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Preliminary results after Nuss procedure

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Rezumat

Rezultate preliminare după procedeul Nuss

Introducere: Pectus excavatum (PE) este cea mai frecventă malformație a peretelui toracic anterior având o incidență de 1 la 1000 de nounăscuți. În 1998 Donald Nuss a introdus o nouă tehnică chirurgicală, minim invazivă pentru corecția PE care evită rezecția de cartilaj costal sau osteotomia de stern.
Scop: Scopul acestei lucrări este de a evalua rezultatele terapeutice pe termen scurt și mediu după corecția minim invazivă a PE și de a prezenta îmbunătățirile noastre la această tehnică.
Material și Metodă: Timp de doi ani șapte pacienți cu PE au fost tratați de noi prin tehnica Nuss. Intervenția chirurgicală reprezintă o premieră deoarece a fost prima operație Nuss efectuată de o echipă formată exclusiv din chirurgi români. Vă prezentăm cele șapte cazuri, tehnica operatorie practicată de noi precum și rezultatele pe termen scurt și mediu.
Rezultate: Nu s-a produs niciun incident intraoperator. Evoluția postoperatorie a fost favorabilă pentru toți pacienții. Complicații au apărut la trei cazuri: două revărsate pleurale și o dehiscență de plagă fiind rezolvate imediat după apariție cu succes fără incidente ulterioare. Per global rezultatele terapeutice și cosmetice au fost considerate excelente de către pacienți și aparținători.
Concluzii: Rezultatele preliminare arată că operația Nuss de corecție a PE este o tehnică chirurgicală sigură și cu rezultate cosmetice excelente. Pentru o evaluare completă a acestei tehnici sunt necesare mai multe cazuri și evaluarea rezultatelor după o perioadă mai mare de timp.

Cuvinte cheie: pectus excavatum, Nuss, chirurgie mini-invazivă, toracoscopie

Abstract
Introduction: Pectus excavatum (PE) is the most frequent anterior chest deformity and occurs in approximately 1 in 1000 live births. In 1998 Donald Nuss introduced a new minimal invasive operative technique for PE which avoids any cartilage resection or sternum osteotomy.
Purpose: The purpose of this study is to assess the short and medium time results after minimal invasive correction of pectus excavatum and to present our improvements to the original Nuss technique.
Material and Methods: During a two years period seven PE patients were treated by us using Nuss technique. The intervention represents a premiere because it was the first Nuss operation performed by a team composed exclusively by Romanian surgeons. We present you the seven cases, our operative technique and the short and medium term outcomes.
Main results: No itraoperative incidences were recorded. Postoperative course was good for all patients. Complication occurred in three cases: two pleural effusions and a wound dehiscence. They have been all successfully resolved with no further events. Overall the therapeutic and cosmetic results were considered good by patients and their parents.
Conclusion: Preliminary results indicate that Nuss operation for PE correction is a safe surgical technique with excellent cosmetic outcomes. More cases and long time results are necessary to fully evaluate this technique.

Key words: pectus excavatum, Nuss, minim invasive, child, thoracoscopy

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Introduction

Pectus excavatum (PE) consists in the posterior depression of the sternum and the lower costal cartilages (1). It is the most frequent anterior chest deformity and occurs in approximately 1 in 1000 live births (2). First attempt to correct PE was done by Meyer in v1911 (3). Since the 50's Ravitch technique remained, with various no substantial modifications, the main surgical intervention for correction of PE. The surgical technique consists in bilateral resection of the deformed costal cartilage, transverse sternotomy at the level of the last normal rib and placement of a substernal bone graft (4). The optimal age for operation was considered to be in the early childhood, before the age of 6, when the rib cage is still malleable (4).

