8 Traditional Treatment for Chest-Wall Deformities and Novel Treatment Methods

Natalie L. Simon and Shyam K. Kolvekar

Abstract

Traditional treatment for chest-wall deformities relies upon surgical interventions that aim to increase thoracic function and restore kinetic and structural integrity to halt future chest-wall deformation prevent future deterioration of the chest wall. The Ravitch procedure is the most common intervention and involves subperichondrial resection of the deformed costal cartilages and sternal osteotomy for fixation of the sternum anteriorly. Novel minimally invasive techniques are gaining popularity amongst centers specialising in chest wall reconstruction, such as the Nuss procedure. At our centre we are researching the benefit of patient centered anesthesia on pain management post- Nuss procedure. We are also investigating various different techniques for bar removal and insertion using wire-assisted techniques. All of our research aims to increase the efficacy of minimally invasive corrective procedures.

Keywords

Chest wall deformity • Pectus Excavatum • Sternum • Malformation • Costal cartilages

Ravitch Procedure

The Ravitch procedure is a primary intervention to correct pectus excavatum [1]. The technique involves a midline incision being made from the manubrium to epigastrium, under intratracheal anesthesia. A division at the lateral border of the deformity is made separating the lowermost cartilages of either side and displacing them away from the sternum. This surgical technique may prove difficult in children as the perichondrium is

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not preserved and subperichondrial resection is difficult to perform. Following surgical resection of the cartilages, the xiphisternal articulation is separated, exposing the substernal ligament. This is then further divided and the xiphoid moves away from the sternum dividing any remaining rectus muscle attachments [2]. Pericostal sutures are situated onto the edges of the transverse osteotomy and ruffling sutures onto the perichondrium of resected cartilages. The full method used by Ravitch can be summarised below in four steps. Most methods of surgical correction of pectus excavatum include the basic steps described by Ravitch in 1949 [3].

1. Bilateral parasternal, and subperichondrial resection of the deformed costal cartilages
2. Detachment of the xiphoid process
3. Transverse wedge osteotomy at the upper edge of the sternal depression, and bending the sternum anteriorly to straighten its course
4. Securing the corrected position of the sternum

The following images will illustrate the steps involved in the Ravitch procedure, adapted from the original article [2]. Figure 8.1 shows the midline incision from manubrium to epigastrium. Here, the pectoral muscles are stripped back allowing for bilateral parasternal and subperichondrial resection of the deformed costal cartilages. Figure 8.2 shows how the surgeon gains access to the xiphoid, following division of the xiphisternal joint. Figure 8.3 illustrates the resection of costal cartilages and intercostal bundles on both sides allowing the sternum to be freed from its lower end. A transverse osteotomy is performed. The final stage, as shown in Fig. 8.4, is the elevation and the frac-

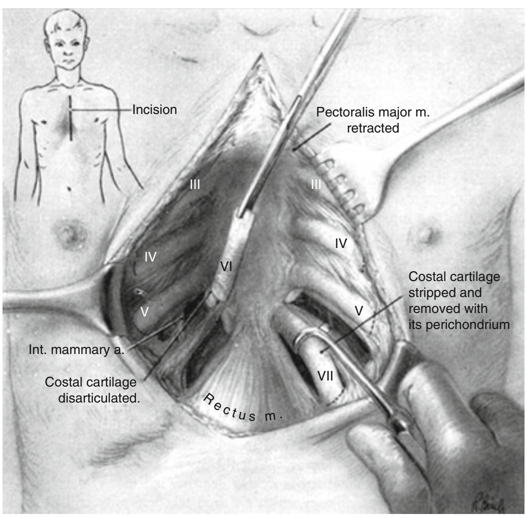

Fig. 8.1 The midline incision from manubrium to epigastrium. Here, the pectoral muscles are stripped back allowing for bilateral parasternal and subperichondrial resection of the deformed costal cartilages [2]

