

Lung: Short Report

To Cross or Not to Cross: The Cross-Bar Technique to Correct Pectus Excavatum With “Costal Flaring”



Frank-Martin Haecker, MD,^{1,2} Thomas F. Krebs, MD,^{1,3} and Kai-Uwe Kleitsch, MD¹

ABSTRACT

BACKGROUND The minimally invasive repair of pectus excavatum (PE), introduced by Nuss in 1998, represents the worldwide “gold standard” procedure for surgical repair. Modifications over years included routine use of unilateral or bilateral thoracoscopy as well as sternal elevation before starting the substernal dissection. In patients with a severe PE deformity, such as Grand Canyon type, use of a second bar or, in selected patients, even a third or fourth bar has to be considered. However, not only the number of bars but also positioning may vary. Park established the so-called cross-bar technique to correct a wider range of PE deformities, especially at the lower part of the depression.

METHODS We report our experience applying the cross-bar technique in 5 PE patients presenting with severe bilateral costal flaring.

RESULTS With unilateral thoracoscopy and sternal elevation using the vacuum bell, surgical repair went well in all patients. Fortunately, we noticed no secondary bar displacement or any other serious postoperative complication; 1 of the 5 patients completed treatment with elective pectus bar removal. Optimal correction of the deformity was achieved in all patients; the outcome was excellent.

CONCLUSIONS Individualized surgical repair is mandatory in PE patients presenting with complex deformities. In PE patients presenting with concomitant bilateral costal flaring or depression of the lower part of the chest wall, we recommend the cross-bar insertion technique for surgical repair to achieve excellent cosmetic results.

(Ann Thorac Surg Short Reports 2023;1:107-110)

© 2022 The Authors. Published by Elsevier Inc. on behalf of The Society of Thoracic Surgeons.
This is an open access article under the CC BY-NC-ND license
(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

The minimally invasive repair of pectus excavatum (PE), introduced by Nuss and colleagues in 1998,¹ represents the worldwide “gold standard” procedure for surgical repair. The initial publication described the use of 1 pectus bar and 1 stabilizer. With increasing frequency and widespread use during 2 decades, the number of pectus bars and the positioning of the implant have been modified.² Pectus surgeons reported their experience with good to excellent outcome using a second bar or, in selected PE patients, even a third or fourth bar,³⁻⁵ in particular in patients with a severe PE deformity, such as Grand

IN SHORT

- In patients with severe pectus excavatum deformity, multiple bar placement has to be considered.
- The cross-bar technique achieves excellent results to correct pectus excavatum deformity, in particular with concomitant bilateral costal flaring or depression of the lower part of the chest wall.

Canyon type, or in adult patients with a rigid and stiff chest wall. Pilegaard,⁶ in 2015, reported the use of 2 short bars crossed under the sternum. In 2016, Park⁷

Accepted for publication Oct 25, 2022.

¹Department of Pediatric Surgery, Children’s Hospital of Eastern Switzerland, St Gallen, Switzerland; ²Faculty of Medicine, University of Basel, Basel, Switzerland; and ³Department of General, Visceral, Thoracic, Transplant and Pediatric Surgery, UKSH University Hospital of Schleswig-Holstein Kiel Campus, Kiel, Germany

Address correspondence to Dr Haecker, Department of Pediatric Surgery, Children’s Hospital of Eastern Switzerland, Claudiusstrasse 6, CH-9006 St Gallen, Switzerland; email: frank-martin.haecker@kispisg.ch.

