

Minimally invasive repair of pectus carinatum using a newly designed bar and stabilizer: a single-institution experience

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Abstract

Objective: A modified technique of the Nuss procedure for the minimally invasive repair of pectus carinatum was defined by Abramson, and it has been gaining support for the last few years. We have been performing the Abramson procedure in our institutions since 2006. This article describes our recent experience with a novel instrument for pectus carinatum correction. **Methods:** In 2008, we developed a new pectus bar and stabilizing system for this procedure and started using it on our pectus carinatum patients. Between July 2008 and December 2009, 18 patients were operated on with these newly designed implants. **Results:** Excellent esthetic results obtained regarding the postoperative course, verified with the patients' and parent's answers on a satisfaction questionnaire; all patients except one (94.4%) feeling satisfied with the operation. Two of the bars have been removed during the 18-month follow-up. Three fixating steel wire breakages requiring re-fixing of the stabilizers and two local skin adhesions over the bar were seen as postoperative complications. **Conclusion:** This article describes a novel instrument and surgical technique that is safely and easily used in minimally invasive correction of pectus carinatum deformities, with minimal complications and high satisfaction rates.

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Keywords: Pectus carinatum; Minimally invasive surgery; Chest wall deformity

1. Introduction

The Nuss procedure has become the treatment of choice for pectus excavatum (PE) in the last decade, as it is a minimally invasive technique and has been performed with a high degree of success [1]. A modified technique of the Nuss procedure for pectus carinatum (PC) repair was defined by Abramson [2,3], mainly consisting of a pre-sternally placed metal bar compressing the sternum, fixed on both sides of the chest wall on metal plates. Having been inspired by Abramson's presentations in congresses and in close collaboration with him, we have been performing his procedure for PC repair at our institution since 2006 [4]. In our first three PC cases in 2006 and 2007, standard bars and stabilizers for the Nuss procedure were used pre-sternally. At the beginning of 2008, in search of a higher degree of success and stamina, a new bar and stabilizing system for the minimally invasive surgical correction of PC were designed, to get a better result in compressing the sternum and stabilizing the bar on the ribs on both sides of the chest wall.

This article reviews the outcomes achieved using this novel instrument (Patent no. TR 200810055) in minimally invasive repair of PC.

2. Patients and methods

From July 2008 to December 2009, a total of 18 patients were operated at our institution for minimally invasive repair for PC deformity. Written consent was obtained from all patients or from their parents if their age was under 18 years.

2.1. Patients

The median age was 14 years (range, 10–26) and all of the patients were male. All patients were presented with cosmetic complaints. Two patients had a medical history of failed open surgery for the correction of pectus deformity and 3 out of 18 patients had a family member with PC. The deformity involved the lower sternum (chondrogladiolar type PC) and the sternum was compressible in all patients, 11 of them having asymmetrical deformity.

Compression test was performed to check the flexibility of the chest wall, by compressing the sternum while the patient was leaning against a wall. Postero-anterior and lateral chest X-rays were taken. Cardiac and pulmonary function evalua-

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tions were routinely done on preoperative course, with no abnormal findings.

Patient satisfaction was evaluated with the answers provided on questionnaires done preoperatively and in the postoperative 6th month.

In addition, photographs of all patients were taken before and after surgery for comparison.

2.2. Surgical technique

All operations were done by the same surgeon (M.Y.), with the principles defined by Abramson et al. [3], using our newly designed bar and stabilizing system made of 316L steel (Hipokrat Medical Devices Manufacturing and Marketing Inc., Izmir, Turkey).

An epidural catheter was placed in all patients prior to surgery. To choose the location for the incisions, a horizontal line was drawn through the region with the highest degree of protrusion on the anterior chest wall. Two transverse incisions were made on both sides, approximately 2.5 cm each, at the midaxillary line. The fibers of the latissimus dorsi muscle were separated. Two neighboring ribs on both sides for the placement of the stabilizers were chosen and incisions (1 cm) were made through the periosteum. While the ventilation line is disconnected from the intubation tube, the ribs were encircled subperiostally with a Doyen rib raspator and then with a suction catheter to serve as a sheath for the steel wires to avoid pneumothorax. Following the placement of the steel wires, the suction-catheter sheath was removed and the patient was connected to the ventilator again. The stabilizers with grooves for the bar to fit in and with two screw holes were placed perpendicularly on the ribs and secured with the wires on both sides (Fig. 1). The bar of appropriate size, with grooves on the sides of both edges to fit in the stabilizers, was selected using templates while

