

Cardiac perforation by a pectus bar after surgical correction of pectus excavatum: case report and review of the literature

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Abstract Pectus excavatum (PE) is a congenital sternal depression. The two most popular methods of correction are the highly modified Ravitch repair (HMRR) and the Nuss procedure. Presented here is a case of PE surgical correction in a 17.5-year-old male, beginning with the Nuss technique and converting to the HMRR during surgery, due to unsatisfying results. The procedure inadvertently culminated in perforation of the heart and lungs by the inserted pectus bar, with aggravation of the damage by resuscitation efforts. This article analyzes the chain of events leading to the patient's death and reviews the literature on the subject.

Keywords Pectus excavatum · Nuss procedure · Ravitch repair · Cardiac perforation · Death

Introduction

Pectus excavatum (PE) is a congenital deformity of the anterior thoracic wall, presenting with sternal depression of various degrees of severity, which usually increases at puberty due to progressive loss of elasticity of the chest skeleton. It occurs in up to 1 in 400 live births, with males affected five times more. There is no known genetic link,

although there is a strong relation to connective tissue abnormalities such as Marfan's syndrome, Ehlers-Danlos syndrome and scoliosis [1].

The most acceptable current theory as to the etiology of this condition is the overgrowth of ribs pushing a normal sternum backwards, thus decreasing the distance between the sternum and the vertebral column, which results in sternal concavity [2]. Physiologic effects of PE range from absence of symptoms to mild exercise intolerance, chest pain and recurrent respiratory infections, in addition to the noticeable cosmetic defect with its psychological consequences [3].

The condition does not resolve spontaneously and for many decades the most popular corrective surgery for the deformity was the Ravitch procedure, performed by bilateral resection of the deformed rib cartilages subperichondrially, osteotomy of the sternum and then fixation with sternal wires with or without the support of a temporary sternal bar [4]. Since the introduction of the procedure in the 1940s it has undergone many modifications culminating in today's highly modified Ravitch repair (HMRR), which entails minimal cartilage removal.

The minimally invasive repair (MIRPE), introduced by Nuss in 1997 [5] consists of placing and stabilizing a convex steel bar under the sternum, at the deepest point of deformity, without the need for a large incision across the thoracic cage. Initially, the bar was placed blindly, but after reports of myocardial injury many surgeons added the use of videothoracoscopy for guidance. The pressure exerted by the bar induces the correction of the bony deformity and it is removed after about two years [6].

The MIRPE became the preferred procedure carrying negligible consequences.

We report a rare case of fatal cardiac and lung perforation during surgical PE correction with the conversion

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from the MIRPE to the Ravitch procedure, and the subsequent attempt at resuscitation.

Case report

A 17-year-old male, affected by PE with severe asymmetric deformity of the chest wall (Fig. 1) and limitation of physical activity, was submitted to elective corrective surgery with the Nuss procedure, performed by a board-certified pediatric surgeon well acquainted with the technique. After the introduction of the Nuss bar retrosternally the surgeon realized that the chest was still severely deformed on the lower right side and therefore decided to remove the bar and complete the surgery using the HMRR technique. The surgery, which consisted of resection of several right rib cartilages and insertion of a sternal bar, was reportedly uneventful and the patient was extubated and hemodynamically stable.

A few hours later, the patient's blood pressure suddenly dropped and was temporarily restabilized with IV fluids. It then decreased again, along with the onset of respiratory distress and loss of consciousness. The patient was ventilated with AMBU and regained consciousness, but subsequently became unconscious once more and bradycardic. He was treated with volume resuscitation, ventilation and cardiac massage. A needle inserted into his right chest released air, indicating a pneumothorax, and drains were placed into the thoracic cavities.

