Preoperative and Postoperative Abnormalities in Chest X-ray Indices and in Lung Function in Pectus Deformities*

Luc Derveaux, M.D.; Ignace Clarysse, B.Sc.; Ignace Ivanoff, M.D.; and Maurits Demedts, M.D., F.C.C.P.

In 88 patients with pectus deformities radiologic chest indices and routine pulmonary function tests were measured before and 1 to 20 years after corrective surgery. A combination of anteroposterior indices at the upper and lower level of the chest were investigated to quantitate and to discriminate the different pectus deformities. The study comprised four groups: pectus excavatum, pectus carinatum, pectus deformatum and pectus excavatum with scoliosis. These indices were also assessed in 250 healthy males and females. Generally, several indices showed significant and discriminative changes in the different patient groups and improved again after surgery. Preoperative lung function was decreased in pectus excavatum only. In all groups lung function worsened after surgery. A stepwise discriminant analysis performed on the large group with pectus excavatum indicated that postoperative lung function was decreased if the preoperative value of FEV₁ or VC was more than about 75 percent predicted and vice versa, but that it was not related to other factors such as radiologic indices, age at operation or time since operation.

(Chest 1989; 95:850-56)

LVI = lower vertebral index = BC/AC; UVI = upper vertebral index = EF/DF; CI = configuration index = DE/AB; BC = vertebral body diameter at xiphisternal level; EF = vertebral body diameter at sterno-manubrial level; AC = perpendicular distance from xiphisternal junction on backside of vertebral body; DF = perpendicular distance from sternomanubrial junction on back side; DE = perpendicular distance from sternomanubrial junction on front side; AB = perpendicular distance from xiphisternal junction on front side

C orrective surgery in pectus deformities is mostly performed for cosmetic reasons but also for alleviation of possible cardiopulmonary dysfunctions and for prevention of progressing postural deformities. Generally, surgical reports mention a subjective improvement postoperatively, although late recurrences may occur. In several studies, increased exercise performances also have been demonstrated, especially in upright posture, attributable to cardiac and hemodynamic favorable effects of the operation. In other studies, no significant differences in work capacity were found. Furthermore, lung function improvements have been shown in some studies while these remained grossly unchanged or even worsened in others. These discrepancies and controversies are at least in part attributable to the frequent lack of accurate evaluations of the severity of the deformation (e.g., by radiologic indices) and of the cardiopulmonary deficit, and even more by the lack of estimations of relationships between these functional variables and the degree of chest deformity.

The purpose of the present study was twofold: on the one hand, it was to assess accurately the preoperative and postoperative changes in chest configuration in different pectus deformities, using several radiologic indices. On the other hand, it was to evaluate preoperative and postoperative lung function as were related to the radiologically evidenced abnormalities.

Patients and Methods

Patients

Eighty-eight patients who underwent corrective surgery for different types of pectus deformities and for whom radiologic and lung function evaluations were available, are included in this study. Of them, 54 were operated on for pectus excavatum (funnel chest) at the age of 16 ± 3 (SD) years, 13 for pectus carinatum at the age of 16 ± 3 years, 13 for pectus deformatum (i.e., axially rotated sternum with S-shape in frontal or sagittal plane) at the age of 16 ± 4 years, and eight for funnel chest with scoliosis at the age of 12 ± 4 years. Of the patients, 65 percent were male and 35 percent female; they were followed up for a mean of eight years (range, 1 to 20 years).

Surgical Technique

In all patients surgical correction was performed using a variant of the Baroński technique. This consists of four phases: (1) subperichondrial resection of costal cartilages 2 to 8; (2) transection of the xiphisternal junction, and disconnection of the sternum from its mediastinal and diaphragmatic attachments, but not from its intercostal and perichondral attachments; (3) transverse cuneiform sternotomy just cranially of the sternal deformation (i.e., often just below the angle of Louis); (4) elevation and fixation of the sternum in slight hypercorrection at the osteotomy site with mattress sutures of nonabsorbable material through the tabula externa and the dioploë. For supplementary support the thick periost is reserved and is shortened. Initially the sternum was, in addition, externally supported by a nylon thread passed through the xiphisternal junction and fixed to the manubrium. Yet, this fixation was omitted in later operations, since it appeared to induce a depression at the zone of the sternal osteotomy in some patients.
Radiologic Indices

In all 88 patients, preoperative lateral chest x-ray films were available and in 60 of them postoperative films were available.

