

# Technical Problems in the Operative Correction of Pectus Excavatum \*

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IN 1949, we reported our first experiences with the operative correction of pectus excavatum, describing the technic which had been adopted.<sup>2</sup> Subsequently 164 children and 28 adults have been treated and the operative procedure has been modified.

The principle of the operation remains unchanged. The cartilages are excised subperichondrially for the full length of their deformity, the xiphoid is separated from the sternum and the intercostal bundles are divided from the sternum. No external fixation is employed.

In stripping the perichondrium it is advisable to make an incision just through the perichondrium for the length of the deformity and make transverse incisions at either end, so that a rectangular flap of perichondrium can be reflected. If the upper edge of the incised perichondrium is grasped with sharp, curved forceps, the perichondrium can be stripped away in the actual application of the clamps, either with blunt staphylorrhaphy elevators, used in dissecting atheromas in arterial reconstruction, or with the smooth back of an ordinary scalpel or other available instruments. The perichondrium is a little tougher than the cartilage, except at the upper and lower borders of the cartilage where the perichondrium becomes quite thin. If the cartilage is particularly rigid and very thick it is sometimes best, after having cleared the

anterior surface to seize the cartilage fairly *gently* with a Kocher clamp and then transect the cartilage with a scalpel while applying traction on the Kocher. This allows the cartilage to come away and it then can be stripped away from behind with a blunt elevator.

In our first report we remarked that a superior result might have been achieved in Patient 8 had the sternal osteotomy been performed an interspace higher; we now believe that unsatisfactory postoperative results can be attributed to not having taken the cartilages out far enough or not taking enough cartilages. At present, having resected the three to five deformed cartilages on either side, we merely transect the next higher cartilage, usually the second or third, so that the sternal osteotomy in the interspace above can be made above the beginning of the downward sweep of the sternum. Haller<sup>2</sup> recently suggested that if the incision in the cartilage were made obliquely, passing from in front and medially to behind and laterally, there would be a substantial overlap of the medial fragment upon the lateral, when the sternum had been lifted to its corrected anterior position. In general, the lateral end of the divided cartilage tends to approach the midline sufficiently that even a straight division of the cartilages allows for some overlap. In either case we employ suture fixation. Several years ago, Doctor Geary

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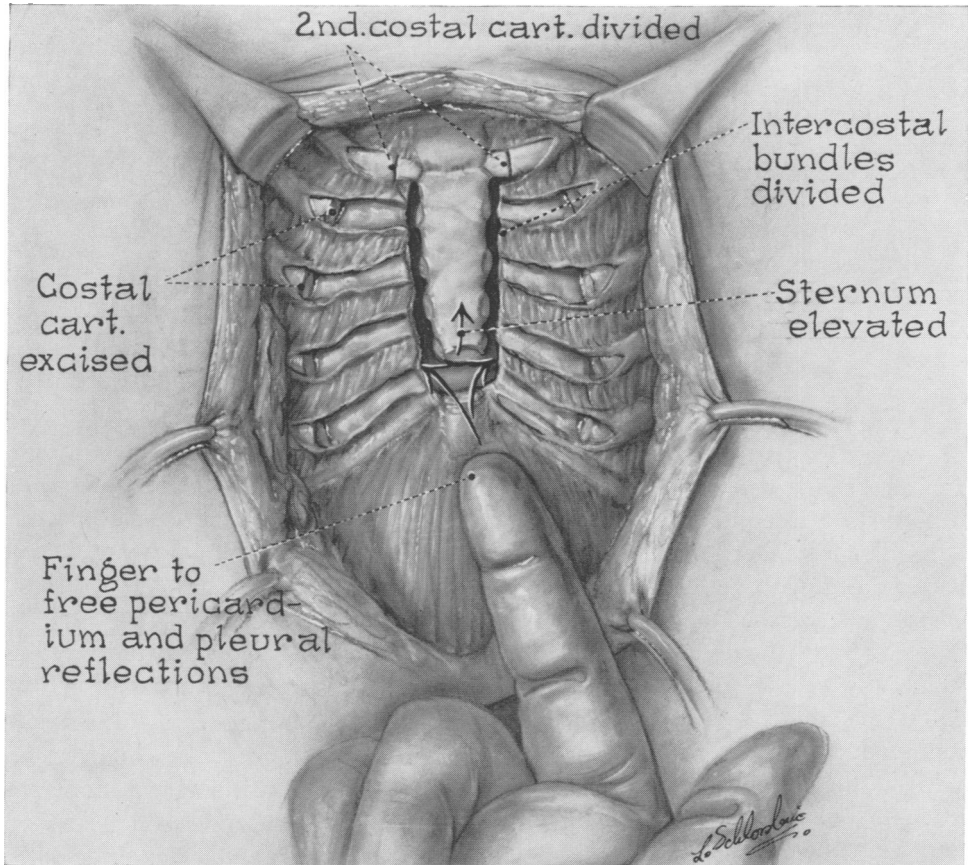


