PIGEON BREAST (PECTUS CARINATUM) AND OTHER PROTRUSION DEFORMITIES OF THE CHEST OF DEVELOPMENTAL ORIGIN*

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PIGEON BREAST (*pectus carinatum*) and other protrusion deformities of the chest of congenital origin are not common but are probably much more prevalent than is supposed. They are not to be confused with the pigeon breast of rickets, which is an acquired deformity. The developmental defect usually is not noticed until the child is a year or more of age. It then continues to increase for a variable length of time, often over a period of years, and may reach its maximum in the teens.

In other instances the deformity may reach its maximum at an early age and may then remain stationary, or even regress as the normal growth of the chest catches up to it. It is not uncommon for other developmental defects to be present also. The hereditary characteristic which is common in funnel chest has been noted once, and two families have been encountered in which one child had a funnel chest and another a pigeon breast. In neither instance was the deformity marked. These protrusion deformities have received scant attention in the literature, although they are occasionally disabling and frequently disfiguring.

These deformities may be divided into two groups. The first comprises the midline deformities involving the sternum and attached cartilages. The second comprises those deformities involving the anterior chest wall lateral to the sternum. In this group can also be placed those deformities which involve the cartilages attached to the costal arch. The lateral deformities are confined to one side except when the costal arch is involved, when they are often bilateral.

In the first group the sternum protrudes either in an oblique fashion from above downward with the lowest part the most prominent (Fig. 1), or in an arcuate manner with the midportion of the sternum the most prominent and the lower end pointing backward (Fig. 2). In both instances the costal cartilages extend forward obliquely from their costochondral junctions to the sternum.

In the second group the sternum seems to be in its normal position and the protrusion corresponds to the costochondral junctions of several consecutive ribs, thus making a ridge lateral to the sternum (Fig. 3). The bony ribs are occasionally forked and the costal cartilages are frequently forked or present some other similar abnormality such as union with the cartilage above or below, a division and reuniting of the cartilage, or a fusion of the adjoining cartilages to make a cartilaginous plate. The cartilaginous abnormalities are not readily apparent because they do not show on roentgenogram and are difficult to palpate.

When the protrusion is in the ribs that form the costal arch the prominence also seems to start at the costochondral junctions but, in the absence of the sternum at this point, the costal arch flares and protrudes and a transverse groove appears, similar to that in funnel chest and resembling Har-

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rison's groove of rickets. If the protrusion is bilateral and the sternum protrudes in an arcuate fashion, the deformity is often confused with funnel chest. I admit to such an error.[4]

The differentiation, however, should be readily made. In funnel chest there is obvious retraction of the xiphoid during inspiration; the distance between the xiphoid and the vertebrae is decreased both by measurement with a pelvimeter and on lateral roentgenogram, and the heart is displaced into the left hemithorax. In pigeon breast, on the other hand, the xiphoid moves forward during inspiration; the distance between xiphoid and vertebrae is normal or increased and the heart occupies a normal position.

No satisfactory explanation of the etiology of thoracic wall protrusions has ever been offered, although many observers believe that the diaphragm has something to do with it. Brown[2] thinks that overstimulation of the peripheral fibers of the diaphragm is a factor. Brodkin[1] studied a 14-months-old mongoloid infant with an interventricular septal defect and a pigeon breast, who died of a respiratory infection. The central tendon of the diaphragm was much enlarged at the expense of the anterior muscle fibers, and it was to this that he attributed the deformity.

