

STRATOS™ system for the repair of pectus excavatum

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Abstract

Open techniques represent a valid repair option for severe asymmetric pectus excavatum in adults. The use of metal supports is recommended to reduce the risk of recurrence. A wide variety of metal supports have been proposed, with pre-, trans- or retrosternal fixation. A novel open technique using titanium bars fixed to the ribs with clips has been recently introduced (STRATOS™ system) for chest wall reconstruction, rib fracture fixation and chest wall malformation repair. We employed this technique in two adult patients with severe asymmetric pectus excavatum: after sternal mobilization, one bar is passed below the body of the sternum and secured with clips bilaterally to two ribs. In the first case, the results remained excellent 5 years after surgery. In the second case, the initial results were satisfying but the bar ruptured after 30 months: removal of the bars and clips was performed and a subsequent recurrence of the deformity occurred. The experiences reported in literature are still too limited to draw firm conclusions about the use of the STRATOS™ system in pectus excavatum repair, but it seems that the use of two bars may reduce the risk of rupture. At present, we are the only ones who reported long-term results.

Keywords: Pectus excavatum • Surgery • Chest wall

INTRODUCTION

Pectus excavatum (PE) can be surgically corrected with open techniques or with the minimally invasive repair technique (MIRPE). The feasibility of MIRPE in adults is controversial, especially in cases of severe and asymmetric deformity. These patients may be better served with a modified Ravitch repair, which employs metal struts to hold the sternum in the correct position. A wide variety of metal supports have been proposed, with pre-, trans- or retrosternal fixation. A new technique using a retrosternal titanium bar (Strasbourg Thorax Osteosyntheses System—STRATOS™, MedXpert GmbH, Heitersheim, Germany) was proposed in 2007 [1]. Here, we report our experience with this technique in two adult patients with severe asymmetric deformity.

CASE REPORT

A 20-year old woman and a 20-year old man underwent surgery in September and in November 2007, respectively. Both patients presented with severe asymmetric PE (Fig. 1A) and complained of psychological troubles; the woman also experienced reduced exercise tolerance and shortness of breath. Spirometry revealed restrictive deficits: predicted forced vital capacity and forced expired volume in one second were 67 and 65% as well as 66 and 67% for the first and the second patient, respectively. Echocardiogram showed anterior compression of the right ventricle and heart displacement to the left in both patients, as well as mitral valve prolapse in the woman.

The operative technique was as follows. A transverse skin incision was made within the inframammary crease. The xiphoid process

was resected and two small cylinders of costal cartilage were sub-perichondrially resected, to the chondrosternal and chondrocostal junctions. Resection extended bilaterally from the third to the seventh costal cartilages. A wedge osteotomy is created through the anterior cortex of the sternal body, at the site of angulation, just above the third chondrocostal junction. We used the STRATOS™ system for the internal fixation of the sternum: a titanium bar was passed below the body of the sternum and secured with clips bilaterally to two ribs (Fig. 1B). The clips were angled with dedicated surgical pliers and then fixed bilaterally to the anterior arc of the fourth rib. The osteotomy was closed and the perichondrial sheaths were sutured.

Postoperative pain was easily controlled and no complications were observed. A satisfying correction of the deformity was obtained in both cases (Fig. 1C and D). The woman referred significant improvement in exercise tolerance, and both patients were satisfied with the aesthetic results. Spirometric and echocardiographic alterations disappeared. Five years after surgery, there was no deformity recurrence in the woman. In the man, the clinical and radiological results remained satisfying until November 2009, but in a routine visit in May 2010 a chest X-ray revealed a rupture of the left lateral edge of the bar (Fig. 2A). Removal of the bars and clips was performed under general anaesthesia (Fig. 2B), and a recurrence of the deformity progressively occurred over 12 months.

