Review Article

Pectus carinatum*

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Abstract

Among the deformities of the thoracic wall, pectus carinatum has not received the same attention as has pectus excavatum. Few pulmonologists, pediatricians, and thoracic surgeons are aware of the approaches to treating this condition. As a consequence, patients with pectus carinatum are not referred for treatment. This deformity, with an incidence of 1:1000 teenagers, is oligosymptomatic. However, for aesthetic and emotional reasons, it accounts for a large number of medical appointments. Such patients are introverted and do not engage in physical activities, since they are unwilling to expose their chest, which also discourages them from going to the beach or to swimming pools. The diagnosis is clinical and visual, and details are obtained through chest X-rays and computed tomography. The treatment is based on a well-known organogram that summarizes orthopedic and surgical procedures. Dynamic compression, combined with physical exercises, is indicated for teenagers with flexible thorax in inferior and lateral pectus carinatum, with limited indication for those with superior pectus carinatum. For individuals of any age with rigid thorax, surgery is indicated for aesthetic reasons. Among the techniques described, the modified sternum chondroplasty stands out due to the excellent aesthetic results achieved.

Keywords: Thoracic wall; Bone Diseases, Developmental/therapeutics; Surgery.

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Introduction

Pectus carinatum (PC) has not attracted as much interest from clinicians, pediatricians, orthopedists, and pediatric surgeons, and not even from thoracic surgeons, as has pectus excavatum (PE). The overall prevalence of these two deformities ranges from 0.6 to 0.97/1000 individuals,[1,2] and they are more common in men. In most published studies, PE is clearly predominant over PC, at a ratio ranging from 3:1 to 13:1.[3] In a study of patients submitted to surgery,[4] and in a study involving schoolchildren,[5] this ratio was 1:2, in contrast to what has been established in literature.

The deformity presents typical progressive growth, and can be accompanied or not by cardiorespiratory symptoms. Patients report palpitations, dyspnea, and wheezing, which are accentuated during exercise and, in the absence of accompanying diseases, disappear after surgery. Symptoms frequently result from accompanying diseases or psychological disorders that make these patients introverted and reserved, as well as lowering their self-esteem.[6,7] Parents are typically anxious and report that the problem appeared within the past few weeks due to trauma or weight loss of the child, or adolescent, since adolescence is the period during which this condition is most commonly noticed.[6,8] Limitations at work and in sports, as well as underachievement in school, in the absence of respiratory and heart diseases, should be attributed to emotional alterations. These patients avoid swimming pools and beaches, refraining from engaging in activities in which they expose the chest. Even when the chest is covered, they bend forward and stoop their shoulders in order to minimize the visual aspect of this aesthetic defect. The most common concomitant associated diseases, responsible for bronchial and pulmonary symptoms, are asthma and chronic bronchitis, which occur in 16.4% of the patients.[7] Kyphosis is present, to a greater or lesser degree, in almost all patients.

Etiopathogenesis

Since PC is rarely noticed at birth, it is believed to be acquired rather than congenital. In most cases, it is perceived by the age of 10, is accentuated at puberty, during growth in adolescence, and reaches its peak at the ages of 16 and 18, respectively, in girls and boys.[8] Congenital etiology is increased by the following: occurrence of two cases of PC or other thoracic deformities in the same family;[5,8] observation in monozygotic twins;[9-11] presence at birth;[8,12] association with Marfan syndrome, association with congenital heart disease, and hand agenesis[8,13] Associations with prolapse, reflux, or mitral stenosis has also been reported.[14] In a series of schoolchildren between 10 and 15 years of age, the incidence of family members with thoracic deformities was 25%,[5] suggesting congenital and hereditary origin.

Some authors, using an experimental rat model, demonstrated that lesions in the cartilaginous growth plates, between sternal bone segments, resulted in shortening of the sternum in all 15 of the rats studied, 9 of which developed sternal depression, and 2 of which developed mild sternal protrusion,[15] demonstrating that the lesion of the cartilaginous growth plates can cause deformity of the anterior thoracic wall. Subsequently, in a radiological study of sternal growth, it was demonstrated that the growth provided by the cartilaginous growth plates is important in the development of upper, lower and lateral PC, as well as in the localized form of PE.[16] Other authors reported a case that could be designated iatrogenic PC in a 17-year-old patient who was submitted to a thymectomy through median sternotomy for the treatment of myasthenia gravis. The probable cause of PC in that case was the lesion in the centers of sternal ossification, responsible for the sternal fusion that is completed between 16 and 25 years of age.[2]

Other authors believe that PE and PC result from the exaggerated growth of the cartilages involved in the deformity.[3,17] In PC, the anterior growth would pull the sternum and make it more prominent, whereas, in PE, the posterior growth would depress it. If the growth were unilateral, or asymmetric, the protrusion would be unilateral or predominantly unilateral; therefore, lateral PC. The cause of this exaggerated growth remains unexplained. It has been observed that PC is accentuated in adolescence, a phase during which the whole body is growing.[8,18] This is the most accepted theory, even as the basis for surgical treatment. Although hypoplasia of the diaphragmatic insertions into the sternum with hypotrophy of the lateral muscles of the chest has been suggested, it has not been confirmed by dissection performed in patients submitted to surgical correction.[1,2]

