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Original Article

Spinal disorders in children and teenagers: clinical data, imagistics and therapeutic principles

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Abstract

Spinal pathology in children and teenagers may be evaluated by the presence of back pain and by the various surgical procedures for different spinal disorders. In our statistics about 40% of the patients presented with back pain and 24% of them, after thorough investigations, had vertebral column lesions. 16% had no obvious bony lesions. MRI with contrast and discography are highlightening intervertebral disk lesions of different degrees. Out of all patients with discal problems only 2% presented discal hernia.

Idiopathic scoliosis represent the most frequent spinal deformity and a very small number of patients accuse back pain, either due to arthritis lesions of the joint processes or to discal issues.

The second most frequent spinal issue is represented by Scheuemann's kyphosis. This disease is usually encountered in teenagers and it requires a surgical procedure, especially if the kyphosis is greater than 75 degrees and it is associated with pain when sitting and during school activities.

Congenital scoliosis has an incidence of 1/4.000 births in Romania. In Romania there are approximately 300 cases with congenital scoliosis, 80 cases being children and teenagers. The first surgical procedure with somatic instrumentation in Romania has been done in "Maria Sklodowska Curie" hospital by Prof. Dr. Gh. Burnei in 2000 with hemivertebra resection and somatic instrumentation with total correction of the axial deviation.

Nowadays in Romania there should be a serious effort to be done in order to detect early spinal disorders to avoid the onset of severe, rigid deformities which may only be treated by extended surgical procedures with high neurological risks and high costs. The data in this paper are meant to guide the medical persons in an early detection of spinal issues. The school

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screening program has to be adapted to our conditions in order that all scoliosis with 40 degrees and kyphosis with 50 degrees to be monitored by centers where spinal procedures are performed.

Keywords: *spinal deformities, scoliosis, Scheuermann kyphosis, lordosis, treatment principles*

Rezumat

Patologia rahisului la copil şi adolescent poate fi evaluată atât sub aspectul durerilor rahidiene, cât şi din punct de vedere al intervenţiilor operatorii efectuate pentru diverse afecţiuni. În cazuistica noastră 40% din pacienţi se prezintă cu dureri rahidiene şi în urma investigaţiilor efectuate, 24% dintre aceştia prezintă leziuni osteoarticulare ale coloanei vertebrale. La 16% nu se decelează leziuni osoase. IRM cu substanţă de contrast şi discografia pun în evidenţă leziuni ale discurilor intervertebrale de diverse grade. Din totalul pacienţilor cu discopatii doar 2 % au prezentat hernii de disc.

Scolioza idiopatică reprezintă cea mai frecventă diformitate a coloanei vertebrale şi un număr foarte redus de cazuri acuză durere rahidiană, fie datorită unor leziuni artrozice ale proceselor articulare, fie a discopatiilor.

Pe locul 2 ca frecvenţă se situează cifoza juvenilă Scheuermann. Această afecţiune este depistată de obicei la vârsta adolescentului mare şi impune o atitudine terapeutică chirurgicală, mai ales când cifoza care depăţeste 75 de grade se insoteste de durere in pozitia sezind, a activitatii scolare si de studiu.

Scoliozele congenitale au o incidenţă în România de 1 la 4.000 de naşteri. În România sunt diagnosticaţi actualmente circa 300 de pacienţi cu scolioză congenitală, dintre care 80 sunt copii şi adolescenţi. Prima intervenţie chirurgicală cu instrumentare somatică din România a fost efectuată la spitalul "Maria Sklodowska Curie" de Prof. Dr. Gh. Burnei în anul 2000 la un copil la care s-a practicat rezecţia hemivertebrei şi instrumentare somatică cu corecţia totală a deviaţiei axiale.

Actualmente în România trebuie depus un efort susţinut pentru depistarea precoce a afecţiunilor coloanei vertebrale pentru a evita evoluţia spre diformitîţi severe, rigide, care nu pot fi corectate decât prin intervenţii de mare amploare cu risc neurologic major şi costuri enorme. Datele consemnate în această lucrare au ca obiectiv orientarea cadrelor medicale angajate în depistarea precoce a acestor afecţiuni. Programul de screening şcolar trebuie adaptat sistemului nostru de organizare astfel încât toţi pacienţii cu scolioze cu unghi Cobb de 40 de grade şi cifoze juvenile ce depăşesc 50 de grade să fie luaţi în evidenţă de centrele unde se efectuează intervenţii chirurgicale.

Cuvinte-cheie: *diformităţi spinale, scoliză, cifoză Scheuermann, lordoză, principii de tratament*

1. THE SPINAL COLUMN

1.1. Anatomical data

Spinal column is the most important segment of the locomotor apparatus, of which are linked all the other segments that make up the torso (thorax and pelvis), respectively upper and lower limbs. Spinal column gives the body symmetry, direction of movement and protects our communication systems providing stability, due to the superposition of many bone pieces from the original cartilaginous tube.

Due to spinal curvatures, projection of the centers of gravity of various segments aren't found on the projection line of the general body center of gravity. Therefore, the action of gravity cause, from one vertebra to another, rotational stresses which tend to accentuate curves and which must be neutralized, because otherwise the column would collapse. Forces that oppose rotational stresses are ligaments. Projection center of the thoracic spinal segment passes anterior. It would collapse if there would not intervene the vertebral common posterior ligament, interspinous ligaments and ligamentum flavum. The situation is reversed at the lumbar and cervical spine: projection of the center of gravity goes posteriorly from the column, and the forces that oppose collapse are represented by the resistance of the vertebral common anterior ligament. Vertebral ligaments were therefore designed to alleviate a great deal of stresses.

Other items that are designed to absorb the forces of demand are intervertebral discs. They don't stay in tension, like ligaments, but under pressure. Between these two categories of anatomical elements, ligaments on one side and intervertebral discs on the other, subject to contrary forces, are established a certain state of balance, named intrinsic equilibrium. In orthostatism and during rest the spinal column has a vertical direction and a slightly sinuous form, especially in the sagittal plane. In physics it is known that an elastic column, with curves, offers a higher resistance to vertical pressures, than a perfectly straight column. Curves absorb vertical shocks and favors maintaining column balance on the pelvis, thus easing spinal muscle belt efforts.

This attitude and this form are maintained thanks to muscle tonicity, ligaments and discs elasticity and due to anatomical jointing of the 34 vertebrae composing the spinal column; vertebrae adapts to each other by different joint surfaces.

1.2. Biomechanics

Column movements, regardless of their magnitude, are complex movements, involving several segments of the spine. They are made by combining slight displacement of the vertebral bodies, which occur at the level of the intervertebral

discs, and at the other joints. These movements are limited by the resistance of ligaments, by the intervertebral joints shape and by the degree of compressibility of the fibro-cartilaginous tissue that makes up the disc.

Small intervertebral movements are only possible due to the presence of the nucleus pulposus. Vertebral movements run on nucleus pulposus as a shaft, nucleus pulposus playing the role of a real mechanical ball. This means such as a ball all movements are possible; though they will be limited and dependent on the various conformations and positions of the articular apophyses, by the spinal ligaments and by the spinal muscular „brace".

