The Vacuum Bell for Treatment of Pectus Excavatum:an Effective Tool for Conservative Therapy

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Abstract

Aim

Pectus Excavatum (PE) is the most common chest wall malformation, and one of the most frequent major congenital anomalies. Surgical repair of PE in childhood is a well-established procedure. Previously used operative techniques to correct PE were largely based on the Ravitch technique. Today, the minimally invasive repair (MIRPE) by Nuss is well established. Conservative treatment with the vacuum bell to elevate the funnel in patients with PE, represents a potential alternative.

Material and Methods

A suction cup is used to create a vacuum at the anterior chest wall. 3 different sizes of vacuum bell exist which are selected according to the individual patients age. When creating the vacuum, the lift of the sternum is obvious and remains for a different time period. The device should be used for a minimum of 30 minutes (2/day), and may be used up to a maximum of several hours daily.

Results

93 patients (77 males, 16 females), aged 3 to 61 years (median 17.8 years) used the vacuum bell for 1 to maximum 24 months. Computed tomographic scans showed that the device lifted the sternum and ribs immediately. In addition, this was confirmed thoracoscopically during the MIRPE procedure. After 18 months in average, the sternum was lifted to a normal level in 9 patients. Relevant side effects were not noted.

Conclusions

The vacuum bell has proved to be an alternative therapeutic option in selected patients with PE. The initial results proved to be dramatic, but long-term results are so far lacking, and further evaluation and follow-up studies are necessary.

Keywords

Pectus Excavatum, Conservative Treatment, Vacuum Bell.

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Introduction

Pectus Excavatum (PE) is the most common chest wall malformation and one of the most frequent major congenital anomalies, occurring in approximately 1 in every 300 births.[1] In more than 85% of infants, the defect is already noticeable at birth. A later onset may be observed in patients with Marfan syndrome. Until the end of the last century, operations to correct PE deformities were largely based on the technique described by Ravitch.[2] In 1998, a new technique of minimally invasive repair of PE (MIRPE) was first described by D. Nuss[3] to avoid several operative features of the modified Ravitch repair procedure. Today, the MIRPE technique is well established and represents a common used technique.[4-9] The short operating time, smaller incisions and considerably less dissection has made the MIRPE procedure very appealing both to surgeons and patients, thereby resulting in a large increase of the number of patients requesting operative treatment, and consequently in an increase of the number of PE repairs. However, with the widespread use of the MIRPE procedure the character and number of complications has increased[4,6-8,10-12] (table 1 and 2). Above all, recent studies report on an increasing number of near fatal complications.[12-18] Additionally, in many cases of PE, the degree of pectus deformity does not immediately warrant surgery, yet patients may benefit from some type of nonsurgical treatment. Other patients are reluctant to undergo surgery because of the pain associated with postoperative recovery and the risk of imperfect results. Due to these facts, the introduction of the vacuum bell for conservative treatment of PE has made this alternative therapy a focus of interest of patients.

Table 1. Intraoperative Complications after MIRPE procedure[4-9]

Pericardial lesion
Perforation of the heart
Cardiac rhythm disorders
Lesion/rupture of intercostal muscles
(Tension)-pneumothorax
Significant blood loss
Perforation of the liver
Lesion/Rupture of the diaphragm

Table 2. Postoperative Complications after MIRPE procedure[4-9]

Pneumothorax (drainage ?)
Pleural effusion (drainage ?)
Pneumonia – atelectasis
Hematothorax (drainage ?)
Pericardial effusion (puncture ?)
Pericarditis
Bar shifts (requiring revision ?)
Dislocation of the stabilizer (requiring revision ?)
Wound infection
Over correction
Bar allergy
Skin erosion

The procedure of applying a vacuum to elevate the sternum was first used more than 100 years ago.[19] Despite the risks and unsatisfactory results after operative therapy for some patients, there has been little progress in the therapeutic use of the vacuum therapy during the last few decades. In the meantime, materials have improved and the vacuum devices can now exert strong forces. Our initial results using this method proved to be promising.[20] Today, we report our ongoing experience using the vacuum bell for conservative treatment of PE. Note that a subset of these patients (the first 34 patients) was reported previously.[20]