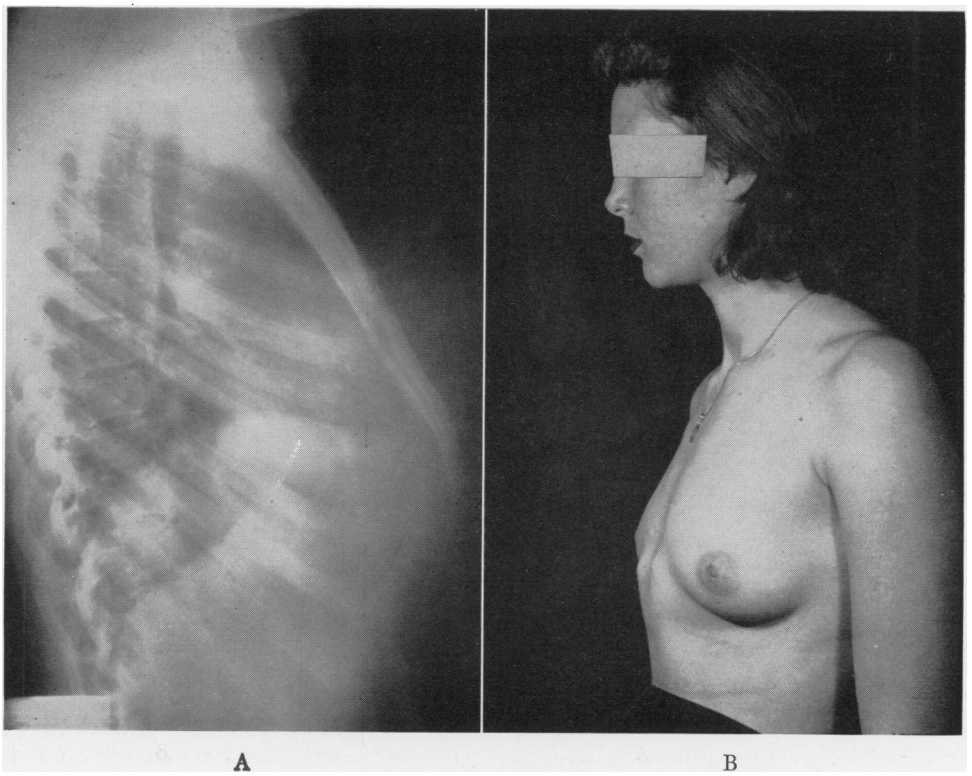

FIG. 1.—Oblique protrusion deformity of the sternum.

To investigate this factor, diaphragms have been examined in the autopsy room. In each instance death was from some entirely unrelated cause. In two subjects the diaphragms were associated with funnel chest and in a third the diaphragm was associated with an arcuate pigeon breast. One funnel chest and the pigeon breast were in individuals of comparable size. The diaphragm from an individual of similar size but with

normal thorax was examined for comparison. The diaphragm from the funnel chest was the smallest and that from the pigeon breast was the largest. In no instance was there any deficiency of anterior muscle fibers.

Observations were also made of the diaphragm in a patient with oblique pigeon breast during the course of a cholecystectomy. This appeared to be the largest diaphragm of all and the aortic-xiphoid distance as related to the anteroposterior

