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Respiratory mechanics in idiopathic scoliosis

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Patients with severe scoliosis (Cobb's angle >90°) run an increased risk of developing respiratory failure and of premature death due to cardiorespiratory distress. The relationship between spinal deformity and respiratory failure has been established, however, no definitive conclusion has been reached about progressive lung involvement. For this reason, a number of mechanisms have been proposed, and the main controversies surround the roles played by the impairment of lung mechanics, thoracic cage deformity, spine curvature and diaphragmatic dysfunction.

The study of respiratory function plays an important role in the clinical evaluation of patients with idiopathic scoliosis, and it has been traditionally based on classical pulmonary functional tests and arterial hemogas-analysis. But these procedures do not give any information concerning the topographical distribution of abnormalities. Several studies in the literature have demonstrated the correlation between angulation, and the rotation of the scoliotic curve with the reduction in lung volumes.

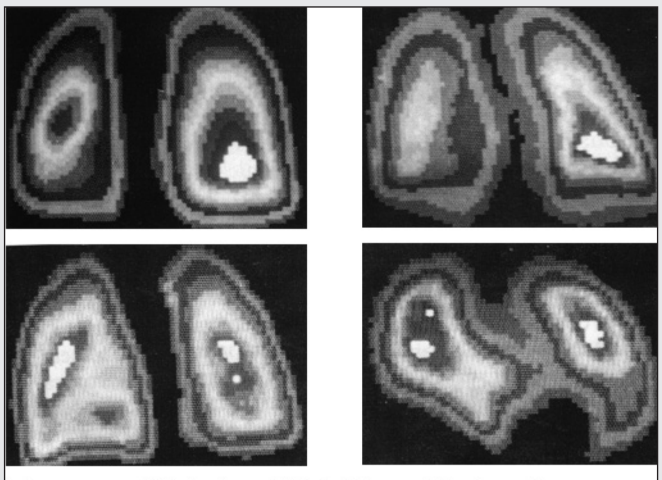
The lung volumes study in patients with idiopathic scoliosis has been effected with pulmonary functionality tests such as the spirometria. Although this test is very useful to determine global respiratory functionality, it does not allow a distinction between the functional characteristics of one lung in comparison to another, and it does not provide information concerning selective respiratory functionality. The spirometria shows meaningful alterations of the pulmonary volumes in scoliotic teenagers only for severe deformities because of lung growth, which continues until complete skeletal maturity. The progress of nuclear medicine tests gave the opportunity to study and to realize what really happens in the lungs of these patients. Scintigraphy, usually used for studying pulmonary function in other clinical situations like pulmonary embolism, chronic obstructive pulmonary diseases and interstitial lung disease, has been only recently introduced to study the respiratory system in patients with scoliosis. The use of radioaerosol lung scintigraphy allows us to acquire more sensitive information on pulmonary ventilation in scoliosis, and it also allows us to study diaphragmatic movement (DM). The scintigraphic pattern of each lung can be classified and scored as follows: homogeneous distribution (score=1), focal hypoventilation (score=2), diffuse mild hypoventilation (score=3), diffuse severe hypoventilation (score=4) (Fig. 1). Diaphragmatic movement can be evaluated through recording two digital scintigraphic scans obtained during maximal inspiration and expiration. After normalization and subtraction, the resulting image represents the respiratory movement of the lung edges, mainly the diaphragmatic movement (DM-index). Comparison between the lungs shows that the lung on the concave side of the scoliotic curve, has significantly greater ventilation distribution impairment and a significantly reduced DM-index of the corresponding hemidiaphragm compared with the other lung, located on the convex side of the curve. There is a significant inverse correlation between the severity of scoliosis and the right and the left DM-index, respectively. The functional impairment detected by lung scintigraphy is mainly localized in the lung on the concave side of the scoliotic curve and seems to derive from the reduction in ventilation volume and in diaphragmatic movement, as demonstrated by a significantly lower DM-index.

Some studies have reported the role played by the inefficiency and/or the decreased strength of the respiratory muscles in the functional derangement of scoliotic patients. Therefore, we can hypothesize that the reduced diaphragmatic movement is directly related to the severity of the scoliosis. As a consequence, this reduction in movement could be responsible for reduced functional efficiency and abnormal lung ventilation distribution (15) The scoliotic curve can produce a distortion and a rotation of the pulmonary parenchyma, resulting in a significant reduction in the bronchial lumen. Therefore, the functional derangement due to scoliosis can be characterized not only by a restrictive but also by an obstructive pattern (14). It is possible that both the regional impairment of pulmonary ventilation and the reduced diaphragmatic movement could be due to the thoracic cage deformity rather than to the spinal curvature. It is well known that in idiopathic scoliosis, curvature in the frontal plane is always co-existent with the rotation of the spine and concurrent changes in the dorsal kyphosis (16). A major derangement of the thoracic cage geometry is thus produced with the consequent involvement of the respiratory muscle mechanics.

The diagnosis of respiratory dysfunction cannot attend the onset of clinical symptoms, since it is known that the corrective orthopedic provisions for scoliosis are effective if applied in time.