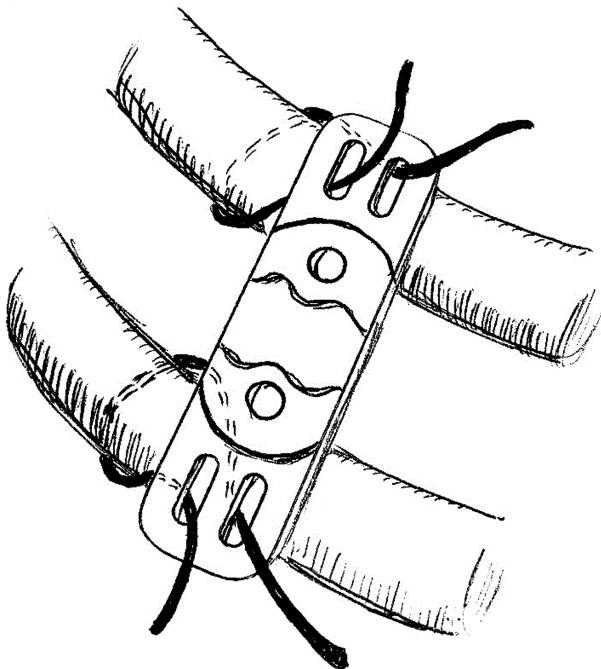


Fig. 1. Fixation of the stabilizer to the costae; schematic drawing.



Fig. 2. Newly designed bar end with notches and screwed stabilizer.

compressing the sternum by hand and then bent into a convex configuration as needed. Using clamps, subcutaneous tunnels toward the sternum were created on both sides and a polyvinyl chloride tube with a trocar was passed from one incision to the other, posterior to the pectoralis major, then through the pectoralis major close to its origin near the sternum. The trocar was removed from the lumen of the tube, and the bar was inserted into it with the concavity facing posteriorly, to withdraw it through the pre-sternal tunnel. Compressing the bar over the sternum, both edges were placed into the stabilizers at an appropriate level and secured with two metal screws on both sides (Fig. 2).

The wounds were closed in layers with absorbable sutures. A postoperative chest X-ray was obtained to view the bar in place and to look for pneumothorax (Fig. 3). No intervention was done for pneumothorax less than 10%. Others were followed up with X-rays for an increase in the pneumothorax rate needing a tube thoracostomy. Pain control was maintained with patient-controlled analgesia (PCA) using epidural fentanyl and bupivacaine during the postoperative 48 h, followed by oral tramadol and etodolac.

3. Results

Satisfying esthetic results were achieved in our patients (Fig. 4(a) and (b)), using one bar ranging between 25 and 43 cm length and two stabilizers on both ends. As many as 16 patients (88.9%) commented on their postoperative physical look as 'excellent' and one reported his postoperative physical look as 'good' on the satisfaction questionnaire. Only one patient, with mixed asymmetric chest-wall deformity with a previous unsuccessful correction operation for PE, complained about his physical look postoperatively. The median operation duration was 65 min (range, 45–110 min), and without any significant blood loss. Tolerance of the implant was good; 16 patients (88.9%) were off analgesics on postoperative day 14, and two patients required prolonged usage of oral analgesics for total of 4 and 6 weeks, respectively. The median duration of hospital stay was 5 days (range, 2–8 days).

The complications seen were unilateral opening of the pleura in one patient and stabilizer fixating steel-wire

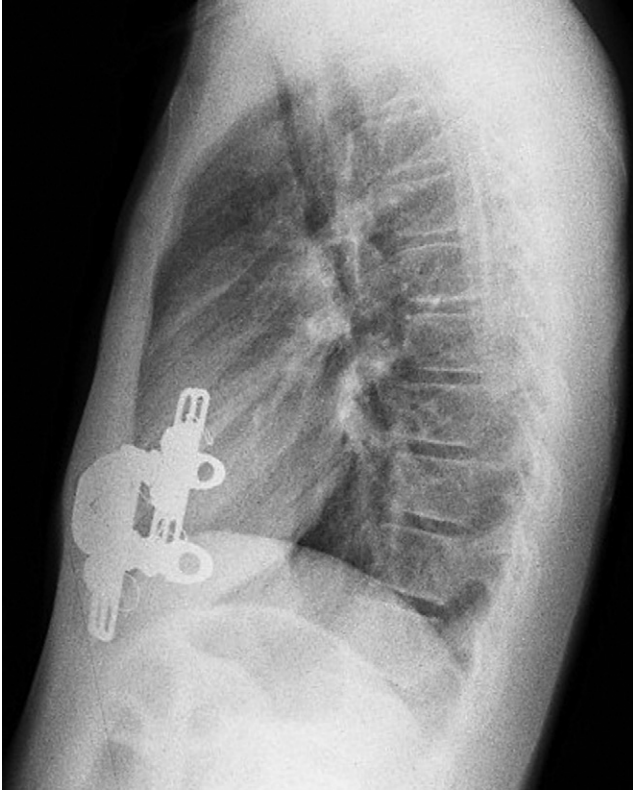


Fig. 3. Postoperative lateral chest X-ray of a patient, showing the bar and the stabilizer in position.