The vacuum bell

A suction cup is used to create a vacuum at the chest wall. A vacuum up to 15% below atmospheric pressure is created by the patient using a hand pump (Figure 1). Three different sizes exist allowing selection according to the individual patients age (Figure 2). The medium size model is available in a supplemental version with a reinforced silicon wall (type "bodybuilder"), esp. made for adult patients with a small deep PE. Additionally, a model fitted for young girls and women is available. Pilot studies performed by Schier and Bahr[21] showed that the device lifted the sternum and ribs immediately. In addition, this was confirmed thoracoscopically during the MIRPE procedure (Figure 3). The vacuum bell should be used for a minimum of 30 minutes, twice per day, and may be used up to a maximum of several hours daily.

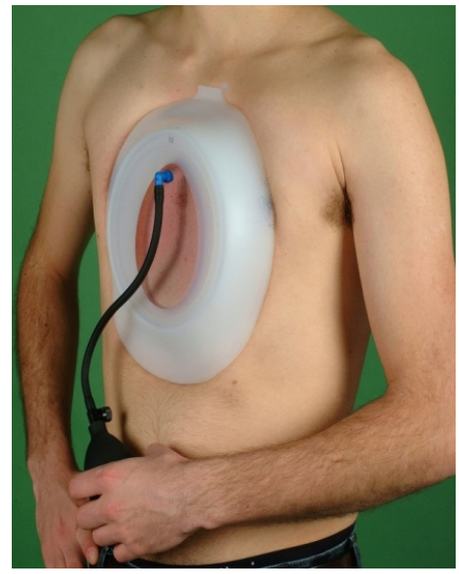


Figure 1. Application of the vacuum bell

Indication for conservative therapy with the vacuum bell include patients who

- present with mild degree of PE
- want to avoid surgical procedure
- are reluctant to undergo surgery because of pain associated with the operation
- are afraid of "imperfect" results after surgery

Contraindications of the method comprise skeletal disorders such as osteogenesis imperfecta and Glisson's disease, vasculopathies (e.g. Marfan's syndrome, abdominal aneurysm), coagulopathies and cardiac disorders. To exclude these disorders, a standardised evaluation protocol was routinely performed before beginning the therapy. Complications and relevant side effects include subcutaneous hematoma, petechial bleeding, dorsalgia and transient paresthesia of the upper extremities during the application as well as rib fractures in rare cases what was not seen in our series.

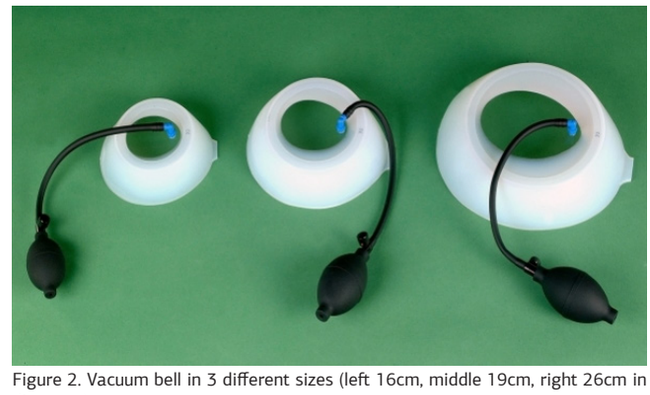
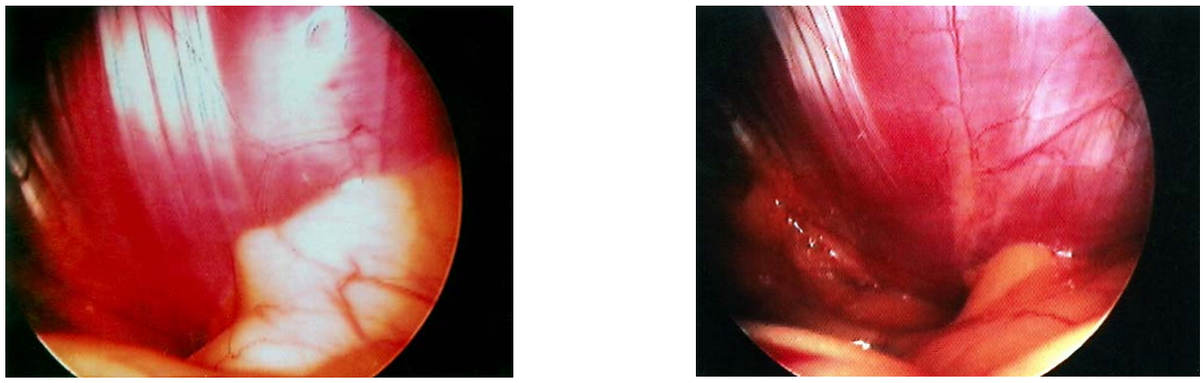


