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Case Report

Repair of Recurrent Pectus Excavatum with a Huge Chest Wall Defect in a Patient with a Previous Ravitch and Pectus Bar Repair: A Case Report

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Recurrent pectus excavatum (PE) after a Ravitch operation is not uncommon. Extensive costal cartilage resection from the previous Ravitch procedure can lead to an irregular, unstable chest wall depressions with a varying degree of deformity. The optimal approach to cover the chest wall defect and remodel the deformity, remains unknown. We report the case of a 27-year-old woman seeking surgery for the third time for recurrent PE. The patient presented with 2-time recurrent pectus excavatum following a failed Ravitch procedure and subsequent pectus bar repair. The entire chest wall reconstruction and remodeling entailed covering the chest wall defect with 2 titanium plates across both sides of the rib cage, and lifting and fixing the depressed chest wall with 2 parallel pectus bars.

Keywords: Recurrent pectus excavatum, Chest wall defect, Chest wall reconstruction, Ravitch operation, Case report

Case report

A 27-year-old female patient presented with recurrent pectus excavatum (PE). She had a history of 2 operations for her deformity. She was first diagnosed with symmetric PE (Park classification type 1A) and underwent a Ravitch operation elsewhere at 5 years of age. Two years later, she required a redo PE repair using a pectus bar for a recurrent deformity involving a large and defective chest wall. The patient underwent repair using 2 parallel pectus bars with good correction of the deformity, and the bars were removed successfully 3 years later. She visited our clinic 10 years later (at 20 years of age) with a recurrence of PE (Fig. 1).

A chest X-ray examination showed significant depression of the anterior chest wall and residual fragments of sternal wire. Chest computed tomography (CT) revealed a large chest wall defect around the half-remaining sternum. The chest wall depression was considerable, with a Haller index of 5.64 and an asymmetry index of 1.01 (Fig. 2).

Since the patient had a huge chest wall defect following a failed Ravitch operation and subsequent pectus bar reoperation, we searched for the optimal approach to ensure a long-lasting and durable outcome. Initially, chest wall remodeling with a 3-dimensional (3D)-printed artificial chest wall was considered. However, we could not proceed with this surgical strategy due to an inability to obtain approval from governmental authorities. The alternative option was reconstruction of the chest wall defect in addition

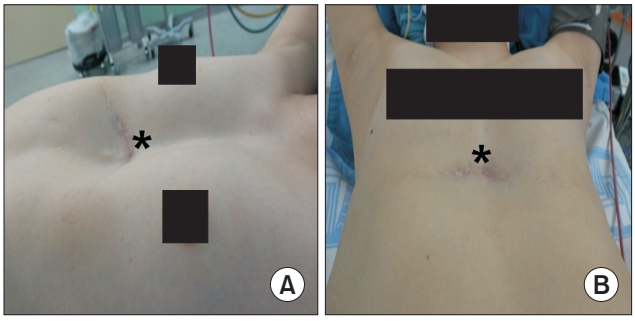

Fig. 1. (A) Depression of the anterior chest wall in a lateral view. Asterisk (*) represents the wound from the previous Ravitch procedure. (B) Pectus excavatum type 1A (symmetric classical type) in an anterior view. Written informed consent for publication of this image was obtained from the patient.