Three indices were calculated (Fig 1). First, the LVI, obtained as the ratio of BC/AC on a line from the xiphisternal junction perpendicular on the vertebral body. Second, the UVI obtained as the ratio of EF/DF on a line from the sternumanubrial junction perpendicular on a vertebral body. Third, the CI was obtained, i.e., the ratio of DE/AB.

The normal values of these indices were determined in a group of 115 males and 135 females aged 1 to 40 years. For each index, the mean values ± 1 SD and 90 percent confidence limits were calculated (Fig 2 to 4). The LVI increased curvilinearly up to the age of 10 years, and remained constant beyond this age (Fig 2). It could be described by the function: 0.193 \( (1 - 0.326 \times e^{-0.038 \times \text{age}}) \) with a 90 percent confidence limit of ± 0.038. The classic vertebral index generally corresponds with this LVI and the reported values also are very similar. The UVI was independent of age (Fig 3). Its value was 0.192, with a 90 percent confidence limit of 0.038. The CI increased linearly until the age of 11 years: 0.7004 + 0.0091 \( \times \text{age} \), with a 90 percent confidence limit of 0.105. It decreased linearly from the age of 12 years: 0.8223 - 0.0014 \( \times \text{age} \), with a 90 percent confidence limit of 0.134 (Fig 4). There was no relationship between the different indices except between the LVI and CI at the age of 1 year \((r = 0.49)\) and of 2 years \((r = 0.72)\). The LVI was most significantly related to age, yet the CI provided some additional information. No sex differences were found in any of the indices.

In order to compare preoperative and postoperative values of the indices in the patients, age-dependent changes in predicted values were taken into account. For each individual index the difference between the measured and predicted values at that age, divided by the normal variability at that age, were calculated, i.e. (measured - predicted/SD). From this, for each type of pectus deformity the mean \((± 1 \text{ SD})\) differences between measured and predicted indices were calculated preoperatively as well as postoperatively. Finally the preoperative and postoperative differences were subtracted from each other in order to evaluate the effect of surgery.

Lung Function

Vital capacity and FEV\(_i\) were measured in all 88 patients preoperatively and in 59 of them postoperatively. Values were expressed in percent predicted values of Zapletal et al\(^*\) for children and of the European Community of Coal and Steel for adults.\(^*\)

Statistical Calculations

Means \(± 1 \text{ SD}\) were calculated. Paired and unpaired t tests, and analyses of variance were applied. A discriminant analysis was performed on the preoperative radiologic indices with the purpose to establish whether a differentiation could be made between the different groups based on these indices.

A stepwise regression analysis was performed on VC and FEV\(_i\) to calculate the effect of different factors (ie, age, VC, FEV\(_i\),

---

**CHART**

**Figure 1.** Schematic representation of indices obtained on lateral chest x-ray films. The LVI at the xiphisternal junction = BC/AC, the upper vertebral index at the sternumanubrial junction = EF/DF, the CI = DE/AB.

**Figure 2.** LVI (i.e., BC/AC of Fig 1) in 250 healthy subjects: mean values \(± 1 \text{ SD}\) are calculated for each one-year group between the ages of 1 and 10 years, for each 3-year group between the ages of 11 and 30 years, and for the 10-year age group between the ages of 31 and 40 years. Also shown are the mean values of the regression line: 0.193 \((1 - 0.326 \times e^{-0.038 \times \text{age}})\) and the 90 percent confidence limits: ± 0.038.
Radiologic Indices

Preoperative Values: Table 1 presents the mean (± 1 SD) preoperative values in radiological indices in the different types of pectus deformities, in comparison with the control subjects. An increased value of the UVI or LVI means a narrowing of the chest at that level, and an increased value of the CI implies that the narrowing is more pronounced at the lower end of the chest, and vice versa. Since these indices are age-dependent, the age-corrected differences between the preoperative values and predicted values were calculated and are shown in Table 2. All values of Table 2 are divided by the standard deviation (of the healthy subjects of that age), thus accounting for the dispersion or scatter of the data. A result of 0 ± 1 means that