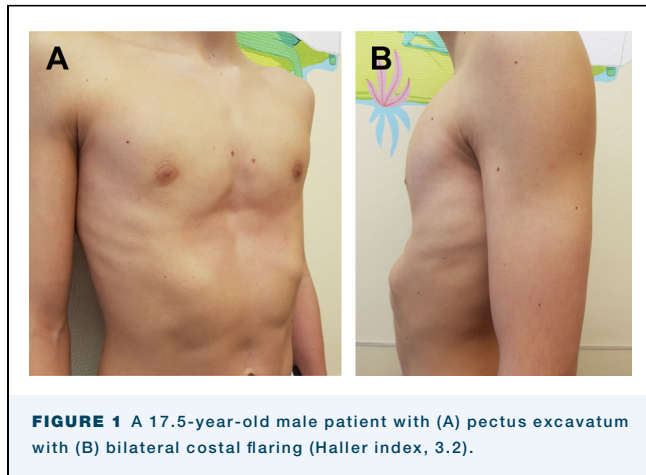


FIGURE 1 A 17.5-year-old male patient with (A) pectus excavatum with (B) bilateral costal flaring (Haller index, 3.2).

published a case using the cross-bar technique (CBT) for correction of complex PE, with the advantage of avoiding depression on the lateral chest wall. Moon and colleagues⁸ analyzed the use of parallel bars in comparison to CBT and concluded that CBT might be superior to the parallel bar insertion technique for correcting a wider range of chest wall deformities, especially at the lower part of the depression.

In 2018, we applied first-time CBT in a 17-year-old male PE patient who presented with severe bilateral depression of the chest wall combined with obviously pronounced costal flaring. We report our experience applying CBT in 5 PE patients presenting with severe bilateral costal flaring and analyze the early results.

MATERIAL AND METHODS

Within a 3-year period, a total of 35 PE patients underwent minimally invasive repair of PE. In 10 of 35 patients, placement of 2 bars was performed. Of the 35 patients, 5 underwent CBT with 2 bars. The final decision to apply CBT was taken during surgical procedure. Demographic data including imaging, data from surgical procedures, length of stay, and early and late postoperative complications of these 5 patients are presented.

All patients are placed in supine position with separated arms, under general anesthesia with single-lumen endotracheal intubation. The deepest point of the pectus deformity with the caudal end of the xiphoid and the targets to be lifted are marked with a pen on the skin. Right-sided thoracoscopy confirms the correct position of the extracorporeal marked targets, including the optional targets for application of CBT. Skin incisions are made on the lateral chest wall between the midaxillary and the ventral axillary line. For sternal elevation, we perform intraoperative application of the vacuum bell.⁹ After insertion of the introducer on the right side, right-to-left side retrosternal dissection is performed under

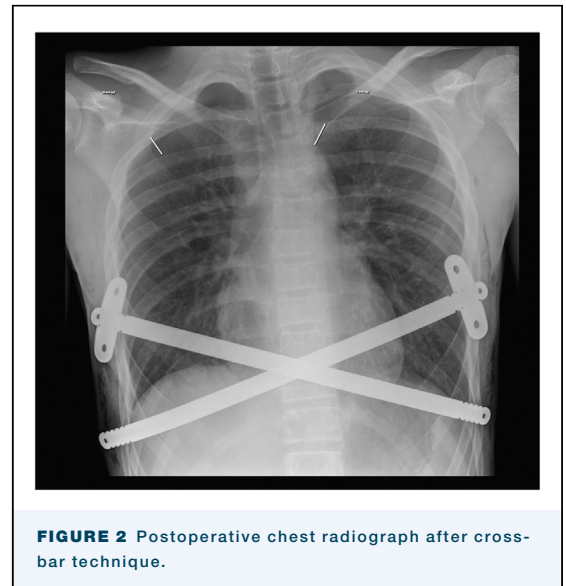


FIGURE 2 Postoperative chest radiograph after cross-bar technique.

direct thoracoscopic guidance. Sternal elevation allows direct visual control from the right entrance to the left exit. The first bar is usually directed from the right upper chest to the left lower chest; the second, from the right lower chest to the left upper chest, crossing the same retrosternal tunnel under the tip of the sternum. Individual bending of the bar according to the individual shape of the chest wall includes a soft twisting to optimize the position of the lateral bar ends on the lateral chest wall. The upper ends of the bars are secured with lateral stabilizers. In selected patients, additional lateral stabilizer placement at the lower bar end might be useful.

