

Institutional report - Thoracic general

Early results following the Nuss operation for pectus excavatum – a single-institution experience of 383 patients[☆]

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Abstract

The prevalence of pectus excavatum is low but many patients are disabled from this thoracic deformity. The Nuss operation is a well-established surgical correction, however, until recently it has been rarely used in Europe. We have performed the Nuss operation regularly between 2001 and 2006 where a total of 383 patients were operated on for pectus excavatum. The indication for surgery was disabling cosmetic appearance as described by the patient. Patient records were reviewed for retrospective analysis. The median age was 16 years (range 7–43) and 86% were males. A satisfactory peri-operative result was achieved in all but one patient with one pectus bar (81%), two bars (19%) and three bars in one patient. Postoperative complications included bleeding, pleural effusion, seroma and deep infection. Seven patients were reoperated because the bar dislocated. At present the bars have been removed in 73 patients and their final result was excellent in all but one. The Nuss procedure for pectus excavatum can be implemented with excellent early results and few complications. There is a surprisingly high demand for surgical correction of pectus excavatum and the number of referred patients continues to increase as patients learn about the ease of this procedure and its excellent results.

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1. Introduction

Pectus excavatum is the most common chest wall deformity in children with an incidence of 1:800 [1]. For decades the traditional repair was an open procedure, but in 1998 a minimally invasive repair of pectus excavatum was reported by Nuss [2]. It involves remodeling of the anterior chest wall by employing a retrosternal metal bar with avoidance of cartilage resection. The Nuss operation has since rapidly gained acceptance as the preferred method for pectus excavatum repair because the procedure is associated with small skin incisions, a shorter operation time, minimal blood loss, and early return to full activity. Several papers have been published on the results of this technique. Most series are small in numbers but some centres have extensive experience [3–6] and reports are emerging where the technique has been used in adults [7–12]. From several websites on the internet many patients have become aware that their deformities can be corrected with a high degree of success and the number of patients referred for surgery has increased over the last decade. The aim of the present study was to report an extensive experience from a single institution, including a technical modification and routine application of the procedure in adults.

2. Methods

From 2001–2006, a total of 383 patients were operated on for pectus excavatum. The indication for surgery was disabling cosmetic appearance as described by the patient. All patients were seen preoperatively for clinical examination. If the pectus excavatum was evaluated to be <2.5 cm deep the patient was not considered for surgery. During the first four years patients were routinely scheduled for computed tomography but we never used the Haller index as a reason to exclude patients for surgery. No routine echocardiography or pulmonary function tests were requested except for patients who were under suspicion for cardiac or pulmonary disease.

All operations were performed by the same surgeon. All hospital records were retrieved and the following data recorded: symptoms, length of hospital stay, postoperative complications, duration of the surgical procedure, and signs of pneumothorax on the routine postoperative chest roentgenogram. Statistical analysis included cross-tabulation implemented in the SPSS 10.1 statistical software package (SPSS, Chicago, IL). All *P*-values <0.05 were considered statistically significant.

2.1. Surgical technique

All patients were operated on in the supine position with abduction of both arms under double-lumen intubated anaesthesia. A 5-mm blunt-tip trocar was introduced into

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the thorax for the use of a 30° videothoracoscope (Olympus Winter & Ibe, Hamburg, Germany) to define the deepest point under the funnelchest. A template was formed with a similar shape as the anterior thoracic wall and a pectus bar (Lorenz Surgical, Inc., Jacksonville, Florida, USA) was bent to match the template. We routinely used bars that were 5 cm shorter than the ones originally described by Dr. Nuss because this facilitated placement of the stabilizer close to the entry of the pectus bar into the thoracic cavity. A subcutaneous tunnel was created by blunt dissection to the highest point of the funnel (thoracic entry and exit points). A long steel rod (introducer) was inserted into the thorax and pushed between the sternum anterior to the pericardium (Figs. 1, 2). A 0-ethibond suture was tied to the eyelet at the end of the introducer which was then pulled back guiding the suture through the thoracic cavity. The pectus bar was attached to the suture and pulled through the tunnel with the convex side facing down. Finally, the bar was rotated 180° and the sternum was

tilted upward. A stabilizer was placed on the left side of the bar as close as possible to the entry into the thoracic cavity to avoid rotation. In addition, the pectus bar was secured on the right side by two or three 0-polydioxane (PDS) sutures around the ribs. If an acceptable cosmetic result could not be achieved with a single pectus bar an additional bar was introduced, and if the patients presented with asymmetric pectus excavatum the metal bar was bent asymmetrically according to the method described by Park et al. [9] (Fig. 3).