Table 1—Mean Preoperative Radiologic Indices*

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Age (yr)</th>
<th>LVI (BC/AC)</th>
<th>Upper Vertebral Index (EF/DF)</th>
<th>CI (DE/AB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>250</td>
<td>14.14 ± 10.66</td>
<td>0.183 ± 0.026</td>
<td>0.192 ± 0.023</td>
<td>0.769 ± 0.077</td>
</tr>
<tr>
<td>Pectus excavatum</td>
<td>54</td>
<td>16.13 ± 6.41</td>
<td>0.292 ± 0.067†</td>
<td>0.235 ± 0.045†</td>
<td>1.175 ± 0.214†</td>
</tr>
<tr>
<td>Pectus carinatum</td>
<td>13</td>
<td>16.23 ± 2.71</td>
<td>0.168 ± 0.016†</td>
<td></td>
<td>0.189 ± 0.025†</td>
</tr>
<tr>
<td>Pectus deformatum</td>
<td>13</td>
<td>16.23 ± 4.28</td>
<td>0.211 ± 0.045†</td>
<td></td>
<td>0.197 ± 0.032</td>
</tr>
<tr>
<td>Pectus excavatum + scoliosis</td>
<td>8</td>
<td>11.63 ± 4.44</td>
<td>0.372 ± 0.110†</td>
<td></td>
<td>0.276 ± 0.044†</td>
</tr>
</tbody>
</table>

*Analysis of variance shows a significant difference between the patient groups for each of the indices (p<0.001).
†By t test, p<0.001 with control subjects.
‡By t test, p<0.001 with control subjects.
§By t test, p<0.001 with pectus excavatum.
**By t test, p<0.001 with pectus carinatum.
††By t test, p<0.001 with pectus deformatum.
‡‡By t test, p<0.001 with pectus deformatum.
§§By t test, p<0.001 with pectus deformatum.

Chest X-ray Indices and Lung Function in Pectus Deformities (Derveaux et al)
there is no difference, a positive value means that the index is increased, i.e., for the UVI or LVI that the anteroposterior chest diameter is decreased at that level, and for the CI that the ratio of upper to lower chest diameter is greater than predicted or has postoperatively become greater than preoperatively.

In pectus excavatum, and even more so if this is associated with scoliosis, both vertebral indices but especially the lower one are increased, and in agreement with this the CI also is increased. This means that especially the lower anteroposterior chest diameter is decreased, but to a lesser degree also the upper diameter. A discriminant analysis showed that the LVI and CI suffice to discriminate between the healthy and the pectus excavatum patients and that the UVI is superfluous in this respect. The discriminant analysis for the large group of pectus excavatum is 

\[ -0.822 \times \Delta \text{LVI} + 1.645 \times \Delta \text{CI} + 5.912; \] 

\[ \Delta \text{LVI}, \] 

\[ \Delta \text{CI} \] 

are (preoperative value - predicted value)/SD (all at same age) for LVI, respectively, CI. A positive value implies a normal configuration, a negative value pectus excavatum. By this analysis all 250 healthy subjects are considered to be within normal limits, and 47 of the 54 subjects with pectus excavatum are recognized as such.

In pectus carinatum, the LVI and CI are slightly but significantly decreased. This means that the lower anteroposterior chest diameter is increased. In the heterogenous group with pectus deformatum, the indices do not show significant changes except for a slight increase in CI (i.e., in the same direction as in pectus excavatum).

Postoperative Changes: Table 3 shows the age-corrected differences between preoperative and postoperative values. In pectus excavatum the LVI is postoperatively increased (i.e., improved) by about 20 percent (-1.25/4.72) and the abnormalities in CI are almost halved (-2.86/6.67) i.e., the lower anteroposterior chest diameter is significantly increased, without change in the upper chest diameter. The improvements are even clearly more pronounced in the small group of pectus excavatum associated with scoliosis.

In pectus carinatum, surgery causes a significant improvement in all indices, even the UVI, and there is a tendency for overcorrection, i.e., the postoperative positive values of the indices are greater than the preoperative negative values. As a consequence the final result is a slight narrowing of the anteroposterior diameter especially at the lower level, in comparison with predicted values.

In the heterogenous group of pectus deformatum, surgery does not result in significant changes of the indices.

