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ORIGINAL ARTICLE

Assessment of the possibilities of B-mode ultrasonography in the diagnosis of lumbar intervertebral discs protrusion in adolescents

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ABSTRACT

Objective: To improve the efficiency of lumbar intervertebral discs protrusion by determining the ultrasound biomarkers. **Materials and Methods:** The study included 68 patients with the disc protrusion and 65 healthy adolescents with normal lumbar intervertebral discs and neurologic status aged 16-18 years. Ultrasonography (USG) was performed at the level of disks L1-L2, L2-L3, L3-L4, L4-L5, L5-S1 in longitudinal and transverse projections. In longitudinal section was measured height of lumbar vertebrae and intervertebral discs, in axial section – the sagittal sizes of intervertebral discs and spinal canal, width of spinal nerve canals, thickness of the yellow ligament. **Results:** In 31 (45.6 ± 6.0%) cases the protrusion was paramedian, in 16 (23.5 ± 5.1%) – posterolateral, in 13 (19.1 ± 4.8) – median and in 8 (11.8 ± 3.9%) – circular types. The paramedian protrusion was significantly more frequently recorded than the posterolateral (P<0,05), median and circular (p <0.001) types. In 7 (10.3 ± 3.7%) cases the protrusion was localized at the level of L2-L3, in 13 (19.1 ± 4.8%) – L3-L4, in 27 (39.7 ± 5.9%) - at the level of L4-L5 and in 21 (30.9 ± 5.6%)-at the level of L5-S1 respectively. There were no significant differences in the frequency of occurrence between L2-L3 and L3-L4, as well as L4-L5 and L5-S1. The lower located lumbar discs were significantly more affected than the upper ones (P <0.05; P <0.001). **Conclusions:** In adolescents in the lumbar spine, paramedian protrusion are most commonly found, which are most often localized at the level of both L4-L5 and L5-S1. The greatest narrowing and deformation of the spinal nerve canal is observed by posterolateral and paramedian protrusion. The greatest thickness of the yellow ligament, radiculopathy is observed at level of L5-S1 protrusion.

***Keywords**: lumbar intervertebral discs protrusion; spinal canal; ultrasound diagnostics; adolescents*

Introduction

CBack pain is one of the most common presenting complaints to Emergency Departments all over the world; 60–90% of the population will experience back pain in their lifetime. Back pain is second only to upper respiratory tract infection as a cause for lost work time. Over 5 million people are disabled with low back pain, which makes it the number one disability for workers less than 45 years old. The L5-S1 spine segment is a very common source of low back pain. Because of the forces acting on this segment, as well as the range of motion it provides, it is susceptible to injury or degeneration[1,2].

Common causes of pain include disc herniation, disc degeneration, facet joint arthritis, spondylolisthesis, spondylosis, spondylolysis and spinal stenosis. Surgery is considered when conservative treatment has failed. Because of the functional and socioeconomic consequences of chronic low back pain, numerous surgical treatments to improve this condition have been attempted by spinal surgeons through the years. Degenerative disk disease is a common cause of low back pain and leg pain in children and infants. It is often unrecognized and under-diagnosed. Degenerative disc disease in the lumbar spine, or lower back, refers to a syndrome in which a compromised disc causes low back pain[3].

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Although there is a slight genetic component to individuals who suffer from degenerative disc disease, the true cause is probably multifactorial. It could be from simple wear and tear, or may have a traumatic cause. However, it rarely starts from a major trauma such as a car accident. It is most likely due to a low energy injury to the disc that progresses with time. In 2002 Kamanli and Genc[4] reported a study population consisting of 503 healthy young male candidates for sports training. Lumbosacral transitional vertebral (LSTV) abnormalities were found in 37 (7%) of subjects and were unilateral in 14 (3%) subjects (lumbarisation/sacralisation). Lumbar rotoscoliosis (LRS) was present in 14 (3%) subjects and facet asymmetry in one subject. LSTV and LRS together were present in 3 subjects. Spina Bifida Occulta (SBO) was present in 107 of 503 candidates (21%)[4].

