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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2024;13(1):126-30

Outcomes of the minimally invasive nuss procedure for pectus excavatum

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Received 07 December 2023; Accepted 08 January 2024
Available online 15.02.2024 with doi: 10.5455/medscience.2023.12.229

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Abstract

Because of some disadvantages of the "Ravitch method," which is the classical open surgical method used for many years in the treatment of pectus excavatum (PE), as an alternative to it, a minimally invasive surgical method called the "Nuss procedure" has been developed. This procedure has become the most preferred surgical method in the treatment of PE in recent years. In our study, we aimed to share the results of the "Nuss procedure" that we applied to our patients with PE in light of the literature. The files of 77 patients who underwent a Nuss operation for PE in our clinic between July 2007 and March 2023 were evaluated retrospectively. The age, gender, surgical method, complications, and length of hospital stay of the patients were recorded. The median age was 17.71±4.84 years (range, 2.5-33) and the majority of patients were male (63 males, 14 females). As symptoms, 14 (18.2%) patients had dyspnea, 32 (41.5%) had chest pain, and almost all patients had psychosocial problems. While minimal pneumothorax was the most common early postoperative complication (n=18, 23.4%), bar dislocation was the most common late complication (n=5, 6.5%). None of the patients had serious complications such as death, organ injury, or massive bleeding during the operations. We think that the Nuss procedure, which is a minimally invasive approach, can be safely applied to selected patients due to its short operation time, low complication rate, and success in correcting the deformity.

Keywords: Pectus excavatum, minimally invasive surgery, nuss method

Introduction

Pectus excavatum (PE) is the most common chest wall deformity [1]. Although there are varying degrees of depression of the sternum and costal cartilages in this deformity, the manubrium and the first two ribs are mostly in their normal position [2-3]. Indications for surgery include cardiac and respiratory problems, as well as mostly aesthetic concerns [2]. There are numerous surgical treatment options, including open and minimally invasive procedures. In open surgery, the operation time is long, and the patient's hospitalization and return to normal life are delayed. Due to large incisions, patients have more surgical scar problems. In addition, the recurrence rate may be high. Due to such disadvantages of open surgery, minimally invasive surgery was sought, and the Nuss procedure for PE was first described by Donald Nuss in 1987 [4]. In this procedure, the steel bar is placed in the retrosternal space, thereby reshaping the chest wall. It is the most preferred method currently [5]. In this study, we aimed to share the results of the Nuss procedure, which we applied to our patients with PE deformity, in light of the literature.

Material and Methods

This study was approved by the Ethics Committee of Cumhuriyet University (No. 2023-04/21). The files of 77 patients who underwent Nuss operation due to PE in our clinic between July 2007 and March 2023 were evaluated retrospectively. All patients agreed to participate in this study. The diagnosis was made by physical examination. The indication for the Nuss operation was cosmetic reasons. Before the procedure, posterolateral and

CITATION
Katrancioglu O, Karadayi S, Katrancioglu N. Outcomes of the minimally invasive nuss procedure for pectus excavatum. Med Science. 2024;13(1):126-30.

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DOI: 10.5455/medscience.2023.12.229

lateral radiographs were taken to evaluate the deformities of the patients. Three-dimensional thorax computed tomography (CT), complete blood count, coagulation tests, biochemistry, respiratory function test, and echocardiographic examinations were routinely performed preoperatively. The age, gender, length of hospital stays, surgical method, and complications of the patients were recorded. Complications occurring per operation and up to the first postoperative month were classified as early, and complications occurring after the first month were classified as late complications. Physical examinations and chest X-ray of the patients were used for early and late follow-up. The cases were followed until their bars appeared (2-4 years). Scoliosis was detected in 4 patients as an additional anomaly among the patients included in the study. The patients were discharged after being advised to avoid physical exertion for 4 weeks, not to lift more than 2 kg for the first 2 months, and to avoid contact sports for the first 3 months. It was emphasized that the patients should do walking exercises for the development of the musculoskeletal system in the first month after discharge.

Surgical method

All operations were performed under general anesthesia. In the technique applied by our clinic, the intercostal spaces at the deepest point of the deformity were marked on both sides of the thorax with a sterile skin pen (Figure 1). By determining the starting-end point and the deepest place of the collapse, the appropriate bar size was determined, and the appropriate bar was shaped. To view the right hemithorax, a thoracoscope was inserted into the thorax through the 4.–6. intercostal space. The hemithorax was examined with 0- or 30-degree optics. A subcutaneous tunnel was created under the pectoral muscles and above the ribs by entering the right and left anterior axillary lines with 2 and 3 cm incisions. With the help of right video thoracoscopy, the guide (intraducer) was passed through the retrosternal area, and the left incision line was reached. Nylon tape was attached to the introducer and passed through the retrosternal tunnel to the contralateral hemithorax. The bar was passed to the left hemithorax with the help of nylon tape. Afterwards, the bar was rotated to correct the deformity. In the meantime, more than one steel bar was used when it was seen that there was not enough improvement or in patients with large deformities (Haller index >5) and advanced age. After the steel bars are placed and rotated with the help of optics, they are mostly fixed by placing a steel or absorbable stabilizer on the left side. On the right, the bars were attached to the rib with absorbable sutures. The operation was completed by evacuating the air in the right hemithorax with the help of an aspiration catheter and positive pressure ventilation. Following the procedure, a standard chest X-ray was performed to determine the location of the bar and rule out pneumothorax. In pain management, intravenous morphine and paracetamol treatment were continued for 3-4 days. Then, oral pain treatment consisting of paracetamol and ibuprofen was started.