Lung Function

Preoperative Values: Table 4 shows that the mean preoperative routine lung functions are within normal ranges except in pectus excavatum with scoliosis in

| Table 2—Age-Corrected Changes (Δ) in Preoperative Radiologic Indices* |
|---------------------------|---------------------------|---------------------------|
|                           | Δ LVI (BC/AC)             | Δ UVI (EF/DF)             | Δ CI (DE/AB)             |
| Control                   | 0±1                       | 0±1                       | 0±1                       |
| Pectus excavatum          | 4.75±2.89†                | 1.85±1.94†                | 4.67±3.23†               |
| Pectus carinatum          | -1.17±0.69‡               | -0.12±1.09‡               | -1.38±0.83†               |
| Pectus deformatum         | 0.34±1.17§                | 0.01±1.27§                | 1.47±1.29†§               |
| Pectus excavatum + scoliosis | 8.47±5.24‡‡               | 3.66±1.93††               | 9.47±8.16††               |

*Δ = (value - predicted value at same age) / SD of predicted at that age. Δ LVI and Δ UVI are significantly correlated with each other in all groups; Δ LVI and Δ CI are correlated with each other in the pectus excavatum group and the pectus excavatum + scoliosis group; Δ UVI and CI also are correlated to each other in the pectus excavatum and pectus excavatum + scoliosis group. Analysis of variance shows for each of the indices a significant difference between the patient groups.

†By t test, p<0.001 with control subjects; ‡By t test, p<0.001 with pectus excavatum; §By t test, p<0.001 with pectus carinatum; ¶By t test, p<0.01 with control subjects; ¶¶By t test, p<0.001 with pectus deformatum.

| Table 3—Age-Corrected Differences in Preoperative vs Postoperative Radiologic Indices (Δ')* |
|---------------------------|---------------------------|---------------------------|
|                           | Time Interval (Preoperation-Postoperation) | Δ' LVI (BC/AC) | Δ' Upper Vertebral Index (EF/DF) | Δ' CI (DE/AB) |
| No.                       | yr                        |                |                                |                |
| Pectus excavatum          | 35                        | 9±4            | -1.25±3.00†                   | 0.41±1.88      | -2.86±3.13†       |
| Pectus carinatum          | 5                         | 7±3            | 2.22±0.76§                   | 0.92±1.00†     | 2.23±0.90§        |
| Pectus deformatum         | 10                        | 8±4            | 0.68±1.21                    | 0.61±1.95      | -0.27±1.55        |
| Pectus excavatum + scoliosis | 7                         | 9±4            | -3.35±4.96                   | 0.87±4.10      | -7.83±7.01†       |

*Δ' = ([preoperative value - predicted at same age] / SD of predicted at that age) - ([postoperative value - predicted at same age] / SD of predicted at that age).

†By t test, p<0.05 for difference preoperation - postoperation; ‡By t test, p<0.001 for difference preoperation - postoperation.
Table 4—Preoperative Lung Function in Different Types of Chest Deformations

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>VC, L (% Predicted)</th>
<th>FEV₁, L (% Predicted)</th>
<th>F, % (% Predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectus excavatum</td>
<td>54</td>
<td>3.51 ± 1.06</td>
<td>2.95 ± 0.92</td>
<td>86 ± 9*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(90 ± 10)*</td>
<td>(93 ± 13)*</td>
<td>(103 ± 9)*</td>
</tr>
<tr>
<td>Pectus carinatum</td>
<td>13</td>
<td>4.42 ± 1.31</td>
<td>3.81 ± 0.99</td>
<td>84 ± 10*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(104 ± 12)</td>
<td>(104 ± 14)</td>
<td>(101 ± 10)</td>
</tr>
<tr>
<td>Pectus deformatum</td>
<td>13</td>
<td>3.93 ± 1.14</td>
<td>3.44 ± 1.05</td>
<td>88 ± 9*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(99 ± 21)</td>
<td>(104 ± 23)</td>
<td>(106 ± 10)†</td>
</tr>
<tr>
<td>Pectus excavatum + scoliosis</td>
<td>8</td>
<td>2.08 ± 0.70</td>
<td>1.87 ± 0.59</td>
<td>59 ± 13‡</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(67 ± 11)*</td>
<td>(72 ± 16)*</td>
<td>(106 ± 15)†</td>
</tr>
</tbody>
</table>

*By t test, p<0.001 for difference with predicted values; †By t test, p<0.05 for difference with predicted values; ‡By t test, p<0.01 for difference with predicted values.

which these are moderately reduced. In pectus excavatum the mean values are within normal limits (ie, more than 80 percent predicted), yet these are for the group significantly lower than predicted (p<0.001).