When external measures failed, the patient was rushed back to the OR, and an emergency thoracotomy was performed, revealing left hemothorax and minor adhesions of the pericardium to the anterior thoracic wall. The metal bar inserted during surgery was in the right-central mediastinum penetrating the anterior aspect of the heart, and a few lacerations in the left lung were observed. The bar was removed, the cardiac and left pulmonary injuries were sutured and the patient was transferred to the ICU.

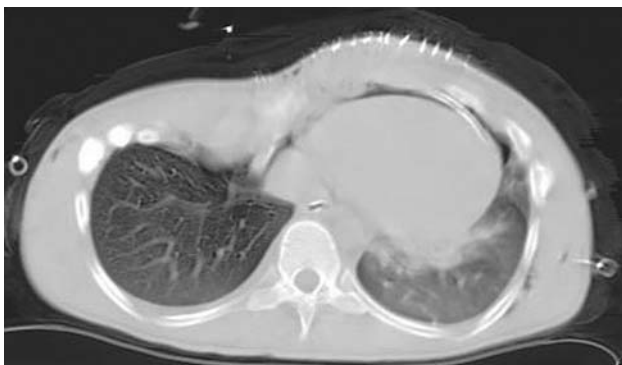


Fig. 1 Chest computed tomography (CT) of the patient after the second surgery. The deformity of the right chest is still evident

Within the next 24 h he was declared brain dead and was taken off life support with the authorization of the hospital's Ethical Committee.

Autopsy

Post-mortem examination was carried out at the National Institute of Forensic Medicine at the request of the family, who suspected that the surgery was inadequately performed.

Autopsy findings included a post-surgical absence of cartilage of ribs 5–9 on the right side and a surgical mid-sternotomy between ribs 4 and 5. The heart was enlarged (410 grams for a body weight of 60 kg), revealing three sutured tears of the right atrium and ventricle, including one in the right coronary artery with a firm thrombus at the suture site (Fig. 2). An unsutured, 1-cm-long horizontal laceration was found in the anterior wall of the right ventricle, covered by clotted blood, and a sutured wound in the left auricle, blocking the proximal left anterior descending artery. In addition, the upper lobe of the right lung had an unsutured tear, 1-cm-long and 3-cm-deep, with surrounding hemorrhage.

The cause of death was hypoxic brain damage due to massive blood loss from cardiac and pulmonary lacerations caused by retrosternal insertion of a metal bar.

Discussion

Since its introduction by Nuss in 1997, the MIRPE has gained increasing popularity in the pediatric surgical community due to its short operation time and favorable cosmetic results. However, it carries a higher complication rate compared with the HMRR [4, 7–12].

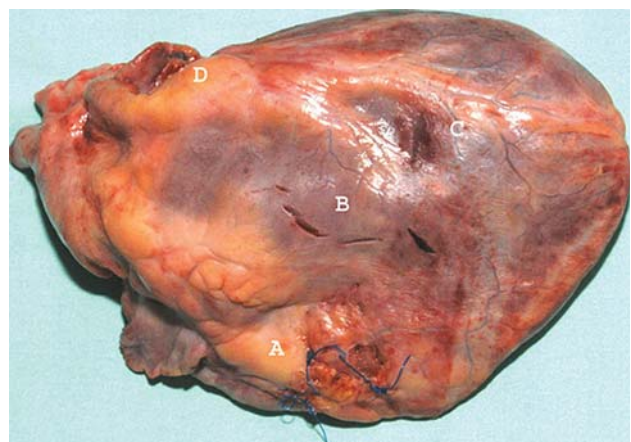


Fig. 2 The patient's heart: *a* Sutured wound of the right ventricle, *b* Cuts made during autopsy, as can be seen by lack of bleeding around them, *c* Unsutured puncture wound in the right ventricle with surrounding hemorrhage, *d* Sutured wound in the left auricle, blocking the proximal left anterior descending artery (LAD)

In their 10-year review of the method, Nuss et al. reported on 42 patients who had undergone the MIRPE, with mostly excellent results. Four patients (1.68%) suffered pneumothorax, two displacement of the bar requiring revision (0.84%) and one (0.42%) superficial wound infection [5].

