



## Preliminary study of efficacy of cup suction in the correction of typical pectus excavatum



Manuel Lopez<sup>a,b,d,\*</sup>, Arnaud Patoir<sup>a,c</sup>, Frederic Costes<sup>d</sup>, François Varlet<sup>b,d</sup>, Jean-Claude Barthelemy<sup>d</sup>, Olivier Tiffet<sup>a,c,d</sup>

<sup>a</sup> Unit of Chest Wall Deformities Children and Adults, University Hospital of Saint Etienne, Faculty of Medicine Jacques Lisfranc, PRES Lyon 42023, Jean Monnet University, Saint-Etienne, France

<sup>b</sup> Department of Pediatric Surgery & Urology, University Hospital of Saint Etienne, Faculty of Medicine Jacques Lisfranc, PRES Lyon 42023, Jean Monnet University, Saint-Etienne, France

<sup>c</sup> Department of General and Thoracic Surgery, University Hospital of Saint Etienne, Faculty of Medicine Jacques Lisfranc, PRES Lyon 42023, Jean Monnet University, Saint-Etienne, France

<sup>d</sup> Department of Physiology Clinical of Exercise, University Hospital of Saint Etienne, Faculty of Medicine Jacques Lisfranc, PRES Lyon 42023, Jean Monnet University, Saint-Etienne, France

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### ABSTRACT

**Objective:** This preliminary qualitative study evaluates the efficacy of cup suction in the correction of pectus excavatum (PE), and examines the place of this system as a strategic treatment and as an alternative to surgery.

**Materials and methods:** Between October 2011 and June 2014, a total of 84 patients (children and adult) presenting with PE were treated by cup suction, in our chest wall deformities unit. On first consultation, the patients with typical PE and with at least partial correction during the first application of cup suction and a maximal suction pressure for correction of less than 300 mbar (millibars) were included in this study. 11 patients were excluded from the present study as they presented with a complex carinatum/excavatum. The remaining 73 patients were divided into two groups: Group I, adult patients  $\geq 18$  year old, 17 patients. The mean age was 22.8 years old. Group II, pediatric patients  $< 18$  years old, 56 patients. The mean age was 11.5 years old. Medical photographic documentation was collected systematically. In addition, the depth of PE was measured.

The management protocol involved: adjustment of cup suction, strengthening exercises, and clinical follow-up every two to three months. The evaluation criteria during, and on the completion of the trial were: depth of the PE, morbidity and treatment compliance.

Partial and final results were evaluated by the patients, their parents, and doctor, using a qualitative scoring scale.

**Results:** A total of 73 patients presenting typical PE (symmetric in 52 cases and asymmetric in 21 cases) were treated by cup suction. The mean depth of PE was 23 mm (9–44). Of the 73 patients, one adult abandoned treatment and three children abandoned follow-up.

The mean time of use of the device was 4 h daily. At six months of treatment, the mean depth of PE was 9 mm (0–30) across all patients. 23 patients completed the treatment and exhibited flattening of the sternum. These patients were considered to have an excellent aesthetic result. The mean treatment duration to normal reshape was achieved at 10 months (4–21). The remaining patients are improving under continuing active treatment. The mean depth of PE in this group was 12 mm (4–30), after a mean treatment duration of 9 months (2–22).

**Conclusions:** Treatment using cup suction is a promising useful alternative in selected cases of symmetric and asymmetric PE, providing that the thorax is flexible. Treatment duration is directly linked to age, severity and the frequency of use. It is becoming a well-recognized therapy, which improves the self-image of those patients whose anterior chest wall is still pliable. The cup suction can be used for pediatrics and young adults waiting for a treatment, possibly surgery, however, the long-term effect of this procedure remains unclear.