DISCUSSION

Open techniques remain a valid option for PE correction, especially in adult patients and in cases of severe and asymmetric

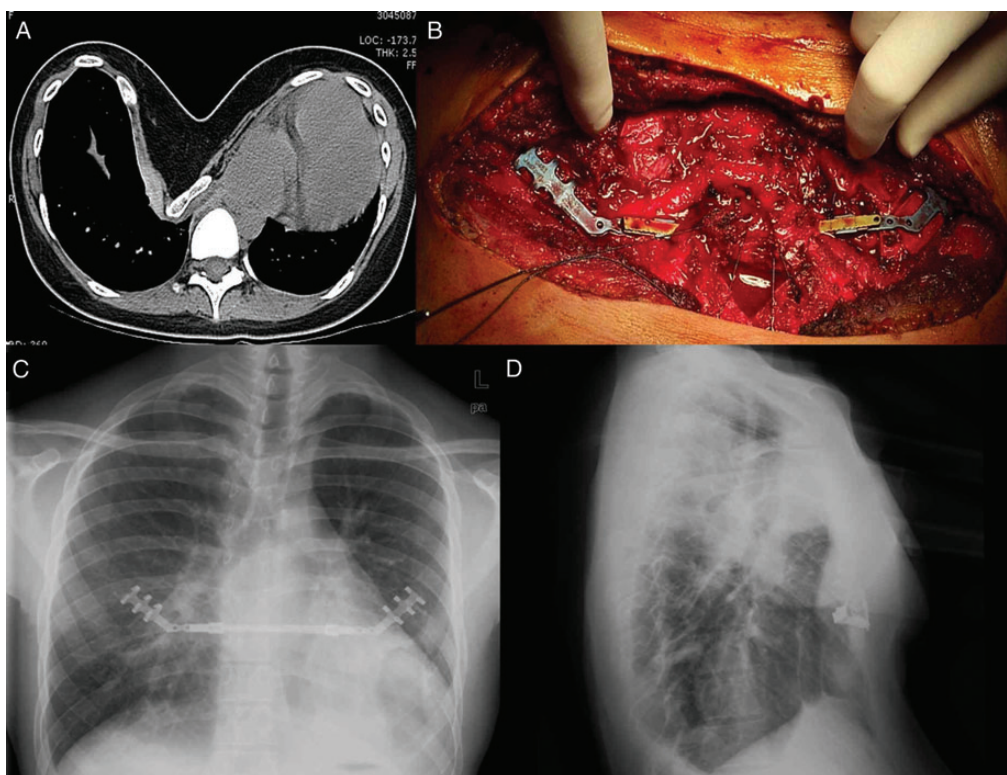


Figure 1: (A) Preoperative computed tomography scan of the first patient and (B) intraoperative picture showing a STRATOS system placement behind the sternum. (C and D) Chest X-rays showing the implant and the final result in the first patient.

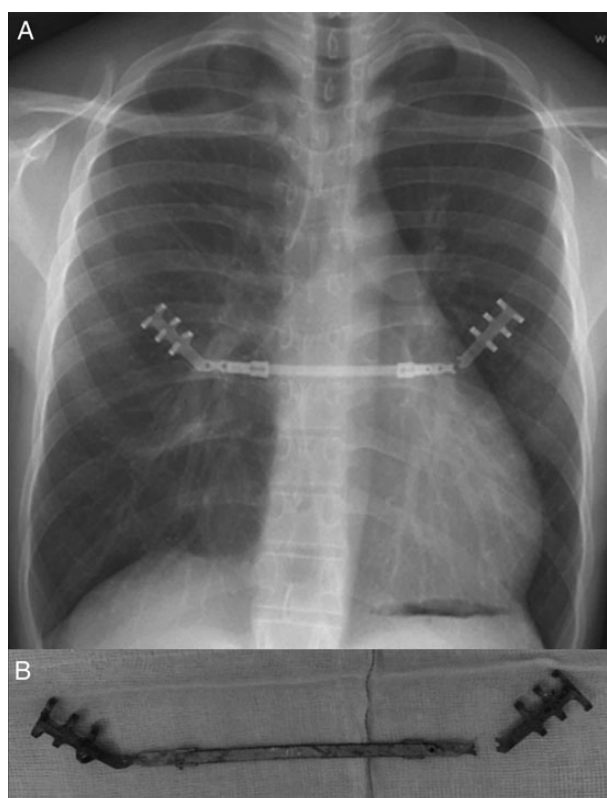


Figure 2: (A) Chest X-rays revealing the ruptured bar and (B) picture of the implant after removal.

deformity. The use of metal struts is recommended to maintain the correction in good shape during the healing process of cartilages; the major concerns include the risk of displacement, the need for a second intervention for removal and the risk of recurrence after removal. Moreover, complications such as pain, infections, bleeding, pleural effusion or pneumothorax can occur while the bar is in place or at the time of removal.