In 1998 Donald Nuss introduced a new minimal invasive operative technique for PE which avoids any cartilage resection or sternum osteotomy (5). A rigid, previously bent, metal bar is introduced with the concavity facing anterior under the sternum trough lateral thoracic incision. The bar is then turned posterior in order to correct sternal bending (5). The main technical improvements in the last decades were the use of thoracoscopy and the introduction of the lateral stabilizers for the bar (6). The bar is removed after 2 years from the operation. Long term favorable outcomes (95%) led to its wide adoption. Ideal age for operation was modified also. Because most of the recurrences occurred in children who undergo repair before completion of teenage growth and also because in these children there were the risk for acquired Jeune syndrome the ideal age is now considered just before puberty when chest is still very malleable and the support bar is in place during the pubertal growth spurt (6, 7).

Material and Methods

During a two years period seven PE patients were treated by us using Nuss technique. The intervention represents a premiere because it was the first Nuss operation performed by a team composed exclusively by Romanian surgeons. We present you the seven cases, our operative technique and the short and medium term outcomes.

The Patients

Male 14 years old child. Severe, symmetric PE in the lower 1/3 of sternum *(Fig. 1A)*. Effort dyspnoea was the only symptom present. EKG and cardiac echografy are normal. Haller index (HI) is 5.98. Left pleural drainage was necessary for 2 days. Postoperative course was uneventful. He left the hospital 8 days after surgery.

Male 12 years old child. Symmetric PE *(Fig. 1B)*. Associated disease: mitral valve prolapsed, myopia, isolated atrial extrasystole. Anamnestic effort dyspnoea was present for a least one year before. Sternum has a compressive effect on the right ventricle at the CT scan. HI is 3.82. After the intervention bilateral pleural drainage was necessary for 4 days. Postoperative course was uneventful. He left the hospital 6 days from the intervention.

Male 18 years old patient. Symmetric PE *(Fig. 1C)*. No symptoms are present. EKG shows a minor right bundle branch block. HI is 3.62. Right pleural drainage was maintained for 5 days. Postoperative course was uneventful. He left the hospital 8 days after surgery.

Male 14 years old child. Left rotated asymmetric PE *(Fig. 1D)*. Associated disease: mitral valve prolaps, dilated cardiophaty, scoliosis, pulmonary hypertension. The thoracic deformity increased significant and the effort dyspnoea accentuated during the past year. CT scan showed that sternum has a compressive effect on the right ventricle and the heart is displaced to the left. HI is 3.7. Bilateral pleural drainage was maintained for 4 days. Postoperative course was uneventful. He was released from hospital 6 days from surgery.

Male 14 years old child. Cup shape PE slightly rotated to the left *(Fig. 1E)*. The deformity increased significant during the past year. Physical exam showed easy effort fatigue. HI is 4.5. The bilateral pleural drainage was removed 2 hours from the intervention. A right pleural effusion developed 14 days from the intervention and was immediately solved by pleural punction with no further complication.

Female 19 years old patient. PE recurrence after Ravitch procedure at the age of 5 *(Fig. 1F)*. Physical exam revealed effort dyspnoea and sinus tachycardia. Haler index is 3.3.Nine days from the operation she developed right pleurisy. Immediate pleural drainage was inserted and intravenous antibiotics were administered. The drainage was maintained for 18 days and the patient was released after another two days.

Male 19 years old male. Severe asymmetric left rotated saucer shape PE *(Fig. 1G)*. The deformity included besides the sternum a major part of the left anterior costal arches with severe heart compression significant reduction of the thoracic cavity. In consequence the patient suffered from restrictive pulmonary deficiency, right brunch block and mitral valve stenosis. Haler index is 5.8. Postoperative course was good and the patient was released 14 days after surgery. He was readmitted two months from the surgery because of wound dehiscence and extrusion of the bar stabilizer on the left side. The left stabilizer was removed and the bar was sutured directly to the thoracic wall. No further incidences were noted and the patient was released after 5 days.

