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Prevention of Sternal Wound Infection in Pediatric Cardiac Surgery: A Protocolized Approach

Cathy S. Woodward, DNP, RN[1], Minnette Son, MD[1], Richard Taylor, MD, MS[1] and S. Adil Husain, MD[2]

Abstract

Background: Sternal wound infections (SWIs) are a costly complication for children after cardiac surgery, increasing morbidity, mortality, and financial cost. There are no pediatric guidelines to reduce the incidence of SWI in this vulnerable population. *Methods*: A quality improvement, multidisciplinary team was formed, and a protocol to prevent SWI was developed. A prospective review of patients who underwent pediatric cardiac surgery was conducted over a two-year period to follow adherence to the protocol and incidence of SWI. The Centers for Disease Control definitions for surgical site infections were used to determine the depth and presence of infection. *Results*: Three hundred and eight children <18 years of age had sternotomies during the study period. There was a reduction in all SWI between the first and second years of the study (odds ratio [OR] = 0.35; confidence interval [CI] 95% 0.12-1.01; $P = .059$). Delayed sternal closure (DSC) was associated with increased risk of SWI (OR = 5.4; CI 95% 2.13-14.9; $P \leq .001$). Institution of a protocol in patients with DSC was associated with decreased infections during the second year (first year: n = 7 (14%), second year: n = 2 (4%), $P = .14$). *Conclusions*: Institution of a protocol was associated with a decreased number of infections in children. A multicenter study of a bundled protocol approach to SWI prevention is needed. Children with DSC had a significantly higher risk of developing a wound infection. Initiating strategies to reduce SWI with a focus on children with DSC may result in improved overall infection rates.

Keywords

sternal wound infection, surgical site infection, sternum, pediatric

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Introduction

Children who develop sternal wound infections (SWIs) after cardiac surgery have increased mortality and morbidity and longer, more expensive, hospital stays.[1] An evidence-based protocol to reduce SWI in children is lacking in the literature. The Surgical Care Improvement Project (SCIP), a national effort to reduce surgical complications, addresses quality performance measures to decrease the surgical site infections (SSIs) in adults, however, no similar efforts have been undertaken to address appropriate measures in children.[2] It remains unclear whether the same quality performance measures utilized for adults would be successful in reducing the infection rate in children as their risk factors (young age, high complexity, previous cardiothoracic surgery, preoperative ventilator support, and genetic abnormality) are not modifiable.[3] A recent survey study performed by our group which evaluated data from 39 children's cardiac surgery programs reported disparities in clinical practices and that pediatric cardiac surgery programs were not consistently following adult national guidelines.[4]

Efforts to reduce hospital-acquired infections in children using a protocolized approach have been successful. The National Association of Children's Hospitals and Related Institutions (NACHRI) has supported a national collaborative effort to reduce catheter-associated bloodstream infections in children utilizing a protocol for maintenance and insertion of central lines which lead to a reduction in line infections in 43%.[5] Evidence-based practices to reduce SWI have been utilized

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Abbreviations and Acronyms

CDC	Centers for Disease Control
CI	confidence interval
DSC	delayed sternal closure
NACHRI	National Association of Children's Hospitals and Related Institutions
NHSN	National Healthcare and Safety Network
OR	odds ratio
PICU	pediatric intensive care unit
RACHS	risk adjusted for congenital heart surgery
SCIP	Surgical Care Improvement Project
SSI	surgical site infection
SWI	sternal wound infection

to develop protocols in adults. Haycock et al conducted a retrospective study after initiating a process improvement project to reduce SWIs in their adult heart surgery program. They reported an 86% decrease in SWIs over one year.[6] As a follow-up to our survey study and its findings of no uniformity regarding pediatric guidelines, this quality improvement project was initiated to develop, institute, and monitor compliance with a SWI prevention protocol for patients with pediatric cardiac surgery with an aim to reduce this serious complication.

Materials and Methods

The investigational review board at the University of Texas Health Science Center at San Antonio concluded that this project was a quality improvement effort and no further review was required.

