respiratory compromise is related to the wasted thoracic muscles.

When faced with this patient, we were unsure about the extent of contribution to the symptoms related to the diaphragm paralysis. Initially, we were keen to try noninvasive ventilation as a treatment strategy. After some deliberation, we decided to try plication as mainly a method by which the patient could be more able to recline. We were pleasantly surprised by the improvements in the patient’s symptoms and by the objective improvement seen in the PFT results.

The staged approach allowed not only for stabilization of the patient but was also helpful in assessing improvement. We present this case to highlight the point that bilateral plication of paralysed diaphragm in Charcot-Marie-Tooth disease can lead to a dramatic improvement in quality of life, supported by objective evidence, and should be considered in this subgroup of patients.

References

Thoracoscopy-Assisted Minimally Invasive Surgical Stabilization of the Anterolateral Flail Chest Using Nuss Bars

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Flail chest is caused by complex fractures of multiple ribs as a result of severe chest injuries, which results in paradoxical chest movements that severely compromise respiratory function. We report our experience of thoracoscopically assisted, minimally invasive surgical stabilization of massive anterolateral flail chest using a Nuss bar in three patients. This technique offers effective stabilization while having the advantages of short surgical time, minimal blood loss, less trauma, quicker recovery, and small and inconspicuous incisions.


Flail chest is caused by complex fractures of multiple ribs as a result of severe chest injuries. Because of the paradoxical movement, a flail chest can cause a significant decrease in tidal volume and an inability to clear airway secretions. These patients are prone to developing pneumonia and respiratory failure. Traditionally, patients with flail chest are treated with prolonged mechanical ventilation. In recent years, surgical fixation of the flail segment has become more accepted in selected patients. Several studies have shown that surgically treated patients have decreased ventilation and ICU requirements, a lower risk for pneumonia and mortality, less residual chest wall deformity, reduced total cost of care, and quicker return to work [1, 2]. Despite these advantages, surgical stabilization of flail chest remains underutilized because of the unfamiliarity of surgeons with stabilization techniques and the lack of effective hardware [3, 4].

We report our experience with thoracoscopically assisted, minimally invasive surgical stabilization of massive anterolateral flail chest using a Nuss bar in three patients. This technique offers effective stabilization while having the advantages of less trauma and quicker recovery.

Case Reports
Surgical Technique

Chest measurements were performed before surgery, and steel bars of appropriate length were selected. Steel bars were bent using anvil bar benders according to the three-dimensional reconstruction of their CT images. Using general anesthesia, a 1.0-cm incision was made in each uninjured chest wall on both sides of the flail segment. The pleural cavities were inspected using video-assisted thoracoscopy. Blood clots were removed and the pleural cavities were irrigated. Submuscular tunnels were made from each incision to a position lateral to the flail segment. A Nuss bar (Pectus Support Bar System; PTY Medical Device, Shanghai, China) was passed from a pre-selected uninjured intercostal incision, through the submuscular tunnel, and into the pleural cavity under thoracoscopic monitoring. The Nuss bar was passed across the mediastinum under the flail segment, and we brought out the chest wall through a preselected, uninjured intercostal incision, through the submuscular tunnel, and into the pleural cavity under thoracoscopic monitoring. The Nuss bar was passed across the mediastinum under the flail segment, and we brought out the chest wall through a preselected, uninjured intercostal incision, through the submuscular tunnel, and into the pleural cavity under thoracoscopic monitoring. The Nuss bar was passed across the mediastinum under the flail segment, and we brought out the chest wall through a preselected, uninjured intercostal incision, through the submuscular tunnel, and into the pleural cavity under thoracoscopic monitoring.

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Case 1
A 58-year-old man was transferred to our emergency center 5 hours after sustaining a lorry strike to the anterior chest. Upon arrival, there was severe paradoxical movement of the chest wall. The patient had dyspnea and was unable to clear bloody secretions. His SaO₂ dropped to 80%. CT imaging with three-dimensional reconstruction revealed bilateral fractures of the second to fourth ribs, an upper sternal fracture, disruption of the costochondral junction bilaterally, bilateral hemothorax, and pulmonary contusions (Fig 1A). Surgical stabilization was performed 2 d later with the patient in the supine position. A transverse incision was made in each lateral chest wall between the anterior axillary and posterior axillary lines for thoracoscopically assisted Nuss bar placement. Surgical time was 120 min, and blood loss was 100 mL. The patient was extubated immediately after surgery and was able to breath comfortably without paradoxical movement. He was discharged home on postoperative day 12, and he resumed normal daily activities by 4 weeks. Follow-up chest radiographs showed no displacement of bars (Fig 1B). The Nuss bars were removed at 11 months after surgery without any adverse consequences (Fig 1C).

