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Thorax

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Pectus Excavatum Treatment with the Eckart Klobe Vacuum Bell

Trichterbrustversorgung mit der Saugglocke nach Eckart Klobe

Since the middle of the twentieth century, practical surgical options have been available for correcting pectus excavatum. In 2002, the Eckart Klobe vacuum bell was registered and put on the market as a medical device for the non-invasive lifting of pectus excavatum and for maintaining its raised position. Although funnel chest corrections using a vacuum bell do not always achieve the cosmetic result of a funnel chest operation performed by a specialised medical team, fewer risks, lower costs, and the avoidance of inpatient hospitalisation are causing more and more patients to opt for the vacuum bell.

Key words: funnel chest, pectus excavatum, orthosis, vacuum bell, correction

Introduction

A funnel chest or pectus excavatum is a depression of the anterior wall of the rib cage. As for the frequency of occurrence of a funnel chest, the literature reveals strikingly large fluctuation ranges from well below 1 per thousand to well over 1 per cent. On the one hand, a clear distinction was not always made between the cases of a funnel chest which justify an operation and a general occurrence of this condition. On the other hand, obviously, there is no uniform measure of the extent to which a depression of the anterior chest wall is considered a funnel chest. The threshold for a funnel chest being perceived by a thematically uninvolved individual could be approximately between 0.5 cm and 1.5 cm, depending on whether a toddler or a full-grown person is being considered. A funnel chest appears to be more common in boys than in girls. Depending on the literature, the frequency distribution is stated as at 3:1 to 5:1 (male to female).

In the majority of cases, a funnel chest diagnosed in the course of a person's life was at least partially recognisable at birth. But it may also have formed or at least intensified over the years. The worsening of even the lightest funnel chest manifestations during juvenile pubertal growth in male patients has been reported to be strikingly common and distinctive, but almost never in female patients. Among other things, this may be related to the fact that the increase in oestrogen secretion in female puberty leads to earlier ossification of the female breastbone than in males – and also that boys from this age onwards are often more ambitious about their physical strength development than girls.

Since the middle of the twentieth century, practical surgical options have been available for correcting pectus excavatum. In contrast to the pigeon chest (Pectus carinatum), a keel-shaped protrusion of the sternum, which is almost ideal for an orthosis to depress the sternum, there were no practical orthoses available for lifting a funnel chest for a very long time. In 2002, the Eckart Klobe vacuum bell was registered and put on the market as a medical device. The vacuum bell is an orthosis for the non-invasive lifting of pectus excavatum and for maintaining its raised position.

The vacuum bell raises the chest by means of negative pressure [1] and in most cases easily overcomes the mechanical resistance of the bones, cartilage and ligaments involved in the funnel. Through the viewing window in the vacuum bell, patients can also observe this effect themselves (Fig. 1). The vacuum bell thus applied also serves to keep the lifted funnel in the raised position, because the inner muscles such as the diaphragm tend to retract the funnel again and again to its sunken form. Another function of the vacuum bell is, therefore, to stretch these muscles in order to weaken their tension. Thus, after removing the vacuum bell at the end of a treatment session, a partial sinking back of the funnel is to be expected. This may last a few minutes or hours, depending on the individual patient's situation.

The vacuum bell can be applied for much of the day without interfering with common activities. This is particularly true of lying, sitting, standing and walking, theoretically even school attendance, office work, housework and various types of physical work or sports. This allows long daily wear times that enable the new chest shape to adapt to the biomechanical demands of everyday life. For a successful correction or at least a significant mitigation of the funnel chest, it is necessary to persistently apply the vacuum bell over a longer period of time. Typical application times of the vacuum bell range from one to three hours a day – over a period of one to three years.

Treatment outcomes

More than 13,000 patients, ranging in age from around four to sixty years, are now treated for funnel chest by means of vacuum bells. There are international

Fig. 1 Application of Eckart Klobe vacuum bell.

