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Study of the rib cage deformity in children with 10°-20° of Cobb angle Late Onset Idiopathic Scoliosis, using Rib-Vertebra Angles Aetiologic implications

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Abstract. The aim of the study is to compare the rib-vertebra angles (RVAs) between children with 10° - 20° of Cobb angle late onset idiopathic scoliosis (LOIS) and non-scoliotic children.

Materials and Method: The RVAs of 47 children, with mean age 12.4 years, who presented LOIS with a Cobb angle 10° - 20°, were studied. The children were classified into three groups according to the site of the scoliotic curve: 17 children had thoracic (T), 14 children had thoracolumbar (TL) and 16 children had lumbar (L) curves. The RVAs of the scoliotic children were compared to the RVAs of 60 non-scoliotic children of a similar age group, who were studied in the past.

Results: The comparison of the right and left RVAs within each group showed that the children who had: T curves differ at the level T4, T5, T6, T7 and T8, TL curves differ at the level T3, and L curves differ at the level T7 and T12.

The comparison of the ipsilateral RVA's between the scoliotic groups showed that between: T and TL curves there are no differences at any thoracic level, between T and L curves the RVAs differ at the T7 level on the right side, whereas there are no differences between the RVAs on the left side, between TL and L curves the RVAs differ at the level T5, T6, and T7 on the right and at the level T5 on the left side.

Comparing the RVAs between the scoliotic and nonscoliotic children, it was apparent that the scoliotic children rib cage had lower RVAs ($p<0.01$) at almost all thoracic levels.

Discussion: It has been reported that RVAs is an expression of the resultant muscle forces, which act on each rib. It was also suggested that RVA asymmetries by weakening the spinal rotation-defending system are aetiological for idiopathic scoliosis, (Burwell et al 1992). This study shows that scoliotic children with small curves have underdeveloped thoracic cage compared to nonscoliotic counterparts. The differences are more apparent in the scoliotic children with thoracic curves. It is suggested that the differences of the RVAs between right and left side in this group are an expression of asymmetric muscle forces acting on the thoracic cage. It is concluded that asymmetric muscle forces participate in the pathogenesis of idiopathic scoliosis on the thoracic cage, which deforms early.

1. Introduction

The Difference of the Rib – Vertebra Angle (RVAD) of the apical vertebra was first used by Mehta in 1972 [1] in an attempt to predict whether an infantile scoliotic curve would *resolve* or *progress*. Tolo and Gilespie (1978) [2] found that serial measurements of the RVAD are useful in the evaluation of brace treatment of juvenile IS. They even formulated guidelines about modification of brace treatment based on monitoring of the RVAD. Some years later (1985), Kristmundsdottir et al found that the RVA on the convexity of the infantile scoliotic curve correlates significantly with the spinal curve angle, which was not the fact for the respective RVA on the concavity of the curve [3]. Later Wojcic et al (1990) used segmental RVAs in order to study the thoracic cage of scoliotic children postoperatively [4]. Grivas et al (1992) showed that scoliotic children have a narrow upper chest (T1-T4) compared to nonscoliotic children and that the pattern of the scoliotic chest resembles to the funnel shaped thorax of the embryo [5]. Other authors have studied the segmental RVAs in preoperative scoliotic children (Withers et al 1990, Thirvall et al 1991). Measurements of the RVA difference in humans but also in experimentally induced scoliosis in animals have been performed by Xiong et al [6].

The purpose of this report is to emphasize the significance of the segmental RVAs as a useful research tool in the study of idiopathic scoliosis.

2. Materials and Method

The segmental RVAs of 47 children, with mean age 12.4 years, who presented late onset idiopathic scoliosis with a Cobb angle 10° - 20°, were studied. The children were classified into three groups according to the location of the scoliotic curve: 17 children had thoracic (T), 14 children had thoracolumbar (TL) and 16 children had lumbar (L) curves. The RVAs of the scoliotic children were compared to the RVAs of 60 non-scoliotic children of a similar age group, who were studied in the past.

In an attempt to restrict any possible confounding factor only children with at least one right-sided thoracic curve (primary or compensatory) were included in the study.

The segmental RVAs were measured using the following technique (figure 1): a line perpendicular to the middle of the upper end plate of the vertebral body is drawn. Two points are determined on the respective rib: one at the middle of the head of the rib and the second at the middle of the distance between the head of the rib and the point were the rib reaches the lateral chest outline (midhead to midshaft). The angle between these two lines is the segmental RVA. This method allows measurement of the RVAs at the upper ribs, in which the neck is not always visible on the radiographs, or is too short, so the classic Mehta method would not give accurate and repeatable results.