Classification

A) Lower PC

Also known as *chicken breast* or *pigeon breast*, lower PC is the classical deformity characterized by a prominent sternum, principally in its median and lower portion,[19] almost always followed by lower bilateral costal depression, caused by the downward curve of costal cartilages and the ends of the ribs (Figure 1). A lateral view chest X-ray shows anterior protrusion of the sternum and manubriosternal joint, as well as evident division of the sternum into sternal notch, body (mesosternum), and xiphoid process. Depending on the age of the individual, nuclei of sternal ossification can be observed. In a small percentage of patients, this deformity can be discretely present at birth and become more visible at puberty, when growth is more pronounced. The presentation of PC is subdivided into symmetric (classical) PC, asymmetric PC, and lateral PC (Figure 2). In cases of lateral PC, a computed tomography scan of the chest reveals that the sternum is at an oblique angle to the axis of the body, knowledge that is important for surgical planning.[8,19]

B) Upper PC

Upper PC is also known as *pouter pigeon*, protrusion of the manubriosternal joint with mesosternal depression, or Currarino-Silverman syndrome. It consists of upper protrusion of the sternal notch that is proximal to the mesosternum and lower pseudo-depression (Figure 3). There is accompanying protrusion from the second to the ninth costal cartilage, bilaterally. Upper PC has been confused with PE by inexperienced surgeons. Upper PC is subdivided into upper PC without mesosternal depression; and upper PC with mesosternal depression.[20] In the opinion of some authors, a mixed form of PE/PC results from pseudo-depression, a view that is not shared by other authors.[8]

A lateral view chest X-ray shows an arching sternum, sometimes S-shaped, as a single bone, shorter than expected, with complete fusion

Figure 1 - Lower pectus carinatum.

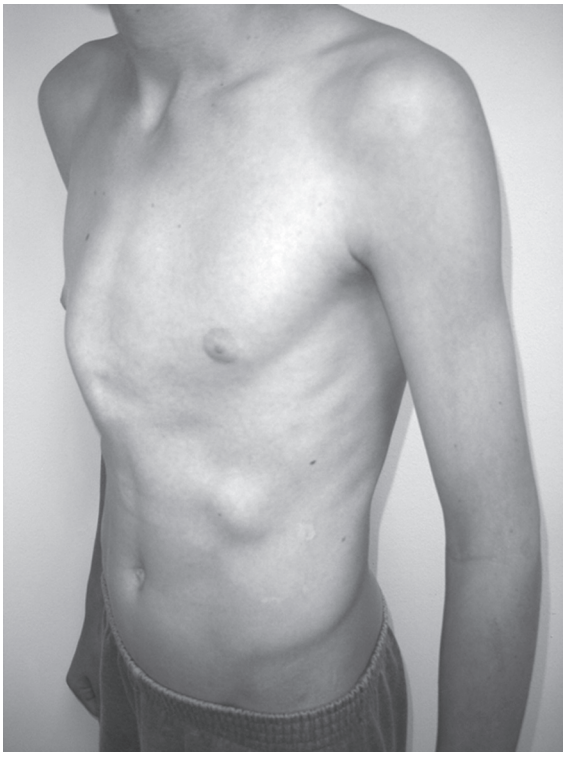

Figure 2 - Lateral pectus carinatum.

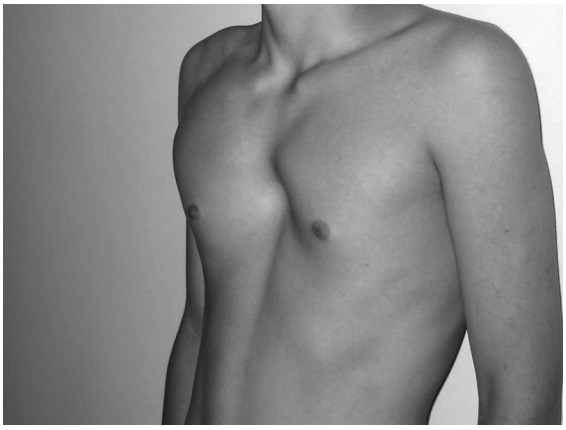

Figure 3 - Upper pectus carinatum.

between the body and the sternal notch. A computed tomography scan of the chest shows absence of the manubriosternal joint, with obliteration of sternal cartilaginous growth plates, as well as ossification of all nuclei of sternal ossification; the areas of the cartilaginous growth plates in the four sternal segments cannot be seen due to their fusion.[8,9,19,20] One group of authors demonstrated that the premature obliteration of cartilaginous growth plates and nuclei of sternal ossification characterizes upper PC, which is, therefore, congenital, caused by an unexplained intrauterine mechanism, since it is perceived at birth.[9] The nonexistence or ossification of the manubriosternal joint, in two patients, at the early age of 4, observed during their first medical appointment, confirms its possible congenital origin. Ocular and electronic microscopy studies of resected cartilages, in upper PC, reveal degenerative exchanges in hyaline cartilages and atypical fibrils, as well as a reduced number of chondrocytes, and the periosteum is thinner than normal.[21,22]

Other anomalous forms of PC can occur and are variations of those described above. Upper or lower, unilateral or bilateral costal protrusions are isolated alterations of costal cartilages.