By the pressure of the liquid located between its components, nucleus pulposus has the ability to be flexible. Due to this property spinal movements are possible and excessive pressure effects or shocks suffered by the spinal column are removed. In a forced flexion attitude, occurs approximation of the vertebral bodies by their anterior side, by partially compressing anterior half disc and by slightly pushing nucleus pulposus posterior. In extension, things happen vice versa. Movements are made possible through the integral role intervertebral disc play, forming a unitary organ. The researches performed to date have shown that if the nucleus pulposus should be considered „the bearing" on who are running the movements of the spine, the fibrous ring remains the most important element of the intervertebral disc that resists compression and decompression forces.

As is known, spine shows complex movements resulting from cumulative micro-movements of all intervertebral joints: flexion-extension, lateral bending, rotation, and - as a result thereof – circumduction.

Ventral flexion of the trunk on the legs is achieved through participation not only by the spine, but also by the hips. Sacrum being fixed, the rest of the spine can fully execute a movement of flexion, but not all the segments equally participate. Largest amplitude in flexion is performed in the cervical and lumbar region. Anterior concave arch that is formed by column in its entirety is not an arc of circle, but a curved line, composed of three segments, namely: one with smaller radius, which is formed by the cervical spine, one with larger radius, which represents the thoracic spineand finally, one with a small radius of lumbar region.

In maximum flexion the transverse line that extends the axis plane intersects vertical line at an angle of 140-160 degrees. In moderate flexion, anterior portion of the intervertebral disc is compressed, while the posterior common vertebral ligament, ligamentum flavum, interspinous ligaments, supraspinous ligament and the back muscles are all under tension.

In orthostatic position, in extension, things happen exactly the opposite. In the lumbar region, extension reaches up to 30 degrees, in the thoracic one up to 55 degrees and in the cervical region up to 60 degrees. In extension movement, the posterior portions of the intervertebral discs are compressed, while the anterior

common vertebral ligament is under tension. The lateral tilt movement is approximately 16.6 degrees, with a maximum of amplitude in the thoracic segment. When there is some degree of twisting of the spine, the trunk is leaning further lateral. The rotation movement is maximum in the cervical region, where it reach 75 degrees. Thoracic spine rotates slightly and only if it tilts laterally. In the lumbar segment, and in predilect mannerthoraco-lumbar, rotation movement execute when the column is in extension. When the column is flexed, the rotation movement in the lumbar segment is impossible, because the vertebrae condyles are placed vertically in the joints and stop the movement, the same case applies inflexion when the lateral tilt of the lumbar segment can't be done. The flexion-extension movement is around a transverse axis passing through the upper part of the atlas glenoidal cavity (1).

Morphofunctional complexity of the column has as consequence varied pathology, with symptomatology as complex, with pathophysiological mechanisms neurosomatic, neurovegetative, vascular, osteoarticular, ligamentary, in the pathologic processes of traumatic, inflammatory, postural, tumoral order. To complete this unitary look must be considered visceral relationships and particular individual reaction. Also, it must be revealed the fact that some of the chronic spinal disorders is installed gradually over years and sometimes decades, with a long evolution, most often asymptomatic, suggesting the idea of a functional adaptation, a compensating form of balance, common to other organs. This explains why many of the bearers of important radiological alterations shows no sign of disease or why noisy clinical manifestations are accompanied by minimal or absent radiological alterations, so that the spine semiology and clinical examination shows the great importance. The rich somatic and autonomic innervation of the spine justifies largely, the echo on the nervous system in spinal disorders. Indeed, some of these patients may occur at clinical examination as mentally ill, secondary to a spinal disease, by disrupting the dynamics of the central nervous system after ascending excitation. These cortical components secondary or primitive and the visceral neuroreflexe manifestations, complicates clinical examination therefore is required a unitary vision, analytical, with careful investigation of all apparatus and systems.

1.3. Statics

There are five general types of postures recognized: normal back, round, flat, flat-concave and flat-round.

Normal back is the type of posture in which spinal curvatures in the anterior-posterior sense shows a normal arching, and the pelvis has a normal tilt. *Round back* is very common, thoracic convexity descends, including the lumbar vertebrae and the lumbar concavity shrinks in size and depth; the pelvis is slightly

tilted ventral and caudal. *Flat back* is more rare than the round back. Thoracic kyphosis and lumbar lordosis disappear, but still maintain pelvic tilt. Shoulder blades appear embossed posterior. *Flat concave back* (lordotic) is less common. Lumbar concavity is more emphasized, but simultaneously it accentuates thoracic convexity (2).

2. DIAGNOSIS

The inclination of vertebral column in the sagittal plane, the frontal plane or horizontally, and often in several planes at once, causes kyphosis, lordosis, or pathological scoliosis.

2.1. Symptomatology

The dominant symptom of spinal conditions is pain, a purely subjective element, whose detailed analysis may reveal some shades so particular that directs the examiner attention to a more pronounced distress of a certain morphological structure.

It is more important to conceptualize the back pain as a potential neurological symptom and such the analysis of the entire neurological system relevant. It may occur a number of neurological symptoms such as: veiled view, double vision, syncope, headache, hearing loss, motor non-coordination, fine or gross. Also can install arm pain, fatigue, sensitivity problems, followed by paresthesia and heaviness of hands. Paresthesias may be accused at the chest and at the back (3). Then it's analyzed the existing pain in joints, interdependence between pain and menstrual periods, and weather effects.

2.2. Clinical examination

At the physical examination of the patient are followed: cervical lordosis, thoracic kyphosis, lumbar lordosis. At skin inspection, it finds any changes that may occur in such cases: macular hirsutism, subcutaneous lesions, localized hyperpigmentation, multiple lipomas, brown spots, dermal sinuses. Are palpable bony prominences of the cervical, thoracic and lumbar-sacral regions and the adjacent soft tissues. The physician is interested in whether the patient has rib hump (gibus) and if scoliosis is clinically evident. Overall flexibility of the spine in the thoracic-lumbar segment is measured by placing the patient in flexion, in extension, laterally tilted and axial rotated left and right. With the patients eated reflexes are checked at the kneecap level. The flexibility of all joints is verified, also the secondary sexual characteristics are inspected (hair growth and development of the scrotum).

Also, in the case of back pain can be useful complete blood tests, and urinalysis, in the case in which the patient is suspected juvenile arthritis, investigations are corresponding to. Therewith can be frequently established a strong link between endocrine disorders and some local deformations of the spine.

„Scoliotic disease" begins with predilection between 10 and 12 years, through a fairly typical clinical picture. Child grows in height in a very short time, although it feeds inadequate (4). These children are pale and CBC highlights hypochromic anemia. Their musculature is less tonic and therefore they are easily fatigued. Sometimes these children experience night sweats and complain of pain between the shoulder blades, or vague, without being able to specify the place, but with some irradiation to the abdomen. Many of the patients had obvious endocrine disorders and the majority is observed with more or less obvious hypertrophy thyroid body. Basal metabolism is altered. Some patients, few in number, are apathetic, they are quickly fatigued and start a school activity with lower value, others, on the contrary, are more irritable, with moist skin, with occasionally insomnia. Girls are often seen with menstrual disorders in this time (5).