RESULTS

Five of 35 patients underwent CBT. Demographic data including imaging, data from surgical procedures, length of stay, and early and late postoperative complications of these 5 patients are summarized in the [Supplemental Table](#). All patients presented with significant bilateral costal flaring ([Figure 1](#)), and 4 of 5 presented with asymmetric PE. The final decision to apply CBT was taken during surgical procedure. The intraoperative and postoperative course was uneventful in all patients. Postoperative chest radiography excluded relevant pneumothorax ([Figure 2](#)); no chest tube placement was necessary. One of the patients presented with a prominent lateral edge of 1 pectus bar ([Figure 3](#)) but did not complain of any symptoms, pain, or any restriction. Of the 5 patients, 1 patient completed treatment with elective pectus bar removal after 3 years, and final follow-up after another 12 months demonstrated a persistent excellent result ([Figure 4](#)). Optimal correction of the deformity was

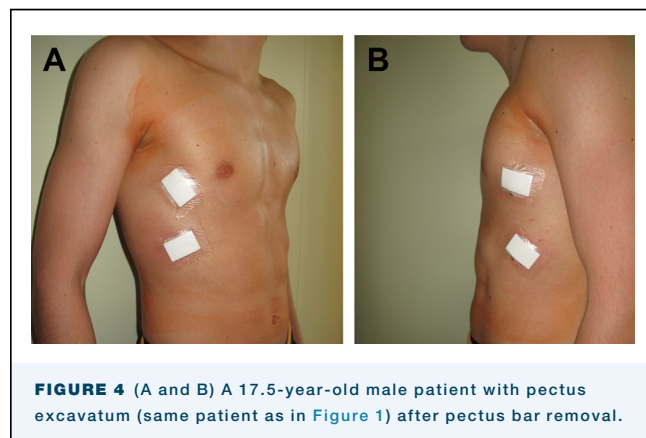
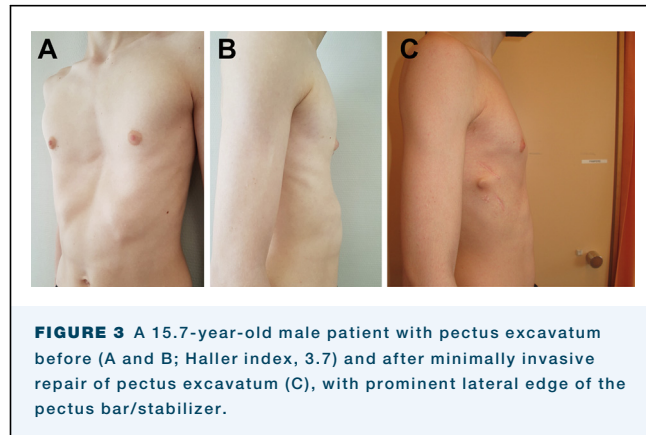
achieved in all patients. The outcome was classified as good to excellent by all patients and their parents.

COMMENT

In PE patients presenting with complex deformities, an individualized surgical repair is mandatory. An increasing number of studies report a good to excellent outcome using a second bar or even a third or fourth bar,³⁻⁵ in particular in adolescent and adult PE patients presenting with a rigid, stiff, and long PE deformity. In PE patients with concomitant costal flaring and lower chest wall depression, CBT is a valuable modification of using 2 bars. Crossing the bars on the right target, CBT enables an effective lifting and secure placement of the 2 bars.^{7,8} The lifting forces of the 2 bars focalize on the area of the deepest impression. The physical forces of the deepest point of the chest wall are distributed to 2 bars. As a consequence, the risk of secondary bar displacement is reduced significantly. Furthermore, CBT enables lifting of the lower lateral chest wall in PE patients with expected bilateral costal depression located lower than the xiphoid, as demonstrated in our patients (Figures 3 and 4).

