Seminars in Pediatric Surgery 27 (2018) 175–182

Contents lists available at ScienceDirect

Seminars in Pediatric Surgery

journal homepage: www.elsevier.com/locate/sempedsurg

Measured dynamic compression for pectus carinatum: A systematic review

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A B S T R A C T

Background: Patients with pectus carinatum have been treated with orthotic braces since the 1970s. By applying external pressure to the anterior chest wall, a normal chest shape can be restored. However, high patient treatment dropout rates were reported because of the subjectively high pressures applied to the patientś skin. Measured dynamic compression allows measurement and adjustments of the brace's pressure on the thoracic wall, leading to a controlled correction.

Methods: We performed an electronic database search (Pubmed and Cochrane) of the medical literature on measured dynamic compression. A total of 14 studies were found and eight studies between 2008 and 2018 were included. Study designs ranged from retrospective chart reviews to cross-sectional cohort studies.

Results: From the 8 studies, 1185 patients were included. The median age was 14 years (range 2–28) and 87% were male. The mean study follow up period was 16 months; 44% of patients were still under treatment, 29% of patients successfully completed treatment. 6% dropped out and 21% were lost to follow-up. Dropout was mainly caused social discomfort (7.2%) and failure of treatment (5.8%). Complications were infrequent. Mild chest discomfort or tightness was reported in 12% and skin lesions occurred in 5.1%. The overall recurrence rate was 2.6%.

Conclusions: Several studies are available on measured dynamic compression. Dynamic compression appears to be a safe, non-invasive and efficient treatment to correct pectus carinatum in patients with a non-rigid thorax. Patients experience less discomfort, which in turn results in better compliance. However, accurate selection of patients based on age, pressure of initial correction and motivation is important and an objective scoring system to assess the esthetic and long-term physical and psychological results of the treatment is needed.

Introduction

Pectus carinatum is a congenital thoracic deformity characterized by anterior protrusion of the sternum. With a prevalence of 0.3–0.7%, it is the second most common chest wall deformity in children, affecting males about four times more frequently than females.[1–4]

Pectus carinatum deformities can be classified as chondrogladiolar or chondromanubrial. Chondrogladiolar is the most common type, representing 92–95% of reported cases. The chest wall is often very flexible in these cases, making orthotic repositioning of the sternum possible. In the chondromanubrial type, the chest wall is more rigid and less suitable for brace treatment.[5]

The pathogenesis of pectus carinatum remains unknown. Chondrogladiolar pectus carinatum is hypothetically caused by overgrowth of the sternocostal cartilages, while in chondromanubrial deformities sternal ossification abnormalities occur.[5] A genetic predisposition is suspected since approximately 25% of pectus carinatum patients have a family history of chest wall deformities.[4,5] Furthermore, numerous genetic abnormalities such as Marfan and Noonan syndromes are associated with pectus carinatum. Concomitant thoracolumbar scoliosis can be found in 12–35% of patients with pectus carinatum.[5]

While often present at an early age, pectus carinatum usually progresses during the pubertal growth spurt and the chest later becomes more rigid with age.

Together with the aesthetical concerns, pectus carinatum can lead to physical symptoms and significant psychological distress. Patients can have a disturbed body image and a reduced quality of life.[6,7] Until recently, the gold standard of treatment for pectus carinatum has been surgery. Worldwide, the Ravitch procedure and its modifications, consisting of sub-perichondrial resection of cartilage and reconstruction of the sternum, have been the most commonly methods of correction. This technique can also be performed thoracoscopically.[8,9] The latest surgical technique for the correction of pectus carinatum is the Abramson procedure (or reversed Nuss procedure), in which a steel bar is placed subcutaneously and fixated to the ribs bilaterally, compressing the sternum.[10]

The disadvantages of surgical correction include pain and discomfort, cost, hospitalization, scars, and risk of associated adverse events such as pneumothorax, wound infection, recurrence, and skin necrosis.[5] Surgery for pectus carinatum was generally indi-

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https://doi.org/10.1053/j.sempedsurg.2018.06.001
1055-8586/

Fig. 1. The FMF dynamic compression system.

cated only in the most severe cases, leaving a majority of patients without a surgical option.