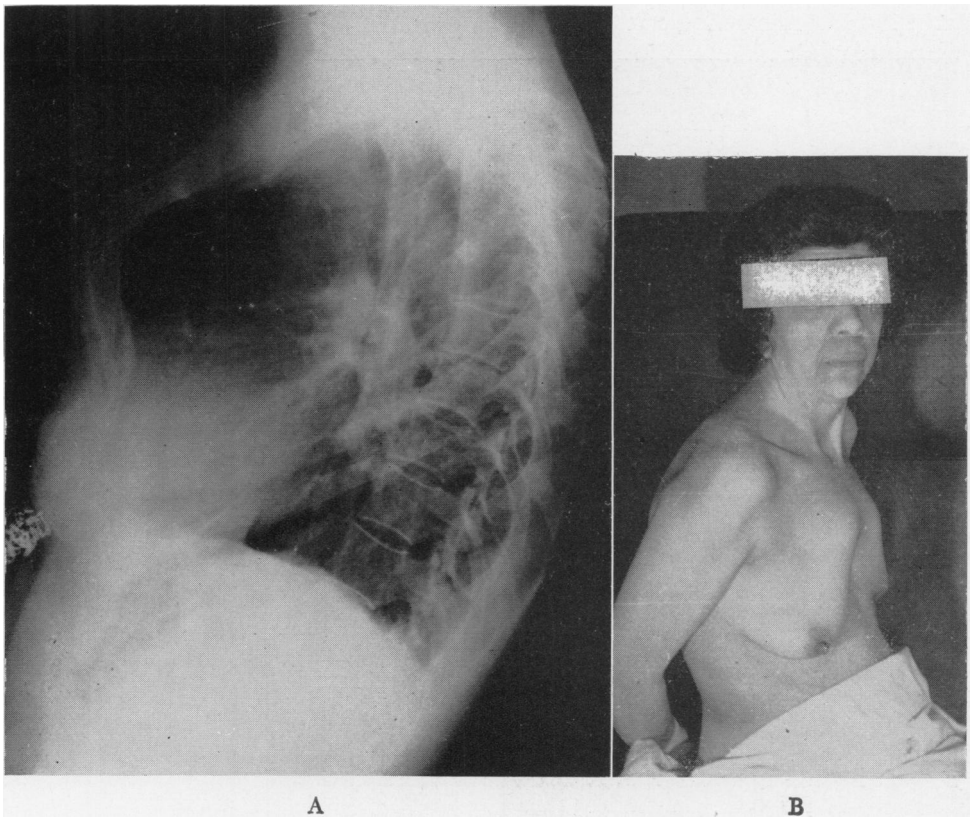

FIG. 2.—Arcuate protrusion deformity of the sternum. Exertional dyspnea developed before this patient could climb one flight of stairs.

On comparing the aortic-xiphoid measurement with the anteroposterior measurement across the center of each diaphragmatic leaf, it was found that the aortic-xiphoid measurement was comparatively less in the arcuate pigeon breast (56 per cent) and the funnel chest (38 per cent) than in the normal (67 per cent). The other funnel chest diaphragm, from a smaller individual, also showed a proportionately smaller aortic-xiphoid measurement, thus confirming the original observation as to the diaphragmatic factor in funnel chest by Brown.[3]

distance across the center of the diaphragmatic leaves seemed greater than in the normal. Accurate measurement was obviously impossible. In this instance also, there was no lack of anterior muscle fibers.

Another factor in the etiology was suggested by the observation, made during operation on the protrusion deformities, that when a rib or cartilage entering into the deformity was divided, there was an immediate and considerable overriding of the divided ends. This is much more than is found, in our experience, when the rib of a thorax without deformity is divided. The

inference from this is that there is an exaggerated push of the rib against the sternum or costal arch in cases with protrusion deformities.

Consideration of these factors, *viz.*: the size and shape of the diaphragm and dis-

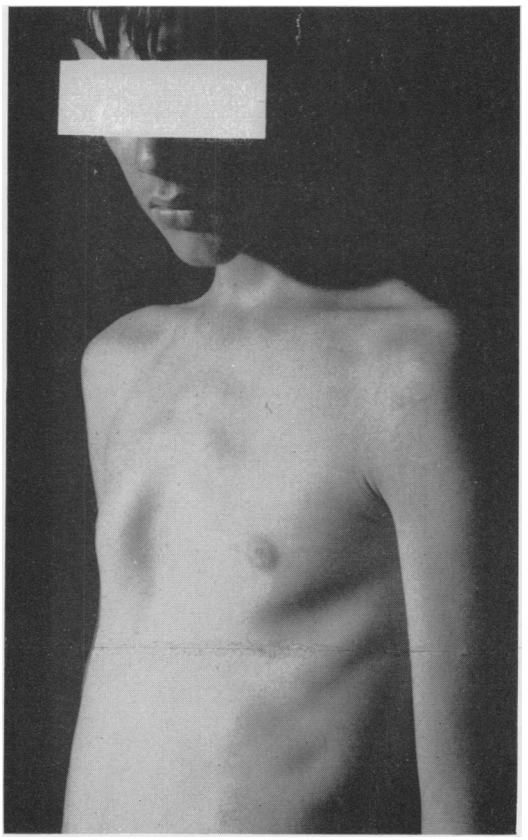

FIG. 3.—Protrusion deformity of chest lateral to sternum.

proportionate length of the ribs can lead to an explanation of the etiology of protrusion deformities. Without consideration of all the forces involved, it can be seen that a bilateral overgrowth of the ribs below the second, or underdevelopment of the upper ribs, will force the sternum forward by buckling the ribs along the weak costochondral junction (Fig. 4A). If the diaphragm increases its size to keep pace with the overgrowth of the ribs, the sternum will protrude in an oblique line from above down. If the diaphragm does not keep pace, especially in the tendinous portion, the xiphoid and lower end of the sternum will be restrained and the protrusion of the sternum will take an arcuate form, curved from above down.