Conservative treatment

Physical therapy

There is virtually unanimous agreement that physical therapy provides no improvement in individuals with PC. The improvement observed would be that of those discrete defects that would be corrected with growth and can only be observed clinically. Sports in general are recommended, especially swimming. Bodybuilding might disguise discrete deformity; however, it should not be used before 16 or 18 years of age. Global postural re-education is indicated for the treatment of poor posture, as well as of kyphosis or scoliosis, which can occur concomitantly, and can also be used for posture correction in the postoperative period.[8]

Conservative orthopedic treatment

Reference has been made to conservative orthopedic treatment involving the use of equipment and belts, aiming at compressing the thorax and, therefore, modeling the defect. Certainly, belts and bands have no therapeutic effect.[19] Few studies have been published on conservative orthopedic treatment for PC. Five patients with lateral PC with sternal rotation were treated with orthesis involving compression over the deformed region, and the evolution of the condition was evaluated at 3, 6 and 12 months, with measurement of the sternal rotation angle obtained through computed tomography. Significant improvement was achieved in 80% of the cases.[23] In Brazil, the dynamic thoracic compressor (DTC) has been used since 1979, with selective compression on the sternum, using the spinal column as counterpressure. The combination of the DTC with controlled physical exercises is designated chest wall remodeling. The DTC is a simple light orthesis, and consists of aluminum handles, plastic cushions, and metal screws, which allow gradual compression exclusively on the protrused areas of the anterior chest wall. The patient dons the DTC, after proper instructions from the doctor, holding the posterior part of the orthesis and of the thorax against a wall and tightening the screws until it is firmly in place.[19] Studies have occasionally been published on the use of other orthopedic equipment, with the same principles. The principles for the use in the treatment of PC are based on a basic orthopedic law, Wolff's law: the bone is a dynamic structure that responds to the effort and tensions of daily life by resorbing and rebuilding itself in a continuous and active manner. This remodeling law is also true for cartilages: the younger the individual, the greater the remodeling potential, which decreases over the course of a lifetime. As a consequence, force regu-

larly applied to deformed bones and cartilages can produce gradual remodeling, principally in young individuals.[19] Bands and belts compress the entire chest cavity, which obviously impairs respiration. The DTC exerts selective pressure on a determined area, with little influence on breathing. The principal inconvenience is the need for prolonged, daily use. For the first 6 months, the patient must use the equipment all day, only taking it off to bathe and, occasionally, to perform physical exercises and undergo physical therapy. The treatment can take up to two years to complete. Orthopedic treatment is indicated depending on the flexibility of the anterior chest wall, type of deformity, and age of the patient. In upper PC, it can occasionally be recommended even in childhood, due to the greater remodeling capacity in this phase of life, since the etiology of this type of PC is different. The sternum is a single bone from birth. In upper PC, the indication for the DTC is relative, since the sternum presents connected, angle- or arch-shaped cartilaginous plates. When submitted to anterior compression, the sternum and cartilages will sink in an irregular manner, depressing the lower portion of the sternum and of the lower costal cartilages. In lower and lateral PC, it is only indicated in childhood when the deformity is highly pronounced, since the child can get tired of using the equipment, and it is known that the defect becomes accentuated during the adolescence growth spurt, and there is therefore a greater probability of recurrence if the DTC is used during childhood. It is best indicated in adolescence, when the deformity is flexible and reducible. The indices of excellent/good results for the patients who completed the treatment were, respectively, 68%/24% in lower PC, 47%/39% in lateral PC, and 9%/21% in upper PC. Family members should be advised and instructed regarding the poor results obtained in cases of upper PC. In the literature, there is no mention of the rate of recurrence of the deformity after the end of the treatment. It is very difficult for children and adolescents to accept this type of treatment, and only 60% of patients return to continue the treatment. Despite the reluctance to use orthesis on the part of patients, its use should be encouraged, principally in pre-adolescents and adolescents. The treatment of PC should follow a well-known flowchart,[10] which summarizes the treatment of PC according to type, level, and age of the patient[10] (Figures 4, 5 and 6).

