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**ABSTRACT** • The traditional method for fixing the sternum during surgical repair of pectus carinatum is through the use of a stainless steel bar (Adkin's strut). In this article we describe a new method of sternal fixation using nonabsorbable sutures which are placed in a transverse and crossed fashion anterior to the sternum. This method provides stable sternal fixation and spares the patient a second operation to remove the steel bar. The absence of metallic implants allows clearer view of the thoracic structures in future X-rays, CT scans and MRI, and is likely to be more acceptable to patients than the implantation of a metallic strut in their chest. In addition, it is less costly.

Keywords : pes carinatum; pes excavatum; chest wall

#### INTRODUCTION

Pectus carinatum refers to a spectrum of protrusion abnormalities of the anterior chest wall. Two types are described, chicken breast (chondrogladiolar) where the lower sternum protrudes, and pigeon breast (chondromanubrial) where the upper sternum protrudes [1]. Other types represent the asymmetric protrusions where the sternum tilts to either side.

Mielke reported an overall prevalence of pectus carinatum of 0.06% [2], an incidence which is six times less than that of pectus excavatum [3]. Males are four times more likely to be affected than females [3]; in addition, 25% of patients have a positive family history of pectus abnormalities [4]. Around 10% of pectus carinatum patients were reported to suffer from congenital heart disease [5]. In 1990, Iakovlev and colleagues reported a 97% prevalence of mitral valve prolapse in 70 patients with pectus carinatum deformity [6]. Some authors indicated that carinatum deformities do not correlate with cardiorespiratory dysfunction [7, 8]. Others have described that the protrusion of the sternum causes fixation of the chest in a position of full expiration [1, 9]. With the decreased chest excursion, patients will have to use the diaphragm and the accessory muscles for ventilation. Consequently, they will experience poor exercise tolerance, recurrent infections and increased incidence of emphysema.

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**RÉSUMÉ** • La méthode traditionnelle de réparer le sternum lors d'une chirurgie de thorax en carène (Pectus carinatum) est d'utiliser les barres d'Adkin en acier inoxydable. Dans cet article, nous décrivons une nouvelle méthode utilisant des fils non absorbables, posés transversalement et croisés en face du sternum. Cette technique assure une fixation stable et épargne au patient une deuxième chirurgie pour retirer les barres métalliques. L'absence de structures en métal permet de mieux voir les organes thoraciques par radio, CT scan et IRM. Cette méthode est en fait plus facilement acceptée par le patient que les barres d'Adkin et moins onéreuse.

Nonoperative management of pectus carinatum consisting of compressive bracing for two years is reserved for the highly compliant, skeletally immature patient with a mild chest deformity [10, 11]. Standard surgical management (Ravitch procedure) consists of subperichondrial resection of the fourth to eighth costal cartilages, osteotomizing and mobilizing the sternum, and temporarily fixing it with a steel bar (Adkin's bar) located posterior to the sternum in the case of pectus excavatum and anterior to it in the case of pectus carinatum [12]. The bar is removed after 12 months. Nuss procedure is a less invasive approach which entails inserting a conforming steel strut under the sternum to correct pectus excavatum [13]. Abramson described what might be called a reverse Nuss procedure for pectus carinatum where the bar is placed anterior to the sternum [14]. The bar would subsequently be removed in two to three years.

#### CASE PRESENTATION & SURGICAL PROCEDURE

A 17-year-old young man presented with pectus carinatum of the chondrogladiolar type. The patient had no complaints regarding exercise tolerance, shortness of breath, or asthma. No family history of chest wall deformities was recalled. He was only concerned about the shape of his chest. The physical exam revealed severe sternal protrusion, normal heart sounds with no murmurs, normal breath sounds and no scoliosis. Routine blood studies were normal and a chest X-ray was unremarkable except for the chest wall deformity. The patient was adamant on having the deformity corrected as this was causing him a lot of emotional distress. The parents shared the patient's insistence on having the surgery done.

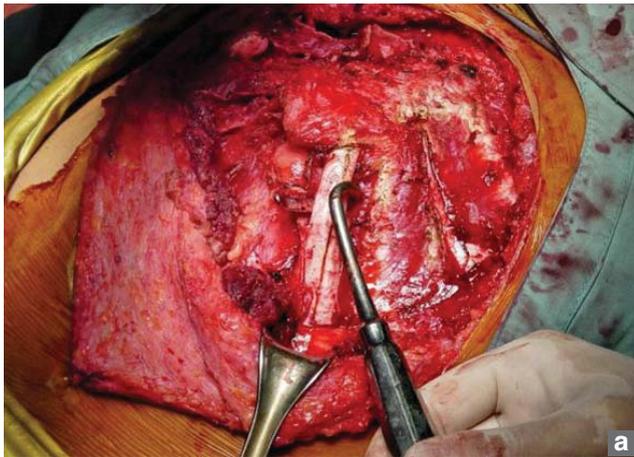
The procedure we employed to correct the deformity was a modified Ravitch approach [12] (Fig. 1 to 3).