Pre-operative preparation

Several evaluations were performed for each patient before surgery: spirometry, cardiologic consult, Rx, CT, CT with 3D reconstruction *(Fig. 2)*, EKG, cardiac echography, abdominal echography, genetic consult, and ophthalmologic consult. Lab tests performed are: Complete blood count, liver function tests, kidney function tests, inflammation tests, glycemia, blood electrolytes, bleeding and coagulation time.

Operative technique

Before surgery the Lorenz bar was shaped to the desired shape in order to reduce the length of the intervention.

The patient is put under general anesthesia with orotracheal intubation.

The thoracoscope was inserted through the 7th right intercostal space in the mid axillary line *(Fig. 3)*. In the 7th

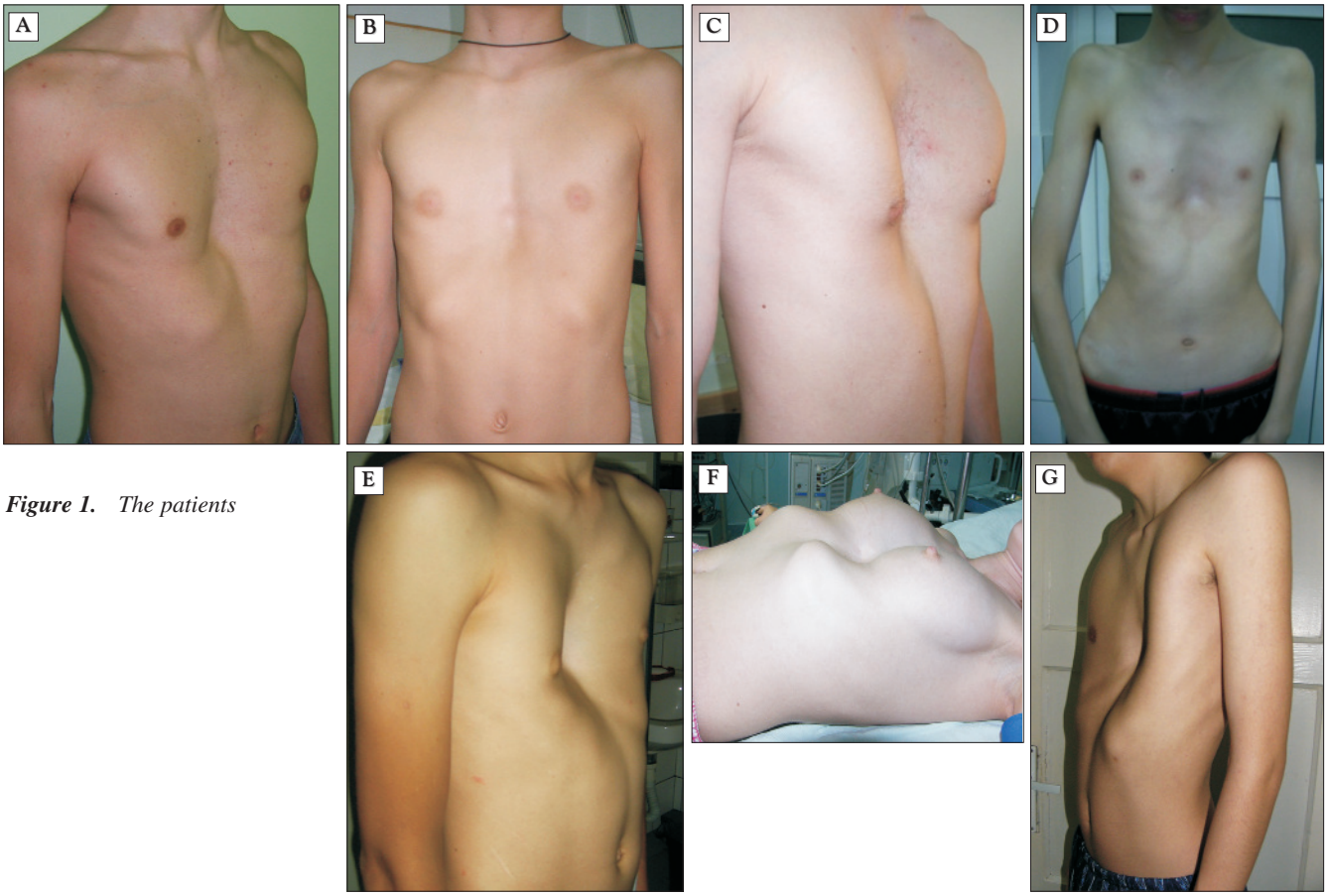

Figure 1. *The patients*

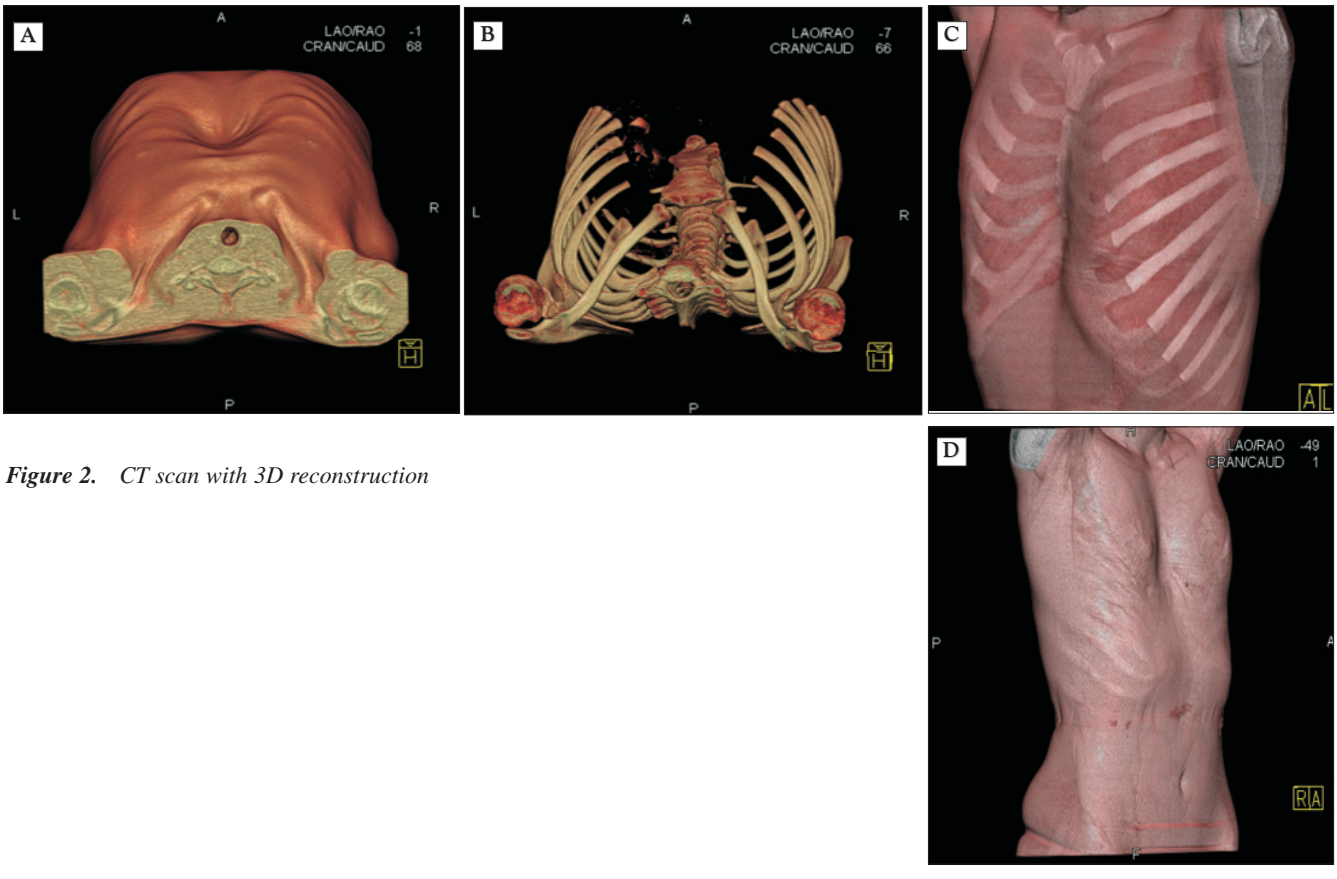

Figure 2. *CT scan with 3D reconstruction*

Figure 3. *Trocar introduction*

Figure 4. *Transverse skin incision in mid axillary line*