If the overgrowth of the ribs is confined to one side, the sternum will not be pushed forward, but these ribs will still buckle along their weak costochondral junctions and the protrusion will take place laterally along this line rather than in the midline (Fig. 4B). The location and extent of the deformity will, of course, depend upon the number and location of the ribs involved. The entire hemithorax may be involved or the deformity may be limited to a single rib.

It is difficult to depict the mechanism of the anterior deformity in the average case where there is an abnormal overgrowth of ribs, but when a developmental defect produces shorter ribs, it is more apparent. Figure 5A is the roentgenogram of the chest of a child in whom the upper ribs on the right are abnormally short and otherwise deformed and the lower ribs are normal. Figure 5B is a photograph of the same child showing the unilateral anterior protrusion produced by the disproportion between the abnormally short upper ribs and the normal lower ribs.

The pull of a diaphragm which is short in its transverse measurements, is another mechanism to explain a midline protrusion. In this case the costal arch is narrow and also protrudes. We have encountered several cases of this type in which an ineffectual cough was also present.

It may be mentioned at this point that two instances have been observed where the sternum was depressed in a straight line (not curved as in funnel chest). The same factors of rib overgrowth may have obtained in these cases, and buckling occurred along the costochondral junctions but for some unknown reason, the sternum was displaced backward rather than forward. In one of these cases there was definite suggestion of cardiac compression,

but this could not be proved because operation was refused.

The physiological effects of the deformity may be definite, but are usually rather vague and ill-defined. One of our patients had a cardio-respiratory embarrassment producing dyspnea on slight exertion which was entirely relieved after operation. Another had chronic bronchitis associated with asthma which disappeared after operation, although she continued to have occasional attacks of asthma. Other physiological effects have to do with underweight, poor posture, and easy fatigability. They are all hard to explain and cannot be measured by functional studies.

The psychological aspects of the deformity are apt to dominate the picture. Modern society looks upon the thorax as an index of masculine virility or feminine attractiveness, and children get the idea at an early age. Under such conditions, if the deformity bothers them at all, it bothers them greatly. They avoid athletics, bathing beaches and, eventually, all social gatherings. This, in itself, may produce physiological symptoms. Whether or not the symptoms are sufficient to warrant surgical intervention is entirely an individual matter. In general, when such a patient seeks medical advice for the deformity, he is probably bothered by it one way or another, and usually to the extent that he considers surgery. As a rule, he is only vaguely conscious of physiological limitations because he has never known what it is to be without them and does not become aware of them until operation has produced an improved status. If operation is reserved for those who earnestly desire it, the results should be good.