Surgical treatment

Parents and patients have been incorrectly informed that sternum chondroplasty for correction of PC results in many complications rather than benefits.[8] Undoubtedly, the benefit will be aesthetic, with improvement in self-esteem and self-confidence, as well as allowing the individual to participate in age-appropriate behaviors, sports activities, and social activities.[6,8] The rate of complications is low. Peridural anesthesia for 48 h, via a catheter installed during the surgical procedure, has been shown to control the pain involved.[2]

Most authors recommend surgery if the deformity is evident or pronounced. It is a cosmetic procedure, and, as such, parents should be exhaustively informed regarding the expected results and the scar that will remain on the chest, although the scar is practically imperceptible, since the incision is made in the inframammary fold. In general, some authors prefer to operate on patients ten years of age or older. However, in cases of pronounced deformity, in patients psychologically affected by the deformity with pronounced growth, the correction can be performed before this age.[10,18] Although other authors have used a technique referred to as less invasive in 87% of their patients below the age of ten,[6] the children who do not present accentuated psychological disorders due to the deformity should be free to play and should be encouraged to engage in sports, especially swimming. Parents are instructed not to give too much attention to the defect, trying to minimize its importance and perception by the children, until they reach the proper age for its correction.[10]

Pre-operative care

The patient and family members should be exhaustively informed regarding the surgery, including the post-operative period, as well as regarding the peridural anesthesia. The tests routinely required are as follows: blood workup; blood glucose; coagulation profile; frontal and lateral view chest X-rays, digital if possible; computed tomography scan of the chest; and electrocardiogram.[8]

Surgical techniques

As for PE, various surgical techniques have been proposed for the correction of PC, principally based

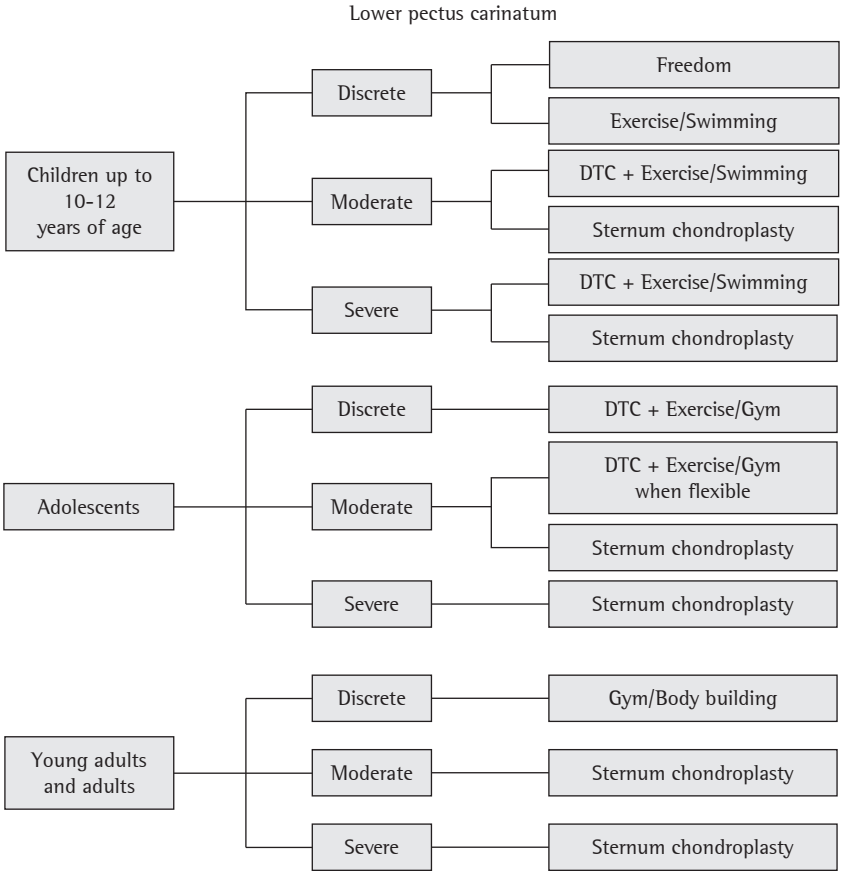

Figure 4 - Treatment flowchart for patients with lower pectus carinatum. (DTC: dynamic thoracic compressor).

on subperichondrial resection of the cartilages involved and, when necessary, sternal osteotomy. The first report of a case submitted to surgery referred to a procedure performed in 1953, using subperiosteal resection of the mesosternum and, subsequently, of the costal cartilages involved.[3] Another author performed subperichondrial resection of the cartilages, sternal osteotomy, and pleating of the muscle-cartilaginous bundles, for better contour and stability of the anterior chest wall.[17] Yet another author, in treating cases of lower PC and lateral PC, performed subperichondrial resection of the cartilages involved in the defect, sternal osteotomy, and sectioning of the xiphoid process near the mesosternum, although leaving the insertions of the straight abdominal muscles intact. The same author subsequently performed the fixation of the set formed by the xiphoid process and the straight abdominal muscles, at a level above, aiming at the traction of the sternum, helping maintain the sternum in its new rectified form.[1,20] Another author performed the subperichondrial resection of the cartilages involved, together with surgical fixation of the xiphisternal joint.[24] Other authors resected the cartilages involved, usually from the second to the seventh, performed single or multiple osteotomies, and fixed the new casting of the sternum with polypropylene sutures.[25] In upper PC, a similar technique to that already used in PE[1] has been performed.[21] The technique consists of the subperichondrial resection of the cartilages involved, which, together with the intercostal muscles, are completely separated from the sternum. This technique also involves sternal osteotomy with resection of the most angular portion of the sternum, to prevent protrusion in the skin; and placement of a Marlex retrosternal mesh. This technique presents the following negative aspects or drawbacks: intercostal and perichondrial muscle bundles of the sternum need to be completely released and not

