Pectus tunneloscopy: making Nuss procedure for pectus excavatum safe

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Abstract

OBJECTIVES: The Nuss procedure for pectus excavatum involves the risk of cardiac injury during the creation of the retrosternal tunnel and during bar introduction or removal across the tunnel. A modified novel real-time technique for the safe introduction of the Nuss bar across the crucial retrosternal tunnel blind spot during introduction and removal is described.

METHODS: In 2012, we devised a technique for real-time endovision-guided introduction of the Nuss bar called pectus tunneloscopy. Between February 2012 and December 2012, 6 patients with pectus excavatum had their bar introduced across the tunnel using this technique.

RESULTS: This technique provided safe introduction and removal of the bar during the multiple times the bar is remodelled before final fixation.

CONCLUSIONS: Pectus tunneloscopy is a real-time endovision surgical technique, providing safe introduction of the bar across the crucial retrosternal tunnel blind spot.

Keywords: Pectus tunneloscopy • Pectus excavatum • Retrosternal tunnel • Blind spot • Nuss procedure • Redo Nuss

INTRODUCTION

One of the major complications of minimally invasive repair of pectus excavatum or Nuss procedure is cardiac injury. This can occur during retrosternal tunnel dissection, Nuss bar introduction or bar removal in the narrow critical anterior mediastinal space where the depressed sternum compresses the underlying pericardium and the heart [1–3]. The incidence of cardiac injury along the retrosternal tunnel during bar introduction is not known, and those reported in the literature are mostly case reports of occurrences during tunnel creation or bar removal [4, 5]. Thoracoscopy and sternal elevation techniques are used to avoid cardiac injury during retrosternal tunnel dissection by visualizing this critical area and by increasing the anterior mediastinal space [6–9]. These techniques, however, fail to give a continuous view of the critical tunnel or direction of the ends of the Nuss bar in the tunnel during introduction or removal, risking pericardial and cardiac and lung injuries. These result in a blind spot across the critical retrosternal tunnel where the bars are most likely to cause injuries. The author describes pectus tunneloscopy, a technique for real-time endoscopic viewing of the critical retrosternal tunnel blind spot during bar introduction in the Nuss procedure.

MATERIALS AND METHODS

Between February 2012 and December 2012, 6 patients with pectus excavatum had the Nuss bar introduced, including 1 case of redo Nuss for bar displacement using pectus tunneloscopy.

Techniques

A bilateral mid-axillary incision is used for dissection and bar introduction. The crane technique and internal visualizing and dissecting device pectoscope as described by Park et al. [7] are used for sternal elevation and retrosternal tunnel dissection in the critical space (Fig. 1). The tunnel is created from the right with the dissector exiting from the left chest wound. A transparent hollow polyvinylchloride tube [PerfX PVC tubing 1/4 × 1/16, 12 ft (heart-lung pack accessories); Fig. 2] or a 28-Fr transparent chest drain is fitted to the tip of the dissector from the left end and withdrawn from the right chest wound. The ends of the hollow tube are used as a conduit for bar insertion. This tube also acts as a port for the passage of a 5-mm 0° rigid thoracoscope. The real-time endoscopic viewing of the retrosternal tunnel blind spot through this hollow transparent port is referred to as pectus tunneloscopy (Fig. 3).

Pectus tunneloscopy procedures

(1) A diagnostic pectus tunneloscopy is performed using a rigid 5-mm 0° thoracoscope passed through the hollow transparent conduit tube that acts as a port for pectus tunneloscopy. It is performed from the right to the left side of the chest visualizing the intercostal wound, right lung, retrosternal tunnel blind spot overlying pericardial surface, left lung and intercostal exit wounds (Supplementary Video 1).

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Therapeutic pectus tunneloscopy directs the safe passage of the Nuss bar during the introduction or removal across the thoracic cavity and the critical retrosternal tunnel blind spot. (I) Pectus tunneloscopy-guided bar introduction: The head end of the Nuss bar that is attached to the left end of the hollow transparent conduit tube is guided across the critical retrosternal tunnel blind spot by pectus tunneloscopy introduced from the right end of the hollow tube (Supplementary Video 2).

(II) Pectus tunneloscopy-guided bar removal: The tail end of the Nuss bar on the left chest is attached to one end of the hollow transparent conduit tube, and pectus tunneloscopy is introduced from the other end of the hollow tube. As the bar is removed from the right chest wound, pectus tunneloscopy guides the direction of the tail end of the bar across the critical retrosternal tunnel blind spot.

The 5-mm 0° rigid thoracoscope is passed through one end of the hollow transparent conduit tube with the Nuss bar attached to the other end of the hollow transparent tube.

Table 1: Patient data

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Hallers index</th>
<th>Intraoperative complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>18/Male</td>
<td>4</td>
<td>Nil</td>
</tr>
<tr>
<td>28/Male</td>
<td>3.5</td>
<td>Nil</td>
</tr>
<tr>
<td>3/Female</td>
<td>4.2</td>
<td>Nil</td>
</tr>
<tr>
<td>16/Male</td>
<td>1.07 Asymmetric index</td>
<td>Nil</td>
</tr>
<tr>
<td>18/Male</td>
<td>Redo Nuss—for bar displacement</td>
<td>Nil</td>
</tr>
<tr>
<td>7/Male</td>
<td>5.3</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Figure 1: Illustration of the pectus tunneloscopy procedure. (A) Crane lift of the sternum increasing the retrosternal space for safe dissection. (B) Transparent hollow conduit tube passing across the retrosternal tunnel for threading the bar and port for pectus tunneloscopy. (C) A 5-mm 0° rigid thoracoscope for pectus tunneloscopy which will be passed through the hollow transparent conduit tube (port).