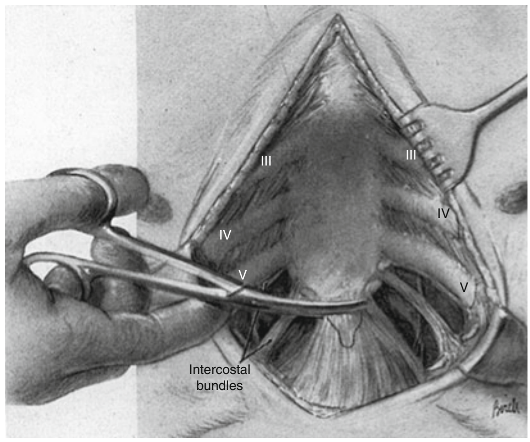

Fig. 8.2 How the surgeon gains access to the xiphoid, following division of the xiphisternal joint [2]

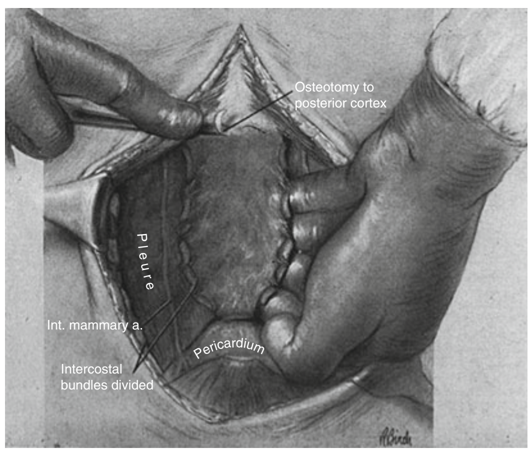

Fig. 8.3 Illustrates the resection of costal cartilages and intercostal bundles on both sides allowing the sternum to be freed from its lower end. A transverse osteotomy is performed [2]

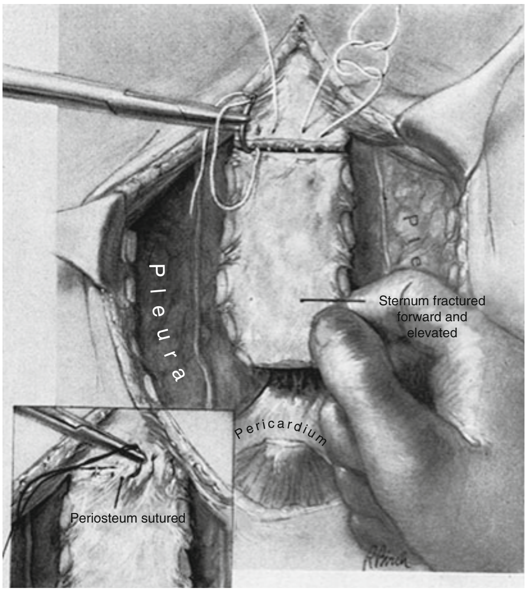

Fig. 8.4 The final stage [2]

turing of the posterior plate at the level of the transverse osteotomy. The new position is secured and maintained by mattress sutures and the periosteum is sutured [2].

Modification of Ravitch

Surgical repair of pectus excavatum relies on the corrected position of the sternum being maintained through the use of a sheet of synthetic mesh. Robicsek, 1978 presented a modification of the Ravitch procedure. This technique uses placement of Marlex mesh behind the sternum. The edge of the Marlex mesh is sutured to the peripheral stump of the resected ribs [3–5].

Following detachment of the xiphisternum, all loose mediastinal tissue is removed from the posterior sternum and the right pleural cavity drained with a chest tube, assuring optimal wound healing. The lower sternal end is bent forwards, breaking the posterior lamina at the transverse osteotomy. The Marlex mesh is spread tightly posterior to the sternum and has lateral attachments to the remaining costal cartilages on their anterior side. The corrected position of the sternum is now maintained and secured with the xiphoid process loosely attached to the lower end of mesh [3–5].

