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Pectus Excavatums

# Nonoperative management of pectus excavatum with vacuum bell therapy: A single center study

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ABSTRACT

*Purpose:* The purpose of this study was to determine variables predictive of an excellent correction using vacuum bell therapy for nonoperative treatment of pectus excavatum.
*Methods:* A single institution, retrospective evaluation (IRB 15-01-WC-0024) of variables associated with an excellent outcome in pectus excavatum patients treated with vacuum bell therapy was performed. An excellent correction was defined as a chest wall depth equal to the mean depth of a reference group of 30 male children without pectus excavatum.
*Results:* Over 4 years (11/2012–11/2016) there were 180 patients enrolled with 115 available for analysis in the treatment group. The reference group had a mean chest wall depth of 0.51 cm. An excellent correction (depth ≤ 0.51 cm) was achieved in 23 (20%) patients. Patient characteristics predictive of an excellent outcome included initial age ≤ 11 years (OR = 3.3,p = .013), initial chest wall depth ≤ 1.5 cm (OR = 4.6,p = .003), and chest wall flexibility (OR = 14.8,p < .001). Patients that used the vacuum bell over 12 consecutive months were more likely to achieve an excellent correction (OR = 3.1,p = .030). Follow-up was 4 months to 4 years (median 12 months).
*Conclusion:* Nonoperative management of pectus excavatum with vacuum bell therapy results in an excellent correction in a small percentage of patients. Variables predictive of an excellent outcome include age ≤ 11 years, chest wall depth ≤ 1.5 cm, chest wall flexibility, and vacuum bell use over 12 consecutive months.
*Type of study:* Retrospective chart review.
*Level of evidence:* Level III treatment study.



## 1. Background

Pectus excavatum is the most common chest wall deformity. It was initially managed with the open Ravitch procedure, and now is most frequently treated with the Minimally Invasive Repair of Pectus Excavatum (MIRPE) since its description by Nuss et al. in 1998 [1–4]. Although the idea of applying suction to the chest wall to elevate the sternum was first described over a century ago, the refinement of this method has taken place in the last 20 years [5–12]. Schier et al. were the first to describe the use of the vacuum bell as an adjunct during the Nuss procedure to elevate the sternum when creating the substernal tunnel [10]. The use of the vacuum bell as an alternative to operative management has been extensively reported on by Haecker, et al. in Switzerland [7–9]. They noted that symmetric and mild pectus excavatum deformities are most likely to benefit. While an optimal age is not defined, they clearly noted that patients beyond adolescence with depths >3 cm often require a longer duration of therapy. They also aptly noted that the growth spurt during puberty likely adversely influences vacuum bell outcomes owing to the typical progression of pectus depth and severity [9]. Lopez et al. also recently reported that patients <18 years old had better outcomes [12]. However, it remains unclear from these studies specifically which patients are most likely to achieve an excellent correction of pectus excavatum with vacuum bell therapy. Our study aims to identify variables associated with an excellent correction and thus help optimize patient selection.

## 2. Methods

An IRB-approved (15-01-WC-0024), single institution, retrospective study evaluating outcomes of vacuum bell therapy to treat pectus excavatum nonoperatively over 4 years (11/2012–11/2016) was performed. Indications for vacuum bell therapy included patients

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| Intro Period (first four weeks) | | | | Increase Duration (15 minutes weekly) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Week: 1** | **Week: 2** | **Week: 3** | **Week: 4** | **Week: 5** | **Week: 6** | **Week: 7** | **Week: 8** | **Week: 9** | **Week: 10** |
| 30 min | 30 min | 30 min | 30 min | 45 min | 60 min | 75 min | 90 min | 105 min | 120 min |

**Fig. 1.** Guide for increasing use of vacuum bell.

with: mild pectus excavatum who are not candidates for surgery, moderate to severe pectus excavatum too young for surgery, recurrence after surgery, aversion to surgery, and rigid chests in preparation for surgery. Contraindications to vacuum bell therapy included: age less than 6 years old, skeletal disorders (e.g., osteogenesis imperfecta, osteoporosis, Glisson's disease), vasculopathies (e.g., Marfan's disease, aortic aneurysms or dilated aortic root), coagulopathies (e.g., hemophilia, thrombocytopenia, etc) and cardiac disorders.

At clinic visits the depth (centimeter), flexibility, symmetry, and shape of the patients' chest wall were documented. Chest wall flexibility was evaluated by having the patient perform a Valsalva maneuver at maximal inspiration and assessing whether there was flattening of the anterior chest wall, henceforth referred to as the Nuss maneuver. If the patient's anterior chest wall flattened during the Nuss maneuver, the patient was classified as having a flexible pectus deformity. Symmetry was simply documented as being symmetric or asymmetric and shape was documented as a localized cup-shape or other (e.g., diffuse saucer-shape, long grand-canyon type) [4]. The patient reported daily vacuum bell use (average minutes applied per day). The duration of therapy (total months used) was also tracked.

