THE ASSESSMENT OF LUNG FUNCTION IN CHILDREN WITH SCOLIOSIS

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Abnormalities of lung function in 92 children with idiopathic or congenital scoliosis are described. The changes are restrictive in type with reduction in vital capacity and total lung capacity but normal residual volume.

In children whose curves had an early onset, the amount by which vital capacity was reduced depended on the severity of the deformity; in those whose curves began in adolescence this severity had little or no effect on vital capacity.

Most adolescents with idiopathic curves had normal or near normal lung volumes and measurement of vital capacity proved to be a reliable screening test. We therefore advocate a simple approach to the pre-operative pulmonary investigation of scoliotic patients; only a few require full spirometry.

In the United Kingdom over the past decade operative methods have become widely used for the treatment of scoliosis. Many articles describing the effects of scoliosis on lung function have been published (Gazioglu et al. 1968; Makley et al. 1968; Nisbet et al. 1973; Shnee, Sutton and Zorab 1978; Jones et al. 1981) but there is little practical advice as to which patients require pre-operative investigation and how this should be done. Relton (1975) states that, "more precise information may be obtained from pulmonary function studies", and Waugh and Riseborough (1977) write, "it is customary to investigate thoroughly the pulmonary status of all patients with thoracic scoliosis." Thus, there is a tendency for those with ready access to a lung-function laboratory to study every patient and for those with no facilities to ignore the subject entirely.

In order to provide clearer guidelines we have reviewed our own experience and discuss the approach we now adopt for the pulmonary investigation of children with scoliosis.

MATERIAL AND METHODS

Between 1976 and 1983 478 patients were referred to the scoliosis clinics at the Royal Hospital for Sick Children and the Western Infirmary, Glasgow. Of these children, 92 who had a major thoracic curve and had been investigated by spirometry are the subject of this study.

Fifty-one children had adolescent idiopathic scoliosis, 16 had infantile idiopathic scoliosis and in 25 the deformity was congenital (Table I). In each child the spinal curves in both coronal and sagittal planes were measured by Cobb's method (1948) from radiographs taken in the standing position at the time of spirometry. The presence of cardiac or respiratory disease was noted.

Table I. Details of the 92 patients with a major thoracic curve

<table>
<thead>
<tr>
<th>Type of curve</th>
<th>Number of patients</th>
<th>Boys</th>
<th>Girls</th>
<th>Mean age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent idiopathic</td>
<td>51</td>
<td>10</td>
<td>41</td>
<td>14.3</td>
</tr>
<tr>
<td>Infantile idiopathic</td>
<td>16</td>
<td>10</td>
<td>6</td>
<td>11.9</td>
</tr>
<tr>
<td>Congenital</td>
<td>25</td>
<td>5</td>
<td>20</td>
<td>12.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>92</td>
<td>25</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

The vital capacity, the forced expiratory volume in one second, the residual volume and the total lung capacity were each expressed as a percentage of the value expected in a healthy child of the same sex and similar height (Cotes 1979). The arm span of each child was measured and the value used to predict the undeformed height using Johnson and Westgate's method (1970).

The results were analysed to determine:
1. The pattern and severity of the ventilation defect in each type of scoliosis.
2. The value of the vital capacity as a screening test.
3. The relationship between the vital capacity and the severity of the deformity.
4. The effect of diminished thoracic kyphosis.

RESULTS

Lung volumes. Abnormalities were restrictive in type. The vital capacity, the total lung capacity and the forced expiratory volume in one second were all reduced, but
Table II. Mean lung volumes in the 92 patients expressed as a percentage of the values expected for normal children of the same sex and similar height

<table>
<thead>
<tr>
<th>Type of curve</th>
<th>Mean curve (degrees)</th>
<th>Vital capacity</th>
<th>Forced expiratory volume in one second</th>
<th>Total lung capacity</th>
<th>Residual volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent idiopathic</td>
<td>52 (20-93)</td>
<td>82</td>
<td>82</td>
<td>87</td>
<td>103</td>
</tr>
<tr>
<td>Infantile idiopathic</td>
<td>74 (41-130)</td>
<td>65</td>
<td>62</td>
<td>62</td>
<td>106</td>
</tr>
<tr>
<td>Congenital</td>
<td>71 (43-130)</td>
<td>67</td>
<td>70</td>
<td>77</td>
<td>107</td>
</tr>
</tbody>
</table>

Figures in brackets give the range of curvatures for each group

Table III. The severity of the ventilation defect in the three groups of children

<table>
<thead>
<tr>
<th>Type of curve</th>
<th>Number of patients</th>
<th>Normal</th>
<th>Defect</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent idiopathic</td>
<td>51</td>
<td>31</td>
<td>16</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Infantile idiopathic</td>
<td>16</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>25</td>
<td>5</td>
<td>12</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

the residual volume was normal (Table II). These changes were greater in children with infantile idiopathic or congenital scoliosis than in those with the adolescent variety (Table III). Using Johnson and Westgate’s criteria (1970), 14 of the 41 children with early onset curves had a moderate or a severe ventilation defect (40% to 59% of the predicted value was considered moderate and less than 40% severe). Of the 51 children with adolescent scoliosis only four were moderately or severely affected.