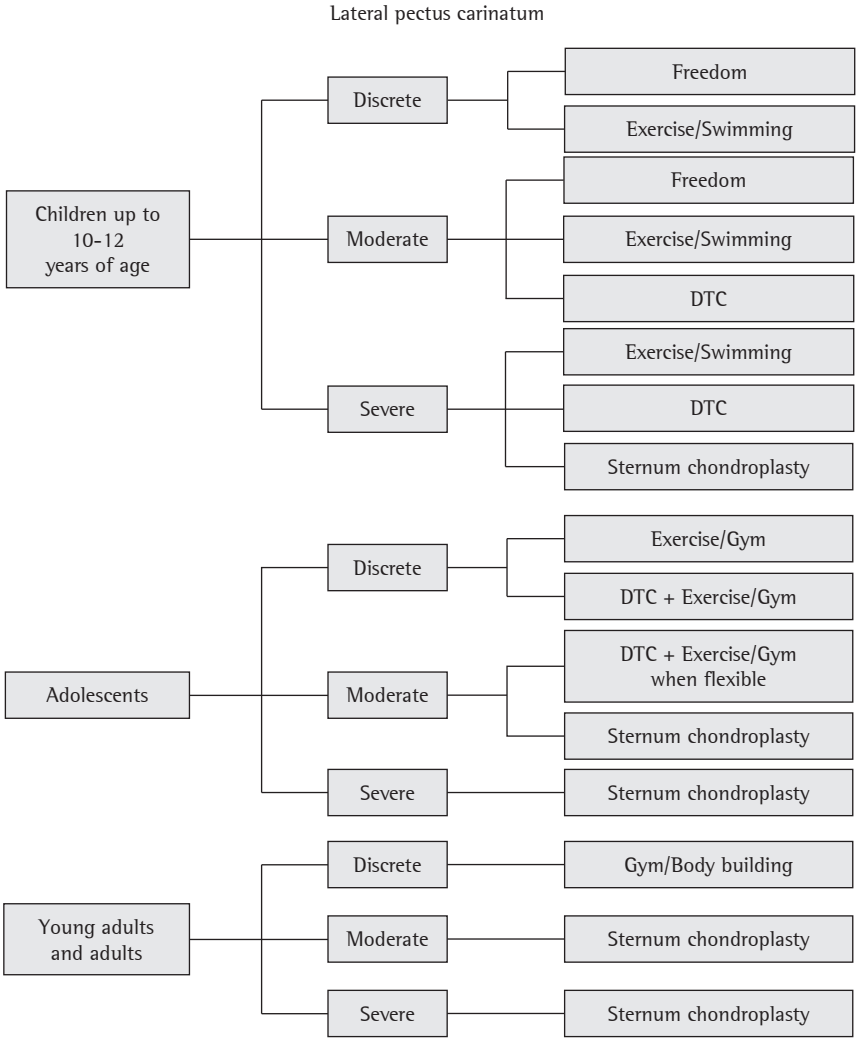

Figure 5 - Treatment flowchart for patients with lateral pectus carinatum.

re-inserted into the sternum but rather sutured to the edges of a Marlex mesh, resulting in a parasternal runlet, palpable and even visible in the post-operative period, which will later result in flaccidity of the anterior chest wall, according to our personal observation; osteotomy is not fixed, favoring sternal flaccidity, which contributes to flaccidity of the chest wall; the Marlex® retrosternal mesh, which is sutured to the extremities of the ribs involved in the defect and/or perichondria of the resected cartilages, does not allow adequate positioning of the sternum, since the limits for support are the extremities of the ribs, not allowing complete modeling of the anterior chest wall and anterolateral chest; the Marlex retrosternal mesh is not absorbable and cannot be withdrawn, which can prevent the growth of costal cartilages and ribs, in our opinion, and can theoretically cause acquired Jeune syndrome when children and adolescents are submitted to the procedure; Since the pectoral muscles are released and the abdominal muscles are no longer sutured to their borders, a lower space remains hollow, or partially filled with another piece of Marlex mesh, causing a depression in post-operative, with a poor aesthetic result.

