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Risk factors and management of Nuss bar infections in 1717 patients over 25 years☆

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ABSTRACT

Purpose: An increase in postoperative infections after Nuss procedures led us to seek risks and review management. We report potential risk factors and make inferences for prevention of infections.
Methods: An IRB-approved retrospective chart review was used to evaluate demographic, clinical, surgical, and postoperative variables of patients operated on between 10/1/2005 and 6/30/2013. Those with postoperative infection were evaluated for infection characteristics, management, and outcomes with univariate analyses.
Results: Over this 8-year period (2005–2013), 3.5% (30) of 854 patients developed cellulitis or infection, significantly more than 1.5% (13) in our previous report of 863 patients, 1987–2005 ($p = .007$). The most frequent organism cultured was methicillin-sensitive *Staphylococcus aureus*. Patients who were given clindamycin preoperatively (5 of 26 patients) had higher infection rates than those who received cefazolin (25 of 828) (19% vs 3%, $p < .001$). Patients treated with a peri-incisional ON-Q (I-Flow, Kimberly-Clark, Irvine, CA) also had higher infection rates (8.3% vs 2.4%, $p < .001$). Of the 30 patients who developed an infection, eighteen (60%) with cellulitis or superficial infections did not require surgical treatment or early bar removal. The other twelve patients (40%) with deep hardware infections required an average of 2.2 operations (range 1–6), with 3 (25%) requiring removal of their stabilizer and 3 (25%) requiring early bar removal. None of these three patients experienced recurrence of pectus excavatum at 2 to 4 years of follow-up.
Conclusion: Preoperative antibiotic selection and use of ON-Q's may influence infection rates after Nuss repair. Nuss bars could be preserved in 90% of all patients with an infection and even 75% of those with a deep hardware infection. Attempts to retain the bar when an infection occurs may help prevent pectus excavatum recurrence.
Level of Evidence = III.

1. Background/Purpose

Pectus excavatum (PE) is the most common chest wall deformity and has an incidence of 1 in 400 births (0.25%). Minimally invasive repair of pectus excavatum (MIRPE) was initially reported in 1998 by Nuss et al. [1–3] and has become the most common method of surgical treatment. This procedure has undergone several modifications over the last two decades, but all patients ultimately require placement of a substernal metal bar to elevate the sternum as originally described. Infectious complications after any surgical procedure are problematic, but they are particularly vexing when they occur after orthopedic hardware is implanted. Furthermore, hardware removal often significantly compromises the outcome of the intended treatment outcome. The accepted rate of infection in surgical cases with a clean wound class is reported to be 1%–5% while more recent reports demonstrate an incidence of 2.6% [4]. The specific infection rate in the literature after the Nuss procedure is reported to be 1.5%–6.9% [5]. A perceived increase in postoperative infections after the Nuss procedure at our institution led us to evaluate our actual rate of infection and seek potential risk factors. In recent literature, preservation of infected orthopedic hardware has been successful in 68% of these cases [6]. The success rate of Nuss bar preservation after a deep bar infection is difficult to extract from other reports. The literature has wide variations in bar preservation rates ranging from 25% to 80% [5,7–9] (Table 1). Inquiries from other surgeons about bar infections over the years led us to review our management and to attempt to provide guidance in these difficult cases.

☆ Authors' role: Obermeyer, Godbout, Goretsky, Frantz, Kuhn, Lombardo, Kelly — chart review and acquisition of data for analysis; Obermeyer, Goretsky, Paulson, Lombardo, Buescher, Kelly — drafting and revising manuscript; Obermeyer, Goretsky, Frantz, Kuhn, Lombardo, Kelly — provided and cared for study patients; Paulson — statistical analysis.

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Table 1
Bar preservation after deep bar infection.

Author	Year	Preserved
Calkins	2005	80%
Van Renterghem	2005	50%
Shin	2007	50%
Tanaka	2012	25%
Obermeyer	2014	75%

2. Methods

An IRB approved protocol (IRB #14-03-WC-0034) was obtained to perform a retrospective chart review on patients who underwent minimally invasive repair of PE and subsequently developed an infection between 10/1/2005 and 6/30/2013. The chart review included evaluation of demographic, clinical, surgical and postoperative variables of patients. We defined an infection as being any case treated with antibiotics for cellulitis, superficial infection with active drainage, or deep infection involving hardware, regardless of the time of presentation. We also report our postoperative infection rate as defined by the CDC (Centers for Disease Control and Prevention) National Healthcare Safety Network (NHSN), which only includes infections with active drainage or hardware involvement that occur within 90 days of surgical orthopedic hardware placement. Descriptive statistics, frequencies, Fisher's Exact test, chi-square analysis, logistic regression, and general linear models were used to evaluate risk factors, infection characteristics, management, and outcomes among patients who developed postoperative infections. All analyses were conducted using SPSS version 19 statistical software. Finally, the type of infections and bar preservation rate after 1717 primary and redo Nuss repairs for pectus excavatum in 854 patients over our recent experience (10/2005–6/2013) was compared to our initial report of 863 patients over eighteen years (1/1987-–/2005).