Case 2
A 30-year-old woman was transferred to our emergency center 4 days after sustaining a crush injury in a motor vehicle crash. There was severe paradoxical motion of the chest wall. Computed tomographic imaging and plain radiographs (Fig 2A) revealed multiple left anterolateral rib fractures and a left hemothorax. The patient also suffered a fracture of the pelvis, left acetabulum, and left olecranon. Nuss bar placement was performed 4 days later in a right recumbent position with two transverse incisions in the anterior axillary and scapular lines (Fig 2B). Surgical time was 80 min with minimal blood loss. Chest wall fixation prevented deterioration of her overall condition and allowed surgical stabilization of the pelvis and other fractures 6 d later. Her Nuss bar was removed 5 months later (Fig 2C).

Case 3
A 46-year-old man presented to our emergency center 2 hours after sustaining a trauma to the anterior chest...
during a motor vehicle accident. An anterolateral segment of the chest wall was noted to move paradoxically with inspiration. CT imaging with three-dimensional reconstruction revealed a 70% left-sided hemopneumothorax, left second to fifth and seventh rib fractures, sternal fracture, and bilateral pulmonary contusions (Figs 3A, 3B). A right thoracotomy was performed with an immediate release of air. Surgical stabilization was performed with the patient in the supine position, using transverse incisions in each lateral chest wall between the anterior axillary and posterior axillary lines (Fig 3C). Surgical time was 60 min with 80 mL of blood loss. He was extubated immediately after surgery and breathing comfortably without paradoxical movement. Chest tubes were removed 4 d after surgery, and he was discharged home on day 13.

Comment

All three patients in this report had anterolateral flail chest with a highly mobile flail segment and intense pain. Therefore, they were good candidate for surgical stabilization.

Several techniques have been described for surgical stabilization, including the use of Judet’s or other struts, acetabular reconstruction plates, intramedullary K-wires, resorbable plates, and Vicryl sutures. All surgical stabilization methods require a long incision with muscle dissection to expose the fractures. These procedures are complex and time consuming, and they have considerable blood loss and slow recovery. These complicated surgical procedures and stabilization hardware are not familiar to most surgeons and therefore have not been popularized.

The Nuss operation for pectus excavatum has become increasingly popular among surgeons and patients because of simplicity, fewer complications, and good outcomes [5]. The technique described herein is analogous to the Nuss operation for pectus excavatum, and it greatly simplifies the procedure for flail chest stabilization. The flail segment was fixed using this procedure. Although the fractures were not completely reduced, the chest wall was stable and a near normal chest wall contour and physiology were restored. The reduction and fixation of the flail segments also immediately relieved pain, thus enabling normal respiration. No pseudarthrosis or chronic pain were found in the three patients during following-up. With small surgical incisions, less muscle dissection, minimal blood loss, and shorter surgical time, the procedure is truly minimally invasive, which prompts the patient’s rapid recovery. Being familiar to most thoracic surgeons, this technique can be learned easily and popularized. Guided by thoracoscopy, exploration of the pleural cavity can be performed easily to treat other potential intrathoracic lesions at the same time. Unlike other procedures, the Nuss bars can be easily removed.

In summary, stabilization of flail chest with Nuss bars is a simple, effective, and safe procedure; it minimizes surgical trauma and shortens recovery.

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References

High-Speed 3-Dimensional Imaging in Robot-Assisted Thoracic Surgical Procedures

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We used a high-speed 3-dimensional (3D) image analysis system (SYNAPSE VINCENT, Fujifilm Corp, Tokyo, Japan) to determine the best positioning of robotic arms and instruments preoperatively. The da Vinci S (Intuitive Surgical Inc, Sunnyvale, CA) was easily set up accurately and rapidly for this operation. Preoperative simulation and intraoperative navigation using the SYNAPSE VINCENT for robot-assisted thoracic operations enabled efficient planning of the operation settings. The SYNAPSE VINCENT can detect the tumor location and depict surrounding tissues quickly, accurately, and safely. This system is also excellent for navigational and educational use.


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A 38-year-old woman had a posterior mediastinal tumor that appeared spindle-shaped at the upper level of the first to third thoracic vertebrae. The SYNAPSE VINCENT was used to define the tumor together with the surrounding anatomic information and determine the appropriate setting of the da Vinci S and the best positioning of the instrument ports. For the computed tomographic scan, the patient was placed in the same position as projected for the operation. The SYNAPSE VINCENT depicts the tumor and all other anatomic information quickly. Details of thorax, ribs, and virtual imaging of the robot arm directions and placement of the surgical ports are shown in Fig 1. Details of the tumor and surrounding vessels after removal of the image of the rib cage are shown in Fig 2. The direction of the da Vinci S, 3D camera setting, and positioning of arms No. 1 and No. 2 for the clinical operation were determined by

![Image](http://dx.doi.org/10.1016/j.athoracsur.2013.08.026)

**Fig 1.** The figures were depicted by the SYNAPSE VINCENT, which showed the tumor (yellow) located in the upper area in the right side of the thorax. Green points on the surface of the patient and lines show the appropriate approaches for the instrument ports and angles of the arms of the da Vinci S and distance of each interval.