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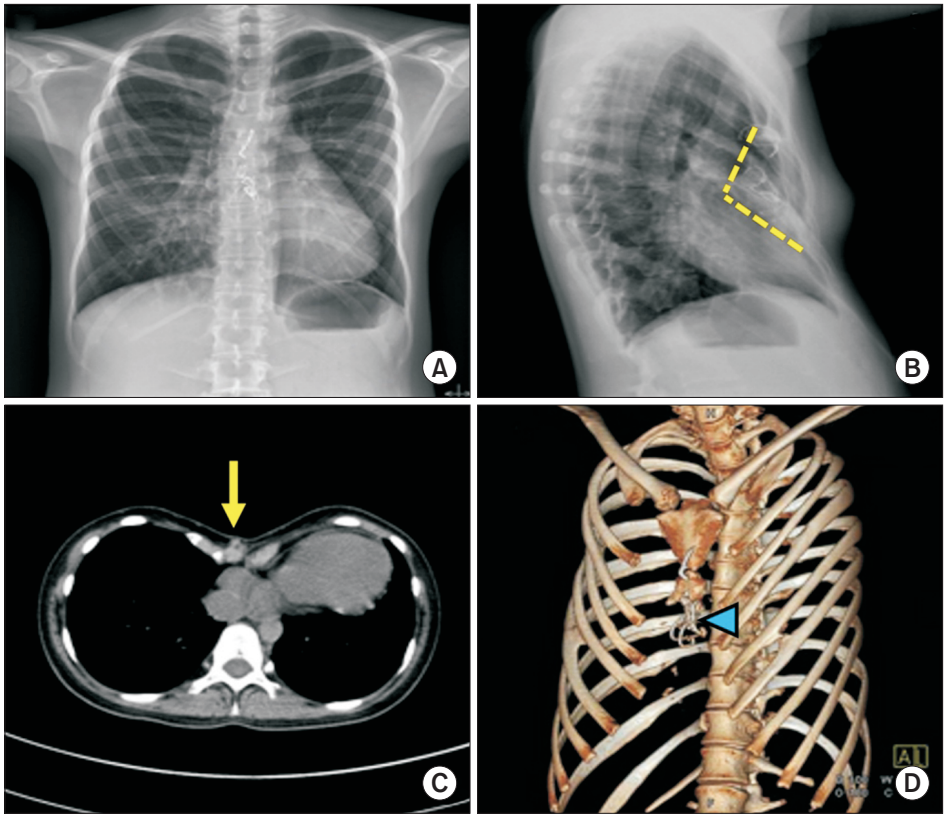

Fig. 2. (A, B) Preoperative chest X-ray showing depression of the anterior chest wall. (C) Axial view of computed tomography (CT) showing a Haller index of 5.64 and an asymmetry index of 1.01 (arrow). (D) Preoperative chest CT 3-dimensional reconstruction showing previous sternal wiring and the anterior chest wall deformity (arrowhead).

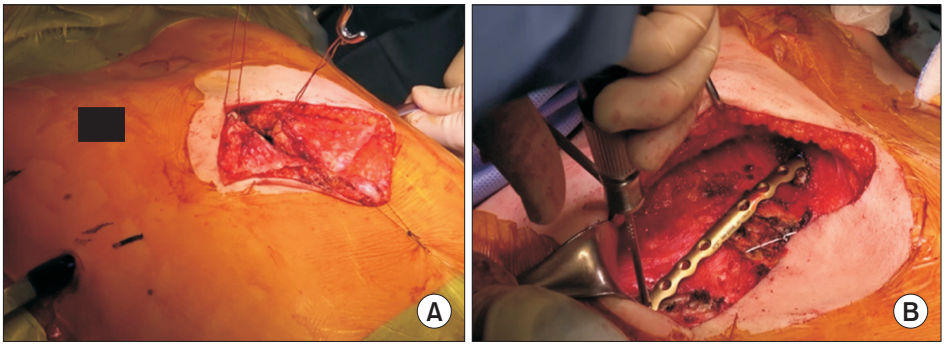

Fig. 3. (A) Retrosternal dissection was performed using the crane technique with wires applied at the bilateral lower sternum. Lower parallel bar insertion (27.94 cm; Primemed, Seoul, Korea) was performed with a pectoscope under chest tube guidance, and additional sternal wiring was done at the second intercostal space. The same procedures were repeated for the upper bar. The positions of both bars were checked. For the fixation, a 10-hole bridge plate was connected. (B) Rib-locking plates with sternal wiring were used to fix the sternum. Written informed consent for publication of this image was obtained from the patient.

to permanent support to the depressed chest wall. Therefore, we elected the permanent pectus bar insertion strategy.