Although the use of a less invasive technique has been recently recommended by some authors,[6] it does not meet the requirements to be thus denominated, since it basically consists of: inverted Y-incision, longitudinal incision of the cartilages,

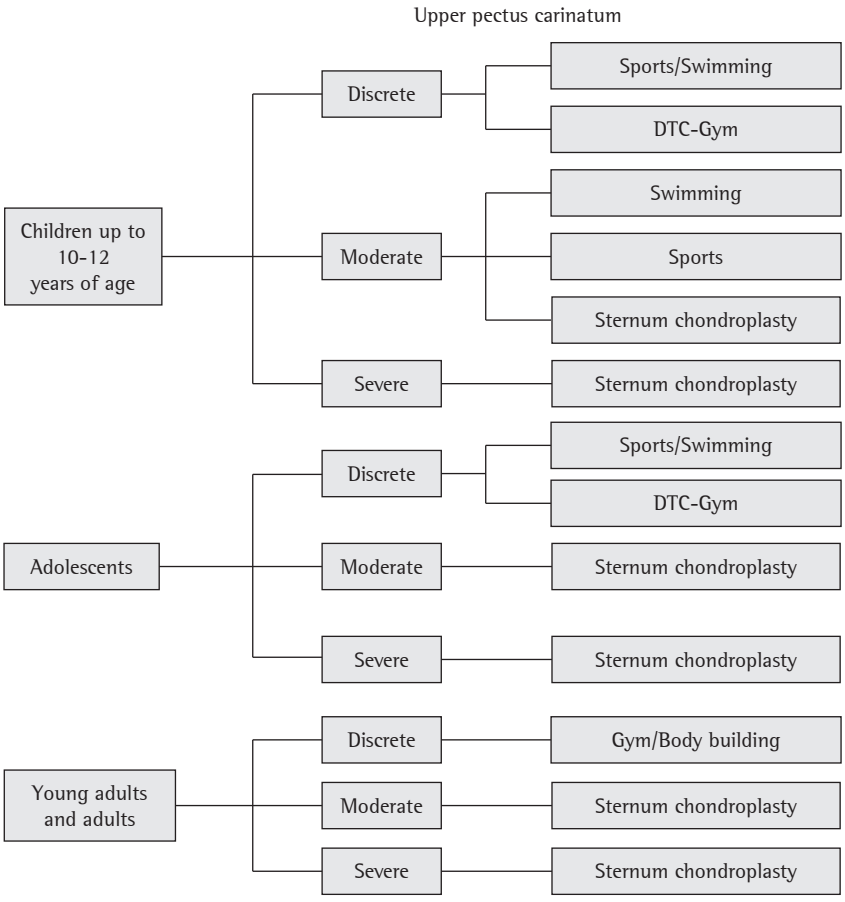

Figure 6 - Treatment flowchart for patients with upper pectus carinatum.

10 mm lateral to the sternal border, releasing them from the sternum; resection of a 3-10 mm segment in the medial and lateral extremity of the cartilages at their junction with the ribs, so that the chest wall is 'loosened', although carefully preserving the cartilaginous cuffs; wedged transversal osteotomy of the sternum; costal cartilages are sutured at the sternum, medially, and at the ribs, laterally; placement of a routine retrosternal bar, to prevent development of unstable chest and paradoxical breathing. Minimal subperichondrial resection of the cartilages at their junction with the sternum and ribs is justified, since it will be replaced by bone and cartilage, making the chest inflexible. It is of note that, in 183 patients submitted to sternum chondroplasty for PC,[2] none of the following aspects were observed: alteration in the flexibility and compliance of the chest, unstable chest, and paradoxical breathing. Nor was admission to the intensive care unit necessary. One author,[26] seeking a minimally invasive surgical alternative for the treatment of PC, used an implant consisting of a presternal metallic plate, fixed bilaterally at the posterior lateral portion of the costal arches using steel wires. The plate remains for a year and is withdrawn in outpatient settings. The method was used in 11 patients, one of whom has already completed the compression period, with excellent aesthetic results. Other authors performed the correction of PC by video-assisted endoscopy, introduced through a 4 cm incision at the base of the xiphoid process, which is also used for the dissection of the subcutaneous cellular tissue, and exposure of the sternum and cartilages involved.[27] A 3-mm incision is made on each hemithorax for the introduction of retractors, scissors, and cautery device. The cartilages involved are partially resected, a transversal sternal osteotomy is performed, and a retrosternal metallic plate is placed. This is a long surgery; in 8 cases, the surgical time ranged from 5.4 to 10 h (mean, 6.7 h).