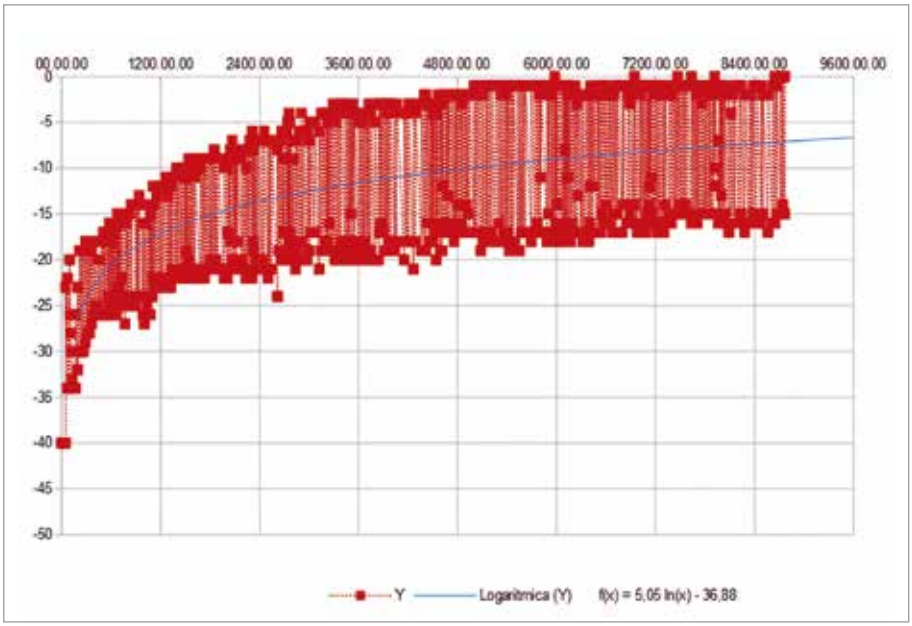

Fig. 2 Case history 11.148: funnel depth (mm) versus time in hours (h.min.sec).

Fig. 3 Different versions of the vacuum bell

publications on the respective application experience and the correction results achieved [2, 3, 4]. In particular, reference is made to the online German-language publication by Häcker et al. [2], which involved 140 patients aged 3 to 61 years. The study by Lopez et al. [3] on an age group of 3 to 40 years is characterised by a spirited therapy concept – with the longest daily wearing times published to date, the most significant pressure differences in the application published, the most striking correction successes and the indication that even six months after the end of treatment no sinking back of the funnel was observed. The study by Obermeyer et al. [4] done on an age group of 4 to 23 years is characterised by the most accurate quantification and the strictest standards (residual depth ≤ 0.51 cm) for an excellent correction outcome. The treatment outcomes described therein can be summarised based on the categories used in the study as follows:

– good + excellent: 1/3 of patients
– fair: 1/3 of patients
– poor: 1/3 of patients

Case study

As an example of a funnel chest treatment in an adult, the funnel depth is documented on the graph in millimetres against hours for the following case history 11.148 (Fig. 2). It should be noted here that 1,200 hours correspond to 50 days, 2,400 hours to 100 days, etc. The upper edge of the area marked red corresponds to the residual funnel depths immediately after discontinuation of the vacuum bell treatment – that is, the temporary treatment successes. The lower edge of the area marked red corresponds to the residual funnel depth immediately before a respective vacuum bell application – that is, a lasting treatment success. The patient was 61 years old at the start of treatment, male, 1.78 m tall and weighed 78 kg. The distance between the centre of the left nipple and the centre of the right nipple was 25 cm. The patient initially had a funnel depth of 4.0 cm. He received a large vacuum bell (26 cm) and wore it three to four hours a day, mostly divided into two or three applications. Figure 2 further illustrates that at least fair to good treatment success is possible even in middle-aged adults.

Selecting and applying a vacuum bell

There are five versions of the Eckart Klobe vacuum bell (Fig. 3):

– A large vacuum bell (26 cm) for male patients with a body height exceeding approx. 1.70 m
– A small vacuum bell (19 cm) for (male) patients with a body height exceeding approx. 1.40 m
– A small “bodybuilder”-type vacuum bell (19 cm) for bodybuilders and special applications
– A small vacuum bell (19 cm) for women and girls from the onset of breast development
– Mini vacuum bell (16 cm) for children with a body height exceeding approx. 1.05 m

It takes a certain level of experience to be able to select an appropriate vacuum bell for individual patients. Vacuum bells are chosen according to different criteria such as gender, age, height, body weight, posture, funnel shape, funnel depth and any sensitivity of the nipples. For women, one also needs to take into account the size and shape of the breasts as well as whether there is enough space between the breasts to place a vacuum bell. On the one hand, the vacuum bell should be large enough to be able to support itself outside the funnel, but on the other hand, it should not be so big that it painfully presses on the neck or stomach or draws air on the sides. Furthermore, the vacuum bell should not press painfully on the breasts of women.

For the selection of the appropriate vacuum bell for each individual patient, the manufacturer requires the following information from the patient:

- Year of birth
- Body height
- Body weight
- Approximate funnel depth
- Distance between the centre of the left nipple and the centre of the right nipple.

Furthermore, a photo from the following perspectives is required (at least neck to waistline):

- View from front (frontal view)
- View from half right/half front (semi-profile, 45 degree angle)
- View from half left/half front (semi-profile, 45 degree angle).

The vacuum bell is ideally placed over the middle of the depression of the chest and then pumped. Although the patient may feel the pull of the vacuum bell, serious pain should be avoided. In other words: As soon as it starts to hurt, the pumping should not be increased further.

In order to protect potentially overmotivated adolescents and adults from over-zealousness, a simple rule of thumb for the application time has worked well:

Fig. 4 *Case history 5.471; data at the start of treatment: patient, male, age 14 years, body height 1.77 m, weight 67 kg, funnel depth 2.3 cm.*

- During the first week of treatment, a maximum of 1 hour per day
- During the second week of treatment, a maximum of 2 hours per day
- and so on.

Side effects

The most common side effect is thick, soft, swollen skin under the vacuum bell due to accumulation of tissue fluid, usually caused by excessive negative pressure or prolonged application time during the first weeks of treatment. Depending on the patient, the individual upper limit of application time can be between 20 minutes and many hours a day. This can only be determined very gradually by trial and error.

