



Management of postoperative infections after the minimally invasive pectus excavatum repair

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Abstract

Purpose: Pectus excavatum is frequently repaired using the minimally invasive placement of a substernal bar (Nuss procedure). Infectious complications after the Nuss procedure are potentially devastating. To date, the management of postoperative infectious complications has not been well described.

Methods: A retrospective review of all patients (N = 168) who underwent the Nuss procedure from January 1, 1997, to October 1, 2003, at our institution was performed. Six patients (4%) had postoperative infections, and their medical records were reviewed.

Results: Of the 6 patients, 5 underwent operative drainage for wound abscesses that developed 2 to 76 weeks postoperatively. The other patient developed cellulitis 12 months postoperatively and was treated effectively with antibiotics alone. Recurrent infections were treated in 3 of 6 patients, one of whom eventually required removal of the bar resulting in a mild, residual pectus excavatum defect. One of 6 patients has had the substernal bar removed electively. The remaining 4 continue to be without clinically apparent infection at this time and are over 1 year removed from their infection.

Conclusions: Although uncommon, infectious complications after the Nuss procedure require complex management strategies. Despite recurrent infection in some cases, most infectious complications occurring after the minimally invasive repair can be effectively treated without having to remove the substernal bar.

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Pectus excavatum is the most common chest wall deformity in children. Since the initial description by Ravitch [1], repair of pectus excavatum has traditionally

involved subperichondrial resection of abnormal costal cartilages with anterior displacement of the sternum to a normal position. In 1998, Nuss et al [2] reported an alternative, minimally invasive technique for repair of this anomaly. The initial description of the repair used 2 small incisions in the lateral chest wall for placement of an appropriately shaped convex metal bar that is secured inside the anterior hemicircumference of the chest. The technique has rapidly gained acceptance and is our preferred approach for the repair of pectus excavatum in children and adolescents. As with implantation of any prosthesis,

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infectious complications often mandate removal of the hardware. Unfortunately, premature removal of the pectus bar may lead to recurrence of the defect. To date, no consensus exists with regard to the optimal management of infectious complications that occur after the minimally invasive placement of the pectus bar. With one of the larger single-center experiences to date, we conducted this clinical review to evaluate the incidence of pectus bar infection and explore management strategies to prevent pectus bar infection and avoid bar removal should infection occur.

1. Methods

After obtaining institutional review board (IRB) approval (IRB Exempt #02 01-04X), the charts of all patients who underwent the minimally invasive pectus repair (MIPR) at Children's Mercy Hospital between January 1, 1997, and October 1, 2003, (N = 168) were reviewed retrospectively. Six patients had postoperative infections and their medical records were extensively reviewed. The management of each infection was investigated, including whether or not the bar was removed to clear the infection. Patient selection for corrective repair is based on history, physical examination, and computed tomography. The deformity classification is based on assessment of computed tomography with a ratio of transverse diameter to anteroposterior diameter (distance between posterior sternum and anterior vertebral body) greater than 3.25 defining a severe deformity.

The minimally invasive repair requires small (2 cm), bilateral, midaxillary transverse incisions, subcutaneous tunneling, and intrathoracic placement of a substernal

convex stainless steel bar (Walter Lorenz Co, Jackson, FL). The bar is bent to conform to the patient's anterior chest wall. Lateral stabilizer bars have been used routinely since September 1999. Also, since the autumn of 1999, the routine modification of a vertical subxiphoid anterior chest wall incision has been added to our repair technique. This modification involves the creation of a small subxiphoid pocket to ensure safe passage of the bar across the mediastinum. Two to 3 years after their initial MIPR procedure, patients are scheduled for removal of the bar.

2. Results

Of the 168 patients repaired during the study period, all successfully underwent MIPR. Six of the study cohort developed a postoperative infectious complication (4%). One (16%) of the 6 patients required premature removal of the substernal bar. The 6 patients and their respective outcomes are summarized in Table 1.