Figure 2. Vacuum bell in 3 different sizes (left 16cm, middle 19cm, right 26cm in diameter)



Retrosternal space without (left) and with the vacuum bell (right) during the MIRPE procedure

Figure 3. intraoperative use of the vacuum bell during the MIRPE procedure

Patients and Methods

93 patients (77 males, 16 females), aged from 3 to 61 years (median 17.8 years) were treated with the vacuum bell for 1 to a maximum of 24 months (median 10.4 months). Standardised evaluation before starting the procedure included history of the patient and his family, clinical examination, cardiac evaluation with electrocardiogram and echocardiography and photo documentation. In addition, the depth of PE was measured in supine position. Patients underwent follow-up at 3 to 6 monthly intervals including photography and clinical examination.

The first application of the vacuum bell occurred under supervision of the attending doctor. The length of time of daily application of the vacuum bell varied widely between patients. Some patients followed the user instructions and applied the device twice daily for 30 minutes each. Patients under the age of 10 years used the device under supervision of their parents or caregivers. Some of the adult patients used the vacuum bell 4-6 hours daily during office hours. Adolescent boys applied the device every night for 7-8 hours. In fact, the duration and frequency of daily application depends on the patients individual decision and motivation.

Since 2006, the vacuum bell was used routinely during the MIRPE procedure to elevate the sternum to allow a safer passage of the Lorenz® introducer as well as the pectus bar.

Results

During the first 1-5 applications, most of the patients experienced moderate pain in the sternum and reported a feeling of uncomfortable pressure within the chest. Adolescent and older patients developed moderate subcutaneous hematoma, which disappeared within a few hours. Some patients reported recurrent transient paresthesia of the upper extremities during the application. This symptom disappeared when lower atmospheric pressure was used during application. One 45 year old patient suffering from recurrent dorsalgia, reducing the application time, prevented the occurrence of discomfort. Analgesic medication was not necessary in any patient. The application of the vacuum bell in children aged 3 to 10 years was without side effects.

When starting with the application, patients presented with a PE with depth from 2cm to 5cm. In 74 patients (69%), after 3 months of treatment an elevation of more than 1.5cm was documented. In 9 patients (10%), the sternum was lifted to a normal level after 18 months (Figures 4 & 5). The longest follow-up after discontinuation is 5 years, and the success until today is permanent and still visible. In three patients with asymmetric PE, the depth of PE has decreased after 9 months, but the asymmetry is still visible. 3 patients were dissatisfied with the postoperative result (2 patients after MIRPE, 1 patient after Ravitch procedure) and started treatment with the vacuum bell. 6 patients stopped the application after 13.5 months in average, due to an unsatisfactory result (2 patients) and decreasing motivation (4 patients). All 6 patients underwent MIRPE. At follow-up, all patients were satisfied and expressed their motivation to continue the application, if necessary.

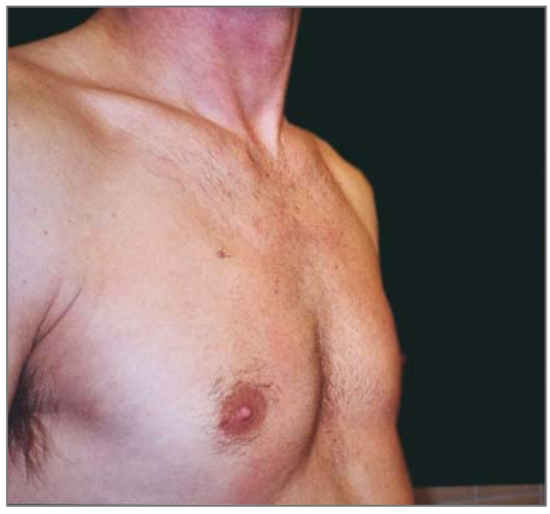


Figure 4a. 45 year old patient, before (left: depth of PE = 2.5cm)