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Pectus excavatum (PE), or sunken chest, is the most common congenital chest wall defect. It is characterized by a posterior depression of the sternum [1]. This defect may be associated with altered cardiac and respiratory functions resulting in a decreased ability for the patients to perform vigorous cardiovascular activities relative to their peers. A

secondary effect of this deformity is the socially limiting psychological stress it can cause [2]. Surgical correction remains the definitive treatment of PE, and multiple techniques for repair have been described. The introduction by Nuss [3] in 1998 of the minimally invasive technique for the correction of pectus excavatum (PE) is being performed worldwide with ever increasing frequency. As a result, a growing number of patients have been requesting operative treatment. There has been a corresponding rise in the number of PE requests for treatment and consequently, an increase of the number of PE repairs. While this is the most widely used procedure, it is not free of complications [4]. It

\* Corresponding author at: Unit of Chest Wall Deformities Children & Adults, Department of Pediatric Surgery & Urology, University Hospital of Saint Etienne, 4205 Saint Etienne-Cedex, France.

E-mail address: [manuel.lopez@chu-st-etienne.fr](mailto:manuel.lopez@chu-st-etienne.fr) (M. Lopez).

is also worth noting that very severe PE may even threaten the patient's life and in some cases patients are reluctant to undergo surgery because of the pain associated with postoperative recovery and the risk of imperfect results [5–8].

Traditionally, the decision to operate was based largely on the severity of the PE deformity as noted on physical examination, the PE severity index, and the severity of symptoms. As a result, many patients with mild to moderate deformity have been left untreated [9] given that, in many cases, the degree of the deformity has not immediately warranted surgery. For these cases, innovative minimally invasive methods have been proposed using gradual correction through a minimal force being applied over a long period; for example, the use of the magnetic minimover procedure, nevertheless long-term follow-up is necessary [10]. However, this procedure is not recommended in older patients.

The concept of nonoperative treatment in PE through the application of cup suction as a depressor device was described in the last century [11], but only in the present century have several reports demonstrated favorable results in selected patients suffering from PE [12–14]. The concept of this depressor device is based on the fact that the chest wall is still pliable during puberty and allows the reshaping of the sternum and costal ribs into a normal position by external depressor applied over the deformity. Conservative treatment of PE has made this alternative therapy a focus of interest for patients. In order to create a vacuum on the chest wall, the patient uses a cup suction device. It is placed over deepest point of PE to produce negative pressure with the help of a hand pump. Different sizes exist allowing selection according to the type of deformity and the age of the patient. The device has an immediate lifting effect for both the sternum and ribs. Vacuum through cup suction was developed by E. Klobe, an engineer who was himself suffering from PE, and who wished to find, for himself, an alternative to surgery [5]. Contraindications for the method include: skeletal disorders such as osteogenesis imperfecta, vasculopathies, coagulopathies and cardiac disorders. Possible side effects include subcutaneous hematoma and petechial bleeding. This preliminary study evaluates, by qualitative score the efficacy of cup suction in the correction of PE, and clarifies the role of this system in strategic treatment as an alternative to surgery.

## Materials and methods

Between October 2011 and June 2014, a preliminary study was carried out in our chest wall deformities unit, after obtaining IRB approval for all patients. A total of 84 patients (children and adults) presenting PE were treated by cup suction, in our chest wall deformities unit. On initial consultation, the patients with typical PE and with at least partial correction during the first test application of cup suction were included in this study.

Partial correction is a qualitative evaluation, defined as a reduction of the deepest point of deformity during first test of cup suction by increasing negative pressure to a maximum of 300 mbar. Greater negative pressure has been shown to cause pain and discomfort to the patients. This helps to establish the criteria for inclusion.

Eleven patients were excluded from the study as they presented a complex carinatum/excavatum and were treated by cup suction for PE and by the dynamic compressor system for the PC; to date with very good results. During the PE deformity physical evaluation, a scoliosis was found in 9 patients (12.3%), and one patient had history of omphalocele. Our physiotherapy team evaluated all patients. Postural abnormalities to different degrees were found in all patients.

The remaining 73 patients were divided into two groups: Group I, adult patients  $\geq 18$  year old, consisting of 17 patients (15 males and 2 females), the mean age was 22.8 years old (18–40). There were 13 symmetric deformities and 4 asymmetric deformities. Group II, pediatric patients  $< 18$  years old, consisting of 56 patients (37 males and 19 females), the mean age was 11.5 years old (3–17). There were 39 symmetric deformities and 17 asymmetric deformities.