A quality improvement, multidisciplinary team was formed at a 200-bed children's hospital in the southwestern United States where more than 300 cardiac surgeries are performed each year. A SWI prevention protocol was developed using evidence based or best practices reviewed in the pediatric and adult literature. The protocol was disseminated to all physicians, surgical and nursing staff in the preoperative, surgical and postoperative units involved in the care of children undergoing cardiac surgery. Items addressed in the protocol were divided into preoperative, intraoperative, and postoperative practices (Table 1) and included three of the SCIP performance measures: preoperative antibiotic timing, antibiotic selection, and discontinuation of antibiotics within 24 hours of surgery. Elements of the protocol were prospectively followed for compliance and glucose levels on postoperative day one were recorded. The surgical program has preset orders for antibiotic selection and patients received a single dose of vancomycin and cefuroxime preoperatively. The selection of antibiotics was based on a history of methicillin-resistant *Staphylococcus aureus* SSIs at the study hospital and no clear pediatric guidelines for preoperative antibiotics. Timing of administration was the responsibility of the anesthesiologists. According to protocol, vancomycin was to be started within 60 to 120 minutes prior to cut time in order to be completely infused within 1 hour of incision. Cefuroxime was to be administered by intravenous bolus 1 hour before incision.

When the protocol was introduced, a prospective review of patients under the age of 18 years who had a sternotomy for cardiac surgery was started and continued over a two-year period for adherence to the protocol and incidence of SWI. Table 2 lists the Centers for Disease Control (CDC) definitions which were used to define a SSI.[12] Findings and occurrences of SWI were reported to the multidisciplinary committee on a monthly basis and to the pediatric cardiology mortality and morbidity review committee and infection control committee on a quarterly basis. The committee that developed the protocol met often throughout the two years of data collection, where problems with compliance were discussed and each SWI that occurred was discussed at length with the congenital heart surgery team. As issues and concerns presented themselves, changes to the protocol were made. Additions made during the first year included keeping disinfectant in each patient room to cleanse personal stethoscopes, echocardiography probes, and electrocardiogram cables. In addition, during the first year, the neonatologists approved using chlorhexidine baths for infants >1,500 g for preoperative baths and for skin disinfectant in the operating room. One additional change occurred six months after the start of the protocol; the surgeons changed their method of skin closure, using an interrupted suture to close the skin in the operating room. No changes were made to the protocol after the first year.

Children admitted for cardiac surgery were admitted on the day of surgery to either a pediatric outpatient unit or to an inpatient step-down cardiac unit that cares for preoperative and postoperative cardiac patients. Postoperatively, all patients who underwent cardiac surgery were admitted to a surgical pediatric intensive care unit (PICU) and followed by a cardiac surgery intensive care team including a pediatric intensivist and acute care nurse practitioner. Surveillance for this project was the responsibility of the nurse practitioner in the PICU and the nurse practitioner on the cardiac surgery team who followed the patients after they left the ICU and for all their postoperative outpatient visits. If infections occurred within one year of surgery, whether the patient was readmitted or not, the infection was reported by the surgery team. When the surgical team was notified of a patient admitted to a different hospital or clinic with a SWI, it was reported.

Children with delayed sternal closure (DSC) were included in our surveillance program. The decision to leave a child's sternum open is made by the surgeons in the operating room based on a variety of factors including hemodynamic stability and edema. The DSC was not routinely used for any specific diagnosis.

Statistical Analysis

The Fisher exact test was used to assess the univariate association between categorical variables and the outcome variable of SWI. The association between continuous numerical variables and the outcome was evaluated with *t* tests for independent groups and the Mann Whitney *U* test, as appropriate to

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Table 1. The SWI Prevention Protocol Interventions