The orthopedic and chinesitherapeutic treatment must begin as early as possible, and be aimed at preventing skeletal dysmorphism progression, aimed at remodeling and recovery, as far as possible, of the elasticity of the thoracic cage, at maintaining good pulmonary compliance, and at the struggle against the asinergisms of the functional muscular chains necessary for the respiratory kinetics and at improving their coordination; is one of the elements of the treatment which is inseparable from the orthopedic treatment. Moreover, the therapeutic exercise must be done in a brace because the corrective pelotes press on the convex side against the "gibbo" and facilitate the thoracic expansion of the concave side, improving the respiratory dynamics. In a brace, with the action of external forces, it is possible to effect all the respiratory re-education techniques that aim to obtain a more homogeneous intrapulmonary ventilation distribution, as shown by scintigrafic studies on the distribution of marked albumin microspheres inhaled by aerosols.

In addition, it is important to learn the regional respiratory strategies that favor the ventilation and the expansion of a determined pulmonary district. To obtain the expansion of a part of the lung there are many postures, which make good use of the inequality mechanism of ventilation promoting the areas that mainly want to expand. The different positions of the body can influence respiratory dynamics that will be different depending on how much the thoracic cage changes its own



A: homogeneous distribution (score=1). B: focal hypoventilation (score=2).
C: diffuse mild hypoventilation (score=3). D: diffuse severe hypoventilation (score=4).

Figure 1 - Scintigraphic patterns.

geometric configuration, which also modifies the length of the respiratory muscles. These exercises also give an important improvement of the propriocectivity. All exercises must be included in a global motor activity protocol capable of maintaining as active and functional the spine's musculature in complete synergism with the abdominal and thoracic cage muscles.

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Evaluation of X-rays and DEXA data integration

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Introduction

The necessity to understand how the different hip prosthesis technical solution can influence the final result of THA make very relevant to analyse the patients follow-up trying to quantify the outcome. In a previous work a software procedure (Gray Inspection Software Procedure – GISP) has been presented which allows to obtain mean gray value of periprotesic Gruen zone (Quagliarella et al 2003). From conventional X-rays it is not possible, up to now, to obtain absolute values of bone-mineral content, however it should be possible correlate gray value with BMD in order to obtain a valuation of bone mineral density (BMD) changes in each patient.

Materials and method

Mean gray level of Gruen zone has been evaluated on the same area which is relevant for DEXA examination, taking into account the gray value of soft tissue; this value has been compared with corresponding BMD obtained from DEXA examination done at the same time of X-ray and a correlation factor has been determined ofr each Gruen zone. In such a way the 75% (training set) of 48 X-rays and Dexa belonging to 28 patients have been analized and the seven mean values of correlation factors related to each Gruen zone have been used to valuate the BMD from the remaining 25% of X-rays (test set). Then the differences among those estimated BMD values and the real BMD from DEXA have been calculated in order to know the errors related to this approach.

Results

Adopting the described procedure a mean error of 26% between BMD data and X-rays exstimation was obtained, with a maximum standard deviation of 25%, as shown in Figure 1. In order to increase the accuracy two exclusion criteria for X-rays were adopted: the first was related to brightness L which have to be L > 30 and L < 220; the second was the brightness distribution D_L, ideally it should assume all the values inside the range 220-30. Then different training set and test set were obtained including all the X-rays which have L > 30 and L < 220 plus D_L = all; D_L > 70; D_L >110; D_L > 140; D_L >160. The result are showed in Figure 2 for each Gruen zone and in fig. 3 as mean value.

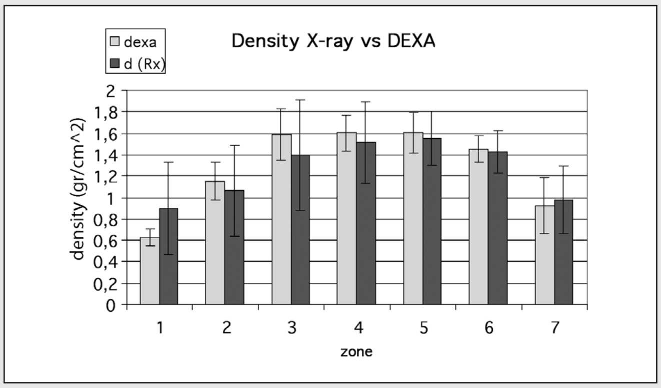

Figure 1

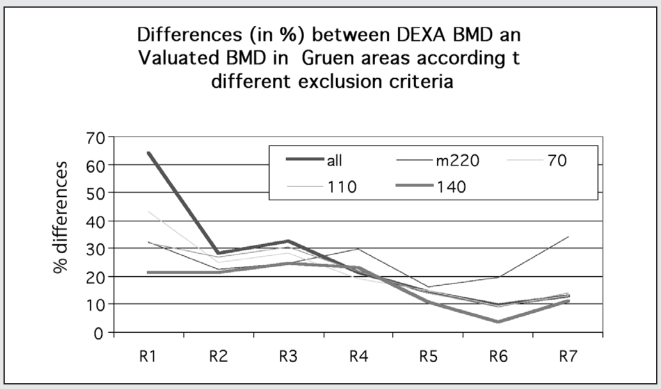

Figure 2