At the first consultation, typical PE is defined, as being of symmetric or asymmetric form. The type of PE is defined as: Grand Canyon, saucer or bowl with the presence or absence of costal flaring. The depth of PE is measured with a special measurement device (Fig. 1). The size of cup suction is chosen and the test is done. During the test, if complete or partial correction is obtained, cup suction will be the first line treatment. Given the age of the patients a CT scan before and at the end of the treatment was not suitable for such a short period of treatment and was reserved specifically for the most severe cases in older patients. Pulmonary function tests, cardiac and spinal evaluations were also carried out used in most of these severe cases. Medical photographic documentation is taken systematically during the treatment (Figs. 2–5). At the same time, all patients are instructed by our physiotherapist to do appropriate exercises and physical activities in order to optimize the results.

The management protocol includes: adjustment of cup suction, and an ongoing evaluation of tolerance and risk of skin lesions. During the first week, the system is to be used 3 times a day for 45–60 min each session. After this period, all patients are instructed to increase the duration of use and wear the system overnight then, as soon as possible, all through the day. Patients are to be checked and the depth of PE measured every two or three months, until complete correction is achieved. The cup suction is used progressively for a few hours as a retainer mode for an additional six months.

Complete correction is based in two factors: When the deepest point is less than 5 mm, and when the patient, their parents and the doctor consider the results to be aesthetically pleasing.

The evaluation criteria were: depth of the PE, morbidity and treatment compliance. Partial and final results were also subjectively evaluated independently by the patients, by their parents and doctor, using a subjective qualitative scoring scale using a three-step grading system; where C is a low or very low result, B is acceptable and A is a very good or excellent result.

## Results

A total of 73 patients (52 males and 21 females) presenting with typical PE were treated by cup suction. These included: symmetric PE in 52 (71%) cases and asymmetric PE in 21 (29%) cases. The type of PE was: 31 cases (42%) localized bowl, 22 cases (30%), diffuse saucer, and 20 cases (27%), Grand Canyon. A CT scan was performed in 29 cases, and the mean Haller Index was 4.5 (3.2–10). Associated costal flaring was noted in 21 (28.7%) cases. The mean age was 16 years old (3–40). The mean depth of PE was 23 mm (9–44) (Table 1). The patients were divided in two groups: adults patients (group I) and pediatric patients (group II).

Of the 73 patients, one patient of group I abandoned treatment owing to an unsatisfactory outcome, and minimal invasive surgery was performed. Three patients in group II, discontinued follow-up; one of them reported skin intolerance as the reason for noncompliance.

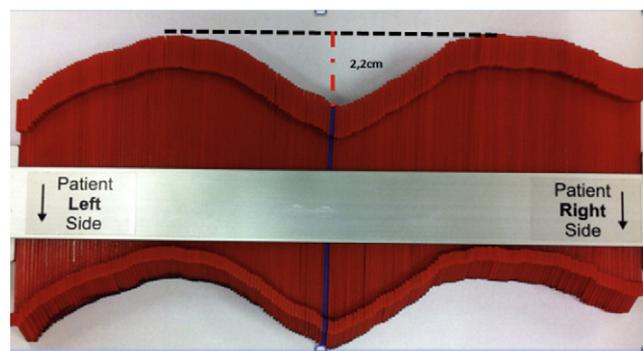
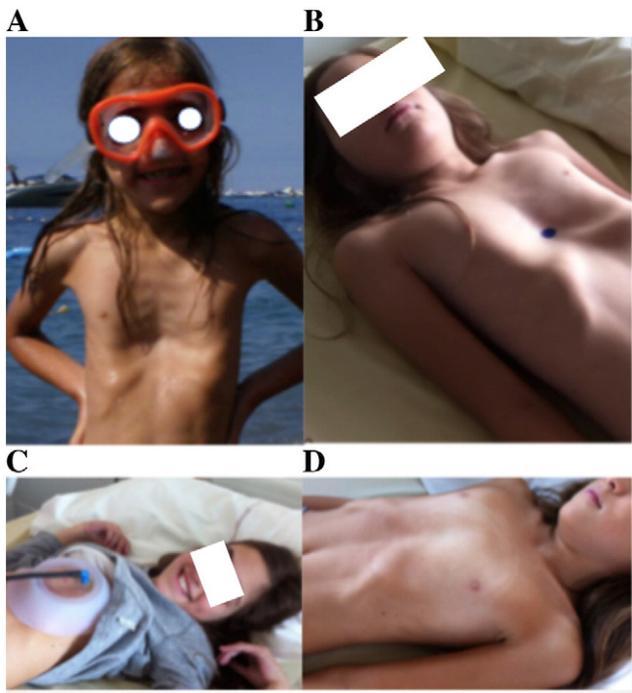


Fig. 1. The depth of PE is measured with a special measurement device.



