Pulmonary function in adolescents with idiopathic scoliosis

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Summary. Two groups of patients, with an average age of 15 years, have been studied to establish the improvement in pulmonary function after surgical correction in relation to the amount of correction achieved. The first group of 33 patients were treated surgically; an average Cobb angle of 72° was reduced to 32.6°. The second group of 30 patients with an average Cobb angle of 33° were not operated on. Results of tests undertaken have shown that pulmonary function was improved by surgical correction, but the improvement does not match the degree of correction achieved. Statistical analysis of the two groups shows a difference in cardiopulmonary function to the advantage of those who were not operated on. This suggests that there is partial irreversibility of ventilation and perfusion in those who are treated surgically.

Résumé. Le but de ce travail est d'évaluer l'amélioration de la fonction respiratoire après correction chirurgicale des courbures scoliotiques. L'étude a porté sur deux groupes distincts de patients, âgés de 15 ans en moyenne. Le premier groupe comportait 33 sujets opérés d'une scoliose de 72° (Cobb), réduite après l'intervention à 32.6°. Le deuxième groupe comprenait 30 sujets du même âge avec une scoliose non opérée de 33°. Les paramètres fonctionnels cardio-respiratoires, statiques et dynamiques, ont été mesurés — avant et 24 mois après l'opération — par spirométrie et pléthysmographie, par analyse des gaz du sang et par le test de tolérance à l'effort. Les résultats ont montré que la correction de la scoliose améliorait la fonction respiratoire, mais que cette amélioration n'était pas proportionnelle à l'importance de la correction obtenue. L'analyse multivariée et l'analyse discriminatoire des patients opérés et non opérés, avec le même degré de courbure rachidienne, a montré une différence des fonctions cardio-pulmonaires en faveur des sujets non opérés. Ces résultats suggèrent une irréversibilité partielle de la ventilation et de la vascularisation chez les patients qui ont été traités chirurgicalement.

Introduction

The natural course of the disease in scoliotic patients show that severe deformity affects cardiopulmonary function significantly [2, 3, 9, 10, 23, 25, 28]. Several reports have demonstrated a correlation between the degree of thoracic curvature and impairment of resting lung mechanics in severe scoliosis [12, 15, 20, 27, 34, 35, 36]. The rate of increase of pulmonary arterial pressure during and after exercise was more closely related to lung volume in terms of measured vital capacity (VA), functional residual capacity (FRC) or total lung capacity (TLC) [29, 30]. The measurement of maximum voluntary ventilation, which is affected by lung volume and respiratory muscle strength, is a useful test to identify impaired ventilatory capacity that may be present in some patients with mild symptomless scoliosis which may progress [17, 19, 24, 31]. In addition to the best possible correction and stabilisation of the spine, improvement in cardiopulmonary function should be a primary aim of surgical treatment [1, 11, 16, 18, 21, 28, 35, 37, 38].
The purpose of this study was to establish whether surgical correction produces improvement of lung function in relation to the degree of correction obtained. The lung function of patients after operation was compared with those treated conservatively, both groups having matching curves.

Patients and methods

The study was of two groups of patients:

1. The first group of 33 patients had undergone operation for an average scoliotic angle (Cobb) of 72° (from 55° to 129°) and a thoracic sagittal angle of 29.9° (~8° to 70°). The postoperative figures were 52.6° (13° to 74°) and 30.6° (15° to 48°) respectively. A surgical correction of 54% was obtained by using the posterior Harrington and Harrington-Luque techniques. After the Harrington technique, a plaster cast was worn for 4 months and a plastic brace for another 4 months; the brace was discarded gradually and physiotherapy continued for up to one year after operation. After the Harrington-Luque technique, a plaster cast was worn for 3 to 4 months and physiotherapy continued for another 4 months.

2. The second group of 30 patients had an average Cobb angle of 33.1° (20° to 39°) and a thoracic sagittal angle of 34.5° (22° to 55°). They were treated by physiotherapy and sports activities (Table 1).

According to the site and apex of the thoracic curve as determined from radiographs of the spine, the first group were divided into two subgroups comprising those with the apex between T5 and T8 and those between T9 and T11 (Table 2). The apex in the second group was between T5-T9.

Lung function was tested on a Godart exipuegraph by forced expiration at rest, standing and with the nose closed. Vital capacity, VC(L), and forced expiratory volume per second, FEV1(L), were measured under BTPS conditions (body temperature and pressure, saturated with water vapour) and expressed in percent: calculated. Maximum flow at 50% and 25% vital capacity, MEF50 and MEF25, expressed in litres per second, was compared with Cherniack's standards [6]. A reduction greater than 30% with respect to the reference value was considered pathological and due to enhanced airflow resistance or greater airway collapsibility.

Static lung volumes (functional residual capacity, FRC, and total lung capacity, TLC) were measured by a volume constant body plethysmograph (body-test – E. Jaeger) [13] in standard conditions corrected for BTPS, with the patient sitting in a closed booth. Total airway resistance (R0) (normal values 0.13 to 0.17 KPa/L/s) was measured and the values compared with Polgar's reference values [26]. A reduction greater than 20% with respect to the reference value was considered to be pathological.

Blood gas analysis (i.e. the determination of partial arterial oxygen pressure (PaO2) and partial arterial carbon dioxide pressure (PaCO2)) was done on an arterial blood sample obtained by puncture of the radial artery. These samples were analysed on the Micro-Autocal pH Blood Analyser 613, Instrumentation Laboratory. The PaO2 values were calculated in percentages of the reference PaO2 values determined by Sorbinil's method [33].

Repeated PaO2 measurements of below 60 mmHg or 0.8 KPa were considered as indications of respiratory failure. The Viograt treadmill was used for the exercise tolerance test (ETT) according to Bruce [4], with continuous increments in 3 min intervals. The test comprised 7 stages: at each increment the speed was changed by 2.7 to 9.6 km/h, and the slope of the treadmill by 10° to 22°. Oxygen consumption in ml/kg/min was calculated as follows [4]:

\[
\text{Men: } 3.88 - 0.056 \times \text{test duration/s.}
\]

\[
\text{Women: } 1.06 - 0.056 \times \text{test/duration/s.}
\]

Bruce standards [4] were also used to evaluate the result in percent:

\[
\text{Men: } 57.8 - 0.455 \times \text{age(years)}.
\]

\[
\text{Women: } 42.3 - 0.356 \times \text{age(years)}.
\]

Maximum oxygen uptake expressed in millilitres per kilogram of body weight per minute was the accepted measurement unit used as an index of cardiovascular function [4]. The arm span/height ratio calculated according to Johnson and Westgate [14] was 1.03±1 (SD±0.02). The difference and the significance of differences between test and control groups at the 5% level were evaluated by test correlation, test differentiation, analysis of variance and multivariate discriminatory analysis [7].

All the respiratory tests were done on patients before, and 12 and 24 months after operation. The same respiratory tests were also done in the conservative group before physiotherapy.

Results

The incidence of change in the scoliotic angle before and after surgical correction, and the incidence of vital capacity changes (% of predictable values) before and after surgical correction, and in the group with mild scoliosis treated conservatively are shown in Figs. 1 and 2. Before operation, 13 patients had a VC of more than 80% which was considered normal, in 16 the VC was 60% to 79%, and in 4 below 60%. In spite of the good correlation between increasing deformity and loss of pulmonary function, blood gas estimates were rarely abnormal. A general increase of vital capacity after operation was confirmed in 25 patients; it was unchanged in 4 and decreased in 4. Correction of the sagittal spinal curve was obtain-