Chapter

48

Pectus Excavatum
The Nuss Procedure

Adam C. Adler

A 16-year-old female with a history of pectus excavatum (CT: Haller index 3.5) without cardiopulmonary dysfunction presents for cosmetic repair of her pectus deformity. She and her parents are most concerned about postoperative pain control.

What Is Pectus Excavatum?

Pectus excavatum is a congenital deformity consisting of abnormal sternum development that leads to a characteristic caved-in appearance of the anterior chest. The severity of the disease varies greatly from a simple cosmetic deformity to one with significant cardiopulmonary compromise. In addition to the physiologic effects, the deformity itself can cause significant psychosocial and emotional disturbances, particularly during adolescence. Pectus excavatum occurs in roughly 1:300–1,000 live births, with a 4:1 male predominance. Often there is progression of the deformity during puberty.

What Are the Indications for Surgical Correction of Pectus Excavatum?

The indications for surgical repair must include at least two of the following:

- Presence of symptoms most commonly including: shortness of breath with exercise, lack of endurance, and chest pain.
- Physical exam shows that there is a moderate to severe pectus excavatum deformity which may be symmetric or asymmetric.
- The chest wall imaging shows severe pectus excavatum deformity defined as a Haller index $>$ 3.2 or correction index $>$10%.
- The chest imaging shows cardiac and/or pulmonary compression or displacement.
- Pulmonary function studies demonstrating a restrictive or obstructive pattern.
- Cardiology evaluation elucidates cardiac compression or displacement, rhythm disturbance, and/or mitral valve prolapse.
- Significant body image and/or psychosocial impairment.

What Is the Haller Index?

The Haller index is a measure of severity of compression. It is calculated using dimensions from an axial CT by: transverse diameter of the chest from the inside of the ribcage and the anteroposterior diameter from the inside of the sternum to the vertebral body (at the shortest distance) (**Figure 48.1**). A normal Haller index is $<$2.5.

Describe the Surgical Repair of Pectus Excavatum?

The modified Ravitch and Nuss procedures represent the two most widely used procedures for pectus repair. The older Ravitch procedure requires significant exposure of the sternum and resection of abnormal cartilage followed by placement of a metal strut that is later removed. This procedure has nearly been abandoned with the creation of the less invasive Nuss procedure, which provides a minimally invasive alternative that does not require osteotomy or cartilage removal.

The Nuss procedure involves two small incisions, one on each side of the lateral chest wall. A thoracoscope is inserted and the chest is insufflated using CO_2 allowing for an introducer to be tunneled under the sternum by direct vision. The bar is pulled through under vision to avoid injury to the heart using umbilical tape as a guide. The bar ends are curved appropriately followed by a 180° rotation of

https://doi.org/10.1017/9781108668736.049 Published online by Cambridge University Press

the bar. The bar ends are affixed to the chest wall to avoid dislodgement (Figure 48.2). The created pneumothorax is evacuated by placing chest tubes with the distal ends under water followed by application of intrathoracic positive pressure to remove all air bubbles.

What Are the Anesthetic Concerns during Pectus Excavatum Repair?

The anesthetic concerns include cardiovascular injury when the introducer and Nuss Bar are placed over the heart, and pain control in the postoperative period. The provider should be vigilant during bar placement for occurrence of arrhythmia and/or hypotension due to external cardiac compression. Rare case reports have documented damage to the right ventricle and cardiac tamponade.

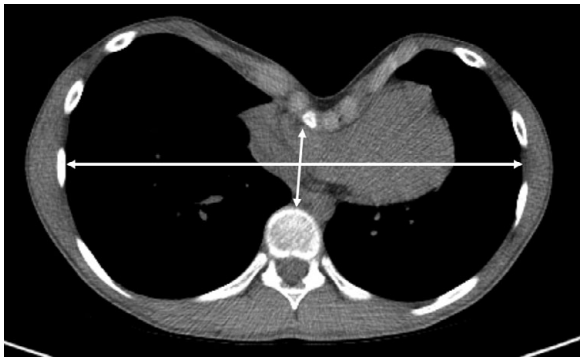

Figure 48.1 Axial CT identifying the Haller index of a patient with pectus excavatum.

Residual pneumothoraces are possible following evacuation of the insufflated CO_2 and should be considered in cases of PACU respiratory compromise.

What Is the Plan for Postoperative Analgesia after Pectus Excavatum Repair?

