Pectus excavatum

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The deformity of pectus excavatum is caused by a negative pressure in the anterior mediastinum sucking in the body of the sternum. This is usually due to the heart lying on the left side, leaving the mediastinum empty so that the sternum and costal cartilages are sucked in to fill the empty space. The operation consists of excising the deformed cartilages, mobilizing the sternum, and suturing the pericardial sac into a central position which corrects the deformity.

Pectus excavatum, funnel chest, depressed sternum, and chonchondrosternon (Ochsner and DeBakey, 1939; Ochsner and Ochsner, 1966) are pseudonyms describing the same deformity of which the aetiology remains unknown and open to speculation. Brodtkin (1953) and Chin (1957) blame the xiphoid origin of the diaphragm pulling the lower part of the sternum backwards. Mullard (1967) considers it is due to failure of osteogenesis and chondrogenesis of the anterior chest wall. Brown (1939) described the pathological changes of the chest wall in advanced pectus excavatum but offered no explanation for its causation.

The diverse ways of correcting the deformity prove that no method is entirely satisfactory. Many authors recommend a rigid internal or external splint (Abrams, 1961; Adkins and Blades, 1961; Griffin and Minnis, 1957; Dailey, 1952; Lester, 1946; Moghissi, 1964; Peters and Johnson, 1964; Rehbein and Wernicke, 1957; Jennings and Addison, 1964; Bradmore 1968; Jensen, Schmidt, and Garamella, 1962; Mayo and Long, 1962). A few describe methods without fixation (Ravitch, 1949, 1965; Lam and Brinkman, 1959; Welch, 1958; Adkins and Gwathney, 1958).

Nobody has yet considered bringing the displaced heart and mediastinum into a central position.

Associated congenital cardiac abnormalities have been described (Edeiken and Wolferth, 1932; Evans, 1946; Sutton, 1947; Wachtel, Ravitch, and Grishman, 1956). Right ventricular pressures have been recorded (Lyons, Zuhdi, and Kelly, 1955). Electrocardiographic (Dressler and Roesler, 1950; Martins de Oliveira, Sambhi, and Zimmerman, 1958; Schaub and Wegmann, 1954) and angiocardigraphic (Garusi and D'Ettorre, 1964) studies have been performed, and also measurement of

pulmonary function (Orzalesi and Cook, 1965; Polgar and Koop, 1963).

The authors who have carried out these investigations blame their abnormal findings on the deformity of the chest wall, but we believe that a negative pressure behind the sternum is the main cause, sucking in the sternum.

This is usually due to displacement of the heart, leaving the anterior mediastinum empty, as we shall explain later. But recently Dr. Olive Scott told us of a case where this suction effect in the anterior mediastinum was produced by a different cause. A boy aged 7 months with marked congenital laryngeal stridor was admitted for investigation because he appeared to be cyanosed. Dr. Scott performed a right heart catheterization and found that there was no congenital abnormality of the heart, but, due to the marked laryngeal stridor on inspiration, the right ventricular diastolic pressure reached as low as -18 mm. Hg (Figs 1 and 2). The child has already developed a moderately severe degree of pectus excavatum.

So a normal, healthy right ventricle exerting a positive pressure in the anterior mediastinum is one of the main factors keeping the sternum forwards and in its correct position. In certain congenital heart lesions, when the right ventricle is greatly hypertrophied and overactive, it pushes the sternum too far forward and produces a pigeon-shaped chest. Indeed while operating on such a heart one has frequently seen thickening of the endocardium on the anterior surface of the right ventricle where the maximal push behind the sternum has taken place.

We have found in the patients with pectus excavatum on whom we have operated that the pericardial sac appears to be too large and unable to support the heart in a central position. If this

FIG. 1. Child aged 7 months with severe laryngeal stridor (Dr. Scott's case).

FIG. 2. The pressure tracing with the cardiac catheter in the right ventricle. Note on inspiration the pressure falls to -18 mm. Hg.

enlarged sac is present at birth, the weight of the ventricular mass will pull the heart over to the left side, causing it to fall into the left paravertebral sulcus. When the child begins to breathe the negative pressure inside the chest pulls in the sternum and costal cartilages. These are mobile structures at this early age, for the costal cartilages are soft and pliable, the costochondral joints are functioning, and the body of the sternum is hinged by a joint with the manubrium at the angle of Louis. The maximum deformity of the sternum occurs where there is the greatest mobility, and this is at the lower end; where, unfortunately too, there is the xiphoid origin of the diaphragm which also exerts a backward pull on the sternum, for infants breathe more readily with their diaphragms than with their chest walls. Here at the

lower end of the sternum the long costal cartilages bend too easily, allowing the sternum to fall back a long way and fill the empty anterior mediastinum.

OPERATION

Applying the principle that the deformity is due to the sternum being sucked in by a negative pressure in the anterior mediastinum, caused usually by displacement of the heart to the left side, we have in three patients performed the following operation, which has in each case entirely corrected the deformity.

A midline incision is made extending from the angle of Louis down the centre of the body of the sternum to below the xiphoid process. The two sides of the skin incision are mobilized with the deep fascia to expose all the deformed costal cartilages. An extensive resection of these deformed cartilages is then carried out, which usually entails resecting completely the third to seventh costal cartilages on both sides.

A transverse wedge of bone is taken out of the sternum anteriorly just below the angle of Louis, allowing the body of the sternum to come forward.

Both pleural sacs are then dissected as far as possible off the pericardium. The right pleural sac invariably extends anteriorly and over to the left side. The pericardium looks thin and lax; at least one third of the sac appears redundant. It is incised longitudinally from its reflection on to the main pulmonary artery to its attachment to the diaphragm. It needs to be mobilized at its lower end and indeed incised along its diaphragmatic attachment in order to allow the heart to regain a central position. The redundant pericardium may be excised or cotted up with mattress sutures. The left incised edge of pericardium is sutured to the anterior right chest wall.

with interrupted silk sutures. These sutures are tightened sufficiently to bring the heart into a central position, so that the ventricular mass comes to lie behind the sternum.

The body of the sternum is attached to the manubrium only by its posterior lamina, for a transverse wedge has already been taken out anteriorly in order

to angulate it forwards near the angle of Louis. If its anterior surface is too concave the anterior lamina may be divided longitudinally and then fractured to produce a convex anterior surface. The body of the sternum is then placed on the surface of the pericardium and left completely free without suturing or attachment.

FIGS 3 and 4. D.R. aged 42 showing the deformity before operation.

FIG. 5. The result after operation.

FIGS 6 to 11. D.K. aged 20 years.

FIG. 6. *Before operation.* FIG. 7. *After operation.* FIG. 8. *Shows the heart displaced into the left chest before correction.*

FIG. 9. *After operation the heart has been pulled over to the right side.*

FIGS 10 and 11. *Lateral radiographs of the chest showing the sternum before and after correction.*

A Zimmer drain is introduced, and the deep fascia and any bits of muscle are sutured together over the sternum. The superficial fascia and skin are then closed.

We have applied this technique on three patients:

1. A man (D.R.), aged 42 years, with an extreme degree of pectus excavatum—operation performed November 1968 (Figs 3, 4, and 5);

2. A youth (M.P.) aged 16 years, with moderately severe deformity—operation performed January 1969;

3. A youth (D.K.), aged 20 years, with a severe degree of pectus excavatum—operation performed February 1969 (Figs 6 to 11).

The deformity in each case has been entirely corrected and the results so far look excellent.

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