Thus, the surgery entailed lifting the depressed chest wall with pectus bars, followed by revising the rib cage defect and creating a new solid chest wall using plate-screw reconstruction. During the operation, the previous incision scar was opened to expose the sternum. The lower part of the sternum was dissected and lifted using a wire-crane system, and the space between the heart and the chest wall was developed using sharp and blunt dissection under direct vision (Fig. 3A). Two pectus bars were safely placed across the mediastinum under visual guidance under the sternum (Fig. 3B). The pectus bars (Fig. 4, *), supporting the chest wall in a parallel fashion, were fixed together with a bridge (Fig. 4, arrows) on each side. Subsequently, 2

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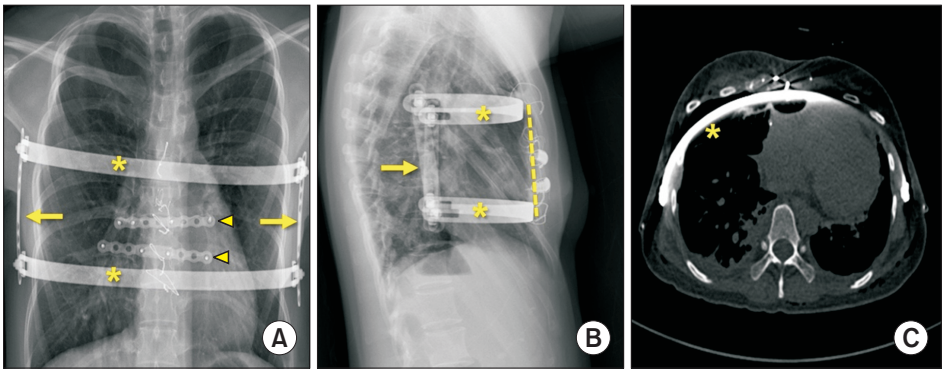

Fig. 4. (A, B) Outpatient chest X-ray revealing correction of the pectus excavatum (PE). The asterisk (*) symbols represent the parallel pectus bars, the arrows represent the bridge plate, and the arrowheads represent the rib-locking plates. (C) Postoperative day 3 chest computed tomography showing correction of the PE with a decrease in the Haller index from 5.64 to 2.76.

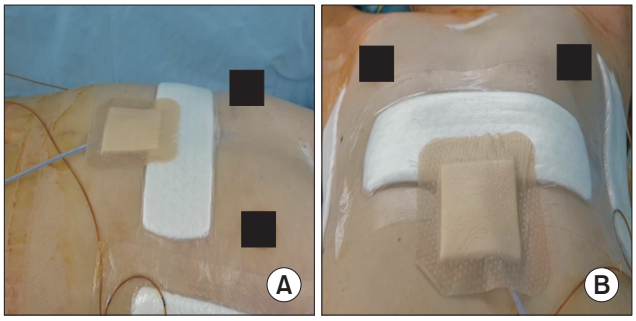

Fig. 5. Correction of the chest wall depression. (A) Lateral view; (B) anterior. Written informed consent for publication of this image was obtained from the patient.

titanium plates (Primemed, Seoul, Korea) were transversely placed to bridge the gap between the right and left ends of the defective rib cages and fixed onto the reciprocal ribs using screws. All procedures were conducted smoothly, and the correction of the chest wall defect and depression was complete (Fig. 5). The repaired anterior chest wall was stout, and the excavatum was corrected to the normal level. The patient's postoperative recovery was uneventful, and she was discharged on postoperative day 8. Postoperative chest CT revealed a well-corrected chest wall with a decreased Haller index (from 5.64 to 2.64) with no residual deformity.

This study was determined to be exempt by the Institutional Review Board of the Catholic University of Korea, Catholic Medical Center (IRB approval no., KC21ZISI0538). The patient provided written informed consent for publication of the research details and clinical images.

Discussion

The Ravitch operation has been associated with several issues. A large anterior chest incision often results in an inferior cosmetic outcome. Extensive costal cartilage resection leads to recurrent chest wall depression [1], chest wall defect, and constriction due to damage to the perichondrial sheaths and incomplete cartilage regeneration, ultimately resulting in sternal instability, acquired thoracic dystrophy, and recurrent PE.

Revision surgery can be challenging due to adhesions between the mediastinum and the sternum, chest wall rigidity from the prior surgical scar that increases the complexity of the subsequent repair [2], and in particular, irregular chest wall deformities due to extensive costal cartilage resections. Thus, the decision to repair failed Ravitch procedure cases requires great attention due to the operative complexity, risk, and the possibility of incomplete repair or less favorable outcomes.

A recurrent chest wall depression, chest wall defect, and a combination thereof are indications for reoperation due to a deformity resulting from a failed Ravitch operation [3]. It is difficult to set a uniform protocol to manage these deformities due to their complexity and diversity.