3. Results

The median age of all 383 patients was 16 years (range 7–43) and 85% were males. The majority of our patients were 16 years or older (220 patients=57%) but only 143 patients (37%) were 18 years or older. The median duration of the surgical procedure was 37 min (range, 17–180 min). There was no operative mortality. A satisfactory perioperative result was achieved in all but one patient with one pectus bar (81%), two bars (19%) and three bars in one patient. The median postoperative hospital stay was five days (range 3–29). Both the hospital stay and the postoperative hospital stay were significantly shorter in the last half of the study period ($P<0.03$). Information on the postoperative chest roentgenogram was available from all charts: a pneumothorax was visible in 178 (49%). Eleven patients (3% of all patients or 6% of those who had pneumothorax) required chest tube drainage. In the remaining 167 patients all of whom were asymptomatic, the pneumothorax was treated conservatively; and on the day of discharge it had resolved completely. Other postoperative complications included bleeding (2), pleural effusion (4), seroma (11) and deep infection in eight patients. Seven patients were reoperated because the bar dislocated. In another 13 patients, the stabilizer was removed because of pain. At present the bars have been removed in 73 patients and their final result was excellent in all but one.

4. Discussion

Surgical management of pectus excavatum has undergone major changes over the last 15 years [13]. In the 1960s and



Fig. 1. A severe case of pectus excavatum before minimally invasive correction.



Fig. 2. Three introducers were placed before the pectus bars were pulled through.



Fig. 3. The final result after placement of three pectus bars.

1970s, radical surgical operations were in vogue, even in very young children. It came to be realized, however, that pulmonary function actually decreased over time because of the scarring of the anterior chest wall, and some patients developed acquired asphyxiating chondrodystrophy from resections that were too extensive and performed at too early an age. As a result, surgeons stopped operating on prepubertal patients and reverted to modified resections of the deformed cartilages.

In 1998, the Nuss technique was introduced as a minimally invasive alternative to the standard open Ravitch technique for the correction of pectus excavatum [2]. The rationale was that it seemed unnecessary to perform an extensive and radical resection when the malleability of the thoracic cage is well demonstrated clinically by the observation that a characteristic 'barrel chest' develops even in adult patients with chronic obstructive pulmonary disease long after their bones have matured and calcified [2]. The advantages of this minimally invasive approach are (1) no anterior chest wall incision, no need to raise pectoralis muscle flaps, and no need to resect rib cartilages or perform sternal osteotomy; (2) short operating time, minimal blood loss, and early return to full activity; (3) normal long-term chest strength, expansion, flexibility, and elasticity; and (4) excellent long-term cosmetic result [2]. Incorporation of thoracoscopic techniques and small but important modification to the technique originally described have made this operation very effective and safe. Patient and physician acceptance has been growing steadily since and it is likely that the minimally invasive approach will become the gold standard for the operative management of pectus excavatum. We have used it routinely since 2001 and our number of referred patients seems to increase year after year.

There is much controversy in the literature about the ideal age for minimal invasive surgical correction of pectus excavatum. In general, the current recommendation is 5–20 years and many authors believe that the ideal age is 8–12 years because at this age the chest wall is still very malleable [6, 14, 15]. Some authors do not hesitate to perform surgery earlier, especially in symptomatic children [16]. Others do not recommend the Nuss technique for teenagers because of an increased rate of complications [17]. Nevertheless, in recent years, this operation has been extended to older patients including adults [7–12], even though the complications and postoperative pain are higher in older patients [5, 8, 10, 17]. Thus, even without the publication of a feasibility study of the Nuss procedure in adults, application of this method in adolescents and adults has been steadily increasing, with a 21.2% procedure rate in pectus excavatum patients older than 15 years of age reported in the recent literature [9]. The present study represents the largest published experience in adults. Fifty-seven per cent of our patients were 16 years or older and 37% of our patients were 18 years or older. Our results demonstrate that the operation may be carried out safely in all age groups up to forty years with excellent results, few complications and a short hospital stay.

The majority of patients who undergo surgical repair for pectus excavatum are asymptomatic children and adolescents. Symptoms are infrequent during early childhood,

apart from a shy awareness of the abnormality and a typical unwillingness to expose the chest while taking part in social or athletic activities [18]. In the absence of objectively proven cardiorespiratory problems, the principal indication for surgery is for cosmetic improvement. Our results demonstrate that the immediate result of surgery with Nuss technique is excellent in almost all patients. We acknowledge that it may be premature to claim that the Nuss procedure is the procedure of choice for correction of pectus excavatum, particularly in adults, because only relatively few patients had the bar removed and the follow-up in that subset was very short. Thus, it may be too early to estimate the true incidence of recurrence of the pectus after bar removal [19]. With the decreased compliance of the adult chest wall, it is logical to expect that the incidence of recurrent pectus excavatum anomalies in this population will be greater than that experienced with children [19].