Anesthesiologists should prepare patients by setting reasonable expectations for their pain after surgery. The extrusion of the chest wall is accompanied by severe pain and a balance must exist between analgesia and respiratory suppression from opioids. Multimodal pain control may include a thoracic epidural, paravertebral block (and catheter), erector spinae plane block and/or intercostal nerve blocks or ablations. An opioid-based patient-controlled analgesia (PCA) is often used either in addition to or in lieu of regional techniques.

Other adjuncts are shown in Table 48.1.

Use of incentive spirometry should be encouraged to avoid atelectasis and postoperative pneumonia. Bowel regimens should be considered for all patients using opioids to avoid significant opioid-induced constipation.

What Are the Complications of the Nuss Procedure?

Early complications include residual pneumothorax, surgical site infection, pneumonia, pleural effusion, pericarditis, and hemothorax. Late complications include bar displacement/dislodgement, over-correction, late wound infection, bar allergy, and need for re-correction.

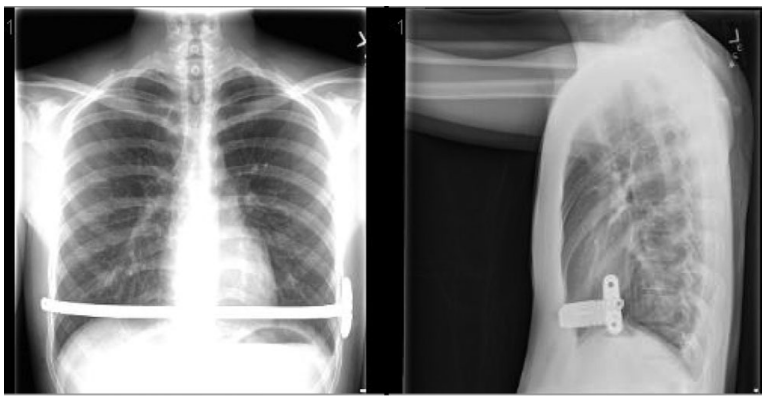

Figure 48.2 Posterioranterior (PA) and lateral chest X-rays demonstrating postoperative placement of a single Nuss bar

https://doi.org/10.1017/9781108668736.049 Published online by Cambridge University Press

Table 48.1 Analgesic agents with commonly used doses for the Nuss procedure by peri- and postoperative courses.

	Perioperatively	Postoperatively
Diazepam	0.1 mg/kg IV	0.1 mg/kg q6hrs
Gabapentin	10 mg/kg PO preoperatively	5 mg/kg PO q8hrs
Methadone	0.1–0.2 mg/kg once	N/A
Ketorolac	0.5 mg/kg IV once Max 30mg/dose	0.5 mg/kg q6hrs Max 30 mg/dose
Acetaminophen	15 mg/kg IV q6hrs	30 mg/kg PO q6hrs

Commonly used bars contain nickel and should not be used in patients with known nickel allergy. Some centers perform nickel allergy testing prior to implantation and use titanium bars in cases where allergy is present. Most patients have the bar removed after two to four years with 98.3% achieving good results after removal.

What Concerns Are Relevant for Removal of Nuss Bar Procedures?

While significantly less complex, removal of the bar involves some of the same risks as during insertion. General endotracheal anesthesia should be performed allowing for positive pressure ventilation and insufflation, should a pneumothorax occur. The ECG should be monitored for arrhythmia when the bar passes over the pericardium. Ventricular damage may occur rarely. A chest X-ray should be done in the PACU to exclude pneumothoraces. Not uncommonly, significant bony formation over the bar and anchoring can make this procedure difficult as the bar becomes affixed to the chest wall requiring greater manipulation which can result in more postoperative pain.

Suggested Reading

Keller BA, Kabagambe SK, Becker JC, et al. Intercostal nerve cryoablation versus thoracic epidural catheters for postoperative analgesia following pectus excavatum repair: Preliminary outcomes in twenty-six cryoablation patients. *J Pediatr Surg*. 2016;51(12):2033–8. PMID: 27745867.

Loftus PD, Elder CT, Russell KW, et al. Paravertebral regional blocks decrease length of stay following surgery for pectus excavatum in children. *J Pediatr Surg*. 2016;51(1):149–53. PMID: 26577910.

Nuss D, Obermeyer RJ, Kelly RE. Nuss bar procedure: past, present and future. *Ann Cardiothorac Surg*. 2016;5(5):422–33. PMID: 27747175.

https://doi.org/10.1017/9781108668736.049 Published online by Cambridge University Press