The case we report here involved the combination of an extensive chest wall defect, loss of all the cartilages around the half-absent sternal body, and a significant chest wall depression. The previous pectus bar repair initially appeared effective for recurrent PE after the failed initial Ravitch operation; however, the deformity recurred again following pectus bar removal.

Our approach for the third repair was designed to address the complexity of the deformity, and primarily to ensure the durability of the repair. We first considered a 3D-printed artificial chest wall reconstruction, which is an anatomically patient-tailored implant, as the best option given the patient's condition including a very large chest wall defect and recurrent PE after multiple previous repair attempts. However, due to legal and administrative issues of approval, we decided to conduct titanium plate recon-

struction of the rib cage defect and placement of permanent pectus bars.

Post-Ravitch chest wall reconstruction or remodeling entailed reopening of the anterior scar to safely explore the densely adherent mediastinum. Pectus bars were introduced through the mediastinal opening, where the sternum was dissected free and already fully elevated with the wire crane. The sternal/costal margins were then trimmed and shaved. The focal chest wall defects were covered with pectus major or rectus abdominis muscle partial flaps (pectoplasty) or commercially available patches (polytetrafluoroethylene patch or polypropylene mesh).

Other studies reported different strategies for the revision of failed Ravitch procedures, such as using a hybrid technique using a pectus bar placement after osteotomies of the sternum and lateral ribs [4]. The use of a thoracoscopic bar is similar to our technique, but we advocated placement of the pectus bars under direct vision through the anterior scar opening and dissection between the heart and the chest wall. The most critical part of this operation is to avoid cardiac injury due to the dense mediastinal adhesions.

Biomaterials have also been utilized in pectus repair for a failed Ravitch procedure with an absorbable pectus bar (poly-L-lactide) [5]. However, the long-term effectiveness and durability of this technique, which avoids bar removal, is questionable.

The case we report here presented a challenge due to the extensive chest wall defect around the sternum and recurrent sternal collapse. We selected a complex technique combining chest wall reconstruction with titanium struts and long-lasting support for the weakened, defective chest wall with pectus bars.

Since minimally invasive pectus surgery started merely around 20 years ago, the outcomes of permanent pectus bars have yet to be explored. Major concerns regarding metal implants are allergic reactions, infection, and durability of the implant. However, titanium is one of the most preferred metal implant materials that has been used for more than 50 years due to its strong nature, fracture toughness, and high biocompatibility. Another concern related to permanent pectus bar insertion may be the limitation of chest compressions during cardiopulmonary resuscitation events [6]. Nonetheless, permanent pectus bar insertion seemed to be the most appropriate option for this patient.

Here we present a case of repair after the failure of a Ravitch procedure and minimally invasive repair of PE. The defect was successfully repaired using titanium plate reconstruction and permanent pectus bar placement. Although 3D-printed artificial chest wall reconstruction was not feasible, our approach represents a reasonable alternative in the interim.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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References

1. Jaroszewski DE, Ewais MM, Lackey JJ, et al. *Revision of failed, recurrent or complicated pectus excavatum after Nuss, Ravitch or cardiac surgery*. J Vis Surg 2016;2:74.
2. Johnson KN, Jaroszewski DE, Ewais M, Lackey JJ, McMahon L, Notrica DM. *Hybrid technique for repair of recurrent pectus excavatum after failed open repair*. Ann Thorac Surg 2015;99:1936-43.
3. Sacco Casamassima MG, Papandria D, Goldstein SD, et al. *Contemporary management of recurrent pectus excavatum*. J Pediatr Surg 2015;50:1726-33.
4. Redlinger RE Jr, Kelly RE Jr, Nuss D, Kuhn MA, Obermeyer RJ, Goretsky MJ. *One hundred patients with recurrent pectus excavatum repaired via the minimally invasive Nuss technique: effective in most regardless of initial operative approach*. J Pediatr Surg 2011;46:1177-81.
5. Miller DL. *Reoperative pectus repair using biomaterials*. Ann Thorac Surg 2020;110:383-9.
6. Stearns JD, Twaibu J, Kwaku D, et al. *Efficacy of standard chest compressions in patients with Nuss bars*. J Thorac Dis 2020;12:4299-306.