None of our patients experienced secondary bar displacement, which is a well-known complication in particular in adolescent and adult PE patients with severe deformity. Based on the diagonal position of the bars, with the lateral ends resting on the lower rib cage, not only is a potential secondary flaring using parallel bars avoided, but a costal flaring can actually be corrected. A visible and palpable prominent edge of the stabilizer and the lateral end of the pectus bar was noticed as the only complication in our study group. Some authors recommend the bridge fixation technique connecting multiple bars to guarantee stable bar placement and to avoid secondary bar displacement and our observed adverse effect.¹⁰

A recently published study listed the following indications for CBT: acute pointy xiphoid depression; inflexible focal chest wall depression; bilateral costal depressions lower than the sternal tip, as demonstrated with our patients; reoperation cases; and long deformities, such as Grand Canyon type PE.¹⁰ Hyun and Park reported on their experience including an impressive number of patients who underwent CBT.¹⁰ Of course, the number of our patients is not comparable with this high-volume center and other published study populations. However, despite the small study population and the lower case load, we may confirm their experience that CBT is a safe and effective technique, even though it was selected to correct more complexities. Today, CBT is an inherent



part of our routine program of minimally invasive repair of PE.

In conclusion, individualized surgical repair is mandatory in PE patients presenting with complex deformities. In PE patients presenting with concomitant bilateral costal flaring or depression of the lower part of the chest wall, CBT is an effective technique in repair of these deformities. CBT provides comprehensive chest wall coverage and more effective chest wall lifting while the force of elevating the sternum is distributed on 2 bars, without compromising the lateral chest wall. We recommend CBT for surgical repair of complex PE deformities to achieve excellent cosmetic results.

The Supplemental Table can be viewed in the online version of this article [<https://doi.org/10.1016/j.atsr.2022.10.019>] on <http://www.annalsthoracicsurgery.org>.

FUNDING SOURCES

The authors have no funding sources to disclose.

DISCLOSURES

The authors have no conflicts of interest to disclose.

REFERENCES

1. Nuss D, Kelly RE, Croitoru DP, Katz ME. A 10-year review of a minimally invasive technique for the correction of pectus excavatum. *J Pediatr Surg.* 1998;33:545-552.
 2. Notrica DM. Modifications to the Nuss procedure for pectus excavatum: a 20-year review. *Semin Pediatr Surg.* 2018;27:133-150.
 3. Ewais MM, Chaparala S, Uhl R, Jaroszewski DE. Outcomes in adult pectus excavatum patients undergoing Nuss repair. *Patient Relat Outcome Meas.* 2018;9:65-90.
 4. Jaroszewski DE, Ewais MM, Chao CJ, et al. Success of minimally invasive pectus excavatum procedures (modified Nuss) in adult patients (≥ 30 years). *Ann Thorac Surg.* 2016;102:993-1003.
 5. Ben XS, Deng C, Tian D, et al. Multiple-bar Nuss operation: an individualized treatment scheme for patients with significantly asymmetric pectus excavatum. *J Thorac Dis.* 2020;12:949-955.
 6. Pilegaard HK. Nuss technique in pectus excavatum: a mono-institutional experience. *J Thorac Dis.* 2015;7(suppl 2):S172-S176.
 7. Park HJ. A technique for complex pectus excavatum repair: the cross-bar technique for Grand Canyon type deformity (Park classification). *Ann Cardiothorac Surg.* 2016;5:526-527.
 8. Moon DH, Park CH, Moon MH, Park HJ, Lee S. The effectiveness of double-bar correction for pectus excavatum: a comparison between the parallel bar and cross-bar techniques. *PLoS One.* 2020;15:e0238539. <https://doi.org/10.1371/journal.pone.0238539>
 9. Haecker FM, Krebs T, Kocher GJ, Schmid RA, Sesia SB. Sternal elevation techniques during the minimally invasive repair of pectus excavatum. *Interact Cardiovasc Thorac Surg.* 2019;29:497-502. <https://doi.org/10.1093/icvts/ivz142>
 10. Hyun K, Park HJ. The cross-bar technique for pectus excavatum repair: a key element for remodeling of the entire chest wall. *Eur J Pediatr Surg.* Published online July 12, 2022. <https://doi.org/10.1055/a-1897-7202>
-