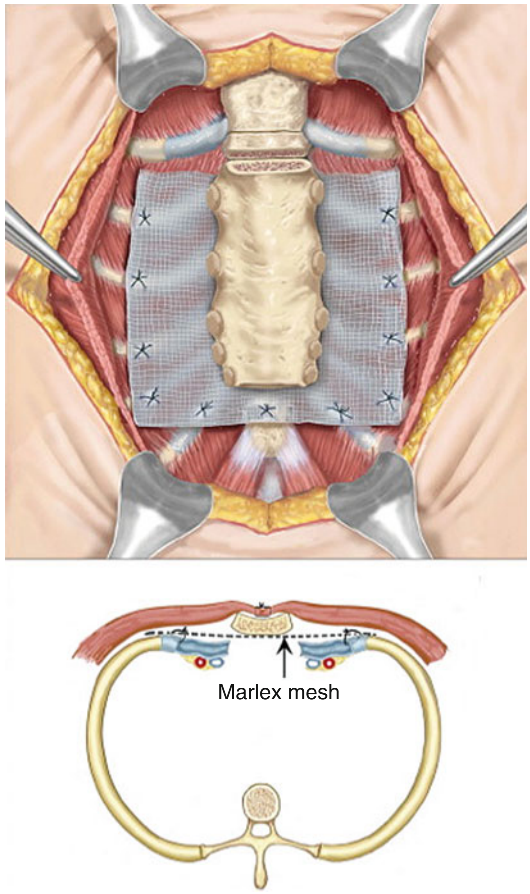

Fig. 8.5 Dr. Robicsek technique of Marlex mesh insertion to maintain the corrected position of the sternum

Figure 8.5 shows Dr. Robicsek technique of Marlex mesh insertion to maintain the corrected position of the sternum [3–5].

Comparative Studies

Recurrent pectus excavatum is experienced in a range of 2–37 % of patients having undergone corrective surgery for pectus excavatum.

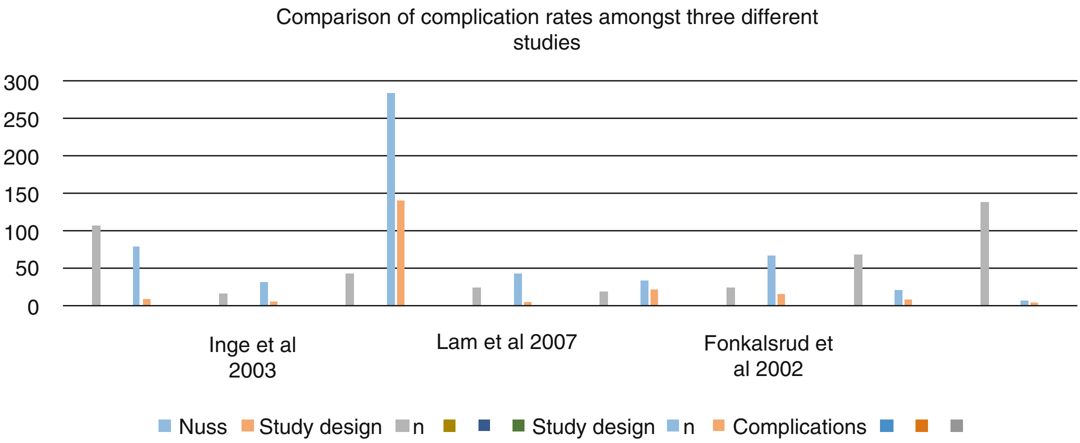

Fig. 8.6 Nuss procedure can be used in the corrective surgery of pectus carinatum. Two stabilisers are used to apply force to the sternum to depress the elevation and allow for fixation to the ribs on either side. This method is minimally invasive and does not require thoracoscopy (Adapted from Nasr et al. [1])

