the PICU. The secondary outcome risk attributed to SSI was determined by multivariate logistic regression, for which presence of SSI along with ASA score were entered for each outcome.

RESULTS

A total of 1,017 surgical procedures were included in the 24-month study period. Forty case patients and 120 control patients were analyzed. Monthly SSI rates ranged from 1% to

10.3%. The median time to onset of infection was 9.0 days (range, 2.0-82.0 days). Twenty-six (65%) of 40 SSIs were deep, and 14 (35%) were superficial.

The organisms isolated from patients with SSI, according to type of SSI, are listed in Table 1. Coagulase-negative *Staphylococcus* (CoNS) was the organism most commonly recovered. Eight patients had secondary bloodstream infections due to CoNS, *Staphylococcus aureus*, *Klebsiella pneumoniae*, or methicillin-resistant *Staphylococcus aureus*.

Significant risk factors for SSI by univariate analysis are listed in Table 2. Weight (less than 4.5 kg), age (less than 2.5 months), and increased ASA score (greater than 3) were significant and strongly correlated. An ASA score greater than 3 was used in the multivariate logistic regression model. Independent risk factors for cardiothoracic SSI included having had more than 1 cardiothoracic procedure performed in the operating room (OR, 3.6 [95% CI, 1.5-9.0]; $P = .005$); another infection present or being treated at the time of surgery, as documented in the patient's medical record (OR, 5.5 [95% CI, 1.4-22.0]; $P = .015$); and having surgery performed on a Monday (OR, 5.6 [95% CI, 2.0-15.4]; $P = .001$). Docu-

TABLE 2. Univariate Comparison of Significant Risk Factors for Surgical Site Infection in Case and Control Patients

Variable	Case group (n = 40)	Control group (n = 120)	OR (95% CI)	P
Patient characteristic				
Weight, mean $\pm$ SD, kg	7.9 $\pm$ 7.1	19.0 $\pm$ 22		.003
Age, mean $\pm$ SD, months	19.8 $\pm$ 34	51.0 $\pm$ 65		.004
Cyanotic heart disease	19 (48)	40 (33)	2.2 (1.1-4.6)	.03
Preoperative risk factors				
Infection at time of surgery	9 (22)	7 (7)	4.1 (1.5-11.4)	.008
Preoperative NICU stay	11 (28)	14 (11)	2.9 (1.2-7.0)	.02
Same-day surgery, preoperatively	7 (17)	55 (46)	0.25 (0.10-0.61)	.002
Intraoperative risk factors				
Receipt of prostaglandin	10 (25)	11 (9)	3.3 (1.3-8.5)	.01
Surgery performed on a Monday	14 (35)	17 (14)	3.3 (1.4-7.5)	.005
Blalock-Taussig shunt procedure	8 (20)	4 (3)	7.3 (2.1-25.6)	.002
Tricuspid procedure	5 (12)	2 (2)	8.4 (1.6-45.3)	.01
Multiple procedures	25 (63)	39 (32)	3.5 (1.6-7.3)	.001
ASA score >3	22 (55)	35 (29)	3.0 (1.4-6.2)	.004
Implant	30 (75)	68 (57)	2.3 (1.0-5.1)	.04
Subclavian line placed in operating room	20 (50)	38 (32)	2.2 (1.0-4.5)	.04
Intraoperative PRBC transfusion	30 (75)	67 (56)	2.4 (1.1-5.3)	.03
Procedure duration, mean $\pm$ SD, min	209.3 $\pm$ 102.2	209.9 $\pm$ 98.2		.97
Cardiopulmonary bypass pump used	30 (75)	99 (83)	0.64 (0.27-1.5)	.3
Intraoperative glucose level, mean $\pm$ SD (range), mg/dL	238.1 $\pm$ 102.5 (73-463)	267.3 $\pm$ 91.7 (99-476)		.13
Lowest intraoperative temperature, mean $\pm$ SD (range), °C	28.3 $\pm$ 6.3 (14.8-36.5)	30.0 $\pm$ 5.2 (15.8-37.0)		.11
Antibiotic prophylaxis administered within 60 min of incision ^a	20 (50)	75 (62)	0.6 (0.28-1.3)	.19
Postoperative risk factor				
Sternum left open postoperatively	10 (25)	13 (11)	2.7 (1.1-6.8)	.03

NOTE. Data are no. (%) of patients, unless otherwise indicated. ASA, American Society of Anesthesiologists; CI, confidence interval; MRSA, methicillin-resistant *Staphylococcus aureus*; NICU, neonatal intensive care unit; OR, odds ratio; PRBC, packed red blood cells.

^a Cefazolin or vancomycin if patients had a β -lactam allergy or an MRSA-positive culture result.

mented preoperative infections included 3 cases of bacteremia (2 due to CoNS and 1 due to *K. pneumoniae*, and *Enterobacter* species), 1 case of endocarditis, 2 upper respiratory tract infections, and 3 urinary tract infections. Two cases of SSIs due to CoNS occurred in bacteremic patients.

Procedures performed on all days of the week were analyzed, but only procedures performed on a Monday were found to be significantly associated with cardiothoracic SSI. No individual healthcare worker or worker job category was associated with surgery performed on a Monday or with cardiothoracic SSI. No differences in the nursing, perfusion, or environmental services involved in preparation for surgery on Monday were identified, compared with those used on other days of the week.

When patients with SSI were compared with patients without SSI, PICU length of stay (18.9 vs 4.5 days; $P < .001$) and hospital length of stay (mean, 35.6 vs 12.4 days; $P = .003$) were significantly increased. A total of 5 patients with SSI died, 4 of whom had a deep SSI. After controlling for ASA score, patients with deep SSI had an increased risk of death (OR, 4.9 [95% CI, 1.1-22.8]; $P = .04$).