The STRATOS™ system is a novel technique for chest wall surgery, which is comprised of a titanium bar fixed to two rib clips [1]. Compared with other implants, titanium is easily and precisely adaptable to the shape of the thoracic wall, corrosion free, chemically inert and better tolerated and it is associated with fewer radiological artefacts. Therefore, titanium is especially indicated for long-term or permanent implants.

The use of this system is well established in chest wall reconstruction and rib fracture fixation, where good results have been described [1–3], but the experience in PE repair is very limited. Wihlm *et al.* [1] reported the feasibility of this technique in 12 Ravitch procedures and described good early results using two bars in each procedure. Mier *et al.* [4] reported a case of successful repair using a single bar to correct a recurrent deformity.

Our standard technique consists of a modified Ravitch procedure, with the use of two steel supports, which are removed 6 and 12 months after operation [5]. We obtained good results but found an increased rate of recurrence in adults compared with younger patients after support removal (18 vs 7%). Moreover, we observed a case of migration of a support into the abdomen [5]. In an attempt to reduce the risks of displacement and recurrence after removal, we employed the STRATOS™ technique in two adult

patients. We implanted a single bar in each case, to reduce the amount of permanent prosthetic material in these young patients. In the first case, we obtained excellent results, whereas in the second case, although the initial results were satisfying, a delayed rupture of the bar occurred. The rupture occurred on the left edge, at a point of minor resistance of the system (the joint), where the clip is angled to be adapted to the rib angle. It is likely that the pressure the sternum applied over the bar finally caused the rupture, favoured by the manoeuvre of angulation of the joint. Berthet *et al.* [2] described 2 cases of delayed titanium bar rupture, in his series of 19 reconstructions for chest wall tumours; in both cases, only one bar was implanted and rupture occurred at the joint. Aware of this eventuality, Wihlm *et al.* [1] implanted two bars in each patient. However, neither Wihlm *et al.* [1] nor Mier *et al.* [4] described long-term follow-up of their patients. The experiences reported in the literature are too limited to draw firm conclusions about the STRATOS™ system in PE repair. Even if a single bar may be sufficient to correct and stabilize the repaired chest wall, it is likely that two bars are needed to better distribute forces and pressures, thus reducing the risk of support rupture. Although we were concerned about the large amount of prosthetic material if 2 bars were employed, we acknowledge that this might represent a minor problem, taking into account the good titanium tolerability.

Conflict of interest: none declared.