All patients received perioperative antibiotics. Of the 6 patients, 5 developed wound abscesses that came to medical attention anywhere from 2 weeks to 19 months postoperatively. The sixth patient developed cellulitis 12 months postoperatively and was treated effectively with antibiotics alone. When obtained, positive cultures grew methicillin-sensitive *Staphylococcus* species (*aureus* or *epidermidis*). Two of 6 patients demonstrated no evidence of nickel allergy by skin testing. Recurrent infections were treated in 3 of these 6 patients, one of which required removal of the substernal bar 1 year after the initial placement resulting in a mild, residual pectus excavatum defect. One of these 6 patients has

Table 1 Summary of patients sustaining infectious complications after minimally invasive placement of pectus bar

Patient age (y)/sex	No. of bars placed	Complication	Postoperative duration to infection	Treatment	Outcome
14/female	1	Unilateral abscess	2 wk	I&D, removal single stabilizer, IV antibiotics, postoperative antibiotic suppression	Bar retained
5/male	1	Unilateral abscess	18 mo	I&D, removal single stabilizer, IV antibiotics	Bar retained, removed electively
10/male	1	Bilateral abscesses (metachrynous)	3 wk/3 mo	I&D, removal bilateral stabilizer, IV antibiotics, postoperative antibiotic suppression	Bar retained
13/male	1	Unilateral abscess	3.5 mo	I&D, wound care, IV antibiotics, postoperative antibiotic suppression	Bar retained
14/male	2	Bilateral abscesses (synchronous)	4 mo	I&D, wound care, IV antibiotics, postoperative antibiotic suppression	Bar 1 removed 9 mo postoperatively, bar 2 removed 12 mo postoperatively
16/male	1	Unilateral cellulitis	12 mo	IV antibiotics	Bar retained

Demographics and outcomes of 6 patients who developed postoperative infection after the minimally invasive placement of a substernal bar for pectus excavatum. I&D indicates incision and drainage.

had the substernal bar removed electively 2 years after initial placement (there was no evidence of infection present). The remaining 4 patients demonstrate no clinically apparent infection at this time. All of these 4 patients are now over 1 year removed from their infection.

Patients who developed wound abscesses were admitted to the hospital. The abscess was drained and intravenous (IV) antibiotics were begun. The lateral chest wall stabilizer was removed in cases where the infection occurred within the subcutaneous pocket. The soft tissue was reapproximated over the retained bar, but the skin was left open and treated with sulfamylon solution wet-to-dry dressing changes. No infections occurred underlying the subxiphoid incision. Initial choice of antibiotics varied; yet, either cefazolin, vancomycin, or ceftriaxone was chosen. Once the IV course was tailored to the cultured organism and completed (3 weeks to 3 months), oral antibiotic regimens were instituted and consisted of either cefadroxil or rifampin/clindamycin. Other than the individual who had isolated cellulitis and was treated successfully with 3-week IV antibiotic course, all patients received prolonged oral "suppressive antibiotics" for 6 to 12 months in an attempt to prevent recurrent infection. The single failure of this regimen occurred in a patient who had 2 bars placed at the time of surgery for a severe pectus excavatum defect. Abscesses developed overlying both stabilizers 4 months after the placement of the bars. Local wound care and IV and oral antibiotic regimens were initially successful, but chronic wound drainage ultimately necessitated removal of the inferior bar 9 months postoperatively. The second superior bar was removed 3 months later for persistent wound drainage.

3. Discussion

Since its introduction, the minimally invasive repair of pectus excavatum has become popular with patients because of perceived improved cosmetic results from a less invasive procedure and with surgeons because of reduced operating time. A 3-fold increase in patient presentation for pectus excavatum repair has been appreciated at our institution since the introduction of this new approach. The long-term outcomes and complications of this technique, however, are still being realized.

In this large retrospective review, we have scrutinized our management of postoperative infectious complications. Our infection rate compares favorably with that described in other large series in which infectious complications occur in anywhere from 2% to 5% of cases [3,4]. In a review of 329 cases of the minimally invasive repair reported by Nuss et al [5], wound infection occurred in 2.6% resulting in bar infection in 3 of the 7 patients. Long-term antibiotics were successful in curing the infection in 1 patient, whereas the other 2 required bar removal at 12 and 18 months [5]. Herein, we have described 6 patients who developed an infectious complication after minimally invasive placement

of a substernal bar. Five of 6 developed an abscess that was treated by drainage and long-term antibiotics. Intravenous antibiotics are initially begun using a first-generation cephalosporin or vancomycin at a weight appropriate dose. These should be continued for at least 14 days and discontinued when clinical signs of infection have abated. Based on our experience, we recommend oral suppressive antibiotic therapy in patients who have been successfully treated with wound drainage and IV antibiotic therapy. The optimal duration of suppressive therapy remains unclear, yet we have maintained the last 2 individuals on oral rifampin (300 mg bid) indefinitely (until bar removal).

