

# Nuss procedure for surgical stabilization of flail chest with horizontal sternal body fracture and multiple bilateral rib fractures

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**Abstract:** Flail chest is a life-threatening situation that paradoxical movement of the thoracic cage was caused by multiply fractured ribs in two different planes, or a sternal fracture, or a combination of the two. The methods to achieve stability of the chest wall are controversy between surgical fixation and mechanical ventilation. We report a case of a 33-year-old man who fell from a high place with flail chest due to multiple rib fractures bilaterally and horizontal sternal fracture. The conventional surgical stabilization using metal plates by access to the front of the sternum could not provide stability of the flail segment because the fracture surface was obliquely upward and there were multiple bilateral rib fractures adjacent the sternum. The Nuss procedure was performed for supporting the flail segment from the back. Flail chest was resolved immediately after the surgery. The patient was weaned from the mechanical ventilation on third postoperative day successfully and was ultimately discharged without any complications.

**Keywords:** Nuss procedure; sternum fracture; rib fractures; flail chest

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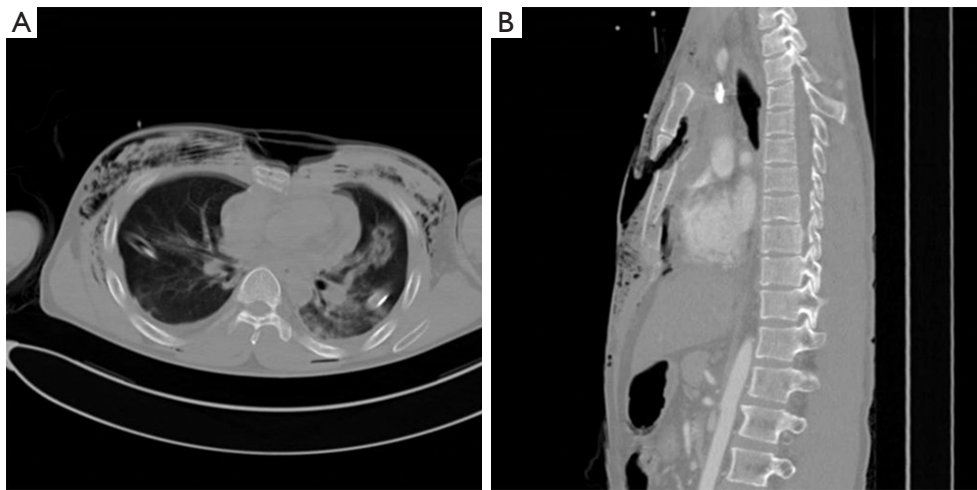
## Introduction

Flail chest is a life-threatening situation that paradoxical movement of the thoracic cage was caused by multiply fractured ribs in two different planes, or a sternal fracture, or a combination of the two (1,2). We present a case in which the Nuss procedure was performed for stabilization of flail chest.

## Case presentation

A 33-year-old man was admitted to the emergency department after severe trauma to the chest by falling from a high place. His initial vital signs were as follows: respiratory rate 31 breaths/minute; heart rate 142 beats/minute; blood pressure 150/90 mmHg. A chest computed tomography revealed a horizontal sternal body fracture, multiple rib fractures bilaterally from the third to the seventh on the right side and from the fourth to the seventh on the left side, and bilateral hemopneumothorax. The lower half of the anterior chest wall was depressed due to the horizontal fracture of

the sternal body and bilaterally fractured ribs adjacent to the sternum (*Figure 1*). Initially, closed thoracostomy was performed bilaterally. The paradoxical movement of the anterior chest wall developed on inspiration and respiratory failure occurred. The mechanical ventilation was applied with positive end-expiratory pressure. The patient was unable to wean from the mechanical ventilation during 7 hospital days. A tracheostomy was performed for the long-term mechanical ventilation. However, the patient was unable to wean from the mechanical ventilation due to remained flail chest until 14<sup>th</sup> hospital day. The surgical stabilization was considered to wean from the mechanical ventilation. Surgical procedures performed in the supine position under the general anesthesia. Skin incision was made on the midline of the sternum. The sternal body fracture was fixed by two metal plates (Matrix RIB™ Fixation System, Synthes CMF, West Chester, PA, USA). However, it could not provide stability of the fractured sternum because the fracture surface was obliquely upward (*Figure 1*) and there were multiple bilateral rib fracture adjacent the sternum. We thought that