Figure 4b. vacuum bell therapy and after 12 months (right: depth of PE = 0.5cm)

Discussion

With the widespread use of world wide web, information on new therapeutic modalities circulate not only among surgeons and paediatricians, but also rapidly among patients. In particular patients who refused operative treatment by previously available procedures, now appear at the outpatient clinic and request to be considered for new

Figure 5. 9 year old boy, before (left: depth of PE = 2.8cm) vacuum bell therapy, after 10 months (right: depth of PE = 1.6cm) and 36 months after therapy (below)







methods. From 1999 on, an increasing number of patients presented with PE at our department and asked to undergo the MIRPE procedure. The vacuum method was used as early as 1910 by Lange.[19] The vacuum bell used in our patients group was developed by an engineer, who himself suffered from PE [Klobe E, www.trichterbrust.de]. We use this method since 2003. Long-term evidence of persistent effects of the treatment modality for more than 5 years are not yet available. However, initial results proved dramatic,[20] and the acceptance and compliance of patients seem to be good. In many cases of PE, the degree of pectus deformity does not immediately warrant surgery, yet patients may benefit from some type of nonsurgical treatment. Other patients are disinclined to undergo surgery because of possible complications after surgery, because of the pain associated with postoperative recovery and the risk of imperfect results. Thus, the introduction of the vacuum bell for conservative treatment of PE has generated much interest among patients with PE.

The success of a therapeutic procedure not only requires a good technique, but also depends on a appropriate indication. In our study patients who presented with symmetric and mild PE, seemed to show a more successful outcome than those with asymmetric and deep PE. All patients except six were satisfied with the use of the vacuum bell, although objectively assessed improvement of PE varied between the individuals. All our patients were recommended to carry on undertaking sports and physiotherapy, so that the accompanying improvement of body control was an important factor in outcome. The participation of patients themselves in the "active" treatment of PE clearly increases motivation to maintain therapy. As demonstrated in the CT scan, the force of the vacuum bell is strong enough to deform the chest within minutes.[21] Therefore, especially in children younger than 10 years of age the application of the vacuum bell has to be performed carefully and should be supervised by an adult.

When creating the vacuum, the elevation of the sternum is obvious and persists for a distinct period of time. Therefore, the vacuum cup may also be useful in reducing the risk of injury to the heart during the MIRPE procedure, where the riskiest step of the procedure is the advancement of the introducer between the heart and sternum. Since the manufacturer of the device has not yet a license to sterilise the vacuum bell, this additional use has to be considered as a clinical trial. In accordance with our hospital hygieneist, we applied the vacuum bell during the MIRPE procedure since 2006 routinely with good experience. In addition, the vacuum bell may be useful in a way of "pre-treatment" to surgery.

In conclusion, the vacuum bell may allow some patients with PE to avoid surgery. Especially patients with symmetric and mild PE may benefit from this procedure. The application is easy, and we noticed a good acceptance by both pediatric and adult patients. However, the time of follow-up in our series is only 5 years, and further follow-up studies are necessary to evaluate the effectiveness of this therapeutic tool. Additionally, the intraoperative use of the vacuum bell during the MIRPE may facilitate the introduction of the pectus bar. In any case, the method seems to be a valuable adjunct therapy in the treatment of PE.

