Abstract:

Pectus excavatum is an anterior chest deformity that is characterized by a depressed sternum. Physical examination is the primary means of diagnosis. Common surgical operations to correct this malformation include the Ravitch and Nuss procedures. This deformity affects physical, emotional and psychological well-being. The Ravitch repair of pectus excavatum removes segments of abnormal costal cartilages after which the sternum is elevated and stabilized. Some investigators have found a worsening in total lung capacity postoperatively. Recently, a technique has been used in which the costal cartilages are preserved, and the sternum is elevated with an internal steel bar (Nuss repair).......

Working definition....Success of the operation is based on relief of cardiac compression resulting in relief of symptoms and increased energy levels, adequate pain management as assessed by post-operative pain scores, length of hospital stay, time to return to normal activity and duration of daily medication.

Imagine that your child is born with the most common birth defect. There are no concerns until he enters puberty and things begin to change. At first he develops a dislike for activities that involve showing his body. You ask your physician about the 'warped chest' and learn that your child has a condition called pectus excavatum. The condition has "...no symptoms and correction is considered cosmetic".

In the following year your child begins to complain about feeling breathless with activity and his heart beating hard against his chest. You return to your physician with these complaints. As he examines your child, you note that the chest has undergone some alarming changes. The cavity is deeper and the chest wall appears to bulge on the left side. Your child is hunched over to hide it all.

Your physician thinks the breathing problems are not related to the pectus excavatum. Following your instincts, you insist on a referral to a specialist. It is granted, but you are forewarned not to expect recognition of either the physical or psychological symptoms of pectus excavatum.

What is Pectus Excavatum?

Pectus excavatum is a chest wall abnormality where the sternum (breast bone) and ribs are depressed inwards (concave) giving the appearance of a sunken chest. Pectus excavatum happens to also be one of the most common chest wall birth defects, some 1 out 8 are born with this birth defect. This sunken chest appearance is often recognized at or shortly after birth (congenital) or may be acquired at a later time. The child may also have rounded shoulders with their abdomen protruding outwardly or a “pot belly” appearance as a result of the rib cage “sticking out.” A pectus excavatum may be caused by an excessive overgrowth of costal (rib) cartilage, low bone densities, poor nutrition and muscle imbalances. It is found more often in boys then girls. Pectus excavatum becomes more noticeable once the child enters periods of rapid growth such as during early adolescence. It is not uncommon for a child with a pectus excavatum to also have curvature of the spine (scoliosis), a hunched over posture (kyphosis) or Vitamin D deficiency (rickets). In addition to the unattractive cosmetic appearance, pectus excavatum displaces the heart into the left chest to varying degrees depending on the severity of the deformity. Compression of the heart will reduce the stroke volume and cardiac output in moderate to severe deformities and thus cause more rapid fatigue that in a person with a normal chest.

The heart usually compensates by having a much faster beat (tachycardia) when the person exercises. The sternal depressions also decrease the cavity in which the heart and lungs lie (thoracic volume), which reduces the amount of air entering and leaving the lung with each respiratory motion. The body often compensates by developing more shallow and rapid respirations, and by having wider movements of the diaphragm when the patient is physically active. Patients thus experience shortness of breath and a considerable decrease in stamina and endurance during exercise. Many persons will experience a compression-type pain and discomfort in the lower anterior chest. Along with these physical signs there are a few physical and psychological symptoms. Physical symptoms associated with pectus excavatum include anterior chest pain, respiratory complications, and a lack of stamina. Psychological symptoms also overlooked range from mild self conscious behavior, loss of motivation, anxiety, and other social problems.
Should You Be Concerned?
It is easy to see what a pectus excavatum looks like from the outside. However, you need to know whether the pectus excavatum is causing problems on the inside. One of the main functions of the rib cage is to “protect” the lungs and heart. In people with a pectus excavatum, the rib cage is shaped differently. Although the heart and lungs are still protected by the ribs, the concave shape of the rib cage may cause these vital organs to be compressed. The chest wall may restrict the lungs from expanding properly interfering with optimal lung growth. This restriction may prevent normal contractions leading to cardiac limitations. Depending on the severity of the chest wall abnormality, the patient may experience restricted function of the heart and lungs. This may become apparent during times of physical activity when the child may have decreased endurance and stamina. Some individuals may experience chest pain, cough, wheezing and recurrent respiratory infection. In addition to bony abnormalities and possible lung and heart restriction, these patients often become very self-conscious about appearance which may impact their lifestyle choices.

Diagnosis

When the classic signs and symptoms are present, consultation with a medical team that specializes in the care of children with pectus excavatum is suggested. This team would include a pulmonologist who specializes in determining the significance of the chest wall compression on the lungs and heart; a physical therapist who can address the consequences of the chest wall abnormality; and a pediatric surgeon who can offer surgical intervention if required. Proper assessment of this condition includes the following:

- A chest x-ray from the front and side view will demonstrate the severity of the deformity and permit calculation of the pectus severity index;
- A CT (computerized tomography) scan of the chest provides slightly more information and is more accurate in determining the severity index (Figure 3 & 4);
- An EKG and ECHO (picture of the heart) study are helpful if a heart murmur, or known heart disease are present;
- Pulmonary function (exercise) tests during exercise to determine how the heart and lungs respond to physical stress (Figure 5).
Treatment Options
Treatment may include non-invasive physical retraining and realignment physical therapy, invasive surgery, or both. Aggressive physical therapy may have a role in slowing the progression of the chest wall abnormality and may even reverse some of the cosmetic appearance. Consultation with an experienced physical therapist with expertise in respiratory disorders can assist you in this non-invasive approach.