case the intervention was performed using bilateral thoracoscopy. Bilateral thoracic incisions are performed in the mid axillary line at the level of deepest point of the depression. In first 4 patients the incision was transverse *(Fig. 4)* while in the last 3 case the incision was orientated vertical *(Fig. 5)*. Skin tunnels are raised anterior from each incision to the top of the deformity where the thoracic cavity is entered *(Fig. 6)*. When the pleural cavity is opened an iatrogenic pneumothorax is made which is used to form the necessary work chamber. Under thoracoscopic surveillance the introducer we inserted in the right pleural cavity. Facing upwards and immediately under the sternum we slowly passed the introducer through the anterior mediastinum to the left pleural cavity. The assistant introduces his finger in the left pleural cavity and elevates the sternum when the introducer is passed through the mediastinum. This maneuver increase the distance between sternum and heart. The assistant introduces his finger through the intercostal space, which will be the exit for introducer, to elevate the sternum when the instrument is passed behind it. The introducer is than elevated and pressure applied above the sternum in order to correct the deformity *(Fig. 7)*. We attached an umbilical tape to the left end of the introducer and pulled through the tunnel by withdrawing the introducer from the right side. We attached the umbilical tape to the Lorenz bar and pulled the bar to the left side with the concavity facing anterior *(Fig. 8)*. After is introduced the bar is rotated with concavity facing posterior *(Fig. 9)*. Lateral stabilizer are fitted at each end and sutured to the rib cage *(Fig. 10)*. The skin is closed using non-resorbable sutures. We use bilateral pleural drainage in 5 cases *(Fig. 11)* and unilateral in 2 cases. On the right side we used the thoracoscope incision for drainage *(Fig. 12)*. For pain management we inserted an epidural catheter. The patient receives intravenous antibiotic, an anti-inflammatory and an analgesic drug for 5 to 6 days.

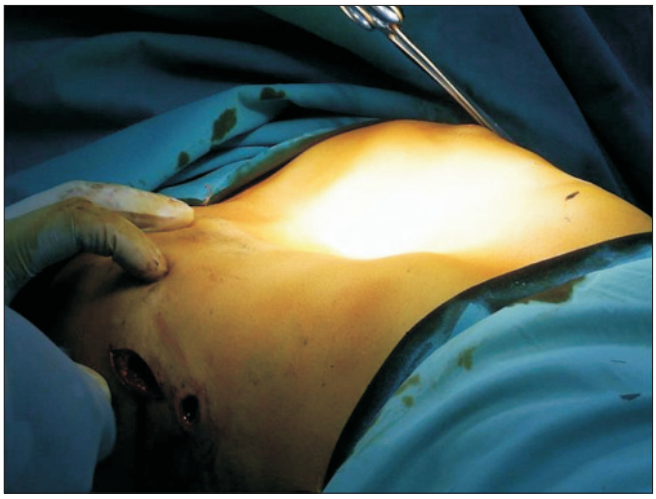

Figure 5. *Longitudinal skin incision in mid axillary line*

Figure 6. *Tunneling*

Figure 7. *The deformity is corrected by applying pressure on sternum and ribs*

Figure 8. *The bar is inserted with the concavity facing anterior*

Figure 9. *The bar is rotated with the concavity facing posterior*

Figure 10. *Lateral stabilizer are fitted at each end and sutured to the rib cage*

