



Complications associated with the minimally invasive repair of pectus excavatum

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ABSTRACT

The minimally invasive pectus excavatum repair (Nuss repair) is performed by pediatric general surgeons and pediatric and adult thoracic surgeons around the world. Complications related to pediatric surgical procedures are always a major concern for surgeons and their patients, and as with all surgery, especially pectus surgery, complications can be life-threatening. The purpose of this article is to discuss early and late complications of pectus excavatum surgery and potential preventive strategies to minimize them.

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Introduction

The minimally invasive repair of pectus excavatum (MIRPE), also known as the Nuss procedure, has gained significant popularity since it was first described in 1998¹. It is considered the procedure of choice around the world for repair of pectus excavatum, and numerous reports have demonstrated excellent long-term outcomes and safety². Complications associated with the Nuss repair are low, but can be life-threatening in very rare circumstances^{3,4,11}. The overall incidence of minor and major complications that have been reported ranges from a low of 2% to a high of 27%^{5–8}. For the Nuss procedure, complications can be divided into intraoperative/early complications and late postoperative complications that are unique to this surgical procedure.

The Clavien-Dindo severity grading system classifies complications into 5 grades with grade 4 being life-threatening complications and grade 5 being death of the patient⁹. Most of the complications associated with the Nuss repair are fortunately grade 1–3 and either cause minimal to no harm to the patient, or with grade 3 complications require some surgical or radiographic intervention. For grade 4 and 5 complications with the Nuss repair, the true incidence is not well-established but should be less than 0.1%. It is also reassuring that in the NSQIP data base, which now consists of over 100 pediatric centers, there has not been a single case of a life threatening occurrence or any mortality associated with Nuss repair. Only 0.1% of cases in the entire database since its inception have required a postoperative transfusion¹⁰.

Life-threatening complications

Life-threatening complications with the Nuss procedure are extremely rare. Worldwide, there have only been 4 reported cases of mortality secondary to the Nuss procedure, with an additional 7 cases identified in the worldwide survey of members of the chest wall interest group (CWIG)¹¹. Cardiac injury with the Nuss procedure is probably the most serious complication and reported very rarely. The most common scenario associated with cardiac injury is during an attempted Nuss procedure for pectus excavatum after previous open cardiac surgery¹². Cardiac injury can also occur with very deep pectus excavatum and/or stiff chests. There are numerous reported modifications to assist with the substernal dissection as ways to minimize and avoid cardiac injury. Thoracoscopy with CO₂ insufflation and optimal intrathoracic visualization at all times during the substernal dissection is almost universally accepted as a minimum standard to avoid cardiac injury. However, some surgeons have reported safe bar placement without thoracoscopy by using digital guidance¹³. If adequate visualization cannot be obtained, adjuncts to assist with sternal elevation should be utilized and from the “toolbox” of the surgeon performing the procedure. These adjuncts consist of, but are not limited to, the use of the vacuum bell, sternal hook, and various elevation techniques with a Rultract retractor.^{14–19}

For all patients, avoiding cardiac perforation is focused on ensuring optimization of exposure of the substernal region by utilizing thoracoscopy, manual elevation, or any of the temporary external elevation techniques. During the substernal dissection it is crucial that the pectus introducer tip is in view at all times as it is advanced across to the left side. In patients where the plan is for multiple bars, it is helpful to make the superior tunnel first and leave that introducer in place to assist with sternal elevation.

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The patient who has had previous cardiac surgery where the pericardium was opened is at the highest risk for cardiac injury. The surgeon needs to be aware that in those patients where the pericardium has previously been opened, sternal elevation, (which should be mandatory in this scenario), may not preclude cardiac injury due to the dense adhesions between the sternum and the myocardium. The author's group experience of over 2000 Nuss repairs have seen only 2 cardiac injuries. Both of these occurred in patients who had previous open heart surgery with opening of the pericardium at the time of median sternotomy. One injury occurred when the cardiac surgeons were taking the adhesion off the myocardium down from the back of the sternum before bar placement. The other injury occurred while the pediatric surgeon was passing a second lower introducer requiring an emergent limited sternotomy to repair the injury. The first upper introducer, that was placed uneventfully, was actively being used to elevate the sternum when passing the second lower introducer. Of note, the pediatric surgeon correctly left the second lower bar in place to help maintain tamponade until the cardiac surgeons arrived in the operating room suite. This is a critical step as removal could have resulted in rapid exsanguination, potentially even augmented by enlargement of the cardiac injuries. These patients both survived with good ultimate outcomes. Both of these injuries occurred despite sternal elevation. In the case of previous open heart surgery, the authors recommend a very large experience prior to offering repair in this patient population. Having instruments immediately available for open heart surgery, availability for cardiac bypass, and a cardiac surgeon on standby are necessary if offering a Nuss procedure after previous open heart surgery where the pericardium is opened. In many cases cardiac injury may be unavoidable with any type of pectus repair due to the intimate attachment of the myocardium and posterior sternum.