References

1. Molik KA, Engum SA, Rescorla FJ, West KW, Scherer LR, Grosfeld JL. Pectus excavatum repair: Experience with standard and minimal invasive techniques. J Pediatr Surg 2001; 36: 324-328.
2. Ravitch MM. The operative treatment of pectus excavatum. Ann Surg 1949; 129: 429-444.
3. Nuss D, Kelly RE, Croitoru DP, Katz ME. A 10-Year Review of a Minimally Invasive Technique for the Correction of Pectus Excavatum. J Pediatr Surg 1998; 33: 545-552.
4. Croitoru DP, Kelly RE, Goretsky MJ, Lawson ML, Swoveland B, Nuss D. Experience and Modification Update for the Minimally Invasive Nuss Technique for Pectus Excavatum Repair in 303 Patients. J Pediatr Surg 2002; 37: 437-445.
5. Hosie S, Sitkiewicz T, Petersen C, Göbel P, Schaarschmidt K, Till H et al. Minimally Invasive Repair of Pectus Excavatum – The Nuss Procedure. A European Multicentre Experience. Eur J Pediatr Surg 2002; 12: 235-238
6. Nuss D, Croitoru DP, Kelly RE, Goretsky MJ, Nuss KJ, Gustin TS: Review and Discussion of the Complications of Minimally Invasive Pectus Excavatum Repair. Eur J Pediatr Surg 2002; 12: 230-234
7. Haecker F-M, Bielek J, von Schweinitz D. Minimally Invasive Repair of Pectus Excavatum (MIRPE): The Basel Experience. Swiss Surgery 2003; 9: 289-295
8. Park HJ, Lee SY, Lee CS: Complications Associated with the Nuss Procedure: Analysis of Risk Factors and Suggested Measures for Prevention of Complications. J Pediatr Surg 2004; 39: 391-395
9. Dzielicki J, Korlacki W, Janicka I, Dzielicka E. Difficulties and limitations in minimally invasive repair of pectus excavatum – 6 years experiences with Nuss technique. Eur J Cardio-Thorac 2006; 30: 801-804
10. Shin S, Goretsky MJ, Kelly RE,Gustin T, Nuss D: Infectious complications after the Nuss repair in a series of 863 patients. J Pediatr Surg 2007; 42: 87-92
11. Berberich T, Haecker F-M, Kehrer B, Erb T, Günthard J, Hammer J, Jenny P. Postcardiotomy Syndrome after Minimally Invasive Repair of Pectus Excavatum. J Pediatr Surg 2004; 39: e1-e3.
12. Van Renterghem KM, von Bismarck S, Bax NMA, Fleer A, Hoellwarth M. Should an infected Nuss bar be removed? J Pediatr Surg 2005; 40: 670-673.
13. Barakat MJ, Morgan JA: Haemopericardium causing cardiac tamponade: a late complication of pectus excavatum repair. Heart (2004) 90: e22-e23
14. Barsness K, Bruny J, Janik JS, Partrick DA: Delayed near-fatal hemorrhage after Nuss bar displacement. J Pediatr Surg 2005; 40: E5-E6
15. Hoel TN, Rein KA, Svennevig JL: A Life-Threatening Complication of the Nuss-Procedure for Pectus Excavatum. Ann Thorac Surg 2006; 81: 370-372
16. Adam LA, Lawrence JL, Meehan JJ: Erosion of the Nuss bar into the internal mammary artery 4 months after minimally invasive repair of pectus excavatum. J Pediatr Surg 2008; 43: 394-397
17. Gips H, Zaitsev K, Hiss J: Cardiac perforation by a pectus bar after surgical correction of pectus excavatum: case report and review of the literature. Pediatr Surg Int 2008; 24: 617-620
18. Haecker F-M, Berberich T, Mayr J, Gambazzi F: Near-fatal bleeding after transmyocardial ventricle lesion during removal of the pectus bar after the Nuss procedure. J Thorac Cardiovasc Surg. 2009 Nov; 138 (5): 1240-1. Epub 2008 Sep 19
19. Lange F. Thoraxdeformitäten. In: Pfaundler M, Schlossmann A (editors): Handbuch der Kinderheilkunde, Vol V. Chirurgie und Orthopädie im Kindesalter. Leipzig, FCW Vogel 1910: 157.
20. Haecker F-M, Mayr, J. The vacuum bell for treatment of pectus excavatum: an alternative to surgical correction? Eur J Cardio-Thorac 2006; 29: 557-561
21. Schier F, Bahr M, Klobe E: The vacuum chest wall lifter: an innovative, nonsurgical addition to the management of pectus excavatum. J Pediatr Surg 2005; 40: 496-500