3. Results

The segmental RVAs of scoliotic and nonscoliotic children were plotted on the same diagram (figure 2) and the t value of their difference at each thoracic level was calculated.

The comparison of the right and left RVAs *within* each group showed that the children who had:

1. T curves differ at the level T4, T5, T6, T7 and T8
2. TL curves differ at the level T3
3. L curves differ at the level T7 and T12.

It is concluded that the within group asymmetry is more prominent at primary thoracic curves.

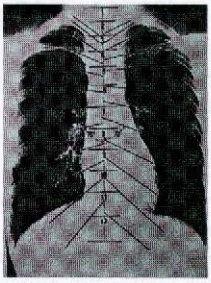

Figure 1: the segmental RVAs

The compare of the ipsilateral RVA's *between* the scoliotic groups showed that between:

1. T and TL curves there are no differences at any thoracic level
2. T and L curves the RVAs differ at the T7 level on the right side, whereas There are no differences between the RVAs on the left side
3. TL and L curves the RVAs differ at the level T5, T6, and T7 on the right and at the level T5 on the left side.

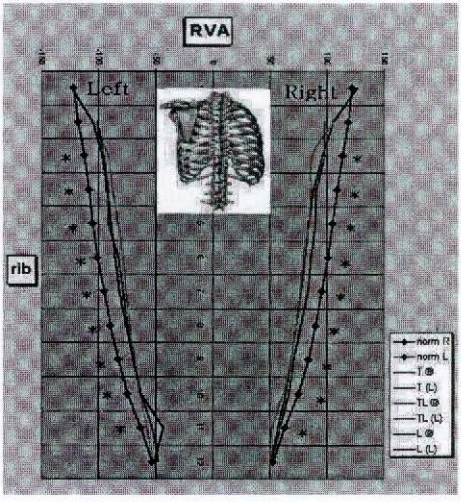

Figure 2: the RVA in nonscoliotic (blue line) and scoliotic (green = thoracic curves, green = thoracolumbar curves, red = lumbar curves). "*" means that the respective segmental RVAD between nonscoliotic and scoliotic RVA is statistically significant ($p<0.01$)

More interesting is the asymmetry between nonscoliotic and scoliotic children. It is apparent that the rib cage of scoliotic children had lower RVAs ($p<0.01$) at almost all thoracic levels, which means that the scoliotic rib cage is *smaller* than the nonscoliotic rib cage.

4. Discussion

It is widely accepted that only severe scoliotic curves impair lung function. Pulmonary function tests are seldom abnormal in thoracic deformities with a Cobb angle <60°. Cardiopulmonary symptoms and subjective complaints occur more frequently in patients with thoracic deformities > 90-100° [7]. In such cases, preservation or improvement of lung function is one main goal of surgery. Upadhyay [8] found that the RVAD of scoliotics (mean Cobb angle 59°) correlates well with the percent of predicted value of Vital Capacity, Forced VC, and Forced Residual Capacity. He also used the change in RVA from standing to supine position as an index of the rib cage rigidity. McAlindon et al showed that RVA measurement is highly reproducible and valid [9].

The prominent within group segmental RVA asymmetry in primary thoracic curves compared to thoracolmbar and lumbar curves is attributed to two factors: first, the greater Cobb angle of the primary curve and second, the involvement of more thoracic levels (higher apical vertebra) when the scoliotic curve is entirely located in the thoracic spine. The asymmetry between scoliotic groups was not prominent at many thoracic levels, because the sample of children studied includes only children with one right thoracic (R primary thoracic, R thoracolumbar, R compensatory thoracic) curve. Therefore, it could be said that rib cages with an underlying right thoracic curve have practically the same pattern of RVA asymmetry. The between noscoliotic and scoliotics group RVA asymmetry is significant at almost all thoracic levels, indicating that there is drooping of the ribs in scoliotic children.

The RVAs are a functional index which is visible on the chest X-rays. It is concluded that that measurement of the RVAs, whether as apical RVAD or as segmental RVAs gives *early* information about the process of curve initiation and progression. Significantly asymmetric RVAs have been observed even at Cobb angles of 8°, i.e. before the diagnosis of scoliosis is made [6].