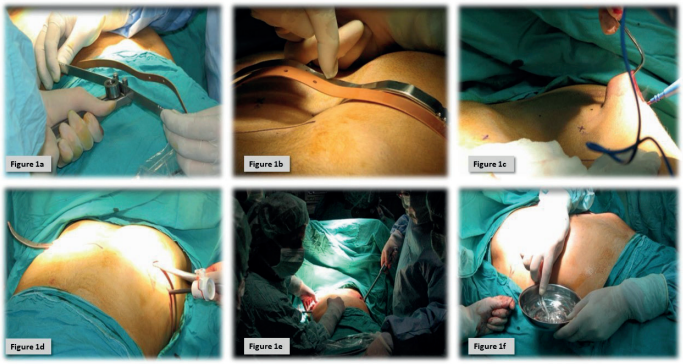

Figure 1. Operative images of the Nuss procedure. **1a.** Formation the template and steel bar, **1b.** Shape control of the bar on the chest wall, **1c.** Skin tunnel preparation **1d.** Passing the intraducer, **1e.** Turning the bar, **1f.** Evacuation of air

Statistical analysis

The data obtained from our study was uploaded to the SPSS 22.0 program. The evaluation of the data used arithmetic mean, standard deviation, frequency, and percentages.

Results

The median age was 17.71±4.84 years (range, 2.5-33) and the majority of patients were male (63 males, 14 females). 14 patients with PE had dyspnea, 32 had chest pain, and almost all patients had psychosocial problems. The demographic characteristics of the cases are given in Table 1. The surgeries were performed on all patients without serious complications such as death, organ injury, or massive bleeding. While the deformity improved with a single bar in the majority of patients (n=71), two bars were inserted in six patients due to insufficient improvement. Absorbable stabilizer was used in the first eight patients, while steel versions were used in other patients. One of these stabilizers broke in the first month postoperatively. The broken stabilizer was removed and replaced with a metal stabilizer. In our study, minimal pneumothorax was the most common postoperative early complication (n=18, 23.4%). In all of these cases, the pneumothorax regressed spontaneously, and a tube thoracostomy was unnecessary. Four patients (5.2%) experienced wound site leakage after one week postoperatively. These patients recovered with recurrent dressings and antibiotics. The most common late postoperative complication was bar dislocation (n=5, 6.5%). All patients with bar dislocations were revised, and corrections were made in four patients. In a patient with too much dislocation, the bar had to be removed in the 9th month. Since the deformity was seen to have resolved, no revision was required, and no recurrence was observed in the follow-up. Bar removal was required in one patient after 9 months due to pain intolerance. This patient was also the patient who developed a wound infection in the acute period. The complications seen in the patients and the number of patients are given in Table 2.

The mean hospital stay of the patients was found to be 4.39±0.73 days (3-6 days). In particular, patients under the age of 15 had shorter hospital stays.

DOI: 10.5455/medscience.2023.12.229

In the postoperative period, the patients were checked with a physical examination and two-way chest radiography 10 days, 20 days, and 1 month after discharge, and then every 3 months until the bars were removed.

The time to remove the bars was planned as two years in the first 20 cases and three years in subsequent cases. Bars were removed at the earliest, at 24 months, and at the latest, at 42 months. During the removal of the bars, problems were experienced in 14 patients, mostly due to fibrosis, ossification, and shifting of the bar to the intrathoracic area. Patients whose bars were removed were discharged within the first 24 hours.

Table 1. Demographic characteristics of the cases, symptom, and operation indication

Gender	n (number of patients) and ratio
Male	63 (81.8%)
Female	14 (18.2%)
Symptom	
Chest pain	32 (41.5%)
Shortness of breath	14 (18.2%)
No symptoms	37 (48.1%)
Operation indication	
Cardiac pressure	1 (1.3%)
Cosmetic	77 (100%)

Table 2. Early and late complications

Early complications	n (number of patients) and ratio
Pneumothorax	18 (23.4%)
Wound infection	4 (5.2%)
Late complications	
Bar dislocation/revision done	5 (6.5%)
Absorbable stabilizer breakage	1 (1.3%)
Overcorrection	3 (3.9%)
Wound infection	3 (3.9%)
Recurrence	3 (3.9%)
Pain intolerance	1 (1.3%)

Discussion

PE is the most common chest wall deformity and accounts for 90% of all congenital chest wall deformities [6]. Deformity is four times more common in men [7]. In our study, the majority of the patients were men (81.8%). While most patients do not have symptoms in PE, chest pain, dyspnea, decreased exercise tolerance, syncope, decreased self-confidence, and social relations can be observed in the presence of symptoms [7,8]. Consistent with the literature, in our study, 37 (48.1%) of the patients did not have any symptoms, while 32 (41.5%) patients had chest pain and 14 (18.2%) patients had dyspnea.