Aging and general wear and tear are usually the primary causes of a disc protrusion. However, many additional factors can encourage or accelerate this degenerative spine condition, including: sudden injuries; genetic predisposition to degenerative disc disease; spine-related congenital conditions; obesity or carrying excess weight; lack of exercise and regular activity; malnutrition. A diagnosis of lumbar degenerative disc disease as the cause of the patient's pain is a 3-step process: patients' history, including when the pain started, a description of the pain and other symptoms, and activities, positions and treatments that make the pain better or worse; physical exam, in which the physician examines the patient for physical signs of a symptomatic degenerated disc. This exam may include testing the patient's range of motion, muscle strength, local tenderness, and more, with a focus on the lower back and legs. The magnetic resonance imaging (MRI scan) is used to confirm a formal diagnosis of lumbar degenerative disc disease and, if relevant, to aid in surgical planning[5,6].

Ultrasound is usually most effective with tissues that have high collagen content such as tendons, ligaments, joint capsules, and fascia[7,8]. Spinal ultrasonography has been used to investigate degenerative disc disease to determine whether back pain is a consequence of fissuring or herniation of the gelatinous discs that separate the vertebrae. Spinal ultrasound has also been used in the assessment of injuries to paraspinal ligaments after spinal fractures. Although ultrasonography has limited ability to reveal bone and tissues surrounding bone, it has been studied as a means to assess the posterior ligament complex that contributes to the maintenance of spinal stability[9,10].

The American Institute of Ultrasound in Medicine (AIUM) Ultrasound Practice Accreditation Council has developed standards for the accreditation of ultrasound practices. These standards serve as a benchmark for ultrasound professionals seeking to meet nationally accepted protocols[11,12]. In previous studies, the protrused cervical discs for screening programs in the late childhood and teenage are presented[13]. Development of ultrasound semiotics of the lumbar discs protrusion is an actual task.

Objective: To improve the efficiency of lumbar intervertebral discs protrusion by determining the ultrasound biomarkers.

Materials and Methods

The study included 68 children aged 16–18 years with the disc protrusion, confirmed by magnetic resonance imaging. All patients had lumbar spinal pain, 29 from them–clinical signs of sciatica. The comparative group (CG) consisted of 65 healthy children the same age with normal lumbar intervertebral discs and neurologic status. Ultrasonography (USG) was performed at the level of disks L1-L2, L2-L3, L3-L4, L4-L5, L5-S1 in longitudinal and transverse projections. In longitudinal section was measured height of lumbar vertebrae and intervertebral discs, in axial section–the sagittal sizes of intervertebral discs and spinal canal, width of spinal nerve canals, thickness of the yellow ligament.

Ethics Statement

Prior to the inclusion of the patients in the study, an ethical clearance was sought from the competent authority of Kharkov Medical Academy of Postgraduate Education. Written informed consent was obtained from patients' guardians for publication of this research and any accompanying images..

Results

In 7 (10.3 ± 3.7%) cases the protrusion was localized at the level of L2-L3, in 13 (19.1 ± 4.8%)–L3-L4, in 27 (39.7 ± 5.9%)-at the level of L4- L5 and in 21 (30.9 ± 5.6%)–at the level of L5-S1 respectively (Table 1). In 31 (45.6 ± 6.0%) cases the protrusion was paramedian, in 16 (23.5 ± 5.1%) cases – posterolateral, in 13 (19.1 ± 4.8) cases–median and in 8 (11,.8 ± 3.9%) – circular types (Table 2). The paramedian protrusion was significantly more frequently recorded than the posterolateral (P <0.01), median and circular (p <0.001) types.

Table 1. The cervical intervertebral discs levels with hernia.

The level of IVD		Protrusion, n = 68
1	L1-L2	-
2	L2-L3	7 (10.3 ± 3.7%)
3	L3-L4	13 (19.1 ± 4.8%)
4	L4-L5	27 (39.7 ± 5.9%)
5	L5-S1	21 (30.9 ± 5.6%)

Table 2. Localization of hernia in cervical intervertebral discs.

The type of hernia		Protrusion, n = 68
1	Paramedian	31 (45.6 ± 6.0%) P1-2 <0.01 P1-3 <0.001 P 1-4 <0.001
2	Posterolateral	16 (23.5 ± 3.9%) P2-4 <0.05
3	Median	13 (19.1 ± 4.,8%)
4	Circular	8 (11.8 ± 3.9%)

Among healthy children, the total number of boys was 41 (63.1 ± 5.9%), girls - 24 (36.9 ± 5.9%), the difference between them was significant (P <0.01). At the level of L2-L3 and L3-L4, the rear contour of the disk is somewhat concave, at the level of L4-L5 and L5-S1 it has a horizontal shape. At the level of L1-L2 the spinal cord can be visualized (Figure 1).