Timing	Intervention	References	Notes
Preoperative	1. Nares screened for methacillin resistant *Staphylococcus aureus.*	[a]	CHG to be used on children >1,500 g with no evidence of allergy. Wipe skin for 30 seconds and allow to dry for 30 seconds before dressing in clean gown.
	2. Soap and water bath, night before surgery.	[a]	
	3. Two preoperative baths with 2% chlorhexidine gluconate (CHG) wipes with emphasis on anterior thorax. On night before surgery after soap and water bath and on the morning of surgery. Place child in clean hospital gown after first CHG bath.	[7]	
	4. Place disposable telemetry leads on chest after first CHG bath.	[8]	
Intraoperative	1. Timing of preoperative antibiotics. Cefuroxime given 60 minutes prior to skin incision. Vancomycin started between 60 and 120 minutes prior to skin incision.	[9]	
	2. CHG used for skin preparation for children >1,500 g.	[a]	
Postoperative	Sternum closed		
	1. Hand washing for all persons entering and exiting patient room.	[7]	
	2. Stethoscopes to be cleaned with unit stocked disinfectant wipes prior to use.	[a]	
	3. Avoid draping telemetry leads or other equipment across sternotomy.	[a]	
	4. Postoperative antibiotics discontinued within 48 hours of surgery.	[10,11]	
	5. Sterile dressing applied in surgery and removed by surgery team within 48 hours of surgery.	[7]	
	6. Chest tube drain sites covered with occlusive dressing and changed if wet, soiled or loose.	[a]	
	7. Electrocardiograph technicians clean 12-lead cables with disinfectant wipes prior to being placed on bed.	[a]	
	8. Sterile gel used by technician or cardiologist for postoperative echocardiography.	[a]	
	Sternum open—additional interventions	[a]	
	1. An individual stethoscope for exclusive use on that patient will be placed in room.	[a]	
	2. Daily CHG baths for children >1,500 g	[a]	
	3. Sign placed on door of patient's room to declare "sternal wound infection precautions."	[a]	
	4. During sternal closure procedure, the doors of the patient's room remain to be closed with minimal traffic in and out of room.	[7]	
	5. All staff in room during closure will wear a mask and cap. Surgical personnel wear sterile gowns, gloves, caps, and masks.		

[a] Decision to use based on consensus of committee.

the particular data. A logistic regression of the outcome variable was done looking for independent associations with the risk variables and patient characteristics. A final logistic model including all variables with associations approaching significance ($P < .1$) was used to evaluate the independent variable associated with the development of a wound infection.

Results

A total of 308 children under the age of 18 years underwent sternotomy for cardiac surgery over a two-year period at the study hospital. The patient characteristics, demographics, incidence, and depth of infections are presented in Table 3. Nineteen (6%) children developed a SWI during the study period. Univariate analysis indicated a trend toward decreased SWIs for all children during the second year (odds ratio [OR] = 0.35, confidence interval [CI] 95% 0.12-1.01, $P = .059$). Fifty (16%) children had DSC; of those, 9 (18%) developed a SWI. Children with DSC were more likely to develop an infection (OR = 5.4, CI 95% 2.09-14.21, $P = .001$). Although there was a decrease in SWI in the children who had DSC in the second year of protocol use, the difference was not significant (first year 7 [14%], second year 2 [4%], $P = .14$). The days between infections lengthened during the second year of protocol use

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Table 2. Centers for Disease Control Definitions of SSI[a]

Superficial incisional SSI	Infection occurs within 30 days after operative procedure and involves only skin and subcutaneous tissue of the incision and patient has at least one of the following: a. Purulent drainage. b. Organisms isolated from an aseptically obtained culture of fluid or tissue. c. At least one of the following: pain or tenderness, localized swelling, redness or heat and superficial incision is deliberately opened by surgeon and is culture positive or not cultured. d. Diagnosis of superficial incisional SSI by the surgeon or attending physician.
Deep incisional SSI	Infection occurs within 30 days after operative procedure if no implant or within one year if implant left in place and involves deep soft tissue of the incision and patient has at least one of the following: a. Purulent drainage from the deep incision not from organ/space component. b. Incision spontaneously dehisces or is deliberately opened by a surgeon and is culture positive or not cultured and patient has at least one of the following: fever or localized pain or tenderness. c. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation or by histopathologic or radiologic examination. d. Diagnosis of a deep incisional SSI by a surgeon or attending physician.
Organ/space SSI	Infection occurs within 30 days after the operative procedure if no implant is left in place or within one year if implant is left in place and infection involves any part of the body, excluding skin incision, fascia, or muscle layers that is opened or manipulated during the operative procedure and the patient has at least one of the following: a. Purulent drainage from a drain that is placed through a stab wound into the organ/space. b. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space. c. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation or by histologic or radiographic examination. d. Diagnosis of an organ/space SSI by a surgeon or attending physician

Abbreviation: SSI, surgical site infection.
[a] http://www.cdc.gov/nhsn/dpfs/pscManual/9pscSSIcurrent.pdf.