FIG. 1. Through a midline incision in males, and through a curved submammary incision, bowed upwards in the midline, in females, the pectoral muscles are stripped back on both sides, exposing the full extent of the deformity. The deformed cartilages are removed, subperichondrially, for the full extent of their deformity—in infants and children this will be 3 to 5 cm., and we usually stop short of the costochondral junctions. In older children and young adults the deformity usually continues out into the bony rib. The finger is inserted into the mediastinum behind the sternum after the xiphi sternal articulation has been divided, and the pleura is dissected back on either side. The intercostal bundles are then divided with the scissors, preferably medial to the internal mammary vessels. The lowest normal cartilage is now divided obliquely, from anteriorly and medially to laterally and posteriorly.

Stonesifer, then Assistant Resident in Surgery, pointed out that if the sternal osteotomy were made through the posterior rather than anterior cortical lamella, any tendency to progression of the deformity of the sternum produced by operation would be in the direction of anterior tilting of the distal segment of the sternum, and this would be desirable. In a number of cases we had found that after performing an anterior cuneiform osteotomy and fracturing the posterior cortical lamella, the

posterior periosteum had stripped back a little, allowing the distal fragment subsequently to assume a stepped-back or recessed position which detracted from the excellence of the result. We therefore now routinely perform a transverse, posterior osteotomy of the sternum, achieved simply by scoring the posterior surface of the sternum with the corner of a sharp osteotome as the sternum is held and lifted forward. To achieve a precisely transverse cut we pass a wire around the sternum and

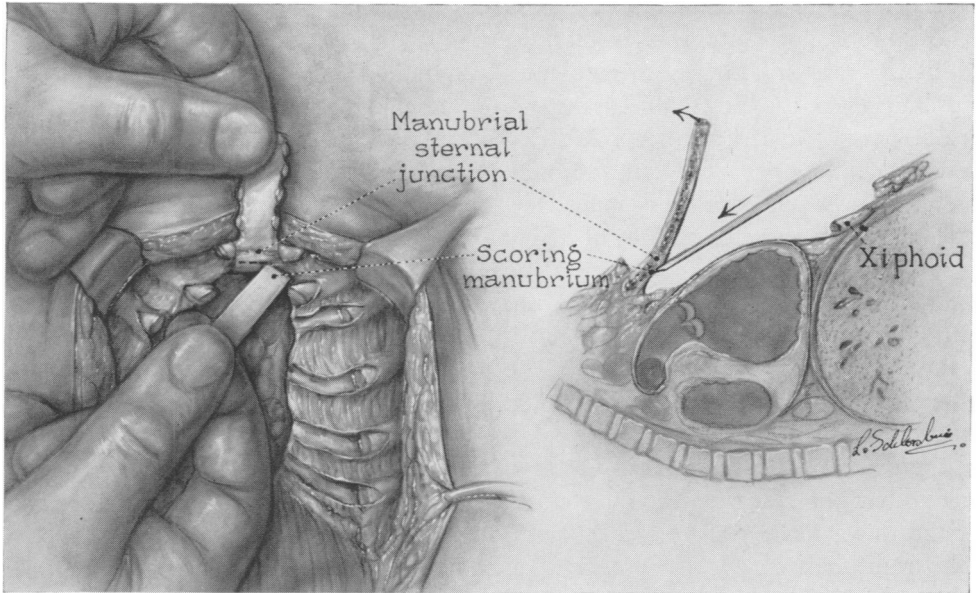


FIG. 2. The sternum is now lifted forward and with the corner of a sharp osteotome the sternum is scored in the interspace above the divided cartilage until it fractures forward. It tends to remain readily in the now corrected position.