3. Results

3.1. Incidence

In over 25 years, we have experienced an overall infection rate of 2.5% (43 of 1717 patients), but in the last 8 years (2005–2013), the infection rate increased to 3.5% (30 of 854 patients). This rate is significantly higher than the 1.5% (13 of 863 patients) rate observed in our previous report from 1987 to 2005 ($\chi^2(5.96) = 2.15$, $p = .007$). The infection characteristics were the similar between the two different time periods. Both the initial and recent time period demonstrated a higher percentage of deep bar infections (Table 2). When using the CDC NHSH definition of a postoperative infection, our infection rate was 2% (17 out of 854) in the last 8 years, which is below reported rates of infection for clean cases in over 600,000 cases reviewed by Ortega et al. [4] using the ACS-NSQIP database. Using this same definition the infection rate in our initial report was 0.7% (6 out of 863) and our overall incidence over 25 years is 1.3% (23 out of 1717).

3.2. Potential risk factors

In the recent time period, patients who were given clindamycin preoperatively (5 of 26 patients) had higher infection rates than those who received cefazolin (25 of 828) (19% vs 3%, ($\chi^2(1) = 15.12$, $p < .001$). A total of 156 patients were treated with a peri-incisional ON-Q (I-Flow, Kimberly-Clark, Irvine, CA) at our facility. Thirteen of those patients (8.3%) developed an infection which is significantly higher than the infection rate observed in patients who did not receive an ON-Q (2.4%); ($\chi^2(1) = 10.37$, $p < .001$). Multivariate analysis was not performed but only two patients got both clindamycin preoperatively and an ON-Q postoperatively. After January 1, 2010, our protocol regarding duration of postoperative antibiotics changed from 72 h or more to 48 h or less. Patients who received ≥72 h of postoperative antibiotics had a lower infection rate (11 of 404) than patients with ≤48 h (19 of 450) but this was not statistically different (2.7% vs 4.2%, χ^2 (1) = 0.925, $p = .34$). There was one case of *Clostridium difficile* diarrhea in a patient who received 24 h of antibiotics. Recently (May 2012), in an effort to lower our infection rate we began using Sage applicator cloths (2% chlorhexidine gluconate, Sage Products, Cary, IL) as part of our patient's preoperative preparation. We currently instruct the patients to use the cloths the day before surgery and immediately before going back to the operating suite. Since initiating this, our rate of infection decreased to 2.1% (3 of 144) compared to 3.8% (27 of 710). Although this addition indicates a promising trend, it is not statistically significant ($\chi^2(1) = 2.15$, $p = .143$). To date, our infection rate with the use of chlorhexidine/alcohol skin antiseptic (ChloraPrep, chlorhexidine gluconate (CHG) 2% w/v and isopropyl alcohol (IPA) 70% v/v, CareFusion, San Diego, CA) is 1.6% (1 of 63) while the infection rate with betadine is 3.7% (29 of 791). This variable also did not reach statistical significance (Fisher's Exact = 0.718) and the low number of patients in the CHG group makes the analysis suboptimal (Table 3). Of note, the only patient that developed a wound infection after both preoperative skin preparation with CHG cloths and intraoperative CHG/IPA skin preparation also received IV clindamycin as their antibiotic prophylaxis.

3.3. Patient characteristics

All patients with an infection presented a median of 33.5 days (range: 8–595 days) after the initial operation. Presenting characteristics included erythema (73%), drainage (70%), swelling (43%), pain (43%), and fever (33%). All patients were male with an average age of 16.7 years. Two bars were placed in 16 (53%) of these patients and two (6.7%) required titanium hardware.

3.4. Cellulitis/superficial wound infections

Eighteen patients developed infections we classified as either cellulitis or superficial open wounds. These patients presented at a median of 34 days but ranged from 8 to 595 days after surgery. All bars were preserved with antibiotic treatment and conservative wound management. Intravenous (IV) antibiotics were used in 10 of the 18 patients (55.6%) for an average of 15.5 days (2–60 days) with the most common antibiotic being clindamycin followed by cefazolin. A peripherally inserted central catheter (PICC) line was used in 28% ($n = 5$) of these cases. All patients were treated with oral antibiotics for a variable amount of time ranging from 10 days to over a year. The most common oral antibiotics used included cephalexin, clindamycin, and sulfamethoxazole/trimethoprim (SMZ–TMP). Some patients were treated at outside facilities so we were unable to capture all antibiotic regimens. None of these patients required drainage in the operating room. Wound cultures were not done in all of these patients because some had no drainage to culture. Positive culture results were documented in only three

Table 2
Infection characteristics.

Time period	Total repairs	Total infections	Cellulitis	Superficial infection	Deep infection
18 years (1/1987–9/2005)	863	13 (1.5%)	4 (31%)	3 (23%)	6 (46%)
8 years (10/2005–6/2013)	854	30 (3.5%)	8 (27%)	10 (33%)	12 (40%)
Totals	1717	43 (2.5%)	12 (28%)	13 (30%)	18 (42%)