Postoperative Changes: Table 5 depicts the postoperative changes in lung function. A significant worsening of FEV₁ and VC is found in all groups, when expressed in percent predicted. This does not imply that there is a decrease in absolute values (in L), but that the possible increase during adolescence is less than predicted.

Relationship between the Different Parameters

A stepwise regression analysis was performed in the largest group (ie, this with pectus excavatum) in order to assess whether the postoperative changes in lung function were related to the preoperative values, the radiologic indices, age at operation, and time since operation. A significant relationship was found only between the postoperative change in lung function and the preoperative lung function values: ie, Δ VC (postoperative-preoperative), percent predicted = 78.2 - 1.038 VC preoperative (percent predicted); Δ FEV₁ (postoperative-preoperative) percent predicted = 61.7 - 0.805 FEV₁ preoperative (percent predicted). This means that postoperatively lung function change was inversely related to the preoperative value and that it was improved if it was less than about 75 percent predicted preoperatively, but that it became worse if it was more than 75 percent predicted preoperatively.

Discussion

It has recently been stated that the apparent discrepancies between studies related to surgical corrections for pectus deformities are at least partially due to a lack of quantitative assessments of the severity of the deformation of the sternum.11 These authors, furthermore, argued that it is necessary to make comparisons between the objective (eg, radiologic) evaluations of these deformities and the cardiopulmonary dysfunction.

In the present study, a comparative investigation was carried out of the radiologic and lung functional repercussions of different chest deformities in 88 patients, and in 58 of them the effects of corrective surgery were calculated.

The radiologic indices were obtained from measurements at two levels of the chest instead of using only the classic vertebral index which is defined as the smallest chest diameter.12 This classic vertebral index grossly corresponds with our LVI and this is reflected in the very similar normal values (Fig 2), as evidenced in the study by Backer et al.13 However, this index provides information of one level of the chest only and not of other levels which possibly also may be abnormal, ie, no quantitative estimation is given of the chest configuration. We clearly showed by means of a discriminant analysis that the CI provides additional

Table 5—Postoperative Changes in Lung Function*

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Δ VC</th>
<th>Δ FEV₁</th>
<th>Δ FEV₁/VC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Pre-operative</td>
<td>Post-operative</td>
<td>% Predicted</td>
</tr>
<tr>
<td>Pectus excavatum</td>
<td>32</td>
<td>17 ± 8</td>
<td>27 ± 9</td>
</tr>
<tr>
<td>Pectus carinatum</td>
<td>7</td>
<td>15 ± 2</td>
<td>21 ± 3</td>
</tr>
<tr>
<td>Pectus deformatum</td>
<td>13</td>
<td>17 ± 3</td>
<td>25 ± 4</td>
</tr>
<tr>
<td>Pectus excavatum + scoliosis</td>
<td>7</td>
<td>11 ± 4</td>
<td>20 ± 6</td>
</tr>
</tbody>
</table>

*Δ = postoperative − preoperative value, ie, + means increase, − decrease.
†By t test, p<0.01 for difference between preoperative vs postoperative values.
‡By t test, p<0.05 for difference between preoperative vs postoperative values.
§By t test, p<0.001 for difference between preoperative vs postoperative values.
information to that of the LVI. Furthermore, since these indices were dependent on age in healthy subjects we did not directly compare preoperative and postoperative values but first related both to age-matched predicted values. The necessity of this step is demonstrated in the following example: in a child with pectus excavatum the LVI is increased, and if this increases further up to the age of 10 years, then this latter increase may merely reflect the physiologic age-related changes in this index, and does, therefore, not necessarily imply worsening of the abnormality.