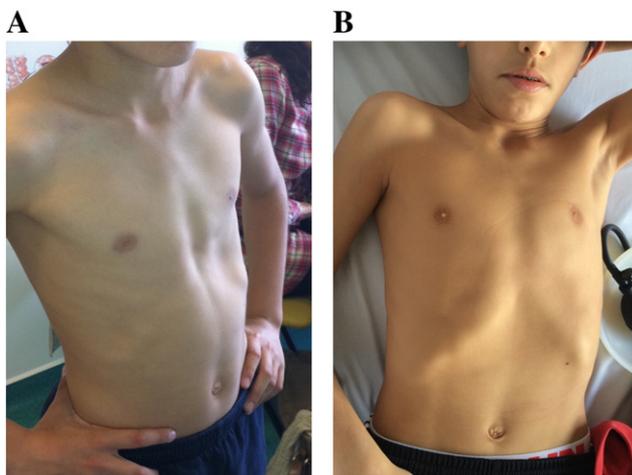
**Fig. 2.** Same patient with a symmetric PE, before treatment (A) and during the treatment (B and C). Picture taken 1 year posttermination of treatment (D).

The final number of treated cases was 69 patients. The mean utilization time was 4 h daily. At six months, all patients were showing improvement under active treatment, with the mean depth of PE of 9 mm (0–30).

In group I, before treatment, the mean depth PE was 25 mm (9–45). At six months of treatment, the mean depth PE was 17 mm (0–30). The mean utilization time was 3 h daily (1–12).

In group II, before treatment, the mean depth PE was 22 mm (10–38). At six months of treatment, the mean depth was 11 mm (5–25). The mean utilization time was 4 h daily (1–12).

Twenty-three of the patients (31.5%) completed the treatment, and exhibited flattening of the sternum. They subsequently continued to wear the cup suction as a retainer for an additional six months. Of these 23 patients: 2 cases were from group I (11.7%), and 21 were from group II (37.5%). The mean age of these patients was 12 years old (5–32). There were 18 symmetric deformities and 5 asymmetric



**Fig. 3.** Same patient with an asymmetric PE with the depth of PE of 27 mm, before treatment (A). Picture taken 1 year posttermination of treatment (B).

deformities. The mean duration of their treatment until normal shape was achieved was 10 months (4–21). The mean duration of daily use of the vacuum device was 4 h (4–8). The mean follow-up period was 13 months (6–24 months). No patients experienced a relapse after finishing the treatment. Both patients and parents rated the results as excellent (A) (Figs. 2 and 3).

The remaining forty-six patients continue in active treatment and are progressing and improving. The mean depth PE was 12 mm (4–30), after a mean treatment duration of 9 months (2–22). Both patients and parents are very satisfied with this partial result (Figs. 4 and 5). In those with satisfactory results, minor side effects such as petechial bleeding were reported. No major related side effects were found. The mean follow-up was 28 months (9–41 months). All pediatric and adult patients were satisfied and expressed their motivation to continue the application. No patients suffered a PE relapse after discontinuation of the cup suction.

## Discussion

The Nuss procedure for PE introduced a paradigm shift by demonstrating that the thoracic wall is a very elastic and pliable structure in children [3]. In light of this concept, nonoperative treatment with the use of cup suction was proposed.

The first description of the use of cup suction for the correction of PE was reported in the last century [11]. At that time, the cup was manufactured in a crystal material, and being anchored into the thoracic wall they produced cutting injuries. Therefore this method was abandoned.