2.3. Radiological exploration

From the moment it was concluded that it is necessary a radiological evaluation of patients with back pain, the question arises which is the optimal method of investigation. Radiological tests are those that provide more precise data for diagnosis, x-rays are usually done in two incidents: anteroposterior and lateral. *Antero-posterior incidence* highlights rotation of the pedicles, interpedicular distance and pedicleserosion. *Lateral incidence* provides information about the structure and alignment of the vertebral bodies, about apophysis, flat ends and also about bone density. In addition are shown sagittal curvature of the lumbar spine, height of the spaces between the vertebrae and the presence of bone calcification. Some specialists request also the *oblique radiograph* plan because in 20% of cases, it highlights spondylosis.

In some cases, to assess scoliosis or kyphosis, radiographs are indicated seated laterally and seated anteroposterior.

2.4. Imaging explorations

CT-scan of the bones is a method of investigation of bones useful in back pain. Perhaps the most common use of this method is the detection of spondylosis in athletes under 20 years old presenting bone changes that occur after intensive stress, performed over a long period of time. The biggest advantage of the method of investigation by computed tomography is the reconstruction details sagittal and axial plane. Computed tomography can be used to identify intracanal fragments

that may occur after the rachis fractures and spinal canal stenosis in congenital scoliosis.

A non-invasive technique that may allow the discovery of asymptomatic pathologies, before the onset of neurological consequences, is magnetic resonance. On the basis of investigations carried out on a group of patients, with or without neurological symptoms, subject to the investigation by this method, anatomical factors of the condition was defined, giving more information than the CT or myelography. The method has proved useful in assessing the etiology of scoliosis in children, to identify lesions that change the spinal alignment and can precipitate a neurological catastrophe. It also helps in the analysis of acute and chronic infections of the skeletal muscles and differentiation of soft tissue by bone infections. It is the recommended evaluation method of assessing spinal infections and was found superior to myelography or computed tomography in following conditions: epidural abscess without meningitis, myelitis, infection, osteomyelitis and interdiscal space infection (6). It is also useful in differentiating tumors from infections.

3. SCOLIOSIS

Scoliosis is a three-dimensional deformation of the spine. 80% of scoliosis cases are of unknown etiology (7). Several hypotheses have been advanced involving genetic, skeletal, toxic, chemical, mechanical or biomechanical and neurohormonal factors.

It is a permanent lateral deviation of the spine, which can be volunteerly reduced by patient, but can not reproduced it in reverse. The name of scoliosis is based on the convexity location and the number of curves that is achieved: single curvature, which may be total or with short range and multiple bends, double or triple.

3.1 Classification

Scoliosis with a single curvature and small radiuses are usually congenital defects or injury. Scoliosis with total unique curvature are commonly polio or rickets. Scoliosis can have multiple etiopathogenesis:

- ***Idiopathic:***
  - Juvenile (90 %)
  - Infantile
- ***Congenital:***
  - Numerical abnormalities
  - Morphological abnormalities
  - Segmentation faults

- Complex abnormalities
- Cleidocranian dysostosis
- Aplasia or ribs synostosis

- ***Sistemic diseases:***
  - Morquio disease
  - Dischondroplasia
  - Ehlers-Danlos syndrome
  - Arthrogryposis
- ***Known cause***
  - Traumatic:
    - fracture-dislocations
    - herniated disc
  - Infectious:
    - spondylitis
    - thoracic-pulmonary disease
  - Deficiency:
    - rickets
  - Neurological:
    - polio
    - tabes
    - syringomyelia
    - neurofibromatosis
  - Postural:
    - visual and hearing disorders
    - vicious professional positions
  - Static (compensatory) - secondary to other diseases:
    - torticollis
    - elevated scapula
    - pelvic limb length discrepancies
    - pelvic, hip or shoulder deformities.

Scoliosis can be compensated or uncompensated. However, scoliosis can be divided into unfixed forms, intermediate and fixed. Thereof, scoliosis can be classified into:

- Grade I: reductible scoliosis
- Grade II: fixed scoliosis, which can be corrected
- Grade III: fixed osseous scoliosis

In case of analyzed scolioses several morphological characteristics were observed:

- Deformation of the vertebral bodies
- Asymmetry of the pedicles

- Facet joint asymmetry and bad orientation
- Deformation of the spinal processes
- Asymmetry of the transverse processes
- Deformation of the spinal canal.

Type I vertebral deformation refers to the vertebra situated above the thoraco-lumbar curvature apex. The body of the vertebra is trapezoidal shaped, the smaller side is the external posterior vertebral wall. This trapezoid is twisted along the cranio-caudal axis. Seen from above, the concave pedicle is longer and narrower than the convex one; seen from below, the asymmetry is even more evident. Side views shows that the concave pedicle is below and longer than convex one. The superior articular facets are asymmetric and oriented differently than normal; facets in concave area are larger and sagittal oriented, while facets of the convex are smaller and closer to the horizontal plane. Vertebral blade has the same thickness in both the concave and the convex areas. Seen from above, the blade in concave zone is shorter than the one in convex area. Spinous process is curved toward the convexity, with a twist around its own axis. The transverse process is shorter in the concave area, that in the convex. Axis from one transverse process to another goes from top to bottom and from back to front, toward convexity. The spinal channel is narrow and oval than normal and the longitudinal axis is oriented from top to bottom and back to front, toward concavity. There's always an angle with variable value, never zero, between the tangent plane of the upper end and the one between superior articular processes. The same is achieved between the plane tangent to the lower end and the lower joint processes. These minimal structural changes allow a hybrid instrumentation to correct a spinal deformity no bigger than 55 degrees **(Figure no.1)**.

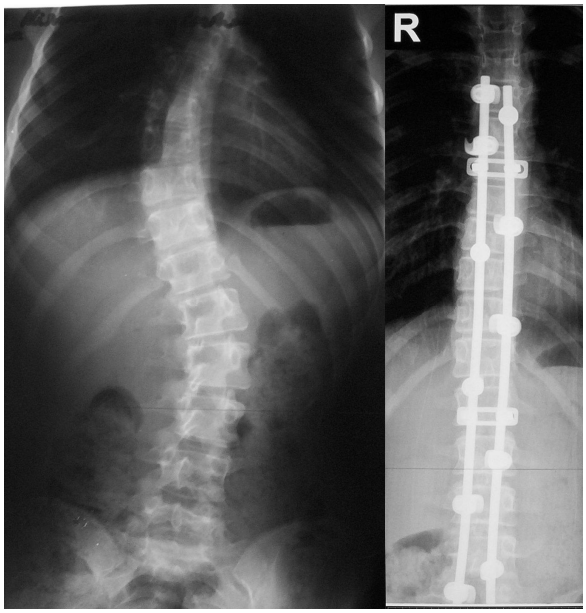

Figure no. 1: ***Thoraco-lumbar idiopathic scoliosis T5-L1 with Cobb angulation of 45 degrees, operated by a posterior approach. A correction index of 100%.***

On a 36 patients series, in "Alexandru Pesamosca" clinics of Maria Sklodowska Curie Hospital, we applied Burnei's instrumentation model which ensures an almost total correction with a minimal amount of implants (**Figure 2**).