In our series, especially the CI in addition to the LVI were able to demonstrate statistically significant differences between healthy subjects and pectus deformities, and also mutually between the different deformities. Both indices also reflected the changes after corrective surgery. In our patients, the LVI appeared to be adequate in identifying pectus excavatum (in which it was increased, especially when there was associated scoliosis) and pectus carinatum (in which it was decreased). In addition, the upper vertebral index showed that the upper part of the thorax also is somewhat narrowed in pectus excavatum. The CI indicated that the ratio of upper vs lower diameter became larger in pectus excavatum (especially when associated with scoliosis) and to a lesser extent also in pectus deformatum, while it became smaller in pectus carinatum. The CI was especially valuable in complex chest deformities (often with axial sternal rotations) and in pectus excavatum with scoliosis where it was more often significantly changed than the other indices.

In all types of deformities, corrective surgery appeared to have a favorable effect on the radiographic indices; yet, it resulted in an undercorrection in pectus excavatum (the values in Table 3 had an opposite sign than those in Table 2, but were smaller), and an overcorrection in pectus carinatum.

The lung function was preoperatively not or only discretely lower than the predicted values in the patients with pectus deformities without scoliosis. The much more reduced function in those with associated scoliosis may very probably be attributed to the latter abnormality. Indeed scoliosis often is responsible for important restrictive defects. The moderate mean restrictive pattern (VC: 83 percent predicted) found by Vétillard et al in 47 patients with funnel chest was also, at least in part, attributable to the inclusion of seven cases with an associated severe scoliosis.

Postoperatively, lung function was improved in absolute values but not in percent predicted, indicating that the increase in lung volumes during adolescence was less than in healthy subjects. This moderate reduction in lung function (in percent predicted) was demonstrated in all pectus groups despite the improvement in radiologic indices. Similarly Gyllenswärd et al found lower pulmonary function values in operated than in pectus patients who did not have operations and there also was no correlation with the severity of the pectus deformity assessed by the sternovertebral distance. They furthermore suggested that the cause of the functional impairment probably is the extensive surgery in the sternal region. By means of a more extensive functional evaluation, we demonstrated in 24 patients operated on for funnel chest that this restriction was, indeed, due to an extrapulmonary factor, ie, limitation of thorax expansion due to musculoarticular changes. The transpulmonary and transdiaphragmatic pressures at TLC were markedly reduced despite the decreased TLC and the rather low static lung compliance. This limitation of thorax expansion is not unexpected taking into consideration the fact that the operation includes resection of cartilage of several ribs, sternophrenolysis and incision of parasternal muscles which are important inspiratory muscles especially near the TLC. Thus, decreased chest wall compliance as well as diminished inspiratory muscle efficiency are complications to be expected with this corrective surgery for pectus deformities.

In the group with pectus excavatum, we compared the postoperative reduction in lung function with several factors, such as preoperative lung function, preoperative radiologic indices, age at operation, and time between operation and reevaluation, using a stepwise regression analysis. We found only a significant inverse relationship with preoperative lung function: the postoperative reduction in lung function was more pronounced in those who preoperatively presented the least functional defect. These data suggest also that patients, especially with preoperative lung function values of less than about 75 percent predicted may have a functional improvement after corrective surgery. The stepwise regression analysis did not show a significant relationship with other factors such as age at operation. In the literature, different opinions exist on the optimal age for operation. Usually surgery is advised at an age between 4 and 6 years which apparently is mainly based on psychological arguments. Technically, equally satisfactory results have been obtained between 3 and 5 years and between 13 and 20 years in patients. Others found that age at operation did not seem to be of any influence on the long-term results. Our stepwise regression analysis also did not show any significant influence of the time between operation and reevaluation. This lack of time influence may suggest that the changes are attributable to the operation itself and not to a recurrence of the deformity afterward (although the latter may occur), or to a progressive effect on an only partially corrected deformity during the growth years. However, since we did not have an unoperated control group, we cannot exclude the latter possibility. In the literature both
progression and regression of the pectus deformity with increasing age has been described: it improved often spontaneously up to the age of 6 years while it remained the same thereafter or worsened.

In conclusion, we propose several quantitative radiologic indices of anteroposterior chest diameter and configuration, and present their normal values in function of age, and their changes in pectus deformities. We also showed that after surgery the radiologic indices were improved but that the pulmonary function mostly was worse, especially if the latter was preoperatively more than 75 percent of predicted.

REFERENCES