Since the last infectious complication (August 2002), we have used additional measures in an attempt to reduce the incidence of wound infection. First, the operating surgeon and assistant use a double-gloving technique with Biogel indicator undergloves (Regent, Norcross, Ga) preceded by a strict 5-minute surgical scrub. Second, the chest is elevated off the operative table with a midline roll placed underlying the thoracic spine. Furthermore, sterile towels along the chest wall are secured with skin staples such that the sterile field is not violated when flipping the bar into position. Next, an iodine impregnated drape is placed before the start of the procedure. Before a 3-layer closure, the wounds are irrigated with antibiotic solution. Finally, perioperative antibiotics (IV cefazolin) are continued for 72 hours after the procedure. Since using these techniques, the sole infectious complication occurred in a patient who developed an abscess within a hematoma which occurred along the anterior portion of the bar after he was struck in this region by a baseball some 3 months after the procedure. In this case, the wound was opened along the right anterior chest wall overlying the subcutaneous portion of the bar lateral to the sternum. The abscess cavity was drained and local wound care used. Despite the exposed bar, the wound contracted over time and is now completely closed.

We routinely use placement of lateral stabilizer bars to prevent rotational or lateral displacement of the retrosternal bar. Since we instituted this practice, we have not needed to reoperate prematurely for bar slippage [6]. Therefore, we believe that the routine use of stabilizer bars is important. Recently, Watanabe et al [7] have suggested that the use of lateral stabilizers increases the incidence of wound complications. In our cohort of patients, all patients who developed wound complications did so after placement of bilateral stabilizers. We removed the stabilizer when an abscess cavity was present overlying the hardware, yet left the bar in place and treated the wound locally and continued IV antibiotic therapy in an attempt to salvage the bar. This strategy was successful in retaining the bar in all 3 patients in whom it was used. We argue that the small risk of wound infection is outweighed by the risk of bar migration or slippage [3].

Patients who develop erythema along the substernal bar are typically treated for cellulitis, yet hypersensitivity and nickel allergy may present in a similar manner. Saitoh et al

[8] have reported nickel allergy to the substernal bar; and this entity should be considered in patients who do not respond appropriately to antibiotic therapy or have persistent erythema in the skin overlying the bar without clinical evidence of infection.

We recommend a 5-minute surgical scrub, double gloving, modification of positioning and prep to ensure a sterile field, and perioperative antibiotics in an attempt to prevent infection from occurring. When a patient presents with signs and symptoms of a bar infection (fever, increasing pain along the bar, erythema along the bar, and drainage from one or more of the incision sites), hospital admission is recommended. If fluid overlying the bar or the stabilizers is suggested by physical exam findings, this is assessed by ultrasonography and drained percutaneously. Fluid is sent for Gram stain and culture, and the patient is started on parenteral antibiotics (cefazolin and clindamycin). Parenteral antibiotic therapy is then tailored to the cultured organism. Thereafter, treatment is guided based on the initial response to therapy. If clinical improvement is noted, we recommend placement of a peripherally inserted central venous catheter where the appropriate antibiotics can be administered at home. We have continued parenteral therapy in favorable cases for 3 to 6 weeks, after which oral antibiotics are continued for a prolonged duration. If the site overlying the bar breaks down or continued drainage is noted from a lateral incision, we recommend incision and drainage of the affected area. Local wound care with moist-to-dry dressing changes and administration of parenteral antibiotics continues until the wound has closed. If such therapy is unsuccessful (continued clinical deterioration or wound drainage), bar removal is unavoidable.