The incision was a transverse curvilinear incision beneath the breast. The pectoralis major and rectus abdominis muscles were dissected off the lower costal cartilages and sternum. The fourth to seventh costal cartilages were resected and the covering perichondrium was left in place (see Fig. 1 a & b).

The sternum was mobilized and the outer cortex

osteotomized leaving the inner cortex intact. A wedge of cartilage fashioned from one of the resected cartilages was inserted into the sternum and fixed with sutures (see Fig. 2 a & b).

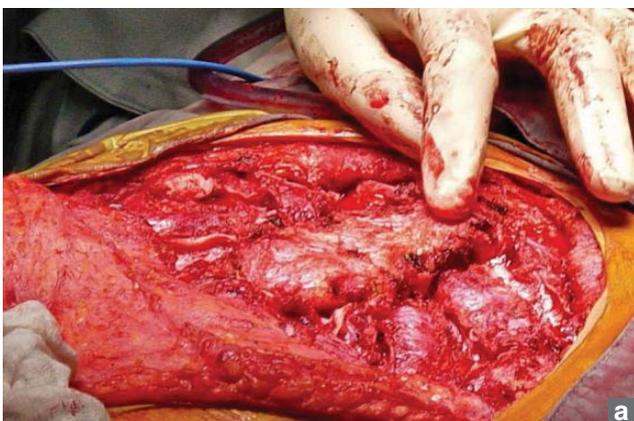
The perichondria were attached back to the sternum which was fixed in place using nonabsorbable sutures applied in a transverse and crossed fashion anterior to the sternum (see Fig. 3 a & b). No steel bar was used.



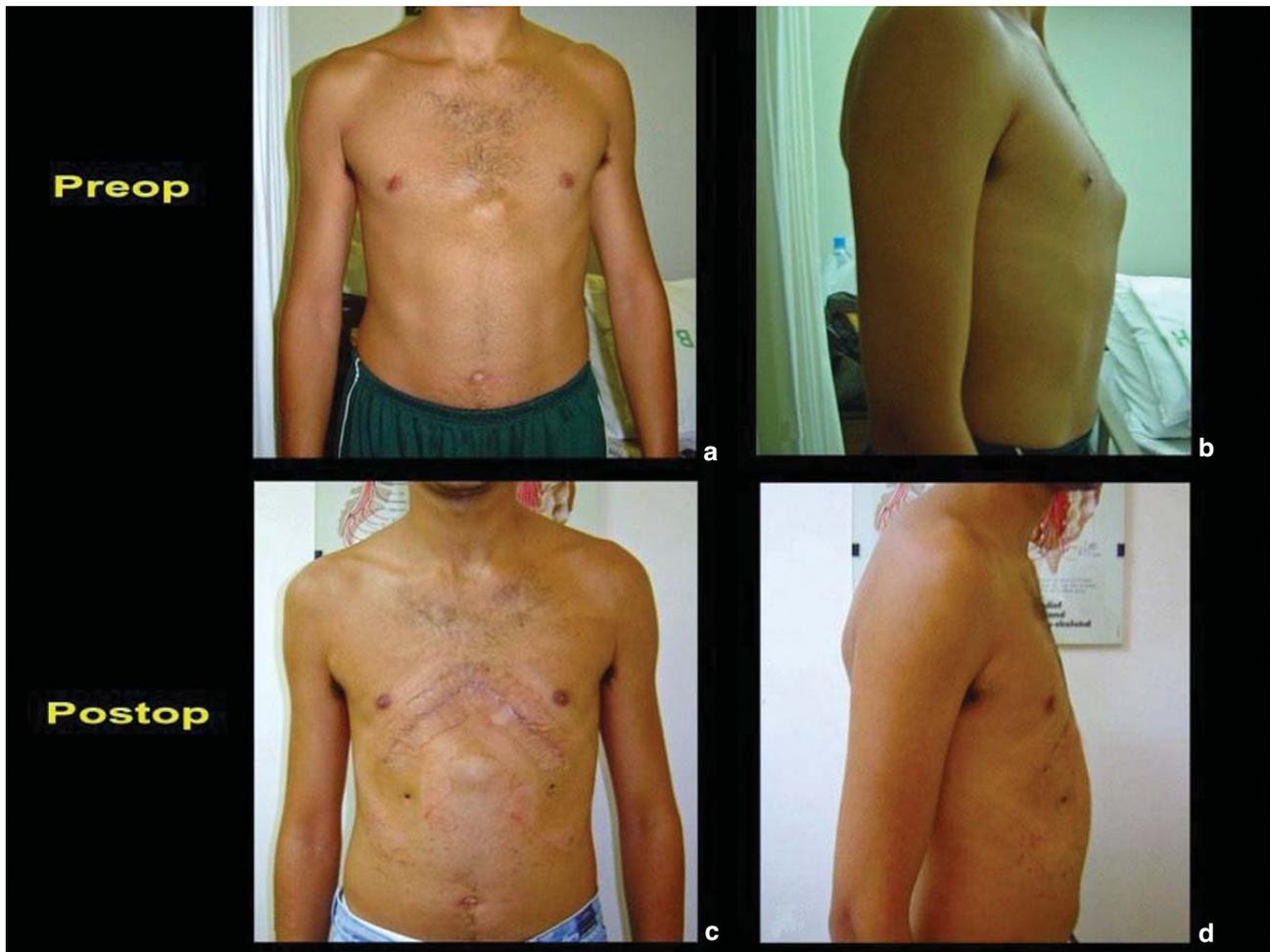
**FIGURE 1.** (a) Subchondrial exposure of the 4<sup>th</sup>-8<sup>th</sup> costa cartilages resected (b) Costal cartilages resected