Modified sternum chondroplasty

After the development of the Ravitch technique,[17] the surgical treatment of PC has improved, leading to a single technique designated modified sternum chondroplasty. The denomination sternum chondroplasty better reflects the surgical procedure for the correction of the deformities of the anterior chest wall, and no other denomination should be used to refer to any technique involving subperichondrial resection of the cartilages and sternal osteotomy. The term thoracoplasty has been established as the denomination for costal resection for chest wall depression. Modified sternum chondroplasty is used in the treatment of PE and PC, with small differences regarding necessity, inclination and form of the osteotomy, retrosternal support by metallic plate being used in cases of PE.[4,10] This technique consists in the subperichondrial resection of the cartilages involved; osteotomy of the sternum when necessary; pleating of the perichondrium-muscle bands to give firmness to the chest wall; skin suture care, and subcutaneous cellular tissue care. The technique consists of the following steps: 1) peridural catheter and general anesthesia; 2) bilateral inframammary incision, with dissection of the skin and subcutaneous cellular tissue above, to the upper limit of the sternal, costal, and chondrial deformity and, below, to the lower limit of the chondrial-costal deformity, exposing the anterior chest muscle and upper abdominal muscle; 3) the pectoral muscles are released at the medial line by a longitudinal incision, and bilaterally dissected up to the chondrocostal articulations and, at the inferior line, the straight abdominal muscles and the external and internal obliques are disinserted in order to expose the inferior portion of sternum, ribs, and costal cartilages; 4) the perichondrium is incised, and subperichondrial resection of the cartilages affected by the defect is performed with appropriate retractors. Resection is always bilateral, even in the asymmetric cases, since, on the side presenting preserved cartilages, the sternum will be pushed forward in the case of PC, and backward in PE, promoting the recurrence of the deformity.[28,29] The perichondrium is the germinative element of (i.e., produces) the cartilage, and the costal cartilage will therefore be restored in the new position within approximately 3 months; 5) the xiphoid process is released and should be resected when it is too angled; 6) in lower PC, the sternum typically assumes the normal position after chondrial resection, and osteotomy is not necessary. In PC, in which the sternum does not assume the correct position, in upper PC, and in PE, the osteotomy is required for the correction of the deformity. Normally, one osteotomy is enough, although there are cases in which three and even four osteotomies are required. To prevent perforation, the sternum is released, bilaterally and carefully, from the loose mediastinal tissue, pericardium, and pleurae. Osteotomy is always performed on the anterior part with chisel and hammer, carefully preserving the mediastinal structures; 7) in most cases, we only resect the anterior cortical of the sternum, so that the posterior cortical will help maintain the sternum in position. To adequately correct the defect, it is sometimes necessary to perform an osteotomy in both cortices. Osteotomy fixation is achieved using two strands of Aciflex 5. In asymmetric PE, and in lateral PC, the sternum is inclined, and the osteotomy is therefore performed in order to rotate the inferior portion of the sternum, which is oblique to the anterior chest wall and to the upper extremity of the sternal osteotomy. Therefore, immediately below the transversal osteotomy, the proximal and distal extremities do not adapt. To maintain the portion of the sternum at the same level, going through the extremities of the exposed ribs, with the resection of the costal cartilages, the approximation of the sternal extremities is performed at the level of the osteotomy, with Aciflex, in a figure-eight pattern,[20] in order to maintain the inferior portion of the sternum aligned with the extremities of the ribs, bilaterally; 8) In patients with PE, for sternal support, 'overcorrection' of the defect is recommended, and, in order to provide better contour to the anterior chest wall, we use a metallic plate for sternal support, which is placed behind the sternum, transversally, bilaterally fixed to the ribs with Aciflex 4, through a hole in each extremity of the metallic plate; 9) Bone and chondrial extremities are regularized so that they will not produce skin protuberances and the thoracic contour will be the most perfect possible; 10) The excess perichondrium is pleated with polyglactin 0, in order to stabilize the anterior chest wall, and help maintain the sternum in position; 11) The pectoral muscles are stitched together at the medial line, and the abdominal muscles at the inferior border of the pectoral musculature; 12) The subcutaneous

cellular tissue is brought near with polyglactin 30, and the intradermal suture is performed; 13) Two Suctor drains are placed, one in the subcutaneous cellular tissue and another at the submuscular level. After postanesthesia recovery, the patients go to a private room. Some authors report that none of their patients needed to be admitted to the intensive care unit, nor did they develop unstable chest and paradoxical breathing, as mentioned by other authors.[2,8,10,14]

In patients with mammary silicon prosthesis, we should be careful not to perforate it. The plastic surgeon and an extra mammary prosthesis should always be made available should perforation of the prosthesis occur. It should be emphasized that the capsule around the prosthesis protects it during the dissection at the subcutaneous and pectoral muscle levels. Should the patient need or want to replace the mammary silicon prosthesis, or even to place a prosthesis, this should not be performed at the time of the sternum chondroplasty since, with the wide subcutaneous and muscle dissection, it will not be possible to provide a pocket for accommodation of the prosthesis in the most appropriate place. It is recommended that this be done 6 months after the correction of the defect in the chest wall, when the patient, after analyzing the result of the surgery, will be able to choose the prosthesis that will best adapt to their body. If indicated, and if the patient wants to, a reduction mastoplasty can be performed concomitantly with the sternum chondroplasty. Lower chondrocostal protrusions, in males, are treated with incision on the cartilages involved, subperichondrial resection, and careful pleating of the perichondrium. In females, the incision is inframammary and bilateral. The muscles of the lower chest and abdomen are dissected, and subperichondrial resection of the cartilages involved in the defect is performed. Resection of the segment of the extremities of the ribs is occasionally necessary, for harmonic and symmetric contour of the costal edges. This is an absolutely cosmetic surgery. Therefore, the surgeon should be very careful with the skin. In a case of lower PC associated with interatrial communication and anomalous venous drainage into the right atrium, a two-phase surgery was performed: at first, the heart disease was treated, and the sternum chondroplasty was performed after 6 months.[4] The thoracic deformity is corrected first, when kyphosis or pronounced kyphoscoliosis accompanies the *pectus*. The surgery on the spinal column is performed after 3 months.

