



## Correspondence on Should the Ravitch Procedure to Correct Pectus Excavatum Be Avoided in Young Children?

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### To the editor:

In addition to the excellent outcome they obtained, the case reported by Rim and Park [1] shows the boldness and inventiveness of the authors: boldness for performing the fourth surgical procedure (previously, the patient had undergone the Ravitch procedure, correction with 2 metal bars, and removal of the bars) for the repair of recurrent pectus excavatum (PE), and inventiveness for proposing a 3-dimensional-printed artificial thoracic wall, which as far as we know is an unprecedented treatment, to correct this serious defect.

This case also has an important aspect that, in our view, should be emphasized. The authors describe severe instability of the patient's thoracic wall. This finding is not unusual after the Ravitch procedure, and one of us (S.A.B.) has already reported this event in the literature [2]. This instability has been attributed to incomplete regeneration of resected cartilage, which can lead to sternocostal instability or even floating sternum, and this pathophysiological explanation has been widely accepted.

However, what is worth noticing in the present case is that the patient's sternum did not develop properly. Regardless of the incomplete regeneration of the cartilage, the "half-remaining sternum" seems to have been the main reason for the chest wall instability. Complications of the Ravitch procedure have been reported in the literature, but even in literature reviews that include many cases, there is no mention of incomplete development of the sternum [3].

It's well known that cardiac surgeons are afraid of using

both mammary arteries for coronary artery grafting because of concerns over sternal devascularization and a higher risk of deep sternal wound infection [4].

If sternal devascularization can be a problem in adult patients, it seems fair to believe that the extensive cartilage resection required in the Ravitch procedure performed in a young child could injure the vessels that originate in the breast and form collaterals between the sternum and the posterior intercostal arteries, which supply the sternum. This probably explains the underdevelopment of the sternum.

We would like to congratulate Dr. Park and his team for their superb result and would like to emphasize that extensive operative procedures for repair of PE (and pectus carinatum) in (very) early infancy can interfere with chest wall growth and result in chest wall instability and severe pulmonary dysfunction.

### Conflict of interest

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

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### The author's reply:

We appreciate the comments from Dr. de Beer and his team. We had great interest in their publication [1] on the cases of "sternocostal instability after Ravitch repair," but we omitted to mention this important work in our recent report illustrating a new approach for post-Ravitch chest wall repair [2].

We completely agree with their statements on the risk of extensive cartilage resection in young patients undergoing pectus excavatum or carinatum repair. In the worst-case situation, insufficient chest wall growth has been linked to thoracic dystrophy and a chest cage that is small and restrictive [3,4]. The following are the author's observations of post-Ravitch repair patients: (1) failure to grow led to a cone-shaped, narrow upper chest cage; (2) the conglomerated frozen chest wall structures caused acquired restrictive thoracic dystrophy; (3) the loss of costal structure resulted in a chest wall defect, leaving the heart unprotected, lying only beneath the skin; and (4) the pectus excavatum deformity recurred.

In the case we reported [2], multiple unsuccessful repair attempts made us frustrated. These included the Ravitch repair, which was done elsewhere, and then the pectus bar repair. We needed to devise a new approach, such as implanting a 3-dimensional (3D)-printed artificial chest wall. We could not obtain permission to use 3D-printed materials for compassionate reasons, and we decided to use sophisticated chest wall support with plate-screw reconstruction of the anterior defective chest wall and semi-permanent pectus bar support.

Unlike a case by de Beer and van Heurn [1], ours seems more complicated because the chest wall was significantly depressed and the cartilage around the half-missing sternal body was completely lost. Due to recurrent failures in the past, we required a durable and long-lasting metal support for the sunk and deficient chest wall deformities. We were satisfied with how the chest wall was fixed and how stable the sternum was in this case, but ultimately, we hope to use

3D-printed artificial chest wall reconstruction in such patients in the near future.

The authors' policy for repairing congenital pectus deformities with pectus excavatum/carinatum/arcuatum has been to use pectus bars to preserve the costal structures and remodel the chest wall in a minimally invasive manner. We do not resect the chest wall; instead, we remodel it. However, for recurrent pectus excavatum after the Ravitch operation, mediastinal adhesion and a conglomerated frozen chest wall made the repair difficult and incomplete. First and foremost, loss of the cartilage around the sternum led to the lack of a sufficient skeleton for remodeling. As a result, the long-term maintenance of the chest wall deficiency was lost when the pectus bar support was removed.

We congratulate Dr. de Beer's group on their successful repair of complicated cases involving floating sternum and a deficient chest wall, using their unique strut and mesh support technique. It is crucial to disseminate the information that excessive costal cartilage injury hinders chest wall growth and jeopardizes structural integrity.

### Conflict of interest

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