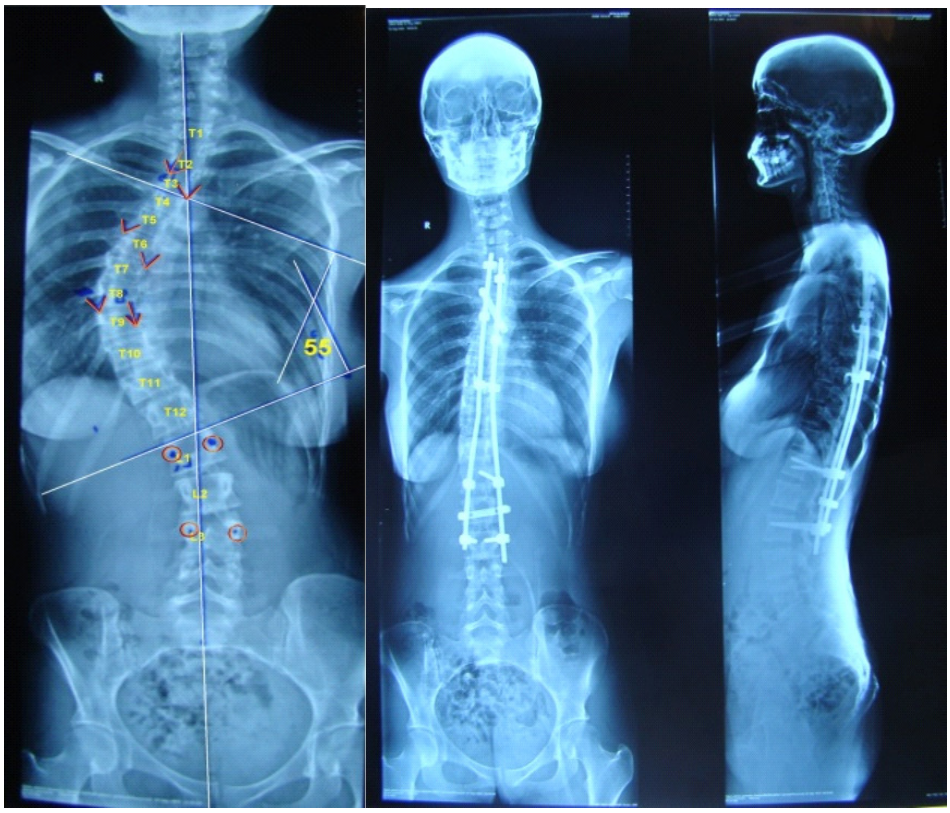

Figure no. 2: ***Burnei's instrumentation model in idiopathic scoliosis with angle between 50 + / - 5 degrees and partly flexible.***

Type II vertebral deformation concerns the vertebra immediately above type I vertebra. It´s the upper thoraco-lumbar curvature limit in all cases studied. Pedicle in the convex zone is shorter and lower than the one located in concave area. Both inferior articular facets are much closer to horizontal than normal. They have the same size, but different shapes, the one in concave area penetrating often in the spinal channel. Spinous process is curved toward convexity. The spinal channel is more oval than normal, with the longitudinal axis oriented from top to bottom and from back to front, toward concavity.

Type III vertebral deformation is found at one or more vertebrae located immediately below the type I vertebra. Rarely it´s the lower limit of the thoraco-lumbar curvature. Tri-dimensional deformation of the patient body diagnosed with idiopathic scoliosis produces postural changes: shoulders are unbalanced, the

pelvis is oblique and there is a major gibosity. Usually these patients present obvious respiratory failure and the Cobb angle excedes 80-90 degrees. Surgical procedures on a rigid spinal column do not allow total correction by somatic instrumentation and usually there rises the need of a double instrumentation on the concave side with lateral traction by means of a rod. The partial correction is meant to preserve pulmonary function and stabilize the spine **(Figure no. 3)**. Severe rigid double scoliosis, in order to correct it below 30 degrees, usually imposes an apical instrumentation and posterior transpedicular one **(Figure no. 4)**.

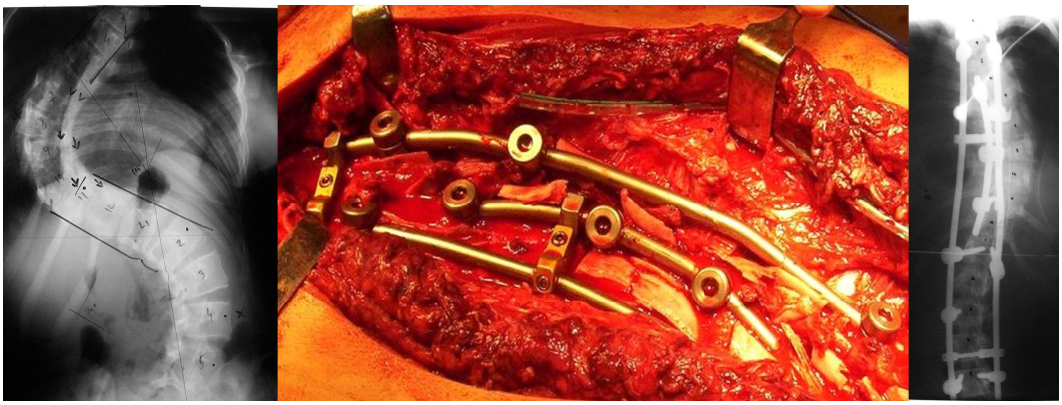

Figure no. 3: ***Pre-, intra- and postoperatively aspect. Double thoraco-lumbar rigid idiopathic scoliosis T4-L1-L5, with Cobb angulation of 114/90 degrees, operated by dorsal approach. Correction index 62/100%.***

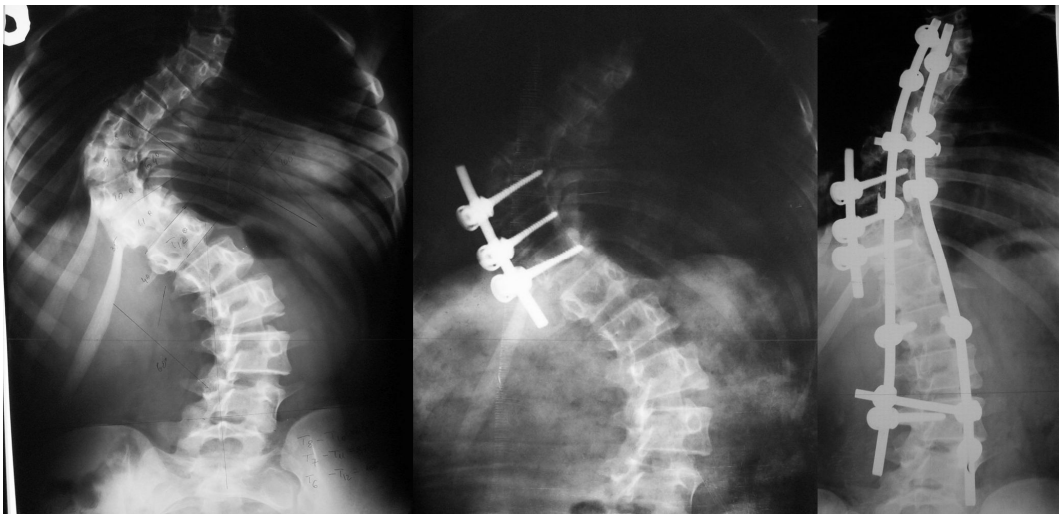

Figure no. 4: ***Double rigid thoraco-lumbar idiopathic scoliosis. Preoperative radiologic aspect after the previous approach and finally, after posterior approach.***

Idiopathic scoliosis in teenagers with a 75 to 90 degrees, partially flexible, a Cobb angle correction about 30%, detected by the X-rays bending probe may be fully corrected by „all body" vertebral instrumentation **(Figure 5)**.