Temporary paralysis

An extremely rare but devastating complication reported by the Norfolk group has been temporary paralysis associated with thoracic epidural catheters used for perioperative analgesia.¹² Two patients demonstrated anterior cord syndrome symptoms with lower extremity paralysis and loss of bowel and bladder control. Both patients had significant recovery over time. Even after a thorough case analysis of both events, no definitive cause or specific injury was identified. It is postulated that patients with pectus excavatum may have an underlying anomaly that makes them more susceptible to a vasospastic event with epidural catheters and thus some centers group have discontinued their use since 2011.¹²

Pleural effusion

Pleural effusion after any thoracic procedures, especially after the Nuss procedure, is almost universally present and rarely needs any intervention. Effusions are present in most postoperative x-rays, and most will be reabsorbed in the first 2-3 weeks after surgery. In a very small percentage of patients, which should be less than 2%, the effusion may enlarge causing symptoms and impaired ventilation and a chest tube may be required. A frankly bloody output should lead to prompt intervention and is extremely rare. In most reports a source usually is not able to be identified and evacuation of the hematoma is usually all that is done and can be done thoracoscopically.¹² A serous effusion that enlarges is usually due to reaction of the pleural surface due to the surgical trauma and often is self-limiting with chest tube drainage. If the patient has not had allergy testing this may also be the first sign of an allergic reaction to the bar.

Pneumothorax

As with pleural effusions, pneumothorax is almost always present after CO₂ insufflation and almost never needs a chest tube. A chest tube may be required if the surgeon is unable to adequately evacuate residual insufflated CO₂ from the pleural space, or there was some identified intraoperative lung trauma due to previous adhesions or infection. Additionally, cases with potential leakage of air from the entry sites of the bar or patients with extreme Haller indexes and a very stiff chest may require a chest tube be left in place. In these circumstances, the chest tube usually does not prolong the hospital stay and can be removed in 48 hours.

Bar displacement

Early bar displacement defined as bar movement in the first month after surgery should be rare, and will be discussed in more detail in the late complications section of this article. However, if a bar moves within the first month, surgical intervention should strongly be considered since this most likely represents an unstable bar which will continue to move. The liberal use of 2 bars and various modifications to stabilize the bar has dramatically decreased this complication.²⁰ It is imperative that in cases where the greatest depression is below the sternum and a bar is placed at that level, that a second bar must be placed superiorly and be securely under the sternum. Bars supported only by cartilage fail to maintain chest support.

Early infectious related complications

Early skin infections after the Nuss procedure are extremely rare and the reported incidence is well below national averages for clean surgical cases. Strict adherence to surgical site infection prevention bundles is highly recommended. Preventative measures utilizing preoperative skin scrubs with 2% chlorhexidine, prophylactic antibiotic coverage with a first generation cephalosporin for 24 – 48 hours, and strict intraoperative sterile techniques greatly minimize early postoperative infection.²¹ As an elective procedure, the Nuss procedure should be delayed if the patient has any remote bacterial infections or is actively smoking.

Pericarditis after the Nuss procedure mimics post pericardiotomy syndrome. Symptoms include retrosternal chest pain, lethargy and fever. Etiologies of pericarditis consists of pericardial injury during bar insertion which should be immediately recognized, or as a first manifestation of a bar allergy especially if allergy testing was not performed.¹² If the patient has clinical concerns for pericarditis postoperatively a cardiology consultation should be obtained. Typical medical management with nonsteroidal anti-inflammatory drugs is usually sufficient. Direct pericardial injury at time of bar insertion will put the patient at a higher risk of pericarditis. It is critical that a Nuss bar is never left through the pericardium. A second substernal tunnel in the appropriate plane is mandatory and confirmation that no hardware is going through the pericardium at the end of the case is crucial. If the bar is left through the pericardium, this will not only increase the risk of pericarditis, but can lead to erosion into the myocardium or aorta with subsequent life-threatening bleeding either while the bars are in place, or at the time of bar removal.

Late complications

Pectus bar displacement

Bar displacement is the most common late complication.^{20,22} This has dramatically decreased over time with various modifications introduced since the first description in 1998. Most recent

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