The question is, how does AIS start: as a functional deterioration of the Neuromuscular System or as a structural abnormality of the vertebral bodies and intervertebral discs? Xiong et al 1994 found significant wedging of the vertebral bodies and disks at the coronal plane even at small nonscoliotic curves with a Cobb angle of 4 degrees. Sevastik claims that the pathogenesis of AIS is possibly related to early vertebral changes rather than to asymmetric muscle forces on the rib cage [10].

The thoracic cage is the location of several muscle groups' origins and insertions, which are involved in the function of breathing but also participate in maintaining the posture of the trunk during movement and rest. The RVAs are an expression of the resultant muscle forces, which act on each rib. It has been proposed that RVA asymmetries are aetiological for idiopathic scoliosis because they result in weakening the spinal rotation-defending system [11].

This study shows that scoliotic children with 10° -20° curves have underdeveloped thoracic cage compared to nonscoliotic counterparts. Children with yet small curves but without lateral spinal profile differences compared to non-scoliotics, as is shown in one of our studies presented in this meeting, have their rib cage apparently already affected. It is suggested that the differences of the RVAs between right and left side in this group are an expression of asymmetric muscle forces acting on the thoracic cage. These differences are more prominent in the thoracic curve group than in the other scoliotic groups.

The authors believe that an extraspinal factor, for instance asymmetric muscle forces, precede and then the curve formation initiates and possibly progresses. It is noteworthy to mention the disclosure of asymptomatic underlying syringomyelia in cases with idiopathic thoracic scoliosis [12]. Asymptomatic neurologic abnormality may exert asymmetric forces on the spine. These forces are transmitted mainly through the ribs. After the curve becomes structural, other factors may contribute to further deterioration of the deformity.

References

1. Mehta MH: the rib –vertebra angle in the diagnosis between resolving and progressing infantile scoliosis. JBJS, 54B, 230-243
2. Tolo VT, Gilespie R: the characteristics of juvenile idiopathic scoliosis and results of its treatment. JBJS 60B:181,1978
3. Kristmundsdottir F, Burwell R G, James J I: The rib-vertebra angles on the convexity and concavity of the spinal curve in infantile idiopathic scoliosis. CORR(201):205-209 1985
4. Wojcic A S, Webb J K, Burwell R G: An analysis of the effect of the Zielke Operation on the rib cage of S-shaped curves in idiopathic scoliosis. Spine, 15(2):81-86 1990
5. Grivas TB, Burwell RG Purdue M, Webb JK, Moulton A: The rib cage deformity in idiopathic scoliosis – the funnel shaped upper chest I relation to specific rotation as a prognostic factor. An evaluation of chest shape in progressive scoliosis and control children during growth. Surface Topography and Spinal deformity VI, Alberty, Drerup, Hierholzer (ed). Gustav Fischer Verlag, Stuttgart, Jena, New York, 1992, pp.93-109
6. Xiong B, Sevastik J A, Hedlund R, Sevastik B : Radiographic changes at the coronal plane in early scoliosis Spine, 19(2):159-164, 1994
7. Lenke L,OKU 6, Chapter 53, 707-711, AAOS 1999
8. Upadhyay, S. S., Mullaji, A. B., Luk, K. D. K. and Leong J. C. Y.: Spine 1995(20); 22, 1995, pp. 2415-2420,Relation of Spinal and Thoracic Cage Deformities and Their Flexibilities With Altered Pulmonary Functions in Adolescent Idiopathic Scoliosis
9. McAlindon et al R J, Kruse R W :Measurement of rib vertebral angle difference. Intraobserver error and interobserver variation. Spine, 22(2):198-199 1997
10. Sevastik J: The thoracospinal concept of the etiopathogenesis of Idiopathic Scoliosis. Spine: State of the art reviews 14(2), May 2000, pp391-399
11. Burwell RG, Cole AA, Cook TA, Grivas TB, Kiel AW, Moulton A, et al 1992: screening, etiology and the Nottingham theory for idiopathic scoliosis. Surface Topography and Spinal deformity VI, Alberty, Drerup, Hierholzer (ed). Gustav Fischer Verlag, Stuttgart, Jena, New York, 1992, pp.93-109
12. Zadeh HG, Sakka SA, Powell MP,Mehta MH: Absent superficial abdominal reflexes in children with scoliosis. An early indicator of syringomyelia. JBJS, 77B:(5) 762-767, Sept 1995.