breakage in three patients, 2, 3 and 10 months after the operation, respectively. Pneumothorax space was evacuated with intra-operative needle aspiration before extubation. No pneumothorax space was seen on postoperative chest X-rays of the patients; therefore, no chest tubes or drains were required on any postoperative course. The broken wires were removed under general anesthesia, using the previous incisions, and the bar was placed in the position after re-fixing the stabilizers around the same ribs, with two- or



Fig. 4. (a and b) Preoperative and postoperative lateral views of a patient.

three-ply No. 5 steel wires, in multifilament style. Local skin adherence on the bar was seen in two patients, but without any evidence of an infection or an occurrence of seroma. One regressed spontaneously while the other required incision revision for dehiscence. No breakage of the bar was seen.

Two bars have been removed prior to the planned date: the first was a patient with overcorrection of PC deformity, resulting in PE on the 13th month. After the removal of the bar, PE regressed spontaneously within a week, revealing a satisfactory look for the patient, on our follow-up for 4 months. The other patient was the unsatisfied one, the bar being removed on the 11th month due to skin necrosis over the left stabilizer. The remaining 16 bars have not been removed yet, as they are planned to be followed up for at least 2 years.

4. Discussion

Classic techniques for the repair of PC are highly invasive procedures that may include resection of costal cartilages, sternal osteotomies, and even resection of the sternum [5–8]. Such techniques are laborious and have the disadvantage of leaving scars on the anterior chest wall. With the minimally invasive technique based on compressing the sternum, correction can be achieved with no need for any extensive incisions, costochondral resections or sternal osteotomy, yet the result in terms of the shape of the chest wall is comparable to that obtained with various invasive techniques [2]. As in the minimally invasive repair of PE, the minimally invasive repair of PC has none of the disadvantages associated with techniques based on the resection of chest-wall structures. Moreover, it can be implemented with satisfactory results and few complications.

The best age range to perform this minimally invasive technique is between 12 and 18 years, according to our experience, as this is the rapid growth phase of puberty when the deformity becomes more prominent and the chest wall is still flexible. We perform a compression test to evaluate the flexibility of the chest wall. Decision for a minimally invasive repair is taken when the chest wall is flexible and the new shape of the chest is acceptable by the patient and the parents when the sternum is compressed with the patient leaning against a wall. If the sternum is too rigid to be compressed or the new shape of the chest is not as good as desired when the sternum is compressed, then open surgery is preferred for the correction of PC.

We perform the minimally invasive repair for the chondrogladiolar type of PC. Asymmetric deformities of this type also benefit from this technique. As chondromanubrial type of PC is mostly rigid and not adequate for placing a pre-sternal bar, we prefer to perform open surgery for the repair of this deformity.

External compression of PC with orthoses and dynamic compression systems has been reported by several authors and the results are promising [9–11]. However, wearing a brace for 14–16 h a day for 2–3 years long is not easy to tolerate for a teenager. The average age for patients treated with braces is approximately 12 years; hence, when we have a patient at a young age, especially younger than 10 years, or

when a patient does not want to have surgery, we prefer to use these systems.

Alternative minimally invasive techniques for the repair of PC have also been introduced by several authors [12–15], the most popular one being the intra–extrathoracic placement of a steel bar. This technique seems to work as well as the pre-sternal bar placement, yet it is more invasive, necessitating thorascopic guidance.

We tend to keep the bar in place for at least 2 years for a satisfying result. Early bar removal may cause recurrence of the deformity, while keeping the bar in place for an extended period of time may end up with iatrogenic PE, especially during puberty. For patients older than 18 years, bar removal can be postponed till the end of the 3rd or 4th year, depending on the follow-up.

Our newly designed bar enables extra grip on the lateral ends for the screws, making the bar almost impossible to disengage. In addition, it can be adjusted for the patient very precisely with the use of its notches. The problem of steel wire breakage is handled with the usage of the wire in multifilament construction. Together with the stabilizers, it is a safe and easy-to-use prosthesis for minimally invasive surgical correction of PC deformities.

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