References

- [1] Ravitch M. The operative treatment of pectus excavatum. *Ann Surg* 1949;129:429-44.
- [2] Nuss D, Kelly Jr RE, Croitoru DP, et al. 10-year review of a minimally invasive technique for the correction of pectus excavatum. *J Pediatr Surg* 1998;33:545-52.
- [3] Hebra A, Swoveland B, Egbert M, et al. Outcome analysis of minimally invasive repair of pectus excavatum: review of 251 cases. *J Pediatr Surg* 2000;35:252-7 [discussion 257-258].
- [4] Hosie S, Sitkiewicz T, Petersen C, et al. Minimally invasive repair of pectus excavatum—the Nuss procedure. A European multicentre experience. *Eur J Pediatr Surg* 2002;12:235-8.
- [5] Nuss D, Croitoru DP, Kelly Jr RE, et al. Review and discussion of the complications of minimally invasive pectus excavatum repair. *Eur J Pediatr Surg* 2002;12:230-4.
- [6] Miller KA, Woods RK, Sharp RJ, et al. Minimally invasive repair of pectus excavatum: a single institution's experience. *Surgery* 2001;130:652-7 [discussion 657-659].
- [7] Watanabe A, Watanabe T, Obama T, et al. The use of a lateral stabilizer increases the incidence of wound trouble following the Nuss procedure. *Ann Thorac Surg* 2004;77:296-300.
- [8] Saitoh C, Yamada A, Kosaka K, et al. Allergy to pectus bar for funnel chest. *Plast Reconstr Surg* 2002;110:719-21.

Discussion

Darrell Cass, MD (Houston, TX): Is there something about the stabilizers that may predispose to infection? Were the stabilizers attached with a wire, and was the wire your source of irritation?

Casey M. Calkins, MD (Kansas City, MO): That's a good question, there's been a recent report by Dr Watanabe in the *JPS* about whether or not the lateral stabilizers predispose to infectious complications. We put stabilizers in on both sides and secure them with an Ethibond suture. We have done so because in our early experience with technique we had a lot of problems with the bar rotation. I think the most important thing for these preventative strategies is to try to attempt to salvage or prevent infection because, since employing them, we haven't had an infectious related complication.

Richard R. Ricketts, MD, FAAP (Atlanta, GA): Can you give us a little more detail about your antibiotic protocol, how long are they on IV antibiotics, how long in the hospital, how long on po antibiotics, and which ones you use?

Casey M. Calkins, MD (Kansas City, MO): All the patients were initially managed with intravenous antibiotics consisting of either cefazolin or ceftriaxone. In the patients that had culture material obtained at the time of incision and drainage, all of the organisms cultured were methicillin-sensitive *Staphylococcus aureus*. In our institution, ceftriaxone is an adequate agent to treat that infection. So in all of these cases patients were hospitalized for either 4 to 7 days, discharged home with a PICC line in place and antibiotics continued parenterally for anywhere from 14 to 21 days. Then, oral antibiotics were continued and our current strategy is to use rifampin and that's at the behest of our infectious disease colleagues who have suggested continuing that for at least 12 months to prevent bar removal.

Daniel Robie, MD, FAAP (Honolulu, HI): I think we really do need to emphasize the catastrophic nature of this complication. I have had some of these myself, not too many I hope, but I have had to remove the bars in two patients and that's very catastrophic for these patients. And so I actually talked to Dr Moriarty a couple of years ago about this very thing and I've instituted these recommendations especially the Ioban and the adherence to strict sterile technique. Because, if these do get infected, we must assume that contamination's occurring at the operation. So there are two principles: one adopted from our orthopedic colleagues, which is absolute strict sterile technique, and then the other one is good wound closure. This can be difficult to do since all you have is the skin and subcutaneous tissues to close over these bars.

Casey M. Calkins, MD (Kansas City, MO): You are absolutely correct, and we attempt to close the lateral

wounds in two layers but to get more than two layers is difficult.

Daniel Robie, MD, FAAP (Honolulu, HI): Can you comment on why you remove stabilizers but leave the bar?

Casey M. Calkins, MD (Kansas City, MO): That's a good question. In the patients that had the stabilizer removed, there was a persistent area of seroma and/or purulent

material that we felt would be most adequately treated with removal of the stabilizer itself. We managed to salvage the bar in all of those patients but that certainly was a possibility of having to remove it should continued drainage occur and that's what happened in the one patient that wasn't treated successfully with this strategy. The stabilizers were initially removed and thereafter the bar had to be removed when that therapy was not successful.