Schier et al reported the first description, in the English literature for correction of PE by vacuum system in 2005 [12]. He treated 60 patients, with a mean age of 15 years old. After 5 months of treatment, 20% of them showed flattening of the sternum. Most patients were satisfied with these partial results. Additionally, cup suction was useful during Nuss procedure, allowing enlargement of the retrosternal space for safer passage of the introducer. Subsequently, some studies have described favorable results [12]. Cup suction is now used by an increasing number of patients, mostly suffering from PE which is not serious enough to warrant surgery, yet sufficiently marked to induce psychological complications. Other patients had previously consented to surgery, but elected to try a nonsurgical method first. However, the long-term effect of this procedure remains unclear.

The largest study was reported in 2011 by Haecker [14], which consisted of 133 patients, with a mean age of 16.2 years old. Flattening of the sternum was observed in 79%, although 10% of them discontinued treatment.

The cup suction system is becoming a well-recognized therapy, an effective nonoperative treatment for PE in selected cases. It is the treatment of choice for patients, particularly for the very young with a mild to moderate defect, where surgical correction could be excessive, or where the option of surgery is rejected. As a result there is a notable improvement in the appearance, as subjectively evaluated by the patient.

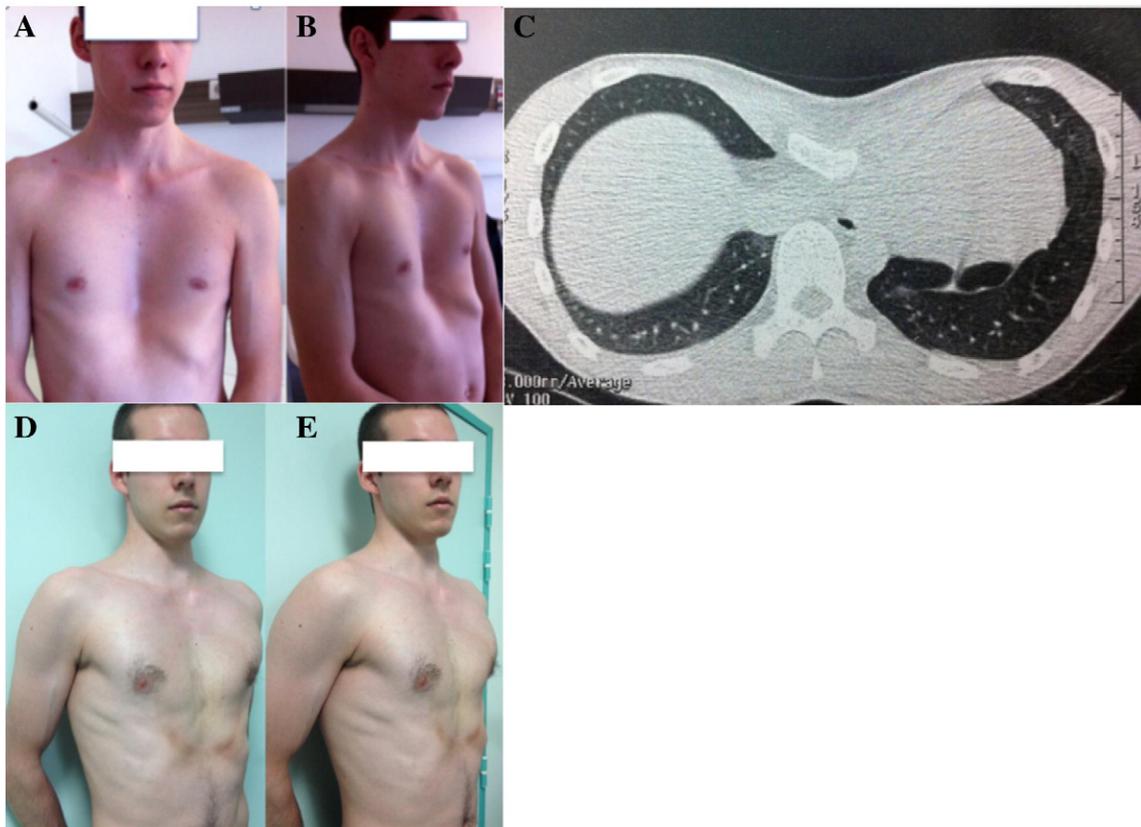
Complete or partial correction is obtained during the initial test of cup suction by increasing vacuum levels to a maximum of 300 mbar. This helps to establish the inclusion criteria.