The suction (vacuum) pressure (millibar) was advanced in four stages: Stage I = 20 to 50; Stage II = 51 to 70; Stage III = 71 to 130; Stage IV ≥ 131. All patients started at Stage I for the first 10 weeks. During the first month the vacuum bell was applied 30 min twice daily, which was gradually increased to 120 min twice daily (Fig. 1). After the patient achieved a use of 120 min twice daily, the suction pressure was increased to a higher stage as described above. Occasionally management did vary owing to patient compliance and physician preferences.

In addition, a reference group of 30 male children without chest wall deformity underwent measurement of their chest wall depth. The chest wall depth in the treatment and reference group was measured using a scaled wooden rod as routinely described by Haecker, et al. (i.e., arms by side, quiet respiration) [9]. The mean depth of the reference group was found to be 0.51 cm, and this was used as the *Normal Depth* to calculate the Percentage Correction of the treatment group as follows:

$$\text{Percentage Correction} = [(\text{Patient Initial Depth} - \text{Patient Current Depth}) / (\text{Patient Initial Depth} - \textit{Normal Depth})] \times 100; \text{ where } \textit{Normal Depth} = 0.51 \text{ cm}.$$

This formula provides an objective measurement that effectively describes any patient with a chest wall depth of 0.51 cm or less as being 100% corrected.

The results were divided into four categories based on the Percentage Correction as follows:

Excellent (≥100%); Good (99%–67%); Fair (66%–34%); Poor (≤33%).

Descriptive statistics and frequencies are reported for primary variables. Bivariate analysis was performed via a series of binary logistic regressions to identify variables that separately predicted an excellent outcome, defined as a final depth ≤ 0.51 cm. All analyses were conducted using SPSS version 19 statistical software.

## 3. Results

The 30 male children used as the reference group were found to have a mean chest wall depth of 0.51 cm (Fig. 2). 180 patients were enrolled over 4 years, with 65 (36.1%) that either were lost to follow-up, discontinued use, or had insufficient documentation to be included in the analysis. There were 43 patients lost to follow up who came for

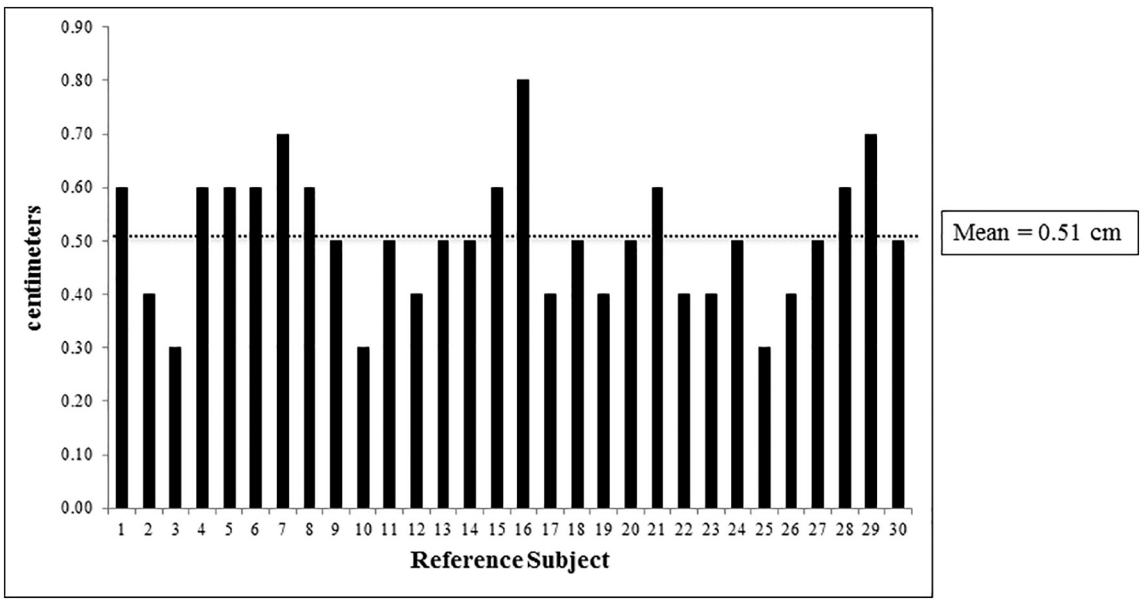


**Fig. 2.** Chest wall depth of reference group subjects.