Figure 11. *Bilateral pleural drainage*

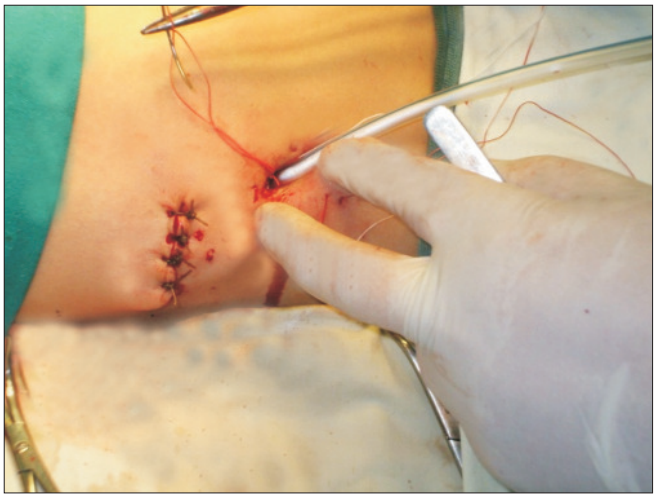

Figure 12. *The thoracoscope incision is used for right pleural drainage*

Results

No itraoperative incidences were recorded. Blood loss was minor. Time of operation was between 60 and 90 minutes. Postoperative course was good for all patients. No complication occurred in 4 of the 7 cases. In the 5th patient a pleural effusion occurred 14 days after the intervention and was resolved by pleural drainage. In the 6th case right pleurisy complicated the postoperative course and was successfully managed by pleural drainage and general antibiotics. In the 7th case reintervention was required 2 months from the initial operation because of wound dehiscence *(Fig. 13)*. The left stabilizer had to be removed and the bar reattached directly to the thoracic wall. In all case postoperative main was minor. Overall the therapeutic and cosmetic results were considered good by patients and their parents *(Fig. 14; Fig. 15A-G)*.

Figure 13. *Wound dehiscence*

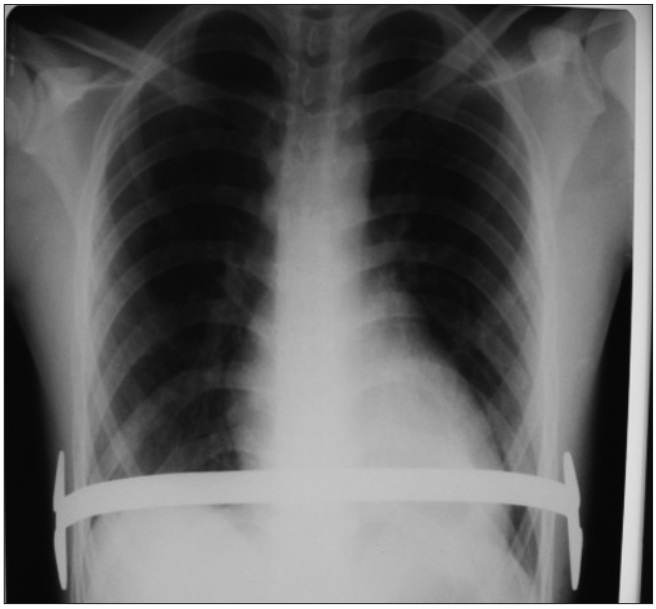

Figure 14. *Postoperative Rx patient 1*

Discussions

Donald Nuss introduced his technique for correction of PE more than 10 years ago changing radically the general overview on PE repair. The highly traumatizing and bloody Ravitch derived interventions were substituted with a cleaner, shorter and with better cosmetic results intervention. This stimulated the interest and was adopted by a growing number of surgeons all over the world. The interventions performed by us were the first ever performed by a team composed exclusively by Romanian surgeons. Even the benefits of this type of intervention are doubtless and were established by numerous studies, the relative high cost made it until now prohibit for Romania. Entering the European Union and the relative healing of the Romanian health system made it possible.