**FIGURE 2.** (a) Sternum after it has been mobilized (b) A costal cartilage being fashioned before insertion into the sternum



**FIGURE 3.** (a) The sternum after it had been osteotomized proximally and tilted downward; the intact perichondria were attached back to the sternum (b) Final fixation of the sternum with transverse and crisscross non-absorbable sutures placed anterior to the sternum



**FIGURE 4.** (a) Preoperative front view of the chest (b) Preoperative side view (c) Front view on the 5<sup>th</sup> postoperative day showing the inverted V incision (d) Postoperative side view showing correction of the deformity

The wound was closed in layers over two hemovac's that were kept for 48 hours.

There were no postoperative complications and the patient left home after three days.

Figure 4 shows the appearance of the chest upon wound inspection on the 5<sup>th</sup> postoperative days, compared to the preoperative appearance. A brace was applied for six weeks. The patient was allowed to resume full activity at twelve weeks, and reported full satisfaction with his appearance during the periodic follow-up visits. At the last follow-up, three years after surgery, he was fully satisfied with the shape of his chest and [he] had no complaints.

#### DISCUSSION

Treatment of chest wall deformities was reported to improve the cardiopulmonary status of patients suffering from pectus excavatum or carinatum [15]. In his series of 252 patients who underwent repair of either pectus excavatum or carinatum, Fonkalsrud [15] found that

“more than 98% of patients had improvements in exercise tolerance, endurance, respiratory symptoms, and cosmetic appearance.”

Nonoperative treatment of pectus carinatum consisting of compressive bracing is a valid alternative, but the patient has to wear the brace for 14 to 16 hours daily for a minimum of two years [11]. This makes bracing a good option for the compliant pediatric patient. Kobayashi described an endoscopic approach for correction of pectus excavatum and pectus carinatum with good results [16]. However, he adds that it is better indicated in children, particularly preschool aged ones, whose skin is more elastic and in whom subperichondrial costal cartilage dissection is easier. Abramson described a technique for the repair of pectus carinatum where he places the conforming bar anterior to the sternum, making it almost a reverse Nuss procedure [13, 14]. Rothenberg states that “these procedures (Reverse Nuss) are still in their early stages and need to be further evaluated.” [10]

Many, including Fonkalsrud and others, still favor a standard or modified Ravitch procedure over a Nuss

approach, and by the same token a reverse Nuss, reporting decreased pain, shorter recovery time, and less complications [17, 18]. Fonkalsrud also described a modification of the Ravitch procedure entailing less extensive surgical repair and minimal cartilage resection [18, 19, 20].

Whether a standard or a modified Ravitch procedure is utilized, a temporary steel bar is kept for an average of six months in most patients. The modification described in this paper makes use of nonabsorbable sutures applied in a transverse and crossed fashion anterior to the sternum at the end of the procedure. This has the advantages of being a stable, easy to apply fixation, and spares the patient a second operative procedure to have the bar removed. Moreover, it is likely to be more acceptable to patients than having a bar in their chest. In addition, an MRI can be done in the postoperative period to check for a complication or otherwise.

Further studies need to evaluate this modification to see the medium- and short-term results and to compare it to other more conventional methods.

#### CONCLUSIONS

The surgical correction of pes carinatum deformity, using nonabsorbable sutures instead of the classical steel bars affords a simple method of fixing the sternum. It is cost effective and avoids using metallic implants that may hinder optimal view of intrathoracic structures in future X-rays, CT, and MRI. In addition, using absorbable sutures will avoid future surgery to remove the steel bar or strut.

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