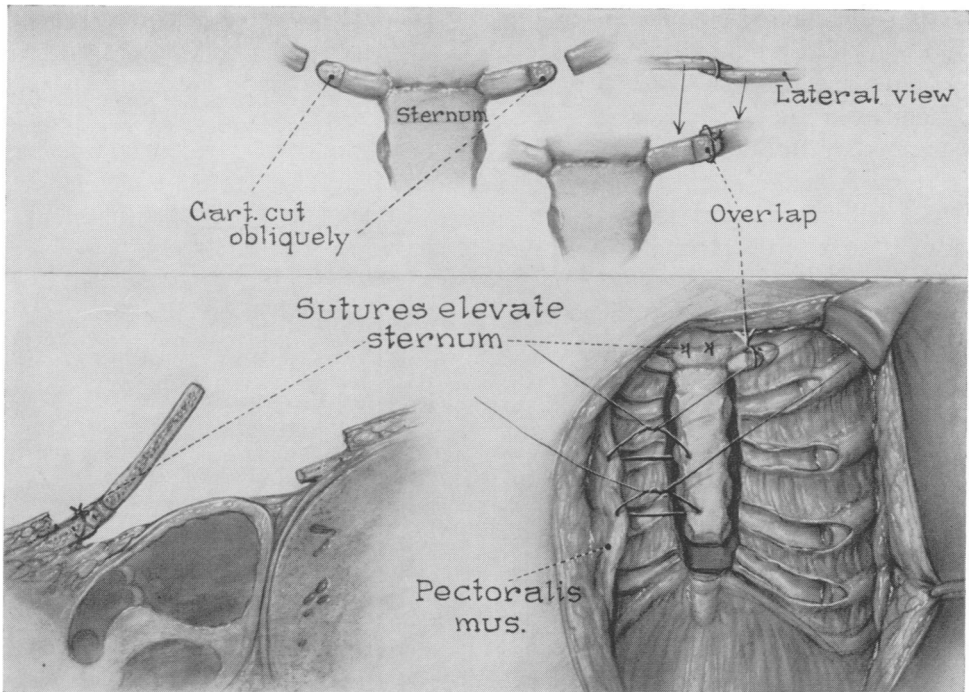


FIG. 3. The sternum is maintained in the corrected position by heavy braided silk sutures across the osteotomy. The inset shows the method of cutting the costal cartilage obliquely so that, with the sternum elevated in its new position, there is sure to be overlap, although it is found that even with a perpendicular incision in the cartilage there is usually some overlap. This cartilage, usually II or III, is now sutured together in this new, corrected position and the pectoral muscles tacked back.

run the corner of the osteotome along the wire. Despite the advantage of inserting a small bone graft or strut in this opening just produced in the posterior cortex, we have not wished to risk its becoming dislodged and falling into the mediastinum. The sternum is held, sutured anteriorly, by one or several mattress sutures of heavy braided silk through the bone, across the osteotomy. Attempts to use wire have not been satisfying. A saddler's awl simplified the passage of sutures through the sternum. We never use external fixation. In many children, frequently older children, the sternum is rather sharply rotated toward the right side, *i.e.*, counter-clockwise, and this is usually corrected by dividing the right half of the osteotomy completely and twisting the sternum back into position before the mattress sutures are placed across the osteotomy and the divided highest cartilages are sutured back in place. Resuturing the intercostal bundles to the sternum was discontinued because of a tendency to recreate the deformity, and these bundles are left quite free. The pectoral muscles are still tacked carefully back to the sternum in the midline and we believe this to be important. The xiphoid is not sutured back to the sternum. Occasionally the sternum in a child is so scaphoid that when the osteotomy has been performed and maintained by suture, the distal end of the sternum projects far forward, requiring transverse osteotomy in the distal portion of the sternum to allow it to fall downward and correct the exaggerated anterior curvature.