DISCUSSION

A significant increase in the rate of cardiothoracic SSI at St. Louis Children's Hospital was identified on the basis of historical surveillance data. If a patient had more than 1 cardiothoracic surgical procedure performed concurrently or had an infection present preoperatively, these factors could plausibly increase the risk of SSI because these variables reflect the patient's underlying severity of illness and/or immune function and could increase surgical complexity. Procedure time did not vary between case and control patients, and therefore surgical duration could not explain the increased SSI risk associated with multiple procedures. Concurrent infections also increase the microbial burden and have been shown to increase the SSI risk in other studies.⁵ The increased risk of infection associated with surgery performed on a Monday is difficult to explain. No obvious difference in the complexity of cases was noted on any particular day of the week. Unfortunately, this finding remains difficult to explain.

Several risk factors associated with SSI in adults were not significant in this study.^{9,10} For example, administration of antibiotic prophylaxis within 60 minutes of incision time was not significant. However, during the study period, the rate of compliance with timing guidelines for antibiotic prophylaxis was low for case and control patients. Similarly, intraoperative hyperglycemia was also not associated with increased risk of SSI, but both groups had similarly elevated glucose levels, making it difficult to discern any significance.

This study represents a single center's experience with a limited number of cases. A small number of patients underwent each cardiac procedure, which meant that they could not be matched by procedure type. Similarly, sample size prevented us from matching patients by age or weight. How-

ever, age and weight were strongly correlated with ASA score. When we controlled for age, weight, or ASA score in the multivariate models, results were similar. Finally, the ASA score is not a pediatric patient-specific score. Lack of a standardized pediatric preoperative risk score limits risk stratification in children.⁶

On the basis of this study, it appears prudent to avoid performing surgery for patients with underlying infections in the immediate preoperative period. Further studies of pediatric SSI that involve multiple centers' experience and increased numbers of patients would be ideal. Establishing standardized interhospital comparisons would better enable benchmarking among institutions.

ACKNOWLEDGMENTS

Financial support. This work was supported in part by the multidisciplinary clinical research training program at Washington University; National Institutes of Health (grant K12 HD052194-01 to V.F.); Centers for Disease Control and Prevention, Washington University, and BJC Epi-Center for Prevention of Healthcare-Associated Infection (grant 1U01CI000333-01 to V.F.); and National Institutes of Health Infectious Disease and Healthcare Epidemiology Mentoring (grant 1K24AI06779401 to V.F.).

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article.

From the Department of Pediatrics, Division of Infectious Diseases (G.H.P.), the Department of Cardiothoracic Surgery (C.H.), the Department of Anesthesia (S.A.), and the Department of Internal Medicine, Division of Infectious Diseases (V.F.), Washington University School of Medicine, the Infection Control and Healthcare Epidemiology Consortium, BJC Healthcare (D.H.-B., A.R., M.H.), and the St. Louis Children's Hospital (P.K.), St. Louis, Missouri.

Address reprint requests to Galit Holzmman-Pazgal, MD, University of Texas Health Science Center at Houston, 6431 Fannin Street, MSB 6.132, Houston, TX 77030 (galit.holzmman-pazgal@uth.tmc.edu).

Presented in part: 16th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America; Chicago, Illinois; March 2006 (Abstract 131).

Received May 25, 2007; accepted September 12, 2007; electronically published November 26, 2007.

© 2007 by The Society for Healthcare Epidemiology of America. All rights reserved. 0899-823X/2008/2901-0014\$15.00. DOI: 10.1086/524323

REFERENCES

1. Nateghian A, Taylor G, Robinson J. Risk factors for surgical site infections following open-heart surgery in a Canadian pediatric population. *Am J Infect Control* 2004; 32:397-401.
2. Allpress A, Rosenthal G, Goodrich K, Lupinetti I, Zerr D. Risk factors for surgical site infections after pediatric cardiovascular surgery. *Pediatr Infect Dis J* 2004; 23:231-234.
3. Mehta P, Cunningham C, Colella C, Alferis G, Weiner L. Risk factors for sternal wound and other infections in pediatric cardiac surgery patients. *Pediatr Infect Dis J* 2000; 19:1000-1004.
4. McAnally H, Cutter G, Ruttenber AJ, Clarke D, Todd J. Hypothermia as a risk factor for pediatric cardiothoracic surgical site infection. *Pediatr Infect Dis J* 2001; 20:459-462.
5. Malviya S, Voepel-Lewis T, Siewert M, Pandit U, Riegger L, Tait A. Risk factors for adverse postoperative outcomes in children presenting for cardiac surgery with upper respiratory tract infections. *Anesthesiology* 2003; 98:628-632.
6. Kagen J, Bilder W, Lautenbach E, et al. Risk adjustment for surgical site

- infection after median sternotomy in children. *Infect Control Hosp Epidemiol* 2007; 28:398-405.
7. Horan TC, Gaynes RP. Surveillance of nosocomial infections. In: Mayhall CG, ed. *Hospital Epidemiology and Infection Control*. 3rd ed. Philadelphia: Lippincott, Williams & Wilkins, 2004:1672-1689.
 8. Keats AS. The ASA classification of physical status: a recapitulation. *Anesthesiology* 1978; 49:233-236.
 9. Furnary AP, Zerr KJ, Grunkemeier GL, Starr A. Continuous intravenous insulin infusion reduces the incidence of deep sternal wound infection in diabetic patients after cardiac surgical procedures. *Ann Thorac Surg* 1999; 67:352-362.
 10. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical wound infection. *N Engl J Med* 1992; 326:281-286.