Experience with FiberWire for pectus bar attachment

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Background: Minimally invasive repair of pectus excavatum has become an established method for repair of pectus excavatum. Bar displacement or rotation remains the most common complication of this repair requiring return to the operating room.

Methods: Retrospective review of all patients at a single institution who underwent repair of pectus excavatum using FiberWire for bar stabilization between December 2009 and March 2013 was undertaken.

Results: 93 patients underwent minimally invasive pectus repair using FiberWire during the study period. The patients included 73 males and 20 females, with an average age of 14.6 years (range 7–21 years). Mean operative time was 102 minutes (range 56–198 minutes). No patients developed wound complications, two patients developed pain because of bar migration and required return to the OR, and no patients had recurrence of their pectus defect because of bar migration during the study period. Median length of follow-up was 17 months (range 3–36 months).

Conclusion: Stabilization of pectus bars using circumferential rib fixation with FiberWire at multiple points on both sides of the bar appears to be effective in preventing bar rotation and displacement, and requires minimal change to the operation as it has been previously described. Early experience shows a low rate of complications.

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1. Background

Since its introduction in 1998 by Nuss, minimally invasive repair of pectus excavatum (MIRPE) has become an established technique for repair of pectus excavatum (PE) [1]. Numerous modifications of the original technique have been reported in an attempt to decrease complications or improve outcomes. The most common complication resulting in surgical revision has been bar rotation or malposition [2]. Lateral stabilizers were introduced to decrease the complication of bar rotation and have been successful in reducing bar rotation at experienced centers. Stabilizers alone, however, have not eliminated bar rotation or migration, and may occasionally be associated with complications in some patients [3].

Polypropylene suture, PDS and metal wire have also been described as options for securing pectus bars to prevent bar displacement alone or in combination with lateral stabilizers [2,4–11]. We present results of a technique of thoracoscopically guided circumferential fixation of the pectus bars to the underlying ribs in children utilizing a commercially available, multistranded polyethylene core fiber with a braided jacket of polyester and polyethylene called FiberWire® (Arthrex, Inc., Naples, FL) without the use of metal stabilizers.

2. Methods

Institutional review board approval was obtained for retrospective review of the medical record of all patients who underwent PE repair at our institution from December 2009 to March 2013. The technique used was similar between surgeons, including use of multiple bars in most cases, FiberWire rib fixation, and no use of lateral stabilizers. Initially, 2-point lateral fixation was used to secure the pectus unilaterally, but later was done bilaterally. Patients included were those with pectus excavatum deformity, with progressive symptoms, and a Haller index >3.2. Almost all showed evidence of cardiac compression on axial imaging. Data collected included age at operation, Haller index, number of bars used, initial or reoperative surgery, operative time, variations from standard procedure, length of
stay, need for reoperation, length of follow-up, and complications, including emergency department visits, readmission, pneumothorax, and bar migration.

3. Technique

Double lumen endotracheal intubation is performed for patients of sufficient size. Small bilateral anterolateral chest wall incisions are made and subpectoral pockets dissected. A 5-mm 30 degree scope or 5 mm flexible tip scope (both Stryker (Kalamazoo, MI)) is used for thoracoscopic guidance, and dissection of the mediastinum is performed. Sternal elevation is utilized for severe defects as previously described [12]. A Lorenz (Biomet Microfixation, Jacksonville, FL) bar passer is weaved under the deepest portion of the defect. FiberWire is tied to the passer tip, and the bar is pulled back out the right chest. A pectus bar (Biomet Microfixation, Jacksonville, FL) is bent to the patient’s chest, and tied to the FiberWire to guide the bar across the chest. The bar is rotated into place and adjustments are made if necessary. This process repeats with each bar. The bars rest on the rib with less than a finger width of space under the bar, and are not allowed to compress or squeeze the chest wall laterally.