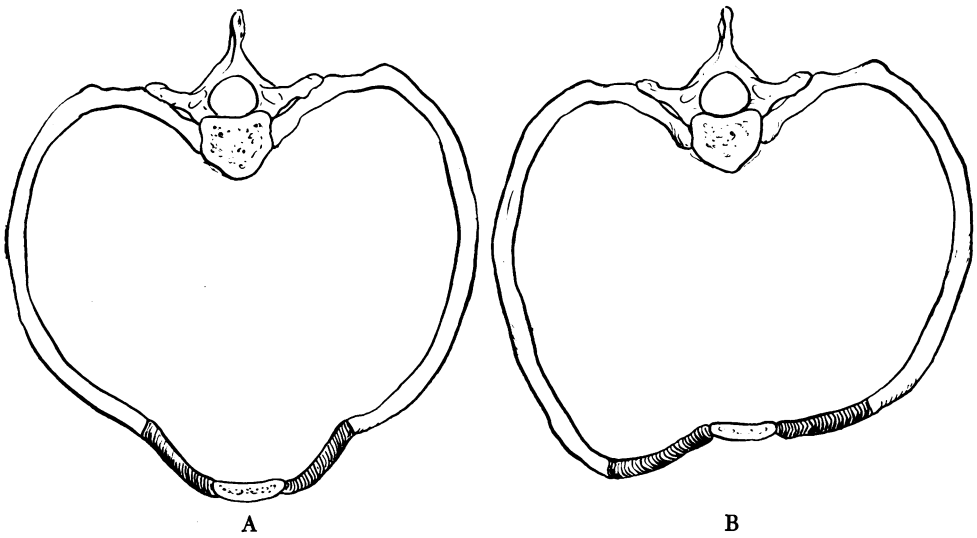

FIG. 4.—Schematic representation of protrusion deformties of the chest: A. Sternal protrusion (pigeon breast). B. Protrusion lateral to sternum.

The surgical procedure is not the same for the midline deformities as it is for the lateral deformities. Both are based on the principles of thoracoplasty, namely that when ribs are resected the chest wall falls in and the ribs regenerate in the new position. The same applies to the sternum.

In operating upon midline deformities, at first we performed a subperiosteal resection of the protruding portion of the sternum, using chisel, hammer and rongeur. This was a relatively sanguinary affair because of the bleeding from the cancellous portion of the sternum. Furthermore, when dressings had

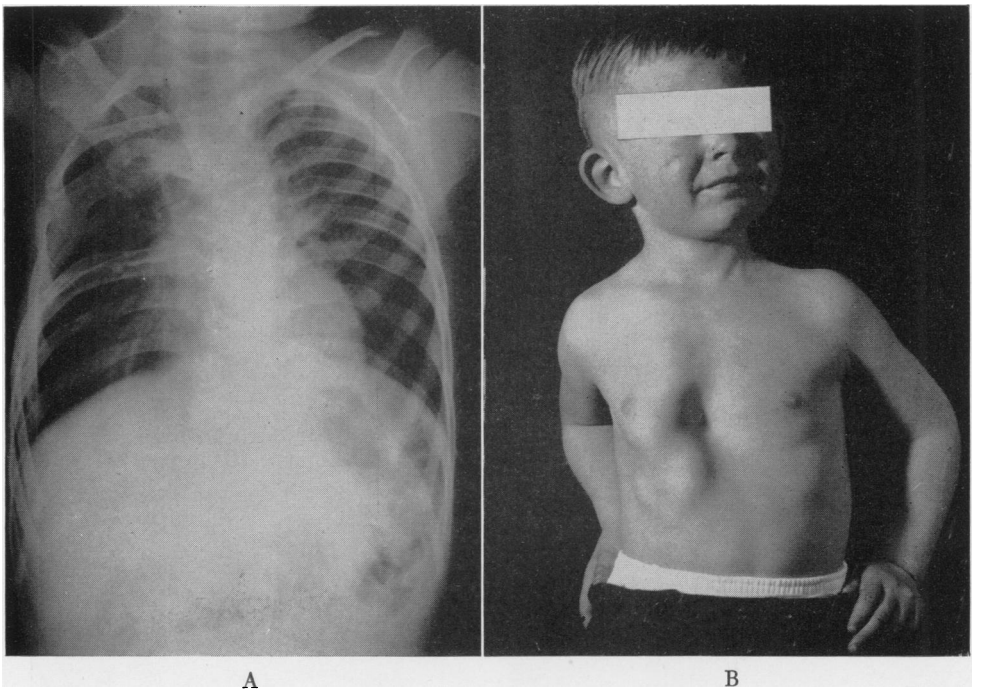

FIG. 5.—A. Roentgenogram of the chest of a child with short and defective upper ribs on the right. The ribs below are normal. B. Photograph of the same child showing protrusion deformity of the normal ribs.