Irritated nipples are the most annoying side effect: The flatter the areola at the beginning of treatment, the lower the risk seems to be. This is mainly a problem in puberty and early adolescence.

Contraindications

Vacuum bells are dispensed only when a physician is in charge of the treatment. The physician is to ensure that there are no health issues preventing the treatment. These include:

Fig. 5 *Case history 5.471, application of a small vacuum bell (19 cm); data 11 months after start of treatment: age 15 years, body height 1.79 m, weight 69 kg, funnel depth 1.0 cm.*

- Skeletal disorders that affect the stability of the bones, such as osteogenesis imperfecta and osteoporosis (in most cases it is sufficient to ask the patient a simple question: "When was the last bone fracture?")
- Vascular disorders, such as in the context of a Marfan syndrome, or even aneurysms (in the case of a marfanoid disposition, measurement of the large blood vessels by way of a Doppler ultrasound is recommended)
- Coagulation disorders of the blood such as thrombopathy or haemophilia (here, too, a simple question is in the most cases sufficient, such as: "How long does it bleed following a small incision in a finger?")

Accompanying physical exercises

Figures 4 and 5 of case history 5.471 illustrate that the vacuum bell can overcome the funnel. However, it cannot be expected that the mere application of the vacuum bell alone will result in an upright posture as shown in Figure 5. An upright posture can be achieved only by one's own muscle strength. The following physical exercises should accompany vacuum bell treatment:

1. A body exercise called "Standing Superman" (similar to the ballet movement "Arabesque"; Fig. 6), performed daily either for about 30 seconds per supporting leg or about one minute under continuous leg changes. The goal is to strengthen mainly the lower back muscles as an essential requirement for an upright posture.
2. Simple swinging of light dumbbells (starting in each hand with a dumbbell of approx. 3 to 5% of the body weight. Later, depending on the training level, it can be increased a little more). The dumbbells can be swung, like a tennis player swinging his racquet, or a boxer swinging his fists, or as if throwing something. This exercise can be done daily for around five minutes. The goal is to strengthen the upper back muscles.
3. Doing pullovers lying on the back with light dumbbells (starting in each hand with a dumbbell of about 3 to 5% of the body weight. Later, depending on the training level, it can be increased a little more) while pressing the resulting hollow-back flat on

Fig. 6
"Standing Superman" exercise.

the floor using one's own motor activity. This exercise can be done, for example, for one minute every day. The goal is to raise the breastbone through the pectoral muscles as well as to flatten any flaring ribs through the abdominal muscles.

4. Gripping an elastic band, at approximately shoulder-width length, in front of the chest and pulling it outward. The goal is to strengthen the upper back muscles.
5. Gripping an elastic band wrist-over-wrist while pulling it outwards (right hand to the left, left hand to the right). This exercise is easy to do while lying down on own's back. The aim is - in the case of a funnel chest extending far upwards - to raise a sunken manubrium or collarbone with the patient's own motor activity via the upper parts of the pectoralis major. Another goal of the exercise may be to overcome a typical and characteristic breathing movement pattern of funnel chest patients, as found in a study by Redlinger and colleagues [5].

Somatic background

In the aforementioned study by Redlinger et al. [5], funnel chest patients surprisingly exhibited no lower respiratory volumes than a corresponding control group without funnel chest. However, in their maximal breaths, they showed a lower elevation of the thorax in the midline, measured at the lower end of the manubrium, at the level of the nipples and the xiphoid process, yet a much greater elevation in the area of the navel. The area of lesser elevation is commonly described in [5] as the funnel chest area, but also represents the surface area under which the heart, or at least its right atrium, is commonly located. In another study [6], it was possible to clearly demonstrate in which way the various forms of the funnel chest press on the heart - and in which places and in which manner they can disturb the functional sequence of the heart. Another study [7] demonstrated that the simple use of a vacuum bell was sufficient to increase the heartbeat volume in patients with a funnel chest justifying surgery, but not in a control group of persons without funnel chest.

Psychosomatic outlook

It is often reported that funnel chest patients tend to have relatively low self-esteem. This observation is usually interpreted as a consequence of the funnel chest, which strictly speaking represents a somatopsychic approach. The author would like to contrast this with the possibility of a psychosomatic approach. Thus, a person is considered conceivable who is handicapped in his/her identity development, who gets into the breathing pattern described in [5], which literally "constricts his or her heart", and who subsequently develops a funnel chest or whose potentially already existing rudimentary funnel chest intensifies.

Conclusion

Contrary to popular belief, a funnel chest is not just a purely aesthetic problem. Rather, the volume requirement of a funnel chest can also significantly limit the cardiac output and thus the overall physical performance of a person affected by the condition. The Eckart Klobe vacuum bell offers the option of a nonsurgical correction of the funnel chest – including the elimination of any limitation in cardiac output caused by the funnel chest. An upright posture, however, can only be maintained by a person's own motor activity by means of properly trained muscles. Sometimes an upright posture is prevented by psychological barriers – as if the patient did "not have the right" to such an upright posture – that would have to be addressed and resolved.

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