When Is Surgery Necessary?
Surgery is necessary for many patients with pectus excavatum because the chest deformity can be putting pressure on several of your vital organs. The deformity often compresses the heart and displaces it to a place where there is minimal room. The concavity also restricts the expansion and growth of your lungs. Once it is determined that the pectus excavatum is compromising either the heart or lungs, surgery is strongly considered. Currently, there are only three options for surgery. The three options are the Nuss, Ravitch procedures, and use of silicone implants.

Nuss Procedure
The Nuss procedure is a newer and minimally invasive surgery. Prior to surgery, a stainless steel bar (Walter Lorenz Surgical, Jacksonville, Fla.) is bent to conform to the contour of the patient’s chest at the level of the deepest part of the excavatum (Figure 6). The bar is selected so that its length is sufficient to extend from the mid-axillary line on one side of the patient’s chest to the mid-axillary line on the other side.

For the operation, the patient is supine with the arms abducted. Incisions are made on the sides of the chest between the anterior and posterior axillary lines. Large pockets are created to accommodate the bar. A Kelly or Crawford clamp is inserted through the openings and passed directly behind the sternum. The electrocardiogram is monitored for arrhythmias during passage of the clamp (Figure 7). An umbilical tape is then tied to the bar, and the bar is then guided across the mediastinum or underside of the sternum (Figure 8). The convex side of the bar faces posteriorly as it traverses the mediastinum (Figure 9, top). The bar is then rotated 180° with a vise grip or rotational device so that the convex surface elevates the sternum (Figure 9, bottom). If the correction is deemed unsatisfactory, the bar is turned over, removed from the chest, and bent further so that an appropriate correction of the deformity can be achieved. In some cases, a second bar is necessary for satisfactory correction. A cross bar is inserted in one end of the bar for stabilization (Figure 10). The convex bar and stabilizing bars are firmly sutured to the chest wall. The surgical wounds are then closed in layers. After two years when the desired shape of the chest has formed, the bar is them removed. This procedure is quicker and offers faster recovery.

Ravitch Procedure
The Ravitch procedure is the most commonly used method although all are performed. The Ravitch procedure consists of lifting up the chest muscles, cutting the costal cartilage, rotating the sternum to lie flat and inserting a bar inside.
For this operation, a transverse curvilinear incision is made midway between the nipples and costal margin, with a short midline extension in most patients (Figure 1). Short skin flaps are then elevated. The pectoral muscles are then reflected laterally over a short distance, and the abdominal muscles are mobilized to expose the deformed cartilage. Short incisions are then made through the deformed cartilage adjacent to the sternum; a second 1.0- to 1.5-cm incision is made laterally near where the chest wall is at the highest level. Short segments of cartilage (1.0–1.5 cm) are then cut laterally from each of the deformed ribs. A thin stainless-steel bar (Adkins strut) is then placed obliquely across the lower chest of the sternum. The thin stainless-steel bar is then used to elevate the sternum as well as the chest to the desired level (Figure 4). The strut was attached to the appropriate rib on each side with fine wire. Finely minced fragments of cartilage, which have been removed earlier, are placed into the short segments of open sheaths to enhance cartilage regeneration. The pectoral and abdominal muscles are then sutured together over the cartilage repair. The skin is then closed with absorbable sutures and Steri-strips.

Materials and Methods
Between April 1998 and January 2001, a study was conducted on twenty four patients 19 to 46 years of age. Twelve patients received the minimally invasive Nuss procedure, while the other twelve received the Ravitch procedure. There were fifteen men and nine women. The patients had symptoms limiting lifestyle, a chest wall index greater than 3.25, and cardiac abnormality on echocardiogram. Chest wall index was determined from a computed tomography (CT) scan image of the chest comparing the anterior – posterior dimensions to the transverse dimension of the chest. A chest wall index greater than 3.25 was determined at the Johns Hopkins Hospital to be an indication for surgery.

An echocardiogram was performed on all patients at rest, and with exercise, if necessary, to document cardiac compression causing structural changes in the heart. Cardiac abnormalities were present in all of the patients (Table 1). Before surgery each patient was advised of the risks and benefits of the Ravitch and the Nuss minimally invasive procedure.

The following data were collected on each patient: operating time, duration of epidural infusion, postoperative pain scores, length of hospital stay, alleviation of symptoms, relief of cardiac abnormality on postoperative echocardiogram, time to return to normal activity, duration of pain medication post-hospitalization, and complications.

Reference


Backer CL, Mavroudis C: The Society of Thoracic Surgeons Congenital Heart Surgery Nomenclature and Database Project: vascular rings, tracheal stenosis, and pectus excavatum.