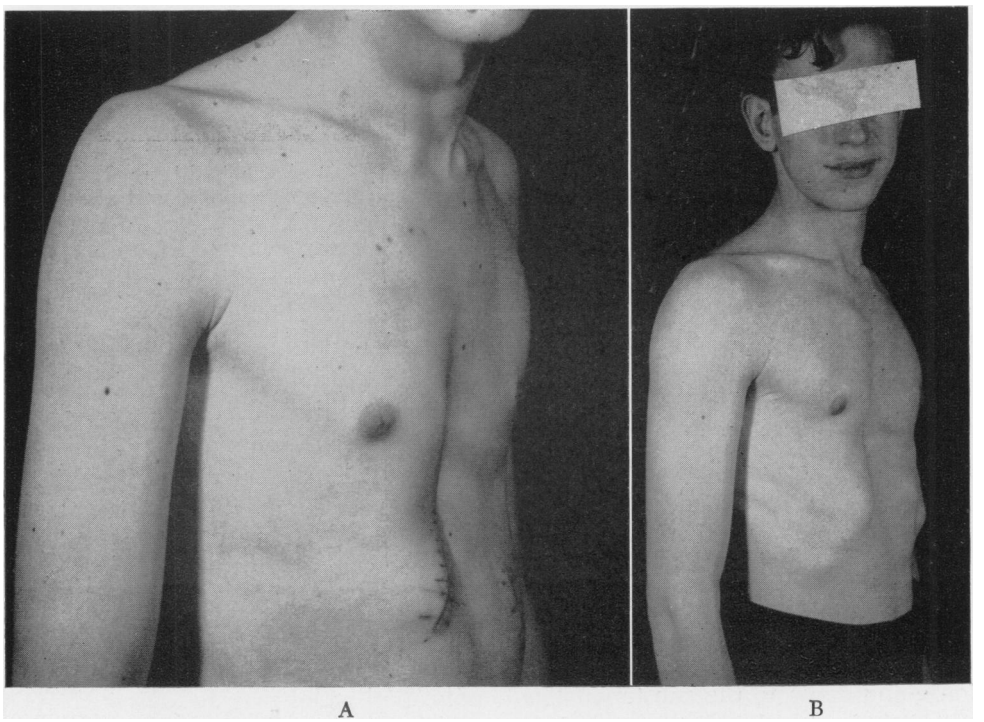

FIG. 6.—Lateral deformity of the chest: A. After first stage operation, showing little correction of the deformity. B. One year after second stage operation, showing deformity corrected.

been removed it was apparent that more sternum should have been resected as well as some costal cartilage. To meet these objections, the plan of operation was radically revised.

A longitudinal incision is made over the midline of the sternum and the skin and subcutaneous tissues reflected. Both pectoralis major muscles are detached from their sternal insertions and also reflected. Subperichondrial resection of about 2 cm. of the sternal end of every cartilage attaching to the sternum below the second is then performed. The sternal periosteum is incised longitudinally and the periosteum stripped laterally from the outer surface of the lower four segments of the sternum. The xiphoid is then carefully detached by a transverse incision going down to the substernal ligament, and this, with the periosteum of the under surface of the sternum, is stripped off, leaving the denuded sternum free. The denuded sternum is removed by transecting it in the second segment. The pectoralis major muscles are sutured together snugly across the midline and the wound closed. A pressure dressing may be applied to maintain the depression. The patient is allowed up on the first or second postoperative day and is usually sent home on the fifth. Stiffening takes place in about ten days, and the sternum regenerates in a normal position. With care it is possible to keep out of the pleural cavities and the mediastinum, and bleeding with this procedure is minimal.

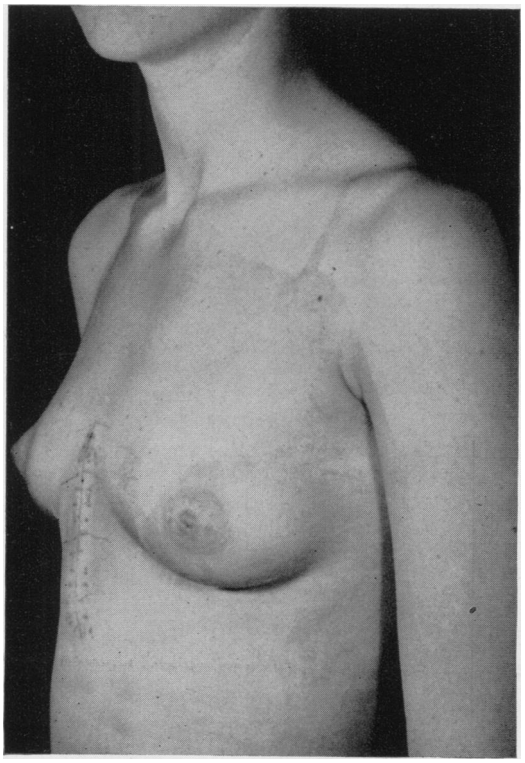

FIG. 7.—The patient shown in Figure 1, after operation.