We have reoperated upon two young children and one young adolescent. In the first we used a bone strut of rib taken subperiosteally from the other side. In a second we used a strut of Teflon felt, stretched from side to side on the anterior surface of the costal cartilages, but behind the sternum. In the third, a six foot two adolescent, we employed the internally placed ribbon

steel struts of Rehbein.<sup>3</sup> These consist of a short sharp arm, about 2 cm. long, which is plunged into the marrow of the distal segment, and coming out at an angle from this arm, in an arc, a flat ribbon of steel which arches anterior to the sternum and is sutured by wire sutures to the anterior sternal surface. A pair of these is put on from either side and the corresponding ones wired together, so that the spring of the bow holds the sternum out. We have used this fixation also in a young adult who was admitted with heart failure and who needed an extremely large chondral resection. In both cases the result has been very good, the sternum has been firm at once, and thus far we have not removed the struts although Rehbein apparently does. We have not had any experience with skewers, whether piercing the skin or lying on the chest wall beneath the skin, but the latter technic may have applications. In young adolescents, particularly those with a very long sternum, we believe that some type of internal support is necessary to overcome the great leverage of the long, free segment of sternum, and sometimes we employ a thin strip of Teflon felt, which is extremely well tolerated. The strip is no more than 1 cm. wide and 8, 10 or 12 cm. long, as necessary for the given defect, so that it can be sutured strongly to the cartilages on either side and lie behind the sternum.

We do not use suction in most instances but depend upon needle aspiration of the area beneath the wound if any puffiness is detected. Some children, however, have discharged fluid after returning home, apparently healed and well. We have treated two wound infections, both staphylococcal, since the one we reported in 1949. In one patient only establishing drainage was necessary and the sternum healed completely in a good position. The other patient lived in a distant state, and ultimately had a sequestered portion of the anterior table of his sternum removed; the sternum re-

mained fixed in good position and the wound healed completely. There have been no other significant complications and no deaths since the first report.

In two boys, about fourteen years old, who had defects so wide that we doubted that the required resections could be tolerated and in whom the manubrium itself was sunken so that it was an obviously limiting factor, we removed the deformed sternum and cartilages intact, reversing and resuturing the entire breast plate except for the first ribs and attached portion of the manubrium. Instant stability was achieved, probably more satisfactorily than could have been achieved by the usual operation. However since the original deformity had become progressively deeper distally, the new sternum is now progressively more prominent caudally. We believe the indication for this operation is quite limited, and in addition, such a huge mass of tissue to be taken as a free graft, together with the intercostal and retrosternal muscles would present a problem in the event of infection. Both patients healed quite promptly, and the results were gratifying.

### Summary

Since our previous report in 1949, we have performed 164 operations for pectus excavatum in children and 28 in adults. The basic principles of operation—subperi-chondrial excision of all of the deformed cartilages, complete liberation of the sternum by division of the xiphoid and the intercostal bundles, transverse sternal osteotomy, and absence of external fixation—have been reaffirmed. One modification has been an oblique division of the lowest normal cartilage which allows osteotomy of the sternum one interspace higher than formerly, and this osteotomy is now always performed on the posterior surface of the sternum. Occasionally internal fixation or support is used, particularly in adolescents or adults with very long sternal structures.

### References

1. Haller, A. J.: Personal communication.
2. Ravitch, M. M.: The Operative Treatment of Pectus Excavatum. *Ann. Surg.*, **129**:429, 1949.
3. Rehbein, F. and H. H. Wenicke: The Operative Treatment of The Funnel Chest. *Arch. Dis. Child.*, **32**:5, 1957.