Alternatively, patients with pectus carinatum in some parts of the world have been treated with orthotic braces since the 1970s. By applying external pressure on the anterior thoracic wall, a normal thoracic shape can be restored. However, initially, patient dropout rates of up to 40% were reported, caused by the high pressures applied to the patientś skin, promoting sweating, rash, skin lesions, and ultimately skin ulceration. For this reason, many patients abandoned treatment or were referred for surgical treatment.[11–13] Use of a measured dynamic compression brace is thought potentially to be superior to other orthotic devices due to prevention of skin lesions and better comfort. A systematic review was performed to evaluate the results of measured dynamic compression bracing since its first publication ten years ago.

FMF dynamic compression system (FMF-DCS)

In 2008, Martinez-Ferro and colleagues introduced the first measured dynamic bracing system, the FMF Dynamic Compression System (DCS). This system allows measurements and adjustments of the brace's pressure over the thoracic wall, leading to a controlled reposition and lateral expansion of the thorax. The theory was that this brace would lead to fewer of the aforementioned complications and therefore to a better patient compliance. The reported success rates are higher than with the classic braces, with a significantly lower patient dropout.[14,15]

The DCS (Fig. 1) is designed to gradually and dynamically redress the sternum to the desirable position with the use of:

I. A custom fitted detachable aluminum brace that can be adapted to any thoracic shape. This brace has an anterior compression plate that is placed against the protruding chest wall. The brace can be adjusted to increase or decrease the pressure
II. A pressure-measuring device that can measure the pressure needed to redress the sternum to the desirable position; the pressure of initial correction (PIC). This device can also be attached to the compression plate of the brace to measure the pressure of treatment (POT) (Figs. 2 and 3).

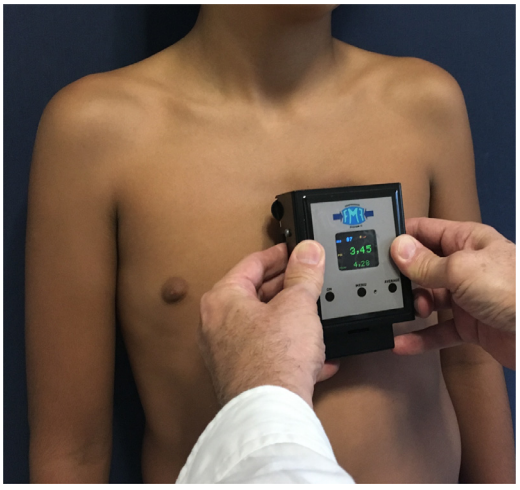

Fig. 2. Measurement of the pressure of initial correction (PIC).

Patients are selected for conservative treatment with the FMF-DCS by measuring the PIC of the pectus carinatum on presentation. Originally a PIC > 7.5 PSI was maintained, but nowadays patients are suitable if PIC does not exceed 7.5–10 PSI. Once the brace is fitted, the POT should not be higher than 2.5–3.0 PSI to prevent skin lesions. Patients learn how to attach and detach the brace and get instructions on how often the brace should be worn.

The first stage of treatment is the "correction" or "active phase" in which patients will return for follow up every 4–6 weeks. During each visit the POT is measured and re-adjusted (to 2.5–3 PSI). As soon as correction of the chest is achieved (PIC around 0 PSI) patients move forward to the "retainer" or "weaning phase". In this second stage, the wearing time of the brace is gradually decreased during a period of two to six months to avoid recurrence.

After finishing the brace treatment, patients are followed every six months until they reach the age of 18 or stop growing.[14]

Fig. 6 shows the results of measured dynamic compression bracing in a 14-year-old patient.