Indications for operation established by Ravitch 60 years ago are still valid: cosmetic, orthopedic and physiologic (4). Kelly summarized that the operation is indicated if two or more of the following are present: cardiac and/ or pulmonary compression on CT, Haller index of 3.25 or greater, mitral valve prolapse, murmurs, or conduction abnormalities, restrictive and/or obstructive lung disease, previous repair has failed (3). All our seven patients had at least two of these criteria. Haller index was greater than 3.25 and various degrees of effort dyspnoea were present in all our patients. Cardiac symptoms were present in four patients and one had respiratory distress due to severe reduction of the thoracic capacity. In one case the PE was recurrent after a previous Ravitch repair.

Age of the patient was also a key factor in the decision for surgery. The ideal age for PE correction is just before puberty, when the chest is still very malleable and the bar is in place during the pubertal growth spurt, reducing the possibility of recurrence (6). For adult PE patient Nuss technique is still a subject of debate. Four of our patients are in pre- and puberty and the other three are all under twenty. The intervention was well tolerated by the older patients too and there no greater difficulties during operation.

One of the main advantages of Nuss technique is the absence of the anterior thoracic incision, whom in open technique, lead in many cases to big, unaesthetic keloids. Originally Nuss technique the incisions were made transversal on both sides of the thorax. For cosmetic reasons we modified the initial technique by performing a longitudinal instead of transversal incision. The stabilizer fits more easily through a longitudinal incision which can be shorter than a transverse on and longitudinal incision is more easily hided under the arms.