The treatment of PE is surgical [8], and the indications can be examined under two main headings: functional causes (pulmonary, cardiac, and orthopedic) and cosmetic-psychosocial indications. When a respiratory and cardiac evaluation is performed, no objective functional finding is detected in most of the cases. The main purposes of pectus surgery are to prevent the pressure of the sternum on the heart and lungs, to allow the normal development of the thorax, and to improve the psychological and emotional state. The most common surgical indications are psychological reasons and cosmetic problems [9,10]. Although cosmetic reasons are at the forefront of patients' complaints, they are rarely present in patients who are symptomatic due to changes in cardiologic and pulmonary physiology. These can appear as shortness of breath that starts with exercise and falling behind in effort tasks compared to their peers [11]. In all patients in this study, the indication for surgery was cosmetic and psychosocial reasons.

Different ages are reported in the literature regarding the time of surgery [12]. According to Donald Nuss, the probability of recurrence is higher in surgeries performed before puberty. For this reason, the most appropriate age range for surgery is between 12 and 16 years old, which also includes adolescence [13]. Patients under 12 years of age with severe sternal depression or severe cardiopulmonary compression can rarely be operated on, even if they are asymptomatic. As a matter of fact, one of our cases was operated on due to severe sternal depression at the age of 2.5 years. In some studies, it has been reported that complications occur more frequently in the adult patient group [14,15]. For this reason, it is recommended to be performed in the pre-adolescent period regarding the timing of the correction surgery. It is thought that the rib cage can take shape better in the pre-adolescent period, recovery is faster than normal, and the recurrence rate is less. As a matter of fact, as we determined in the previous study of our clinic [14], the complication rate was found to be higher in the male gender and over-23-year-old group in our study.

The number of bars inserted in the operation is decided according to the degree and size of the deformity. One bar is usually enough. In some cases, since the chest wall is very collapsed, the use of a single bar is not sufficient, and more than one bar must be inserted [16]. The age of the operation can also change the number of bars inserted. With advancing years, it may also be necessary to use a second support bar to achieve adequate cosmetic results. In different studies, the rate of use of two or more bars in patients in the adult group varies between 19% and 37% [17,18]. In our cases, the second bar was placed because the deformity did not improve sufficiently in only 6 (7.8%) patients. In two of our patients, while a single steel bar was sufficient, a second stabilizer was needed because one stabilizer was not enough. Steel stabilizers were placed on both the right and left sides of these patients. In the first 8 cases, fixation was done with an absorbable stabilizer. However, upon one stabilizer breakage in one patient, absorbable stabilizers have not been used in the following cases.

The most common complications in the literature are bar dislocation and pneumothorax [19]. Consistent with the

DOI: 10.5455/medscience.2023.12.229

literature, the most common early complication in our patients was pneumothorax (n=18, 23.4%). These patients did not need a tube thoracostomy. In the literature, many early complications such as simple wound infection, seroma, pleural effusion, multiple rib fracture, hemothorax, thoracic outlet syndrome, pericarditis, diaphragmatic hernia, and life-threatening cardiac perforation are mentioned [20,21]. There are seven published cases of death during Nuss surgery in the literature [22]. No life-threatening complications were encountered in our cases.

The most common late complication in the Nuss procedure is the sliding of the steel bar to the right-left, up-down, and therefore the need to correct the position of the bar (8-11%) [23,24]. To prevent this complication, stabilizers are used. It has been observed that the use of the stabilizer from both sides reduces the right-left sliding ratio of the steel bar but does not prevent it from sliding up and down. For this reason, it is recommended to put a fixation suture under the sternum in addition to the stabilizers [25]. In our patients, we did not place an additional suture under the sternum because we fixed the stabilizers sufficiently on both sides and placed the entrance holes of the steel bar into the thorax very close to the edges of the pectus crater. In our study, consistent with the literature, the most common late complication, from right to left bar dislocation (6.5%), was observed.

At the end of the planned period, the inserted bars are removed under general anesthesia. During the operation, the lung is kept in an expanded state to prevent the development of pneumothorax, and the cardiac rhythm is closely followed [26]. In this study, the bars were removed at 24 months at the earliest and at 42 months at the latest. During the removal of the bars, the most problems were experienced due to fibrosis, ossification, and the sliding of the bar into the intrathoracic area. Patients whose bars were removed were discharged within the first 24 hours.

Conclusion

As a result of the Nuss procedure, which is generally applied due to aesthetic concerns, we think that it can be safely applied in selected patients because it is a minimally invasive method, complications are few and can be managed, it corrects the deformity at a high rate, the development of the thoracic wall is smooth, and the cosmetic results are good.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
This study was approved by the Ethics Committee of Cumhuriyet University (No. 2023-04/21).

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DOI: 10.5455/medscience.2023.12.229

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