The bars are secured to the ribs with the same #5 FiberWire. The FiberWire is first passed through the bar eylet and then grasped with the tip of a thin right-angle clamp. Under thoracoscopic guidance, the right angle is gently pushed into the intercostal space just above a nearby rib and about 5 cm of FiberWire is placed in the chest and released. The same clamp is guided under the rib to grasp the FiberWire and pull it out of the chest thereby encircling the rib. This assures circumferential fixation around the adjacent rib (Fig. 1a–c). At least two FiberWires are secured around ribs per bar, one laterally at the eyelet and the second medially, closer to the point of pivot, in order to obtain secure fixation and to decrease the risk of bucket handle movement (Fig. 2). This technique is repeated on the left side. To see the left side, the camera position is moved to a port placed through the existing right-sided incision. The camera is then advanced across the mediastinum under direct vision. Apnea is used on the left side to improve visualization. Use of the 5-mm flexible tip scope (Stryker (Kalamazoo, MI), or HD EndoEYE Flex Video Laparoscopes (Olympus, Center Valley, PA)) can improve visualization of the left chest as well, making circumferential fixation easier. Once the bars are secured, the pockets are irrigated, hemostasis is ensured and the pectoral muscle, fascia, and skin are closed with absorbable suture.

We choose to leave the bars in place for 2 to 3 years per the recommendations of the Norfolk group [8]. Bar removal follows a standard technique. Both anterolateral incisions are opened. The overlying muscle is separated, revealing the thick fibrin sheath surrounding the bar. The FiberWire sutures are easily identified because of their color, or the braided knots. The FiberWire is easily cut and removed without difficulty.

4. Results

A series of 93 consecutive young patients who underwent MIRPE using this technique during the review period were identified. The study population was composed of 20 females and 73 males. The mean age at bar insertion was 14.6 years (range, 7–21 years). Mean Haller index was 4.9 (range, 2.85–12.2). The one patient with an index below 3.25 (2.85) had progressive symptoms of dyspnea on exertion, with compression of the right atrium and right ventricle on imaging. Two or more bars were placed in 84 (90%) with 6 (6%) requiring 3 bars.

Fig. 1. a. The #5 FiberWire is advanced into the chest under thoracoscopic visualization with a thin right-angle clamp. b. The FiberWire is grasped from an adjacent intercostal space and pulled out of the chest, encircling the rib. c. Circumferential fixation of the bar around the adjacent rib.

Fig. 2. Placement of sutures in relation to the adjacent ribs and pectus bars.
for adequate repair. Mean operative time for first-time procedures was 102 minutes (range, 56–198 minutes). No patients in the series developed wound infection or breakdown. No patients were found to have pneumothoraces or hemothoraces requiring tube thoracostomy placement. Five (5%) of the male patients were noted to have unilateral numbness in the anterior chest, approximately 2–4 cm in width. These resolved in two of the five by their 6 month follow-up, but three patients still have decreased sensation on the anterior chest. Four patients were either readmitted or seen in the emergency room for pain in the early postoperative period. Patient follow-up included clinical exam and radiographic imaging (median 17 months, range 3–36 months).

There have been two incidents of clinically significant bar movement (2.6% overall). Both required surgery for pain. In the first case, pain occurred after a sudden rotation of the lower bar (Fig. 3) 18 months after initial surgery. There was no change in contour when he presented. He had 3 fingerprint like bruises on his anterior chest that he declined to explain. This patient was early in our series, and the bar was only secured on the patient's right side, which probably contributed to the rotation. The rotated bar was removed with resulting pain relief and no change to the chest contour. In the second case there was lateral migration of the bar (Fig. 4) and this was associated with pain on the side where the bar had extended more laterally, likely because of pressure on the underlying rib. This bar was also removed with resulting pain relief and no change of contour. There have been no incidents of bars rotating enough to cause a loss of sternal lift.

26 patients have undergone bar removal in the study period. Our standard bar dwell time is 2–3 years. Of these patients, we found no

Fig. 3. Patient with rotational movement of the lower bar following a blunt force trauma 18 months after original placement.

Fig. 4. Patient with lateral movement of the lower bar 6 months after surgery.
increased amount of ossification around the FiberWire. The FiberWire was easily identified and removed. One patient with midsternal bar erosion bled, and was reported as a case report [13].

5. Discussion

Following the initial description of the minimally invasive approach to repair of pectus excavatum by Donald Nuss in 1998 [1], numerous modifications have been applied to the technique. These modifications have attempted to make the operation safer, more efficient, or decrease complications. Since PE encompasses a heterogeneous collection of chest wall anomalies, MIRPE appears to have a steeper learning curve than many operations. As more experience has been garnered, the surgical technique has continued to develop, often with improved results.