(Figure 1). There were significantly more pacing wires placed in the second year of the protocol (first year 59 [37%], second year 82 [55%], $P = .001$); however, the presence of pacing wires was not associated with SWI ($P = .48$). The same was true for glucose levels which were lower in the second year of the protocol (mean glucose during first year 141 mg/dL, second year 128 mg/dL, $P = .015$), but high glucose levels were not associated with risk of infections ($P = .13$). Age, weight, gender, genetic/chromosomal abnormalities, and risk adjusted for congenital heart surgery (RACHS) scores were not significantly different between the first and second year and were not found to be significantly associated with the development of SWI.[13]

Multivariate logistic regression analysis was conducted looking at a number of covariates potentially associated with the development of SWI. Age, gender, weight, genetic/chromosomal abnormalities, RACHS category, glucose levels on postoperative day one, and presence of pacing wires did not predict those children who developed infections. A final logistic regression model looking at the two covariates that approached significance, DSC and Year two versus Year one, found the only factor which was a significant predictor of SWI was DSC (Table 4).

Compliance with vancomycin administration timing was met 17% of the time. Compliance with cefuroxime administration timing was 80%. Neither vancomycin nor cefuroxime timing noncompliance was associated with increased SWI ($P = 1.42$). Postoperative antibiotics for patients with closed sternums were discontinued within 24 hours in 100% of patients. Those children who had DSC were continued on antibiotics until 72 hours after sternal closure, this practice of the surgical team was followed in the 50 patients returned to the PICU with open sternums.

Compliance on other elements of the bundled protocol included adherence with preoperative chlorhexidine baths (first year 85% and second year 95%). Compliance with protocol regarding the presence of disinfectant wipes in patient rooms and placement of door signs for patients with open sternums were met >90% of the time both years.

Comment

Sternal wound infection is a costly complication of cardiac surgery in children and no national guidelines exist to help programs reduce the infection rate. In a commentary, Foster and Sabella comment, "the expectation that adult criteria and practices can be used to define, track and eliminate health care associated infections in children is problematic."[14] An assumption that pediatric cardiac surgery programs are following adult guidelines appears to be false.[4] A protocol, utilizing performance measures proven to prevent SWI in children, has not been published. As no national guidelines exist, this project sought to reduce the infections using a protocol, developed using evidence based and best practices.

This multidisciplinary, hospital wide quality improvement project demonstrated a trend toward a reduced infection rate in children utilizing a protocolized approach. The protocol was developed using consensus, evidence based, and best practices from adult and pediatric literature including elements of the SCIP. The quality measures in SCIP include the following: preoperative antibiotic timing, antibiotic selection, discontinuation of antibiotics within 24 hours of surgery, glucose control, hair removal, and normothermia in colorectal surgery. Only the first three elements were prospectively followed for

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Table 3. Patient Demographics and Characteristics by Year of SWI Prevention Protocol Use

Patient Demographics, Characteristics	All Patients (n = 308)	Year One (n = 160)	Year Two (n = 148)	*P* Value
Age in months, median (range)	7.5 (0.1-212)	6.7 (0.1-197)	7.6 (0.2-212)	.43
Weight in kg, median (range)	6.6 (1.8-70)	6.3 (2.3-70)	7.0 (1.8-69.2)	.42
Male, n (%)	189 (61%)	95 (59)	94 (63)	.56
RACHS, mean (standard deviation)	2.6	2.61 (1.07)	2.59 (1.14)	.71
Pacer wires, n (%)	141 (45)	59 (37)	82 (55)	.001
Glucose on POD #1 mg/dL, mean (standard deviation)	135	141 (48.2)	128 (36.7)	.015
Genetic/chromosomal abnormalities, n (%)	46 (14.9)	25 (15.6)	21 (14.2)	.75
DSC, n (%)	50 (16)	26 (16)	24 (16)	1
SWI, n (%)	19 (6)	14 (8.8)	5 (3.4)	.059
Superficial, n (%)	8 (2.5)	7 (4.4)	1 (0.67)	
Deep, n (%)	8 (2.5)	6 (3.8)	2 (1.4)	
Organ space/mediastinitis	3 (0.97)	1 (0.6)	2 (1.4)	
DSC and SWI, n (%)	9 (3%)	7 (4%)	2 (1%)	.14

Abbreviations: DSC, delayed sternal closure; RACHS, risk adjustment for congenital heart surgery; POD, post operative day; SWI, sternal wound infection.