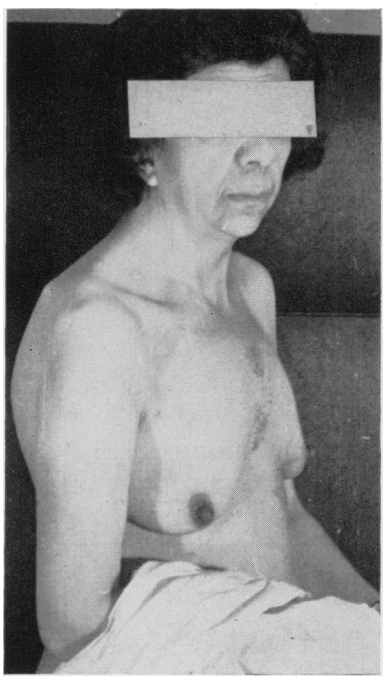

FIG. 8.—Patient shown in Figure 2. Patient can now climb three flights of stairs without dyspnea.

In treating the lateral protrusions a different type of operation is employed—one which is similar to a thoracoplasty. In the lesser deformities it is necessary to resect only the involved rib and cartilage through an incision over the deformity. If there is a bilateral involvement of the costal arch only, both sides may be operated upon at the same time, using similar incisions for the sake of uniformity.

When the deformity is extensive, the complete removal of the deformed ribs at one operation would risk dangerous paradoxical respiration. For that reason the operation is done in two stages (Fig. 6). The first stage is done through an incision placed parallel to the protruding ridge and between it and the sternum. Subperichondrial resection of all the involved cartilages is then performed. Access to the cartilages is obtained by splitting the fibers of the pectoral muscles so as to disturb the muscle attachments to the sternum as little as possible. The effect of this stage is to leave the deformity practically unchanged.

The second stage is done a week or ten days later, through a longitudinal incision in the axilla. The involved ribs are resected subperiosteally from the costochondral junctions to the anterior axillary line or farther if the deformity requires it. The pectoral muscles can be retracted for exposure and no muscle fibers need be cut. This stage corrects the deformity. The objection to the two-stage operation is that there are two scars, one of which, the anterior, may be noticeable.

In discussing results in the 16 cases operated upon, it must be emphasized that operation was undertaken only at the solicitation of the patient, the parents, or both. With that in view, it can be said that the results have been satisfactory. A second operation for the removal of more rib or sternum was done in two instances, but this will probably not happen in the future because of the judgment gained by experience and the use of more radical procedures. When dyspnea and chronic cough have been present, they have been corrected and when poor physique was present this was improved. The psychological improvement has been marked.

Complications have been few and minor. There has been no subglottic edema because the patients were old enough to have tracheas which could tolerate the endotracheal anesthetic tube. There were no fatalities.

SUMMARY

Protrusion deformities of the chest of congenital or developmental origin fall into two main groups: the midline protrusions or pigeon breast (*pectus carinatum*) deformities, and those in which the protrusion is unilateral and parallel to the sternum. In the former group the sternum may be most prominent at its lower end, or it may protrude in an arcuate manner somewhat resembling funnel chest. In the latter group the protrusion follows the line of the costochondral junctions.

An explanation of the etiology of protrusion deformities is offered which predicates an unequal growth of the ribs and the variation in the size and shape of the diaphragm.

The symptoms may be vague and concern poor physical development and easy fatigability; but definite dyspnea and chronic cough have been noted. Psychological disturbances due to the deformity are usually prominent.

Surgical procedures are described which can be used to correct these deformities.

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