REFERENCES

- [1] Wihlm JM, Grosdidier G, Chapelier A. Thoracic osteosyntheses for chest wall malformations, traumas and tumors using the STRATOS titanium system: initial experience. *Interact CardioVasc Thorac Surg* 2007;6:273.
 - [2] Berthet JP, Canaud L, D'Annoville T, Alric P, Marty-Ane CH. Titanium plates and Dual-Mesh: a modern combination for reconstructing very large chest wall defects. *Ann Thorac Surg* 2011;91:1709–16.
 - [3] Fabre D, El Batti S, Singhal S, Mercier O, Mussot S, Fadel E *et al.* A paradigm shift for sternal reconstruction using a novel titanium rib bridge system following oncological resections. *Eur J Cardiothorac Surg* 2012;42:965–70.
 - [4] Mier JM, Fibla JJ, Molins L. Another application of the STRATOS system for the correction of chest wall deformities. Repeat surgery of pectus excavatum after failure of a Ravitch procedure. *Cir Esp* 2011;89:558–9.
 - [5] Stefani A, Morandi U, Lodi R. Migration of pectus excavatum correction metal support into the abdomen. *Eur J Cardiothorac Surg* 1998;14:434–36.
- ribs as shown in figure 1A of the article (chest CT-scan), we use a surgical strategy different from that described by Stefani and colleagues. After complete subperichondrial resection of the elongated/deformed cartilages and transversal wedge osteotomy across the anterior table of the upper sternum, an important step of our procedure is the correction of abnormal curvature of ribs by anterior wedge osteotomy, followed by gentle fracture of the posterior cortex. Then, the running suture of the perichondrial sheaths restores tension to the adjacent intercostal spaces, maintaining the anterior segment of ribs in an adequate position without any complementary rib osteosynthesis. Of 181 patients having undergone a PEx open repair, 15 had severe asymmetric deformity (8%). These 15 patients received additional rib osteotomy as described above, resulting in satisfactory thorax contour [2].
- Another feature of our technique is sternum stabilization by means of a large (generally 20 to 22 cm long in the normal adult population) straight metal support bar (WURTZ thorax bar, Medicaex, Bagneux, France), passed substernally after minimal dissection at the level of the sixth perichondrial sheaths. The remaining parts of the bar are extrathoracic, inserted laterally anterior to the ribs and behind the muscles by means of a back and forth movement. The metal bar is then secured to the base of sternum in the midline with an absorbable suture [2]. This support reduces the risk of potential flail chest phenomenon postoperatively, and allows cartilage regeneration with osseous metaplasia in the proper position within 8 weeks. Finally, the bar is easily removed under local anaesthesia as an outpatient procedure, six months after the initial operation. The video description of this technique is currently available on the CTSNet website [3]. The WURTZ thorax bar has numerous advantages in comparison to the STRATOS system:
- (i) Placement through a significantly smaller incision (mean 13 cm long in adults).
 - (ii) No fixation to the ribs causing pain or rupture as observed by Stefani and colleagues [1] most likely due to constant movements of the rib cage during the respiratory cycle phases.
 - (iii) Excellent mechanical properties as we did not observe any untimely rupture or bending.
 - (iv) Reduced risk for dislocation since the bar is removed at 6 months. Indeed, it has been shown that dangerous intrapericardial dislocation of hard materials used in PEx open repair is related to the time these materials are left in place, or as a consequence of delayed material rupture [4].
 - (v) No re-entry for material removal with the risk of iterative complications [1].
 - (vi) In the setting of concomitant cardiopulmonary bypass surgery, the use of our easily removable material inserted at the lower edge of the sternum does not impede a prompt re-entry or potential cardiopulmonary resuscitation manoeuvres if needed [5].
 - (vii) Significantly lower cost of the WURTZ titanium thorax bar (€810) in comparison with the STRATOS system: €2680 for 1 bar fixed to 2 rib clips, and €5360 when 2 bars are used (priced in 2010).
- Finally, the STRATOS system was found to be useful for chest wall defect reconstruction [1]. It would be interesting to see more information from large series that would allow the evaluation of the STRATOS materials in the field of PEx repair.

Conflict of interest: none declared.

References

- [1] Stefani A, Nesci J, Morandi U. STRATOS system for the repair of pectus excavatum. *Interact CardioVasc Thorac Surg* 2013;17:1056–8.
- [2] Wurtz A, Rouse N, Benhamed L, Conti M, Hysi I, Pinçon C *et al.* Simplified open repair for anterior chest wall deformities. Analysis of results in 205 patients. *Orthop Traumatol Surg Res* 2012;98:319–26.
- [3] Wurtz A, Hysi I, Rouse N, Benhamed L, Conti M. Simplified open repair of pectus deformities available at: <http://www.ctsnet.org/article/simplified-open-repair-pectus-deformities>.
- [4] Zhang R, Hagl C, Bobylev D, Breyman T, Schmitto JD, Haverich A *et al.* Intrapericardial migration of dislodged sternal struts as late complication of open pectus excavatum repairs. *J Cardiothorac Surg* 2011;6:40.
- [5] Rouse N, Juthier F, Prat A, Wurtz A. Staged repair of pectus excavatum during an aortic valve-sparing operation. *J Thorac Cardiovasc Surg* 2011;141:e28–30.

eComment. Substernal metal support after pectus excavatum open repair

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We read with great interest the article by Stefani and colleagues reporting long-term results of the STRATOS system for stabilizing the sternum after severe pectus excavatum (PEx) open repair. This is an important contribution, since there are only 13 cases reported in the literature, although no long-term follow-up is available for them [1]. In severe asymmetric PEx with abnormal curvature of the anterior arc of