The Nuss procedure for pectus excavatum repair has been considered an acceptable method in terms of its decreased invasiveness and excellent cosmetic results. Although a steel bar is usually used for elevating the sternum, we used a titanium alloy plate for pectus excavatum repair for the first time. The characteristics of this plate are that 1) it comes out translucently on X-rays, 2) MRI examination is possible because titanium will not be magnetized, and 3) it is possible to go through the security checkpoint at the airport without setting off the metal detector. Furthermore, the titanium alloy is highly elastic, which reduces complications such as dislocation, and it excels in the conformity to organization. Patients who have received the Nuss operation are forced to somewhat limit their daily life for two or three years until the bar is removed. A plate made from titanium alloy resolves this problem because of its material and it is thought to be an ideal candidate for elevating the sternum during the Nuss operation. (Ann Thorac Cardiovasc Surg 2004; 10: 301–3)

Key words: pectus excavatum, Nuss operation, titanium alloy plate

Introduction

There have been a couple of different types of operations for pectus excavatum, such as sternal elevation,\textsuperscript{1)} sternal turn over,\textsuperscript{2)} and other procedures.\textsuperscript{3,4)} These procedures were constantly evaluated and became a standard procedure for the repair of pectus excavatum. Recently, minimally invasive surgery has spread in many fields; in 1998 Nuss et al.\textsuperscript{5)} reported a minimally invasive sternal elevation procedure using a steel bar for pectus excavatum that requires no cartilage incisions, resections, or sternal osteotomy. We have repaired 47 cases of pectus excavatum using the Nuss technique at our institute since July 1999, and we have chosen a steel bar for elevation of the sternum each time. The interval from insertion to removal of a bar is at least two years,\textsuperscript{5)} and the patients often experience complications during that period, including risks when MRI examinations cannot be performed and inconvenience when the metal detector is set off at the airport, which is not referred to in any literature. Since X-rays cannot permeate a steel bar, some types of diagnosis must use roentgenography. To resolve these matters, a plate made from titanium alloy was created and commercialized. Herein, we report our experience using this new plate.

Patients and Methods

The Nuss operation using a titanium alloy bar (Solve Co., Ltd, Japan) was performed on three girls, ages 6, 8, and 12 years old. Basically we performed the procedure as described by Nuss et al.\textsuperscript{5)} The operation was performed in the supine position under general anesthesia using a single lumen endotracheal tube. An epidural tube catheter was placed to prevent postoperative pain. A 5 mm diameter thoracoscope was inserted into the right pleural cavity via the right 7th intercostal space on the anterior axillary line to observe operative procedure and to be safe. The outer convex diameter of each patient’s chest was measured intraoperatively, and a titanium alloy bar, which was adjusted to the correct length, was inserted under the sternum through the bilateral pleural cavity. The bar was
inserted with the convexity facing posteriorly, and then turned over, thereby correcting the deformity. A lateral stabilizer to prevent bar dislocation was not used in this series and no chest drainage tubes were required. Operative time averaged $63 \pm 8$ minutes and ranged from 58 to 70 minutes and the amount of intraoperative blood loss averaged 5 ml and ranged from 0 to 15 ml. All patients had no complication intraoperatively or postoperatively.

**Postoperative Course**

A chest X-ray was taken in the operating room, and the endotracheal tube was removed when there was no problem on the X-ray. Patient received antibiotics intravenously during the day of operation and after that orally for 4 or 5 days. Each patient had strict bed rest for the first 2 days after operation to prevent bar dislocation. The duration of hospital stay ranged from 7 to 9 days (mean hospital stay: $8 \pm 1.5$ days). Patients were forbidden to participate in athletic events or play contact sports for three months after the operation. Removal of the bar is scheduled three years after the operation.

**Chest X-ray Findings**

X-ray findings with a previous steel bar are shown in

![Fig. 1. X-ray findings of a previous steel bar. (A) Frontal view (B) Lateral view](image)

Portions of the bar come out non-translucent on the X-ray.

Fig. 1. Because the previous bar is non-permeable on X-ray photographs, portions of the bar come out non-translucent on the X-ray, but a titanium alloy bar is permeable to X-rays, so it comes out translucent on the X-ray although the permeability of X-rays is different at each institution. X-ray findings with a titanium alloy bar are shown in Fig. 2.

**Comments**

In 1998, Nuss et al. reported a minimally invasive sternal elevation procedure using a pectus bar that requires no cartilage incisions, resections or sternal osteotomy (Water Lorenzs Surgical, Jacksonville, FL). Since then, this procedure has been accepted among many surgeons and patients because of its less invasive and better cosmetic results compared with previous procedures. But it has been only a short time since the Nuss operation was created, so there are few reports as to long-term results or late complications. There is no literature regarding inconveniences due to metallic bars. Naturally, the most important point in this procedure is the strength of the bar. So it is thought that a pectus bar should be used for the Nuss operation because of its strength and conformation to an organization, but a pectus bar has some problems as well. First, X-rays cannot permeate it (as shown
in Fig. 1), so parts of the bar do not come out translucently on X-rays. It is possible that the bar interrupts diagnosis when patients have X-rays because of another disease while the bar is inserted. Second, MRI examinations are not possible. Although children have a smaller chance of having MRI examinations than adults, it is possible that an MRI examination could be needed in brain injuries or diseases, such as trauma. Third, it sets off metal detectors. When patients walk through metal detectors, they must explain the situation every time. These points are problems with metal bars rather than bars themselves.

A titanium alloy plate for repairing the pectus excavatum, which is currently being reported, solves these problems. That is 1) it is permeable and comes out translucent on X-rays. 2) MRI examinations can be performed. 3) It doesn’t respond to metal detectors. Furthermore, as compared with stainless steel bars, the titanium alloy excels in the conformity to organization, and affinity is high. Also, since titanium alloy is highly elastic, it will reduce complications, such as dislocation, because it makes the external force escape in the direction, which a bar spreads without transmitting the external force to the reverse direction.

Finally, titanium alloy plates are used for the Nuss procedure not only because of their strength, but also because they are an ideal plate for the repair of a pectus excavatum since they resolve some inconveniences that have happened during insertion of a bar, and its use may benefit patients.

References