Our results confirm previous reports that the Nuss technique is not without complications. These include pneumothorax, wound seroma, bar displacement, pericarditis and pericardial effusion, pleural effusion, hemothorax [3]. However, the incidence of complications was lower in our patients compared with previous reports, which may be secondary to the high volume of operations at our institution but is more likely to reflect that we avoided many of the early pitfalls with this technique because we first started out in 2001. Several modifications have been made since the introduction of this operations by Nuss [9]. We, too, have modified the operation by shortening the pectus bar by approximately 5 cm. The rationale for this is that the stabilizer is placed much closer to the entrance of the bar into the thoracic cavity thereby decreasing the risk of rotation or displacement, because the point where the stabilizer is attached will function as a hinge in case the bar is displaced. The closer this point is to the centre of the pectus bar the less likely it is that it will rotate. It is also possible that this generally decreases the movement of the pectus bar in the tunnel created in the anterior part of the thoracic cavity causing less inflammation and reduced problems with seroma. It appears that this theoretical consideration may have some importance because the incidence of bar displacement or rotation was <2% and seromas occurred in <3% of our patients.

In conclusion, our results demonstrate that the Nuss procedure for pectus excavatum can be implemented with excellent early results even in adult patients up to forty years of age. In addition, shortening the pectus bar and placing the stabilizer closer to the entry point into the thoracic cavity is a new modification, which seems to reduce the incidence of bar displacement and seromas. We expect that the number of referred patients continues to increase as patients learn about the ease of this procedure and its excellent results.

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Conference discussion

Dr. W. Weder (Zurich, Switzerland): We are all keen to know the long-term outcome after you have removed the bar.

Dr. H. Pilegaard: I apologize we don't have that information yet. We have removed approximately 75 bars and we have not seen any change after we removed the bars. But we don't have any long observation time, so we have to wait for that. But if you look at the results from Dr. Nuss nearly all the patients will keep the shape so we hope we can have the same results.

Dr. D.E. Wood (Seattle, WA): It is a very nice early result. I am wondering if hidden in some of your experiences there are some secrets that you may give to us, because I note two things: first of all the hospital length of stay of a median of five days is actually similar to the open modified Ravitch procedure and I guess I had expected you to have a significantly shorter hospital stay. What is it that is holding people in hospital and is that improving now, that you have more experience.

The second question is that I note the increasing use of two bars and that would suggest that you have learned something that is making you shift towards using two bars instead of one. I wonder if you could share that with us.

Dr. H. Pilegaard: For the last question, I use two bars, when I place the first bar and there is still an excavation, I put one bar more into the patient because I want to have the best results. Therefore, I think I personally use two bars more and more.

Dr. D.E. Wood: The first question was about hospital length of stay, which seems long for the procedure.

Dr. H. Pilegaard: I think this procedure is very easy, you can see the time is only 30–40 min for the surgeon. If you do an open procedure you need probably 2.5–3 h, so you have a shorter time there. You only keep small scars on the side of the body instead of one in front of the body.

Dr. D.E. Wood: We are not disagreeing about the length of time in the operating, but I was talking about the length of time in the hospital. Why are these patients in the hospital for a median of five days?

Dr. H. Pilegaard: It is because of the pain problems in relation to the operation. Even though all patients have an epidural catheter it is sometimes difficult to cease the treatment. So, therefore, we have to keep the patients in hospital for a median of five days.

Dr. W. Warren (Chicago, IL): These defects are profoundly deep and the passage of the bar initially is all tactile, it is a blind passage. How do you avoid injury to the opposite lung, how do you avoid the internal mammary vessels?

Dr. H. Pilegaard: As I told you, we have had two injuries to the internal mammary arteries and it was by turning the bar. You have the scoop, when you look into the patient and get under the sternum, when you get some experience, you can feel you are just going on the backside of the chest bar and then you can feel the tip by going out of the chest bar. We don't have any trouble. I think we have . . . the pericardium two times but we did not have any lesions to the heart.

Dr. W. Warren: No video assist from the other side?

Dr. H. Pilegaard: No.

Dr. L. Molins (Barcelona, Spain): Two technical questions. One is, have you used the CO₂ insufflation just to keep away the diaphragm to obtain a better view?

Dr. H. Pilegaard: No, it is not necessary, when we started to do the operation we used a double lumen tube in every patient, but now we are only using the double lumen tube in adults. You only need a very short time to look and define the deepest point under the sternum before you can pass the introducer through the patient, which is easy to do in a short apnoe period. So we don't have any trouble with that.

Dr. L. Molins: It helps sometimes to keep you away from the diaphragm. And the second question was about the age. We have seen that you have operated on even a 43-year-old man. How many times have you entered and seen that the sternum didn't rise because it is quite strong and calcified? If not, do you think that a vacuum bell could help in that problem?

Dr. H. Pilegaard: Probably the right vacuum bell could help you when you have a very deep excavation and if the patient is old and then more rigid. In these cases, I nearly always use two introducers so I can raise the sternum with the one before I go through with the next. In this way, I place two introducers at the same time. But most of the time I am able to get through with the first introducer, and then it is very easy to insert the second introducer or even the third, if you want to put three bars into the patient.

Dr. L. Molins: So the sternum raised up in all the patients during the operation?

Dr. H. Pilegaard: Yes.