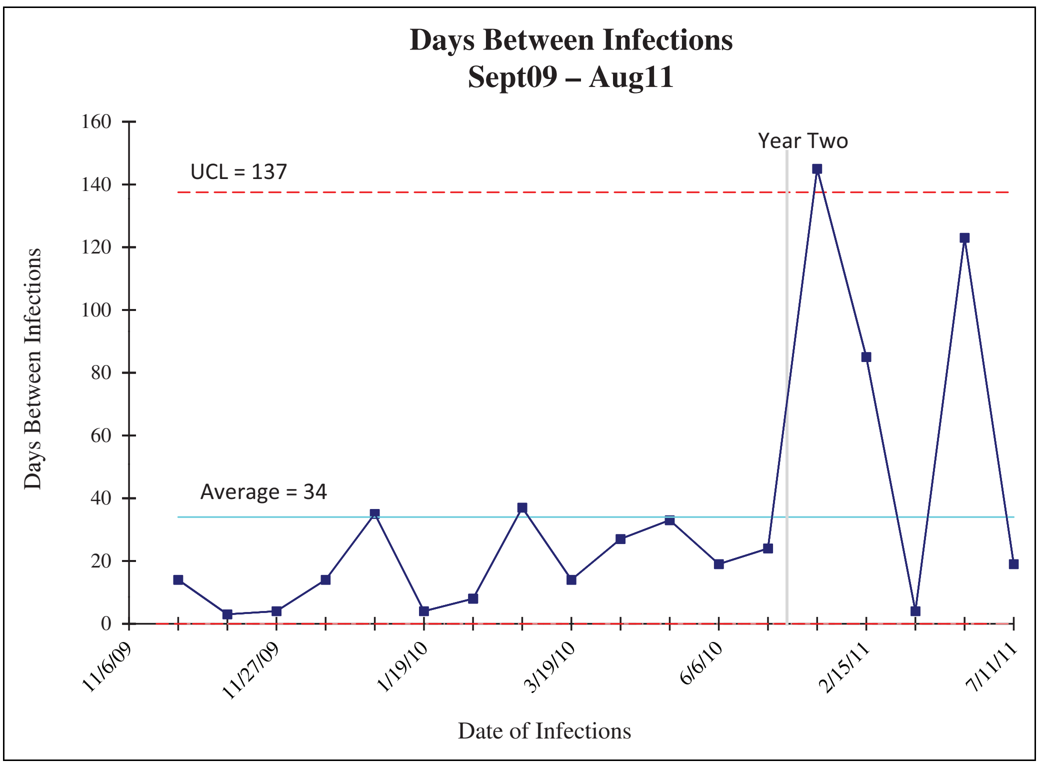

Figure 1. Days between infections.

compliance on patients in this project. Glucose levels on postoperative day one were monitored to ascertain whether hyperglycemia was associated with SWI, but this project did not include a protocol to treat postoperative hyperglycemia which was at the discretion of the pediatric intensivist.

Antibiotic timing presented a compliance issue. The goal was to have the antibiotic tissue levels in adequate concentration prior to cutting skin.[15] Current guidelines from the Society of Thoracic Surgeons recommend that cephalosporin should be given 60 minutes before skin incision and vancomycin, if given, should be completed within 1 hour of incision.[9] Patients who underwent pediatric cardiac surgery at the study hospital receive single doses of vancomycin and cefuroxime prior to the start of surgery. The timing of the antibiotics and start time of the procedure were prospectively monitored and reported at quarterly multidisciplinary meetings of the congenital heart surgery team which included the pediatric anesthesiologists responsible for compliance of this element of the protocol. Reasons for not meeting the goal included the issue of difficult line placement delaying start times of the cases. Other programs have reported similar compliance issues with antibiotic timing in children undergoing other types of surgeries.[16] When

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Table 4. Logistic Regression of Occurrence of Sternal Wound Infection Adjusted for Covariates That Were Significant or Approached Significance

Variable	Significance (*P*)	Estimated OR	95% Confidence Interval
Delayed sternal closure	<.001	5.631	2.128-14.898
Year 2/year 1	.053	0.348	0.119-1.014

Abbreviation: OR, odds ratio.

surveyed about the practice of administering preoperative antibiotics 1 hour prior to surgery start time, 97% of pediatric cardiac surgery programs related that they complied with this SCIP measure.[4] When that measure was followed prospectively for this project it was surprisingly clear that compliance was an issue. The SWI rate did decrease despite noncompliance with timing of antibiotics but could this program have further reduced the infection rate if this performance measure had been met?