Vital capacity. We found a positive correlation between the percentage values for vital capacity and those for both the forced expiratory volume in one second and the total lung capacity (Figs 1 and 2). The percentage forced expiratory volume in one second was reduced below the 95% prediction limit in only two children and only one child had a disproportionately reduced total lung capacity.

Severity of deformity. Reduction in vital capacity was related to the degree of scoliosis in those with infantile idiopathic or congenital curves (Figs 3 and 4). In those with adolescent scoliosis these factors were not related (Fig. 5). There was no statistical difference in the linear regressions for the percentage vital capacity against the degree of scoliosis when the congenital and infantile idiopathic curves were compared.

Diminished kyphosis. Sagittal radiographs of the spine were available for 36 children with adolescent idiopathic scoliosis. Fifteen patients whose thoracic kyphosis was less than 20 were considered hypokyphotic (Roaf 1960) and although, in many cases, their lung volumes appeared to be smaller than those with normal sagittal curves (Table IV) the difference was not significant (0.5 > P > 0.1).
DISCUSSION

Like other workers we found a restrictive type of ventilation defect in patients with scoliosis (Zorab 1973). A linear relationship between the Cobb angle and the reduction in lung volumes also has been reported previously by Johnson and Westgate (1970) and by Shannon et al. (1970). Of prognostic value is the observation that this relationship depends on the age of onset of the scoliosis. In adolescents the effect, if any, is slight and the majority of our patients had normal lung volumes. Only 8% had a moderate or severe ventilation defect. On the other hand, in the children with infantile idiopathic or congenital curves increasing deformity was associated with a steady decrease in vital capacity so that 34% had a moderate or severe ventilation defect.

Reid (1969) showed that during normal lung development the number of alveoli increases up to the age of eight years. She also noted that the lungs of scoliotic patients were hypoplastic. Our findings support the view that the primary factor in reducing ventilation is diminished lung growth rather than the severity or the type of deformity. As reported by Winter, Lovell and Moe (1975) we found individual patients with diminished thoracic kyphosis in whom the vital capacity was surprisingly low, but there was no clear relationship between sagittal curves and lung volumes.
Thus, in planning our investigations we are guided by two principles: first, most children with adolescent idiopathic scoliosis have normal or near normal lung volumes, and severity of deformity is of little help in identifying those few who do have a ventilatory defect; secondly, measurement of vital capacity is a reliable indication of the severity of any such defect present.

In adolescents we measure vital capacity in all patients with a thoracic curve of 40° or more—the figure at which we advise surgery. It is convenient to take the measurement during the initial assessment at the scoliosis clinic. Patients with lumbar curves do not need lung-function examination. The Vitalograph or a similar lung-function analyser is ideal for measuring vital capacity as it is cheap, portable and easy to use. Details of how to use it have been given by Cotes (1979). Provided the value is at least 60% that of comparable healthy children we do not investigate further. We accept that children with curves of less than 40° may have slightly reduced lung volumes and that others with mild restrictive defects may have other evidence of cardiorespiratory dysfunction, such as an abnormal response to exercise (Shneerson 1980). However, this does not affect anaesthesia and only longitudinal studies will show whether these near-normal adolescents will have deteriorating lung function in later life.

In children whose vital capacity is less than 60% we advise full spirometry. Those shown to have moderate lung volumes are unlikely to require postoperative assistance with ventilation. The few who have a severe defect may need help, and preparations should be made accordingly; in practice, however, provided these children are not dyspnoeic and have normal respiratory muscles, help is seldom required.

Early onset curves may progress rapidly and children with these require surgical correction at an early age. Vital capacity should be measured routinely before operation and, as in the adolescent patients, full spirometry is advised in those with moderate or severe defects. However, in the very young vital capacity and peak flow rate may be all that can be measured.

We conclude that the approach described is a simple and reliable method of investigating lung function in children with scoliosis. Vital capacity is easily measured and, used as a screening test, identifies those children who require further investigation before spinal surgery. In our experience no child whose vital capacity was greater than 40% of the value in comparable healthy children and whose respiratory muscles were normal has required postoperative respiratory support. Those with smaller lung volumes may need aid and appropriate preparations should be made before operation.

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REFERENCES