Bar displacement is the most common complication of MIRPE requiring reoperation [2,4–6,14–16]. Many reports describing outcomes with the initial technique described bar displacement of 10% or higher [1,2,14]. The original procedure involved securing the bars to the lateral chest wall muscles with heavy suture. The bar migration rate has been reported to be between 3.4% and 27% when done in adolescents [6,14]. The high rate of bar displacement and the need for subsequent reoperation in these patients has led to several techniques to eliminate or reduce this complication [2,4–6,10,12,14,15].

The use of metal lateral stabilizers has been shown to reduce the rate of bar displacement in several studies [2,5,9,11]. The rate of bar displacement was reduced from 15% to 5% with the use of lateral stabilizers in the study by Croitoru et al. [5]. Lateral stabilizers, however, are expensive and have not eliminated the complication of bar migration. Additionally, they may contribute to discomfort, wound complications and seroma formation [3,7,14]. Other techniques with the metal stabilizers have been described as well, including placement of the stabilizers medially to increase stability and reduce the rate of wound complications [14].

The use of metal stabilizers with PDS suture around the adjacent ribs, as a modification by the Nuss group has decreased the displacement rate to 0.8% in their hands [8]. PDS is an absorbable suture and has worked well in combination with lateral stabilizers.

The use of surgical steel wire to secure pectus bars to the surrounding ribs has also been proposed. Early reports quoted rate of bar displacement or rotation at approximately 5% [17], however wire failure rates as high as 27% were seen in trials monitoring for early complications following MIRPE [15]. In addition to those patients requiring reoperation for bar displacement, some patients required removal of wires because of persistent pain, skin erosion, or serious vascular complications [11,17,18]. Moreover, the difficulty in handling wire makes circumferential rib fixation time consuming. The use of wire may also complicate removal of the bars, with some surgeons using fluoroscopy intraoperatively to confirm removal of all metal fragments that may be present [18].

Alternative techniques have also been described to reduce the rate of bar displacement such as use of a “third point of fixation” [6]. This technique involves the use of a nonabsorbable suture passed around a rib near the sternum to secure the bar medially. Early data in the small series published by Hebra et al. describes good outcomes in 20 patients. This technique requires an additional incision near the sternum to pass the suture, and then introduce an instrument to remove the suture from the chest [6].

Five-point fixation has been used by Park with excellent success and very low displacement rates (0.5% in recent series), combining specialized medially placed metal stabilizers and circumferential rib fixation with wire [10].

We have described results of an alternative technique for rib fixation which is easy, durable, requires no lateral stabilizers, nor additional skin incisions. The rates of lateral displacement we found (1.3%), and bar rotation (1.3%), were similar or lower than other published studies [8–10,16]. FiberWire is commercially available with no special equipment necessary for its use. The technique described here involves thoracoscopic-guided multiple point fixation on both sides of the bar, and utilizes the bar’s lateral holes to minimize lateral dislocation. The tensile strength of the FiberWire is much higher than polypropylene, and in clinical use has proven more resistant to stress fatigue than wire [19]. FiberWire is easy to use, soft, flexible and strong. Regarding fixation once the bars are in place, a scope easily traverses the mediastinum, allowing direct visualization for securing the left side.

5.1. Limitations and future studies

Our study does not compare FiberWire directly to other materials. Further studies directly comparing and evaluating the efficacy of alternative suture material for securing bars would be helpful. We initially started using FiberWire with one-sided fixation, but based on our experience with adult bar migration rate, we began using bilateral fixation. We do not know with certainty if bilateral fixation is required in adolescent patients. Using two bars to reduce movement has been reported to significantly reduce bar movement [20,21]. In the majority of our patients two or more bars were placed and the contribution of this modification is difficult to determine. A comparative study using two bars with stabilizers versus two bars with FiberWire would be helpful to determine the impact of the modifications. Finally, although there were four patients with decreased cutaneous sensation in our series, no chronic pain in an intercostal distribution was seen. Since the neurovascular bundle is protected in the rib groove, the nerve shouldn’t become easily compressed without erosion.

FiberWire did not appear to contribute to wound complications, significant pneumothorax, or hemothorax in our study. We believe these results show FiberWire is well suited for securing pectus bars in patients undergoing MIRPE, while resulting in relatively small number of complications or failures.

Minimally invasive pectus excavatum repair is a relatively new operation, and bar migration and rotation remain common complications. Thoracoscopic circumferential rib fixation with FiberWire at multiple points on both sides of the bar appears to be associated with an extremely low occurrence of bar displacement, and does not require the use of metal stabilizers.

References

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