Figure 2: Transparent hollow polyvinylchloride tube [PerfX PVC tubing 1/4 × 1/16, 12 ft [heart-lung pack accessories]] used as a conduit tube for Nuss bar and a port for pectus tunneloscopy.

Figure 3: Pectus tunneloscopy view showing the lung pericardium and the retrosternal tunnel in the centre.

Supplementary Video 1: Pectus tunneloscopy view.

Supplementary Video 2: Pectus tunneloscopy-guided bar introduction.
(III) Pectus tunneloscopy-guided redo Nuss: It guides the direction of the Nuss bar during its removal and reintroduction across the already formed tunnel. The real-time view of pectus tunneloscopy prevents the bar end from creating new tracks or causing injury to the adhered pleura and in the mediastinal space.

**RESULTS**

This novel real-time technique specifically facilitated the safe introduction and removal of the bar in the already created retrosternal tunnel during the multiple times the bar was introduced and removed for bar modelling to achieve symmetrical chest morphology on the operating table. No patient required blood transfusion. Table 1 summarizes the patient data with the age group varying from 3 to 28 years. No comparison was made, as there are no available studies specifically dealing with complications during bar introduction across the retrosternal blind spot.

**Table 2:** Comparison between pectus tunneloscopy and thoracoscopy for bar introduction during the Nuss procedure

<table>
<thead>
<tr>
<th></th>
<th>Pectus tunneloscopy</th>
<th>Thoracoscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incision</td>
<td>Through the same incision for bar placement</td>
<td>Additional skin incision required</td>
</tr>
<tr>
<td>Access route</td>
<td>A hollow transparent conduit tube acts as a port for the rigid 5-mm 0° thoracoscope</td>
<td>Through a port specifically for thoracoscopy</td>
</tr>
<tr>
<td>Diagnostic view</td>
<td>Right and left hemithorax across the transparent tube and the retrosternal tunnel</td>
<td>Right and left hemithorax using bilateral thoracoscopy, opening of either side of the retrosternal tunnel</td>
</tr>
<tr>
<td>Blind spot/retrosternal tunnel</td>
<td>Visible</td>
<td>Not visible</td>
</tr>
<tr>
<td>Clarity of vision</td>
<td>Clear view in the protected hollow transparent tube</td>
<td>Lens exposed to fogging, lung tissue and blood</td>
</tr>
<tr>
<td>Real-time view of bar</td>
<td>Provides real-time view across the blind spot and the entire hemithorax</td>
<td>Real-time view limited to the hemithorax</td>
</tr>
<tr>
<td>Intervention</td>
<td>Limited to viewing and guidance along the tunnel</td>
<td>Interventional possible through instruments passed via wound for the bar or additional port</td>
</tr>
</tbody>
</table>

The use of thoracoscopy for safe bar introduction has also been described; however, this requires an additional skin incision for inserting the thoracoscope in the already narrow chest cavity, and the view is limited to the entrance of the tunnel, with non-visualization of the bar’s head in the retrosternal blind spot [8, 9]. Table 2 enumerates the limitations and scopes of both techniques for bar introduction. The use of pectus tunneloscopy removes the critical blind spot across the crucial retrosternal tunnel during bar introduction. Its utility is limited to viewing and guiding the bar due to its inherent location. This technique, when combined with sternal elevation and endoscopic-guided tunnel creation, will be an additional armamentarium for the safe conduct of the Nuss procedure during bar introduction. The procedure can be easily performed with no additional cost, time or skin incision.

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**Conflict of interest:** none declared.

**SUPPLEMENTARY MATERIAL**

Supplementary material is available at ICVTS online.

**REFERENCES**

Gips H, Zaitsev K, Hiss J. Cardiac perforation by a pectus bar after surgical repair of the procedure, potentially minimizing the risk of cardiac, vascular (mainly internal thoracic artery) or pulmonary injury during the Nuss procedure. Delayed severe complications, however, could not be avoided, such as mechanical occlusion of the inferior vena cava requiring prompt bar removal [3], late-onset haemothorax, aortic cross or pulmonary artery injuries due to bar dislocation, and last but not least, catastrophic haemorrhage during bar removal due to transmyocardial migration, as observed in two patients and leading to death in one [2]. Besides these cardiovascular complications, postpericardiotomy syndrome, infection of the bar, metal allergy, mechanical conflicts and consecutive thoracic outlet syndrome or sternal erosion, and difficulties encountered at the time of bar removal due to neo-osification are other causes for concern.

Finally, a recent meta-analysis comparing both Nuss and Ravitch-type repair suggested no differences with respect to overall complications, but the rate of reoperation, postoperative haemothorax, and pneumothorax after the Nuss repair were significantly higher compared to the Ravitch-type repair [4]. Furthermore, in the real world, such a meta-analysis does not reflect well on the reality in terms of severe complications, since the majority of these, published in the form of case report/series, were excluded from this study. Thus, the acceptance of the Nuss procedure appears questionable to us. In our clinical practice since 2001, we perform a simplified pectus open repair (using an easily removable metallic strut under local anaesthesia) with no severe complications and favourable outcomes, and providing satisfactory long-term cosmetic results in 97.5% of patients (in line with prior published series) [5].

Conflict of interest: none declared

References