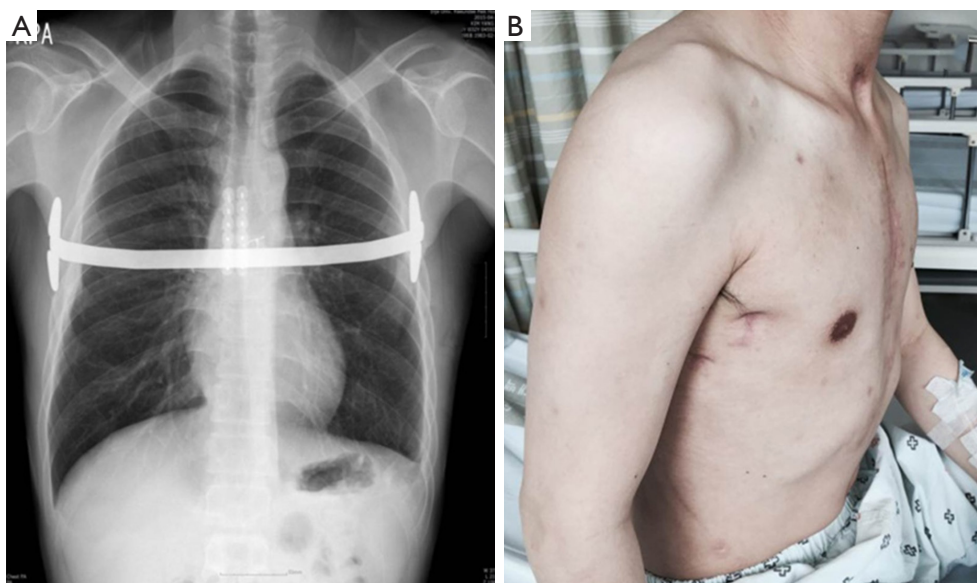
**Figure 1** Preoperative computed tomography. (A) Chest computed tomography reveals depressed anterior chest wall and subcutaneous emphysema; (B) sagittal view reveals an oblique fracture of sternal body.

supporting the fractured sternum and ribs from the back was needed. We decided to perform the Nuss procedure to support the sternum and fractured ribs from the back. Skin incisions were made on the lateral chest wall bilaterally in the mid-axillary line and subcutaneous planes were created for bilateral pleural entry points. A skin tunnel was raised anteriorly, and the left 4<sup>th</sup> intercostal space was entered using a long curved Kelly clamp. The mediastinal dissection was done blindly below the sternum and tip of a long curved Kelly clamp was passed through the 4<sup>th</sup> intercostal space of the opposite side. Thirty-six centimeter pectus bar (PECTUS BAR, Biomet Microfixation, Jacksonville, FL, USA) was bent into a symmetric arc shape. The pre-shaped pectus bar was passed through the tract with the convex side down. The pectus bar was then rotated and the depressed chest wall was elevated. The stabilizers were attached to the ends of the bar bilaterally. The pectus bar was fixed to the rib bilaterally. Flail chest was resolved immediately after the surgery. The patient was weaned from the mechanical ventilation on postoperative day 3 and flail chest did not recur. The patient was discharged on postoperative day 7 without any complication. The pectus bar was removed 6 months after the surgery. The chest wall depression did not occur (*Figure 2*).

## Discussion

Flail chest usually occurs with the multiply fractured ribs in two different planes or a sternal fracture, or a combination of the two (1,2). This leads to instability of the chest

wall that shows paradoxical movement locally, which can result in respiratory failure (1,2). The methods to achieve stability of the chest wall are controversy between surgical fixation and mechanical ventilation. Severe flail chest usually requires the mechanical ventilation with positive end-expiratory pressure for 7 to 14 days until there was no paradoxical movement (1-3). However, the prolonged mechanical ventilation can cause many problems such as hospital-acquired infections (1-5). Several studies have suggested that surgical stabilization resulted in a lower incidence of ventilator-induced complications by decreasing the duration of the mechanical ventilation. They also suggested that the early surgical stabilization might decrease the duration of intensive care unit stay (3-5). Indication for surgical stabilization of flail chest is as follows: associated injury requiring a thoracotomy, respiratory dysfunction despite aggressive medical treatment, thoracic deformity, unremitting pain and excessive paradoxical movement (2-5). However, conventional surgical stabilization may be difficult to apply in some cases, because of the combined diseases and characteristics of the fractures. In this case, flail chest occurred due to the horizontal sternal body fracture and multiple rib fractures bilaterally adjacent the sternum. The conventional surgical stabilization using metal plates by access to the front of the sternum could not provide stability of the flail segment because of characteristics of the sternal fracture and combined multiple bilateral rib fractures. Supporting of the fractured sternum from the back was needed. Therefore, the Nuss procedure was performed



**Figure 2** Postoperative radiography and photography. (A) Post-operative radiography of chest; (B) photography after removal of the pectus bar shows that there is no recurrence of chest wall depression.

which has been widely used to repair pectus excavatum. It provided the stability of the chest wall successfully and allowed to wean from the mechanical ventilation. In conclusion, the Nuss procedure may be useful in the patient with flail chest due to sternal fracture and multiple bilateral rib fracture adjacent the sternum which cannot be corrected by conventional surgical stabilization.

### Acknowledgements

None.

### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Informed Consent:* Written informed consent was obtained from the patient for publication of this case report. A copy of the written consent is available for review by the Editor-

in-Chief of this journal.

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