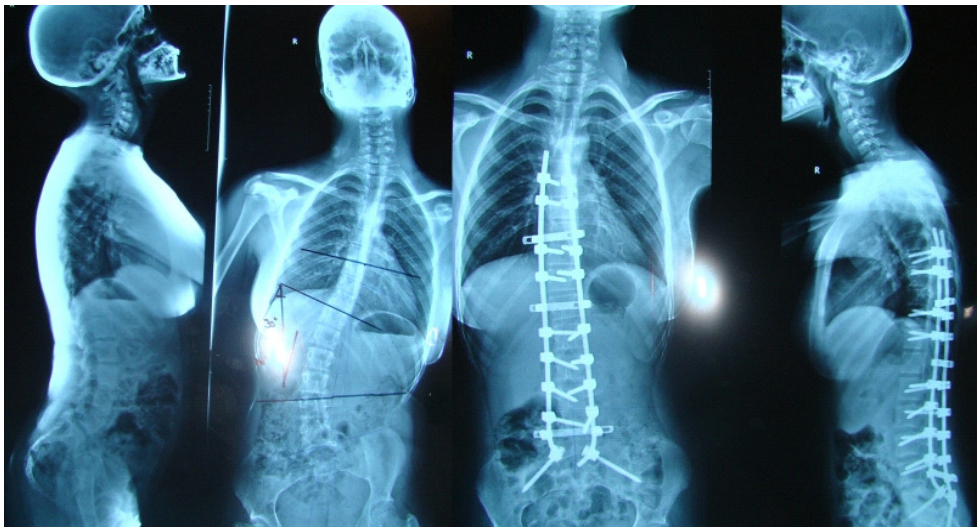

Figure no. 5: Total transpedicular instrumentation T7-S1 with almost complete correction of the spinal deformity.

Clinical researches conducted on a group of children and adolescents with idiopathic scoliosis were made by studying thoracic and lumbar region radiographs of the spine. Deformation is still appreciated by measurements of X-rays and less accurate measurements of the surface. Clinical measurements of spinal radiographs can define the lateral deflection and rotation of the spine. Lateral deflection is usually measured and defined by the Cobb angle. Nash-Moe method, which measures the pedicles movement, is widely used. Pedriolle measures the vertebrae rotation through his own method using a machine called ¨torsion-meter¨. Bunnell invented a "projector " which measures the rotation of the vertebrae by comparing the position of the spinous process with the vertebral body. Axis around which produce axial rotation is not the same at all levels of the spine, so three-dimensional measurement, which is used more frequently, is considered by the authors to be the most accurate. In thoracic area the rotation axis passes through the body of the vertebra and in lumbar area passes through the arch. Explanation for this phenomenon lies in the changing of inclination of the T11 and T12 joint forces.

Gibbus in thoracic scoliosis is measured at the curvature apex using torsion meter and for more accuracy, measurement is correlated with Cobb angle and with

apical vertebral rotation (8). The measurements are performed with the patient seated in three standard positions: sitting, bent forward, bent forward and tilted.

Gibbus measurement results in each of these three positions are compared with serial measurements at several levels, with pedicles and spinous processes rotation, made on anteroposterior radiographs of the spine.

Types of curvature have been classified as: simple thoracic curve, simple lumbar and double curvature (9).

3.2 Congenital scoliosis: spinal anomalies

They are caused by abnormal development of the vertebrae. Typically, they are rare, less common than idiopathic scoliosis.

Congenital anomalies of the spine can be:

- *Simple, benign* - not induce spinal deformities;
- *Complex* - causing severe spinal deformities.

Some of these severe birth defects are present at birth, others develop in childhood and adolescence, becoming progressively severe, with abnormal growth of the spine, they can be associated with many other malformations. A "C" shaped bend of column in a newborn caused by pelvic obliquity and inadequate intrauterine position should not be diagnosed as congenital scoliosis.

Congenital abnormalities of the spine can be caused by a segmentation defects or formation defects, but they are often the result of both pathogenic factors.

3.2.1 Segmentation defects have as a result a column like a non-segmented rod segmentation defects that result in a column of a non-segmented rod. Two or more vertebrae may be affected, involving vertebral bodies, the rear elements or even combinations thereof. Unilateral unsegmented column is the most exposed for deformation. When segmentation is flawed lateral and on one side, the resulting deformation is a severe progressive scoliosis, anterior non-segmentation produce kyphosis, bilateral posterior non-segmentation produce lordosis, and the unilateral one produces lordose-scoliosis. Symmetric circumferential segmentation defect creates a "block" which causes vertebral angular or rotational deformation of the spine, but vertical growth of the spine is affected.

3.2.2 Formation defects can be partial or complete. A partial unilateral Formation failure produces a sharpening of the vertebra vertebra and confer a trapezoidal shape. A a slight pedicular trace can be seen on the radiograph. Hemivertebra, cause of failure of complete unilateral formation may be non-segmented, or segmented semisegmentată from adjacent vertebrae. Hemivertebra can be balanced or unbalanced. A segmented hemivertebra is completely separate

from adjacent vertebrae. In this case, as a result of vertebral asymmetrical growth scoliosis is developed. A hemivertebra semi-segmented is separated from one of the adjacent vertebrae (upper or lower) by a disk or by a vertebral growth membrane, normal, but united with the other adjacent vertebrae. Hemivertebral resection in optimal timing, 1 to 4 years of age, allows total correction by somatic instrumentation **(Figure 6)**.

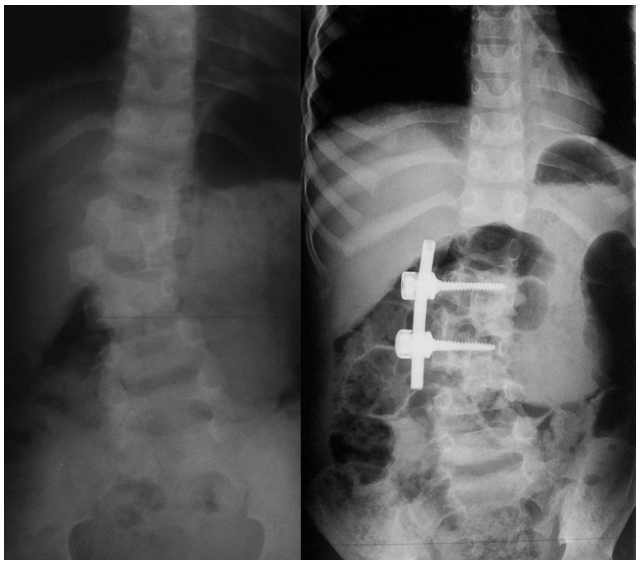

Figure no. 6: Congenital scoliosis with hemivertebra through formation defect - L2-L3 supernumerary hemivertebra, operated by a double approach, dorsal and ventral.