Table 8.1 Nuss procedure

	Jo et al. [10]		Inge et al. [11]		Lam et al. [12]		Fonkalsrud et al. [13]	
	Nuss	Ravitch	Nuss	Ravitch	Nuss	Ravitch	Nuss	Ravitch
Study design	**Retrospective**		**Retrospective**		**Retrospective**		**Retrospective**	
n	107	16	43	25	19	24	68	139
Complications	8	3	6	1	0	13	24	6
Reoperation	3	0	3	0	0	0	7	0
Duration of surgery (min)	67.2 ± 33.1	196.9 ± 61	70	198	72.1 ± 19	84.1 ± 24.9	75 ± 21	212 ± 37.5
Length of hospital stay (d)	8 ± 1.6	15.9 ± 2.3	2.4	4.4	4.5 ± 0.9	3.9 ± 0.7	6.5 ± 0.75	2.9 ± 0.75
Time to ambulation	6.3 ± 0.9	12.9 ± 3.6	–	–	3.8 ± 1.1	2.7 ± 0.8	–	–

	Miller et al. [14]		Nuss et al. [15]		Molik et al. [16]		Boehm et al. [17]	
	Nuss	Ravitch	Nuss	Ravitch	Nuss	Ravitch	Nuss	Ravitch
Study design	**Retrospective**		**Prospective**		**Retrospective**		**Retrospective**	
n	80	32	284	43	35	68	21	7
Complications	9	6	141	5	23	17	9	4
Reoperation	4	0	0	0	8	4	3	0
Duration of surgery	53	143	–	–	198	282	53 ± 42.5	125 ± 2.5
Length of hospital stay	3.7	3.2	–	–	4.8	4		–
Time to ambulation	–	–	–	–	–	–		

	Antonoff et al. [18]	
	Nuss	Ravitch
Study design	**Retrospective**	
n	14	56
Complications	5	8
Reoperation	0	1
Duration of surgery	109 ± 8	110 ± 4
Length of hospital stay	3.9 ± 0.6	2.2 ± 0.1
Time to ambulation	–	–

With permission from Nasr et al. [1]

Table 8.2 Specific complications

	Jo et al. [10]	Inge et al. [11]	Lam et al. [12]	Fonkalsrud et al. [13]	Miller et al. [14]	Nuss et al. [15]	Molik et al. [16]	Boehm et al. [17]	Antonoff et al. [18]	Sum
Reoperation										
Ravitch	0	0	0	0	0	0	4	0	3	7
Nuss	3	3	0	7	4	0	8	3	4	32
Pneumothorax										0
Ravitch	1	0	0	3	1	3	0	1	3	12
Nuss	5	0	0	7	2	12	1	2	1	30
Hemothorax										0
Ravitch	1	0	0	0	2	0	0	0	0	3
Nuss	4	0	0	0	1	0	0	1	0	6
Blood transfusion										0
Ravitch	0	0	0	0	1	0	0	0	0	1
Nuss	0	0	0	0	10	0	0	0	0	10

Adapted from Nasr et al. [1]

Common causes of recurrence include: asymmetric PE, perichondrium cartilage damage, limited space following retrosternal dissection, infection, improper fixation and early removal retrosternal plate [6]. The Ravitch procedure has few, yet potentially serious, complications. One of these is phrenic nerve injury. If there is laceration of the phrenic nerve, the patient has trouble breathing and suffers considerably more pain. Breathing regulation is altered. Phrenic nerve injury can be caused by direct trauma and 10 % of cases of phrenic nerve damage are caused by operative trauma. When diaphragm paralysis occurs, the patient may suffer type 2 respiratory failure and require mechanical assistance.

Complication rates between the Ravitch and the Nuss procedure are similar. Length of hospital stay or time to ambulation post-surgical procedure is also similar amongst the two groups and differs only minimally. The rate of reoperation due to bar movement and migration from site of placement was higher in the Nuss group. This is the main factor causing persistent deformation and worsening long term outcomes. Postoperative pneumothorax and hemothorax were also higher in the Nuss group, whereas duration of surgery was longer in the Ravitch procedure. Patient satisfaction is relatively high in both surgical procedures [1, 7, 8].

In addition, a modification of the Nuss procedure can be used in the corrective surgery of pectus carinatum. Two stabilisers are used to apply force to the sternum to depress the elevation and allow for fixation to the ribs on either side. This method is minimally invasive and does not require thoracoscopy (Fig. 8.6, Tables 8.1 and 8.2) [9].

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