Utilizing SCIP performance measures as the sole method to reduce infections has been shown in adults not to equate to lower SSIs. In a recently published study, Hawn et al, found no improvement in SSI rates in adults at Veteran's Administration Hospitals despite adherence to the SCIP measures.[17] The infection rate was improved for this study despite difficulty in administering preoperative antibiotics as delineated in the SCIP. It is not known whether pediatric programs are following SCIP guidelines or whether adherence would decrease infections in children, but it seems more rigorous guidelines and protocols need to be in place to prevent SWI in children.

Whether DSC presents an increased infection risk for all children undergoing cardiac surgery is difficult to ascertain because recent studies of risk factors for SSI in pediatric cardiac surgery did not report the incidence of DSC for patients who developed a SWI or only reported on patients who developed mediastinitis.[18,19] A retrospective study by Al-Sehly et al reported DSC was not associated with pediatric poststernotomy mediastinitis.[20] Our prospective study found children returning from the operating room with an open sternum were more likely to develop an infection. Infections in patients with DSC decreased from the first to second year of the protocol, but there was not enough power to determine whether use of the protocol significantly contributed to the decrease in infections in this subset of patients. Recently, some states have begun mandatory reporting of SSIs to the National Healthcare and Safety Network (NHSN) database. Children who develop a SWI after DSC are not reported to NHSN as the skin edges are not closed prior to leaving the operating room.[21] The children with DSC in this project were significantly more likely to develop a SWI but comparisons to other programs will be difficult using NHSN data as pediatric cardiac programs are not required to report infections on children with DSC.

Quality improvement projects using a hospital-wide collaborative approach have been successful in reducing catheter-associated bloodstream infections. Wheeler et al initiated a hospital-wide protocol for insertion and maintenance of central lines including close monitoring for compliance and the infection rate decreased from 3.0 to 1.0 catheter-associated bloodstream infections per 1,000 line days.[22] An obvious problem with initiating a protocol in a quality improvement project is that when improvement is noted and compliance has been assured, it is difficult to ascertain which part of the protocol made the infection rate decrease. For this project was it the chlorhexidine baths, the disposable electrodes, the sterile gel, or just the increased scrutiny? A multicenter research study using a successful model such as the NACHRI project should be developed and more focused study of the different components of the protocol can be accomplished.

This article reports on a quality improvement project at a single children's hospital. As such, it is limited in its ability to generalize findings to all children undergoing sternotomy. Despite close scrutiny, there may have been other unrecognized changes in the way children were cared for during their hospital stays that influenced the infection rate. Although this project did not find an association between young age or surgical complexity and SWI, there are other variables (central line days, preoperative intubation, total parenteral nutrition use, and duration of chest tube placement) that may have impacted the infection rate. Assuring that all patients who developed SWIs were counted was another limitation. It is possible for patients who developed a SWI were treated by a different hospital or surgical team without notifying this surgery team which would have falsely decreased our infection rate.

The benefit of conducting this as a quality improvement project was the flexibility to change the protocol when necessary, but the lack of randomization and consistency limited our analysis. In the absence of a control group and with varying degrees of compliance over the time period, no direct relationship between the quality improvement initiative and the decreased rates of SWIs can be reported. This limitation, while decreasing the power of the study, highlights the difficulty encountered in single institution quality improvement initiatives to prevent relatively rare events. There is a lack of nationally recognized guidelines for SWI prevention in children. This project introduces a methodology, utilized in other hospital acquired infections, which may narrow the knowledge gap and encourage cooperation between congenital heart surgery programs.

In our study, institution of a protocolized approach to SWI in children undergoing cardiac surgery was associated with decreased overall infection rates and increased days between infections, although the decrease in the rate of infection was not statistically significant. The patients most at risk of infection were those with DSC after cardiac surgery and the rate of infection in this subset of patients improved during the second year of prospective surveillance using evidence and best practices beyond those recommended by the SCIP. It remains unknown which specific variables contributed to the decreased infection rate. A national multicenter quality improvement project to reduce SWI should be instituted using a protocolized approach with an emphasis on children with DSC, as these children seem to be the most vulnerable to infection.