A non-segmented hemivertebra is connected to both adjacent vertebrae (upper and lower) without disks or growth membranes. In the absence of asymmetric growth, a non-segmented hemivertebra does not cause progressive deformation of the spine. If there are two or more hemivertebrae on the same side of the column, the column degree of mismatch is higher and produces severe spinal deformities. Scoliosis can be balanced, if both hemivertebrae are placed symmetrically, but the degree of curvature remains progressive. Hemivertebrae placed on both sides of the spine, in a 5 and above normal vertebrae row induce double congenital scoliosis requiring a double approach with somatic instrumentation (**Figure 7**, next page).

Kyphoses will occur when the anterior vertebral body is aplastic or hypoplastic due to defects in formation and posterior elements are normally developed. One or more vertebrae may present defects. Resulting kyphosis is more angular than round.

Congenital absence of sacrum and lumbar zone is an extreme form of formation defect of the whole caudal spine.

Absolutely unfavorable circumstances, which produces a very severe scoliosis is that when the segmented hemivertebrae coexist with nonsegmented regions.

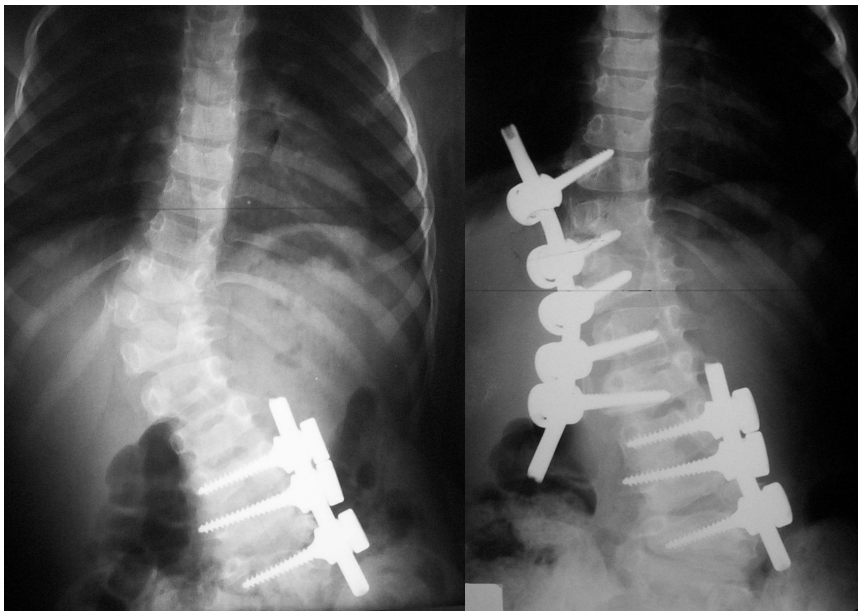

Figure no. 7: Double thoraco-lumbar scoliosis by congenital formation defect- hemivertebra T11-L1 and L4-L5, operated by a double approach, dorsal and ventral.

3.3 Antalgic scoliosis in discal hernia

A particular feature of scoliosis is presented by scoliotic attitude that appears as a symptom of a herniated disk. It is installed suddenly, usually by a lifting effort, is single, uncompensated, irreducible, often very pronounced and can have convexity directed either to the hernia side, or at the opposite side. Herniated disc can be found in childhood and adolescence. The incidence of disease in this age group is not clearly defined, but surgical cases are estimated to be 2% less than other age groups. Patients experience pain in the lower limb, with a typical distribution of sciatica. Many authors suggest that lumbar disc herniation in children is different than that seen in adults. Comparing adults-children, the incidence of loss of reflexes and sensory alteration was higher in adults, but impaired muscle tone was the same. However, there is a considerable difference between adults and children from the point of view of the neurological deficiencies. Multiple other conditions are considered to be related to a herniated disc, among them juvenile rheumatoid arthritis, hip diseases, back dislocation, infections, polio and pelvic limb length discrepancy. Conservative treatment of a herniated disc in children consists of bed rest, restricted activity and anti-

inflammatory medication. Preoperative evaluation includes diagnostic tests to confirm and locate the disease. For pathogenic diagnosis some experts propose lesions visualization by conducting an MRI test, others proposing electromyography or tomography.

Antalgic scoliosis is the result of nerve root compression of the intervertebral disc, which is often inflamed. Therefore, when the hernia has purely "invaded" nerve root, as is usually happens with the L5-S1 disc, for releasing the root and for distance increasing tilt on the affected side is needed to cause "direct scoliosis". When the hernia is outside the root, as usually happens with the L4-L5 disc, for release is needed a lateral tilt on the healthy side, which departs root from hernia and causes a "cross scoliosis".

We note that the terms direct and cross scoliosis have a somewhat inappropriate use as scoliosis is termed, classically, based on the convexity orientation. If we were following this terminology, scoliosis with the convexity on the hernia side, would be direct and with the convexity on the opposite side of the hernia, would be the cross one. So we must take into account the nomenclature used to avoid confusion. This fact determined Forestier to suggest replacement of the cross scoliosis term with crossed vertebral inflection, on the opposite side of the hernia and direct scoliosis term with direct vertebral inflection, on the hernia side.

Disc sciatic pain is accompanied by the presence of several points where pain is obtained by applying pressure on affected nerves, namely: gluteal point, femoral points, fibular point, Achilles point and medial plantar point.

Pain obtained by pressing the iliac artery is common to 80% of cases, at patients suffering from herniated disc. The presence of this sign has a similar meaning to painful points and is due to perivascular sympathetic hyperexcitability.

3.4 Postural scoliosis

Improper posture may be associated with medium scoliosis, characterized by a long thoraco-lumbar curvature. The rotation of the vertebrae towards curve convexity isn't revealed; gibbus is not visible atribs level or unilateral proeminence of the paraspinal muscles on the convex curvature area. Scoliosis is very flexible, but disappears when the patient is asked to stand upright or in lateral flexion on the convex curvature side.

Postural scoliosis does not progress and does not become structural. It is of little clinical importance and usually no treatment is indicated, physical exercise is sufficient.

3.5 Static scoliosis due to lower limb length discrepancy

In this kind of non-structural scoliosis occurs only a long thoraco-lumbar curvature, located usually from the cervical-thoracic junction to the sacrum. Curvature convexity is towards the lowered semi-pelvis, respectively toward the shorter limb. A slight rotation of the vertebrae appears and because the column is ventral arcuate, minimal rotation is to the concave side of the curvature, as opposed to the structural scoliosis, which the rotation istoward the convexity of curvature.

Spinal curvature is present in the sitting position. Column loops evenly on both sides in lateral flexion of the trunk. The patient can voluntarily correct the lateral deviation of the spine. Discrepancy correction between the lengths of the lower limbswith orthopedic boots, straightens the pelvis, removing scoliosis. On radiography, the column does not show structural changes at the vertebrae level (10).