In 2000, Hebra et al. reviewed 251 cases of MIRPE, with the most common complications being bar displacement (9.2%), pneumothorax (4.8%), infectious complications (2%) and pleural effusion (2%) [7].

In Goretski et al.'s review of 557 repairs using MIRPE, the early post-operative complications included mainly pneumothorax (59%), medication reaction (4.3%), pericarditis and pneumonia (1.1% each) and the late complications consisted of bar displacement (12%) and overcorrection (4.8%). There were no cases of cardiac perforation or deaths [1].

In 2004, Park et al. reported 335 patients affected by various degrees of PE who underwent the Nuss procedure, with a total postoperative complication rate of 16.1%. Early complications were pneumothorax (6.9%) and wound seroma (2.4%), while late complications were pericarditis and pericardial effusion (1.5%), bar displacement (1.2%) and hemothorax (0.3%) [8].

More anecdotal reported complications included thoracic outlet syndrome [9], sternoclavicular dislocation and pulmonary vessel erosion [10], post-pericardiotomy syndrome [13] and diaphragmatic hernia [11].

A search through the publications revealed only three reported cases of cardiac perforation. The first case was mentioned by Nuss in his original review, and again by Hebra in 2000 [5, 6]. Another case of an 8-year-old boy who suffered cardiac injury during insertion of a clamp was reported by Moss in 2001 [8]. The third case was of cardiac perforation by a pectus clamp on re-operation for a displaced bar one year after the Nuss procedure [7]. None of the incidents was fatal.

The addition of videothoracoscopy or a subxiphoid incision for manual guidance was meant to prevent this rare but serious occurrence of cardiac perforation [12].

Most authors agree that complication rates decrease as the surgeons gain more experience and confidence using the method.

Nevertheless, a conscious selection of patients is of the utmost importance—complication rates were reportedly higher in patients over the age of 15 years [6], and results were less satisfactory in patients with asymmetric PE [4] and with connective tissue disorders [1].

Despite these measures, compared to the HMRR the Nuss procedure still requires longer hospitalization, an epidural catheter for management of the severe pain that follows, and a higher need for revision surgery [4]. Moreover, complications and limitation of activity caused

by the longer period before retrosternal bar removal (2 years vs. 6 months) are more frequent [14].

Discussion

Surgical correction of pectoral deformity applying the MIRPE technique has become a relatively simple and limited procedure, achieving optimal results through minimal blood loss and a short operating time (less than an hour). However, the correct choice of patients and the technique to be used is crucial [1]. The optimal age for repair appears to be in the range of 12–15 years. Patients who do not undergo repair of severe PE in childhood will experience worsening of the symptoms in their adult life [4].

A search of the literature revealed only three published cases of cardiac perforation during the MIRPE procedure, with no lethal consequences.

We postulate that in the case reported here the initial injuries to the thoracic organs by the metal bar inserted during the HMRR caused the insidious deterioration of the patient, and that the additional, more severe injuries, were created by the vigorous chest compressions during resuscitation attempts. In a case reported by Zoeller et al. [15], a 21-year-old man who had a fatal cardiac event could not be resuscitated because of ineffective cardiac compressions limited by the rigid Nuss bar introduced into his chest 36 months previously. However, we are unaware of any reported case of cardiac perforations caused by a metal bar during rescue measures.

In the present case it seems that a series of ill-considered decisions resulted in the loss of a patient's life: first, the choice of the Nuss procedure for a patient over the age of 15 years and with a severe, asymmetric deformity, necessitating conversion to the HMRR; then, the inability to diagnose the cardiac injury in time; and finally, the failure of the surgical staff during the second surgery in detecting all the iatrogenous injuries.

While surgical correction of PE is considered a relatively simple endeavor, surgeons and patients should be aware of possible complications and scenarios, both during and after the procedure.

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