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References

1. Sparling KW, Ryckman FC, Schoettker PJ, et al. Financial impact of failing to prevent surgical site infections. *Qual Manag Health Care*. 2007;16(3): 219-225.
2. Fry DE. Surgical site infections and the surgical care improvement project (SCIP): evolution of national quality measures. *Surg Infect (Larchmt)*. 2008;9(6): 579-584.
3. Barker GM, O'Brien SM, Welke KF, et al. Major infection after pediatric cardiac surgery: a risk estimation model. *Ann Thorac Surg*. 2010;89(3): 843-850.
4. Woodward CS, Son M, Calhoon J, Michalek J, Husain SA. Sternal wound infections in pediatric congenital cardiac surgery: a survey of incidence and preventative practice. *Ann Thorac Surg*. 2011;91(3): 799-804.
5. Miller MR, Niedner MF, Huskins WC, et al. Reducing PICU central line-associated bloodstream infections: 3-year results. *Pediatrics*. 2010;125(5): e1077-e1083.
6. Haycock C, Laser C, Keuth J, et al. Implementing evidence-based practice findings to decrease postoperative sternal wound infections following open heart surgery. *J Cardiovasc Nurs*. 2005; 20(5): 299-305.
7. Alexander JW, Solomkin JS, Edwards MJ. Updated recommendations for control of surgical site infections. *Ann Surg*. 2011; 253(6): 1082-1093.
8. Bush LM, Disposable items help prevent healthcare-acquired infections. *Infection Control Today*. 2005. www.infectioncontroltoday.com/articles/2005/03/disposable-items-help-prevent-healthcare-acquired.aspx. Accessed March 3, 2012.
9. Engelman R, Shahian D, Sheman R, et al. The society of Thoracic Surgeons practice guideline series: Antibiotic prophylaxis in cardiac surgery, Part II: Antibiotic choice. *Ann Thorac Surg*. 2007;83(4): 1569-1576.
10. Anderson DJ, Kaye KS, Classen D, et al. Strategies to prevent surgical site infections in acute care hospitals. *Infect Control Hosp Epidemiol*. 2008;19(suppl 1): S51-S61.
11. Edwards FH, Engelman RM, Houck P, Shahian DM, Bridges CR. The society of thoracic surgeons practice guideline series: antibiotic prophylaxis in cardiac surgery, Part I: duration. *Ann Thorac Surg*. 2006;81(1): 397-404.
12. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol*. 1999;20(4): 247-278.
13. Jenkins K, Gauvreau K, Newburger JW, Spray TL, Moller JH, Lezzoni LI. Consensus-based method for risk adjustment for surgery for congenital heart disease. *J Thorac Cardiovasc Surg*. 2002;123(1): 110-118.
14. Foster CB, Sabella C. Health care-associated infections in children. *JAMA*. 2011;305(14): 1480-1481.
15. Bucher BT, Warner BW, Dillon PA. Antibiotic prophylaxis and the prevention of surgical site infection. *Curr Opin Pediatr*. 2011;23(3): 334-338.
16. Bucher T, Guth RM, Elward AM, et al. Risk factors and outcomes of surgical site infection in children. *J Am Coll Surg*. 2011;212(6): 1033-1038.
17. Hawn MT, Vick CC, Richman J, et al. Surgical site infection prevention: time to move beyond the surgical care improvement program. *Ann Surg*. 2011;254(3): 494-501.
18. 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.
19. Tortoriello TA, Friedman JD, McKenzie ED, et al. Mediastinitis after pediatric cardiac surgery: a 15-year experience at a single institution. *Ann Thorac Surg*. 2003;76(5): 1655-1660.
20. Al-Sehly AA, Robinson JL, Lee BE, et al. Pediatric poststernotomy mediastinits. *Ann Thorac Surg*. 2005;80(6): 2314-2320.
21. National Healthcare Safety Network Patient Safety Component Manual. Center for Disease Control website. http://www.cdc.gov/nhsn/PDFs/pscManual/9pscSSIcurrent.pdf. Accessed March 3, 2012.
22. Wheeler DS, Giaccone MJ, Hutchinson N, et al. A hospital-wide quality-improvement collaborative to reduce catheter-associated bloodstream infections. *Pediatrics*. 2011;128(4): 995-1004.

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