4. KYPHOSIS

It is the most frequent deviation of the vertebral column, which is caused by increased curvature of the thoracic and appears in a large variety of disease:

- ***Congenital and hereditary***
  - Brachispondylitis
  - Microspondylitis
  - Achondroplasty
  - Osteopsathyrosis
  - Putti platyspondylia
- ***Traumatic***
  - Fracture and fracture-dislocation
  - Disk hernia
  - Drug-induced kyphosis
- ***Infectious***
  - Pott's disease
  - Typhoid / paratyphoid spondylitis
  - Melitococcal spondylitis
  - Vertebral osteomyelitis
  - Mycotical spondylitis
- ***Rheumatic***
  - Ankylopoetic spondylitis
  - Deforming chronic rheumatism
- ***Tumoral***
  - Primitive
  - Secondary

- ***Endocrine***
  - Osteoporosis in Cushing's Syndrome
  - Postmenopausal osteoporosis
  - Hyperthyroid osteoporosis
- ***Deficiency***
  - Ricketts
  - Osteomalacia
  - Painful osteoporosis of digestive diseases
- ***Dystrophic***
  - Senile or presenile kyphosis
  - Scheuermann vertebral epiphysitis
- ***Neuropsychiatric***
  - Hystero-traumatic Kyphosis
- ***Posture***
  - Professional
  - Flat foot

Clinically, there are two main types of kyphosis: kyphosis with small radius of curvature (short arch) and large radius of curvature kyphosis (long arch). *Kyphosis with short arch* appears in diseases that, destroying one or more vertebral bodies, lead to a compaction thereof, as happens in vertebral fractures, Pott disease, spondylitis, vertebral osteomyelitis, in primary postmenopausal osteoporosis etc. *Long arch kyphosis* occurs in conditions that interests backbone on a longer distance, as in presenile and senile primary osteoporosis, ankylosing spondylitis, vertebral epiphysis etc.

Pathological kyphosis can be installed either by emphasizing physiological kyphosis (when the condition interests thoracic region), or by deleting a physiological lordosis (when the disease involves cervical or lumbar region). Kyphosis is essentially the attitude or deformity of the spine that takes the most convenient position for improving pain, knowing that anterior vertebral ligament and the front of the spine are most richly innervated.

A special category of kyphosis is composed by the compressionof the vertebral bodies in osteoporosis or generalized osteopathy. Their differential diagnosis is possible only on the basis of radiological examination and laboratory tests. At teenagers' osteoporosis, alkaline phosphatase increase only in the case of recent fractures.

Kyphoses severity can be measured and objectified using various kyphometres.

4.1 Juvenile kyphosis - Scheuermann's disease

Kyphosis is installed at puberty and it manifests by reducing the anterior volume of one or more vertebrae, deformation that produces certain radiographic changes. This characteristic change of the vertebral bodies, with the anterior height reduction was first described by Scheurmann in 1920.

Radiologically, Scheuermann's disease is defined as a kyphosis which includes at least three adjacent vertebrae, with a decrease of the anterior height of 5° or more. The diagnosis is placed after 11-12 years because typical vertebrae edge changes and kyphoses are not obvious before 10 years. Statistically, it was observed that the condition has a higher incidence in girls than in boys.

The cause of this condition is still unknown, despite the many theories advanced in the literature. Vertebrae changes was explained as a result of aseptic necrosis of the apophyseal cartilage ring, that disturbs the growth in height of the anterior vertebral body. Also the mechanical and static forces acting on the spinehave an etiologicimportance. Ultrastructural and histo-chemical studies revealed changes in the growth of the cartilage plateau and vertebral matrix, observing a high percentage of collagen-protoglicanic. Therefore, enchondral ossificationand longitudinal growth of the vertebrae are reduced. It may not appears ring apophyses necrosis or abnormal intervertebral discs .

In advanced cases, anterior longitudinal ligament is contracted and thickened, acting as a spring along kyphosis. Smaller anterior vertebral body has variable values .

Typically, patients have a faulty posture and accuse pain in kyphosis region. Physical appearance depends on the location of the apex of kyphosis. In almost three-quarters of cases, the disease is purely thoracic, thoraco-lumbar to a quarter of patients and lumbar location in rare. If the disease is located in the chest area, there is an emphasis on normal kyphosis, an increased lumbar lordosis and a protruding abdomen. The shoulders are held back and the center of gravity falls behind the sacrum, with exaggerated pelvic tilt. As a rule, cervical lordosis becomes increased. Exaggerated cervical and lumbar lordosis are acompensatory phenomena.

Scheuermann´s juvenile kyphosis diagnosis is possible only after radiological investigation. Vertebrae becomes cuneiform in the center of kyphotic area and decreases cranial and caudal. This vertebral deformation is due to delayed longitudinal growth of the anterior vertebra part. Measuring vertebra compression is analyzed by profile radiography, by drawing lines through the levels of the two planes and by determining the angle between these two lines with a goniometer. The boundary between normal and abnormal vertebral configuration is 5 degrees. Kyphotic angle is the angle between the upper plateau of the cranial kyphotic vertebra and lower plateau of thecaudal vertebra. The intervertebral discs are normal in the early stages of the disease, maintaining

height between trapezoidal vertebrae; with time it narrows, especially in the center of the kyphotic area. Antero-posterior diameter of trapezoidal vertebra can be increased.

In the early stages, posture defects can be corrected active and passive, gradually, over a period of 6-9 months, after which the kyphosis is final.

A clinical and radiological analysis of condition established following steps in pathological evolution:

- *Functional phase* - clinically characterized by improper posture, at the age of 9-10 years. There may be observed exaggeration of thoracic kyphosis but does not register pain or other clinical symptoms. Scheuermann´s disease is difficult to diagnose at this stage.

- *Typical changes phase,* at the age of 12-18 years, in which the kyphosis and possibly scoliosis installs. Patients complains of back pain and fatigue. Radiologically, this phase is characterized by reducing the anterior height of the vertebrae and presence of irregularities at the anterion edge of the plateau.

- *Late phase* - seen in adults. Appear narrowing of the intervertebral discs and deformation of the vertebrae edges. Spinal pain are permanent and muscles weakness in the kyphosis region.

After lengthy analysis of several Scheuermann´s juvenile kyphosis cases were drawn several conclusions, namely:

• Spinal pain and fatigue are less common after growth, having no effect on the working capacity of the patient;

• Approximately half of the mature patients had spinal pain and almost a quarter suffer from lumbar discs degeneration;

• When the kyphotic area is low or very long, interesting the medular channel and the second lumbar vertebra, lumbar disc degeneration induces great pain;

• Radiological, there is a slow kyphosis progression, due to the slow formation of the trapezoidal vertebrae and narrowing of the vertebrae discs.

Treatment

Scheuermann´s juvenile kyphosis treatment objectives are directed toward pain relief, correction of the kyphosis degree, prevention of the kyphotic growth, improving physical appearance. The choice of treatment is taking into account the following factors:

- Age of the patient;
- Phase of the condition;
- The structural degree and rigidity of kyphosis;
- The posterior convexity location;
- Presence of pain;
- Possible association with scoliosis;

- Psycho-social factors.

Not all patients with this disease require treatment. If a patient is skeletally mature, with an asymmetric acceptable kyphosis, it can be put underobservation without treatment. Overall physical exercises aim to improve patient outfit, but it must be convinced that only exercises doesn't have correction effect on the vertebrae shape or reduction of the fixed kyphoses degree (12).