The initial technique used CO_2 pleural insufflations for

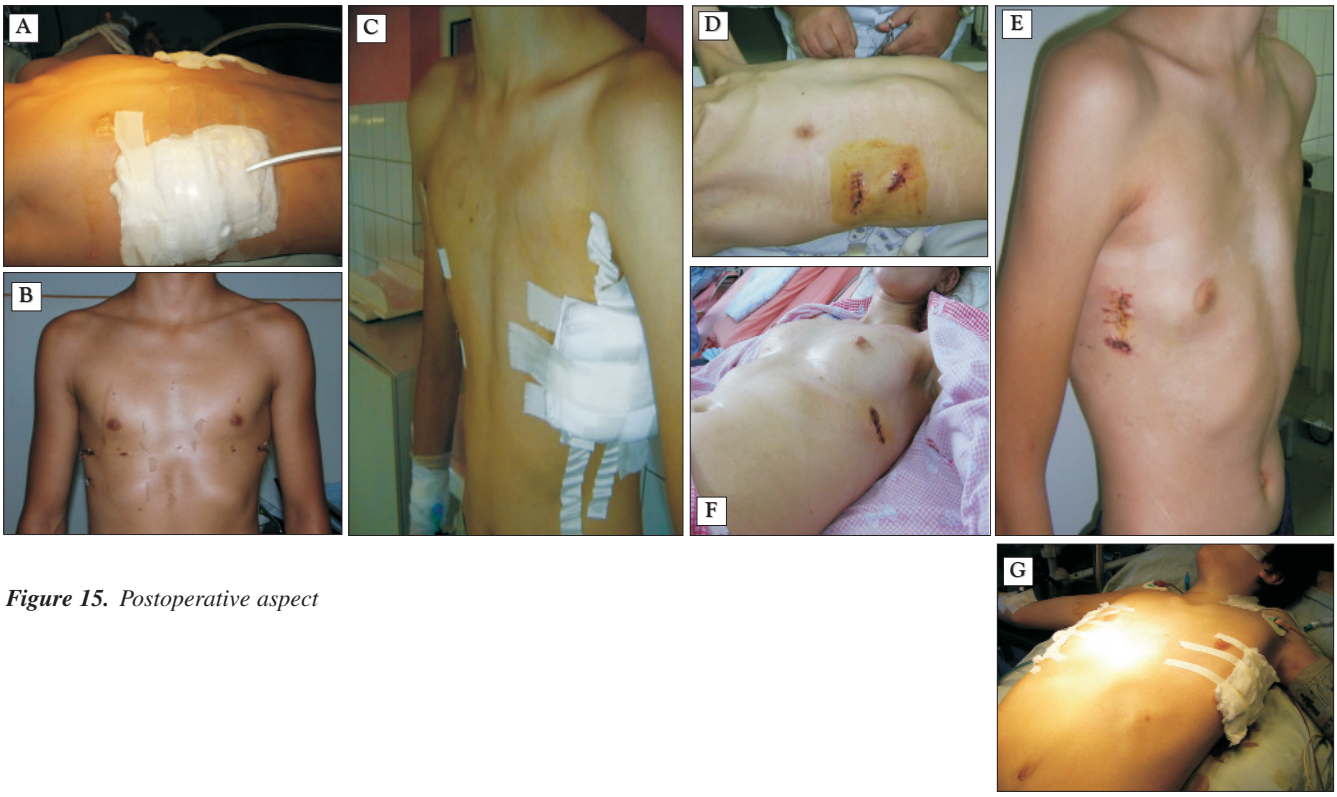

Figure 15. *Postoperative aspect*

creating the necessary work chamber (5). We considered that the pneumothorax formed spontaneously when the pleural cavity is opened offer sufficient space and positive pleural pressure is not necessary. During interventions the thoracoscopic view was good and we managed to introduce the bar easily by the left pleural cavity through the anterior mediastinum to the left pleural cavity without any incidence.

Initially Nuss didn't use thoracoscopy as a routine for the minimal invasive technique (5). All its benefits were later recognized which lead to its wide adoption (8, 9, 10). Most surgeons prefer right thoracoscopy (11). Some surgeons prefer the left thoracoscopy (12). Ultimately the main goal remains the same to be able to visualize all the maneuvers performed in the work chamber in order to avoid any heart or lung lesions. We used thoracoscopy in all seven cases. It was particularly useful for the two cases where the sternum was in direct contact with the heart. For the first six patients right thoracoscopy was sufficient. In the 7th case we used bilateral thoracoscopy because of severe heart displacement.

The assistant introduce his finger in the left pleural cavity to expect and guided out the introducer. This adaptation of the initial technique offered a better control for introducer during the passing through the anterior mediastinum. An additional adaptation used by us is to elevate the sternum when the introducer passed through mediastinum increasing the space between the back of the sternum and the heart. This maneuver is achieved by introducing a finger inside the left pleural cavity through the site prepared for the left side exit of the introducer. In this way Rokitansky's subxiphoid incision becomes unnecessary (13).

One of the main problems for Nuss technique is greater postoperative pain (14). For our patient pain level was lower than that cited before. Pain management was done mainly by intravenous drugs and for short time. The epidural catheter was necessary only in 2 cases and for 3 days only.

The most frequent complication cited before are: pneumothorax (6.9%), wound infection (4.5%), pericarditis (2.4%), bar displacement (1.2%) (15). We considered pneumothorax as part of the intervention and was manage at the end of the intervention by closing the wounds after pulmonary hyperinflation. In one case the bar loosed its attachment to the left thoracic wall two months from the operation and pass out through the skin. Because the right stabilizer remained intact the bar didn't rotate and the situation was resolved by removing the displaced stabilizer and attaching the bar directly to the rib cage. Pleural infection and pleural effusion occurred each in one case. They were resolved by drainage and proper antibiotics treatment. No pericarditis or direct heart lesions occurred.

Conclusions

Preliminary results indicate that Nuss operation for PE correction is a safe surgical technique. Postoperative outcomes are good. Hospital stay length is short. Blood loss is minimal. Cosmetic outcomes are excellent. More cases and long time results are necessary to fully evaluate this technique.

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