In this initial study we observed a difference in the duration of treatment by age, severity of PE, and frequency of use of the system.

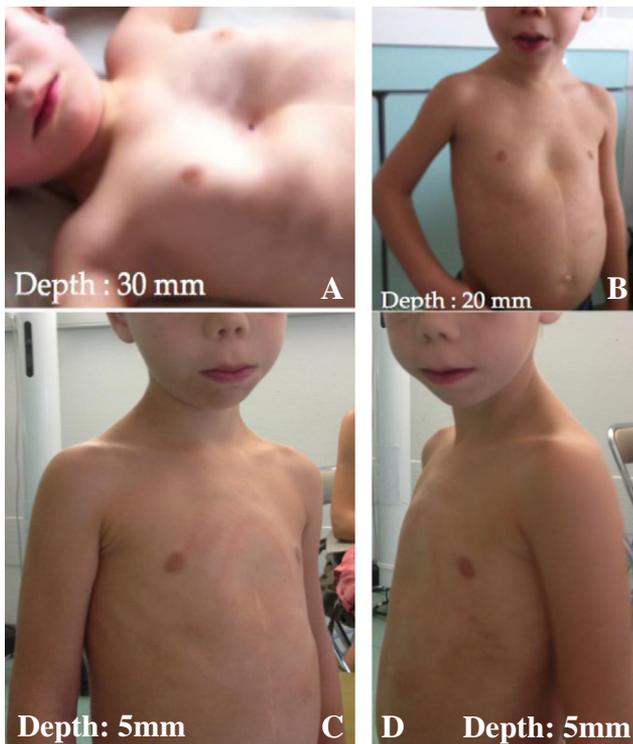
In our series 23 patients exhibited flattening of the deformity, 37.5% of them were children and 11.7% were adult patients.

In the patients who completed the treatment, the mean time for the daily use of the vacuum device was 4 h. Our recommendation is that good results can be obtained, with optimal use of 4 h or more per day.

All patients except for one, in this trial were satisfied with the use of the cup suction, although objectively assessed improvement of PE varied between individuals. It would seem that cup suction depressor in patients with asymmetric PE is more difficult to keep in place. In these cases, the cup suction needs to be improved. However, there was no



**Fig. 4.** Severe PE of a 19-year-old with abnormal cardiopulmonary function (A and B). At CT scan (C), the depth of PE was 45 mm before treatment. After six months under active treatment the depth of PE was 15 mm (D and E), the mean time of use per day was 8 h. Patient and parents are very happy with partial results.



**Fig. 5.** Same patient with history of omphalocele, depth of PE was 30 mm (A). At 6 months, under active treatment, depth of PE was 20 mm (B), at 12 months, with favorable partial results (C and D). Mean use per day was 1–2 h.

significant difference of treatment duration found between symmetric and asymmetric deformities.

In conclusion, treatment using cup suction is a promising useful alternative in selected cases of symmetric and asymmetric PE, providing that the thorax is flexible. Treatment duration is directly linked to age, severity and the frequency of use. It is becoming a well-recognized therapy, which improves the self-image of those patients whose anterior chest wall is still pliable. Nevertheless further studies and a randomized controlled trial are needed. The cup suction can be used for infants and young adults waiting for a treatment, possibly surgery. However, the long-term effect of this procedure remains unclear.

**Table 1**  
Patients characteristics.

	G I (adults)	G II (pediatric)
Patients	17	56
Symmetric PE (45 patients)	13	39
Asymmetric PE (19 patients)	4	17
Mean depth before treatment (mm)	25 (9–45)	22 (10–38)
Mean depth during treatment (mm)	15 (0–30)	9 (0–25)
At mean time of treatment (months)	9 (2–22)	10 (2–21)
Mean depth at 6 months of treatment (mm)	17 (0–30)	11 (5–25)
Mean utilization time (H/day)	3 (1–12)	4 (1–12)
Flattening of the PE-end treatment (23)	2	21
Partial and final results	A, patients and parents are very satisfied	A, patients and parents are very satisfied

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