Surgical correction of Scheuermann´s disease is rarely indicated. It's applied only on mature patients with local chronic pain, kyphotic curves with 60°-70° or more and trapezoidal vertebrae angle greater than 10°. For the permanent correction are needed both anterior and posteriorspinal fusion. Posterior instrumentation provides a good correction.

Complications

A severe complication but rare with Scheuermann´s disease is compression of the spinal cord; may be due to a herniated disk injury and direct mechanical compression of the spinal cord or spinal channel narrowing in the kyphotic area.

It can also be seen atypical forms of the disease which is manifested by changes in the vertebrae body, or by narrowing the anterior vertebral body, but without any other vertebral modifications.

4.2. Congenital kyphosis

Congenital kyphosis may be caused by formation defects or by segmentation defects of the vertebral bodies.

Type I (formation defect) is characterized by partially or total aplasia of the vertebral bodies. May be affected one, two or even three vertebral bodies .

- A - agenesis of T1 vertebral body
- B - L1 vertebral body agenesis and microspondylitis of the adjacent vertebra (T12), at both vertebrae being able to notice the presence of pedicles.
- C - microspondylitis L1 vertebra
- D - microspondylitis of two adjacent vertebrae (T11 and T12).

Type II (segmentation defect) affects the anterior side of two or more adjacent vertebrae.

- E - type II congenital kyphosis due to segmentation fault at the front of the three adjacent vertebrae
- F - the absence of supero-posterior corner of cuneiform vertebra
- G - cuneiform vertebrae (side view)
- H - cuneiform vertebra (anteroposterior view).

Kyphosis correction is performed by a posterior approach in case of a hemisegmented or non-segmented cuneiform vertebra or a double approach, anterior and posterior, if the vertebra is segmented **(Figure no. 8)**. The most affected area by kyphosis is between T10 and L2, however, can be observed anywhere between T4 and L5. Kyphotic deformation is usually observed in neonates and becomes more pronounced when children start to walk. With the increase of the column, kyphosis is emphasized. The deformity may be that severe in teenagers or young adults that it induces respiratory failure and imposes restrictions not only in physical activities, but daily one, too **(Figure no. 9)**.

Figure no. 8: ***Pre-and postoperative radiological aspects in case of a thoracic T6 cuneiform vertebra kyphosis.***

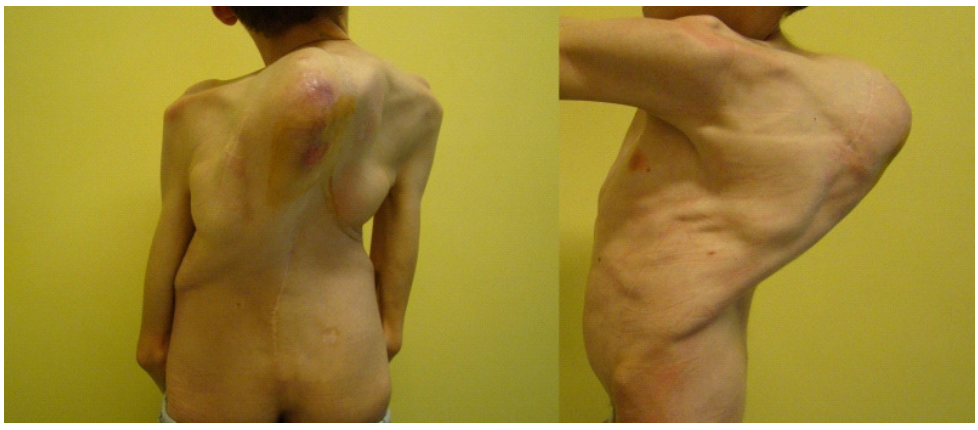

Figure no. 9: ***Extreme kyphoscoliosis with thoracic insufficiency syndrome due to late diagnosis. We intervened to stabilize the deformity in order to prevent onset of spinal stenosis by compression and emphasizing respiratory failure syndrome, heart failure and premature exitus.***

In children it is not painful and does not appear muscle spasms, but in adults, pain is a symptom of degenerative arthritic changes. Typically, the height of the patient is less than average.

Paraplegia caused by spinal cord compression occurs frequently in congenital kyphoses Sequential neurological examinations of the whole column must be made, myelography examination or magnetic resonance visualization method.

Deformation can not be corrected and stopped from evolution by conservative methods. Non-operative measures are ineffective. The surgical procedure is dependent on the type of kyphosis, the severity of the deformation, on the age of the patient. Anterior unsegmented column is treated by posterior spondylodesis, if deflection angle is medium or moderate and has no particular clinical significance. Posterior spondylodesis extends from the first vertebrae, located proximal to the affected area, to the first vertebra located distal to this zone. Moreover, posterior spinal fusion prevents increased kyphosis. Optimal age for posterior fusion is between 1 and 2 years.

When the distortion is severe column fusions are required both anterior and posterior (11). If the posterior fusion does not ensure the stability of the kyphotic column, pseud-arthrosis appears and the kyphosis is progressing.

5. LORDOSIS

Is the third significant deviation of the spine and is characterized by emphasizing the dorsal flexion of the spine. Headquarted in lumbar and cervical region can stretch to thoracic region and sometimes can interest the spine completely. In many cases it is about lordosis attitudeobvious in orthostatism that isdeleted in supine position. They are the result of static tilt adaptations or dynamic asynergy.

By static tilt we mean compensation at the joints level and lumbar discs, for that normal tilting of the pelvis does not cause spinal deformation, which thus recovers at its base. We encounter this at the women who wear high heels or in case of bilateral congenital dislocation.

Lordosis by dynamic disequilibrium correspond to a compromise between the extensor muscles of the trunk and flexors, being the result of a abdominal wall muscle atonia or abdominal distension by: tumors, enteroptosis or pregnancy.

In some cases we can findbone fixed lordosis (lumbarization, spondylolisthesis). In these cases, although lordosis is very pronounced,gluteal regions doesn’t stand out (as in hip congenital dislocation), but remain deleted, and thorax seems to be clogged in the pelvis, the soft tissues above coxal bones showing more or less pronouncedditches.

Lordosis depth is estimated using a lead bob, measuring the distance that separates the plumb bob from the top of the farthest spinous process. Normal pelvis is tilted by 12° related to axis of the pelvic limbs, tending to vertical and hyperlordosis. If the deformity is reducible seated and by bending forward, it is noticed how lumbar muscles relaxes and the medial hole is filled. If it isn't reducible, the flexion is made form the torso and hips, while lumbar region tilts as a block, keeping the concavity.

Progressing in age hyperlordosis leads to suffering of the spinous apophyses, inducing wear injuries that cause pain when touching.

The causes of lordosis can include: carrying heavy loads on head, wearing high heels, traumatickyphosis decompensation, S1 lumbarization, spondylolisthesis, etc. In some conditions we may find the physiological cervical or lumbar lordosis deletion. This symptom can be a sign of disc suffering, of fracture-dislocation or spondylitis. Erasing lordosis doesn't have a specific character but in relation with pacient's normal posture.

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