Post-operative precautions after sternum chondroplasty:

- Position: lying down on the first day. From the second day on, half-sitting, sitting, lying down, or walking, according to the characteristics and possibilities of each patient (help is needed for standing up and sitting, by supporting the neck with the hand and raising the trunk until a sitting position is achieved, in order not to force the pectoral and abdominal muscles, for 15 days).
- Chest X-ray on post-operative day 2.
- Sleeping in the dorsal decubitus position for the first 15 days.
- Not flexing or rotating the trunk for 15 days.
- Peridural anesthesia should be used for a total of 48-72 h.
- Drains are removed after 24-48 h.
- Patients are typically discharged on post-operative day 4 with a prescription for oral painkillers.
- Follow-up appointments after 15 days, 1 month, and 6 months, then annually for 5 years.
- It is recommended that patients avoid physical activities for 3 months; this period is necessary for the costal cartilages to be restored, as well as for the solidification of the osteotomy. After this period, they can lead a normal life, free to engage in any sports. Global postural re-education is routinely used, after 3 months, to improve the posture, principally regarding the addicting stooped-shoulders position, and for complementary treatment of kyphosis or scoliosis, when present.[8]

Results

In women, with incision in the inframammary fold to soften the visual aspect of the scar, perfect thoracic contour is obtained. In men, even though there is no way the visual aspect of the scar can be softened, excellent aesthetic results are achieved, with full satisfaction of the patients and family members, who are exhaustively informed about the scar. Some state that one deformity is being replaced by another (the scar).[19] However, the vast majority of male patients would rather have a small scar

caused by appropriate surgical treatment than the thoracic deformity accompanied by the bad posture and the stigma it carries.

The classification of the results we now present takes into consideration the aesthetic result obtained: good, defined as perfect thoracic contour, the desired result having been achieved from the point of view of the surgery team, as well as from that of the patients and their family members; fair, when patients or family members are not fully satisfied with the result obtained, due to a hypertrophic scar, a less than perfect thoracic contour, sternal/bone/chondrial protuberances, or pronounced inferior costal protrusion; and poor, when the correction is only partial, the patient and/or family members are not fully satisfied with the result obtained, or there is recurrence of the deformity.[2,8]

With the technique described, the results obtained were classified as good in 115 (95.6%) of the patients, who, together with their family members, were fully satisfied with the aesthetic result, fair in 3 (2.5%), 1 due to the hypertrophic scar, and 2 because the patients were not fully satisfied with the final aesthetic result obtained, and poor in 2 (1.7%) who presented sternal depression in late post-operative period.[2] Few series have been published on the treatment of PC, and comparative data regarding results are difficult to obtain, because they are influenced by subjective factors, since this is an aesthetic surgery. Some authors obtained fair and good results in 75% of cases, 25% being classified as poor.[30] Other authors studied 109 patients submitted to correction of PC, with subperichondrial resection of the cartilages, and sternal osteotomy, as well as stabilization with a transversal retrosternal plate and two parasternal plates, and found that 95.5% successful results were obtained in 104 (95.5%), with 2 (1.8%) presenting major recurrence and 3 (2.7%) presenting mild recurrence. The rate of complications was 4.5%: 3 cases of pneumothorax (2.7%); and 2 cases of infection at the incision site (1.7%). Blood transfusion was necessary in 1 (0.8%) of the patients.[31]

Most patients tolerate surgery well, with few post-operative problems. Recurrence is rare in facilities with ample experience.[28] Recurrence tends to occur in children initially submitted to early or incomplete surgical correction.[27] Complications such as serous collection, hematoma, infection at the incision site, pneumothorax, hypertrophic scar, keloid, atelectasis, recurrence, and post-operative sternal depression are less common in PC than in PE.[2,18] In a study involving 60 patients submitted to a less invasive surgical procedure, there were 2 cases of serous collection (3.3%), 1 case of pneumothorax (1.6%), 4 cases of protrusion of costal cartilages (6.6%), and 6 cases of hypertrophic scar (10%). This high index of hypertrophic scar can be attributed to the fact that the authors used an inverted Y-incision, also increasing the perception of the scar.[6]

The PC deformity is not rare, affecting 1/1000 adolescents. Symptoms result from associated diseases, such as bronchitis and bronchial asthma, or emotional disorders, caused by the not aesthetical appearance of the chest wall. Conservative orthopedic treatment, which uses the DTC combined with physical exercises for remodeling of the chest wall, is indicated in lower and lateral PC, basically in adolescents, and is rarely indicated in upper PC. Considering the excellent aesthetic results obtained, as well as the low rate of complications, modified sternum chondroplasty is indicated in adolescents with rigid chest, as well as in young adults and adults. The use of the flowchart will promote an appropriate approach, even for doctors with little experience in the management of deformities of the anterior chest wall.

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