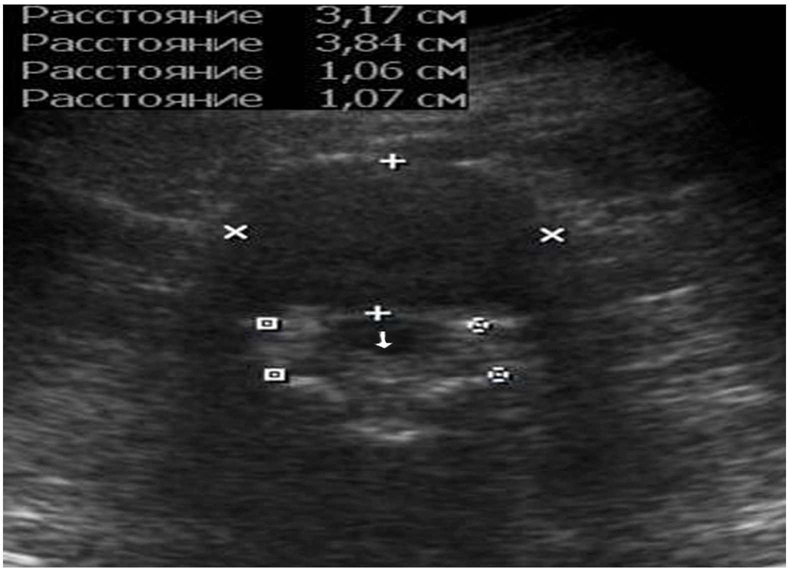

Figure 1. Measurement of the intervertebral disc of L1-L2 and spinal nerve canals. The arrow shoes the spinal cord.

Ultrasonic parameters of the spinal canal and intervertebral discs are presented in Table 3. The smallest sagittal size (15.1 ± 0.9 mm) and area (143 ± 11.5 mm2) of the spinal canal, index of SC/IVD (0.43 ± 0.03) was recorded among the children of median protrusions, but smallest width of the spinal nerve canal (5.3 ± 0.42 mm)–in posterolateral protrusion. The maximum thickness of the yellow ligament was recorded in circular (3.5 ± 0.12 mm) and median (3.4 ± 0.13 mm) protrusion.

Table 3. Ultrasound parameters of IVD and SC in children with disc protrusion

Ultrasound parameters	The healthy children	Protrusion, n = 68			
		Paramedian n = 31	Posterolateral n = 16	Median n = 13	Circular n = 8
Sagittal size SC, mm	18.2 ± 1.1	17.4 ± 0.9	18.3 ± 1.2	15.1 ± 0.9 P <0,05	16.2 ± 1.1
Sagittal size IVD, mm	31.4 ± 1.9	32.7 ± 1.4	32.1 ± 2.1	35.1 ± 1.6	33.1 ± 1.8
SC/IVD	0.58 ± 0.02	0.53 ± 0.03	0.57 ± 0.02	0.43 ± 0.03 P <0.01	0.49 ± 0.02
The width SN canals, mm	8.7 ± 0.36	7.2 ± 0.35	5.3 ± 0.42	8.5 ± 0.39	7.4 ± 0.41
The area SC (mm2) by LxM/2	193 ± 9.4	172 ± 10.3	187 ± 11.2	143 ± 11.5 P <0.01	154 ± 10.7
The area SC (mm2) by its perimeter	204 ± 9.8	169 ± 10.8	192 ± 11.6	162 ± 14.3	151 ± 11.8
The thickness of the yellow ligament	2.8 ± 0.11	2.9 ± 0.12	2.8 ± 0.11	3.4 ± 0.13	3.5 ± 0.12

Changes in intervertebral discs were characterized followed:

- within the nucleus pulpous (NP);
- within the nucleus pulpous and fibrous ring (FC) without disturbing its integrity.

Qualitative changes in the intervertebral discs were:

1) increased echogenicity of the nucleus pulpous;
2) the displacement of the nucleus pulpous;
3) increased echogenicity and thinning of the fibrous ring;
4) protrusion of the fibrous ring more than 2 mm;
5) narrowing of spinal nerve canals.

In all cases, protrusion of the lumbar discs was manifested by a change in the nucleus pulpous, thinning of the fibrous ring and its protrusion toward the vertebral canal or canal of the spinal nerves (Figure 2–5).

Figure 2

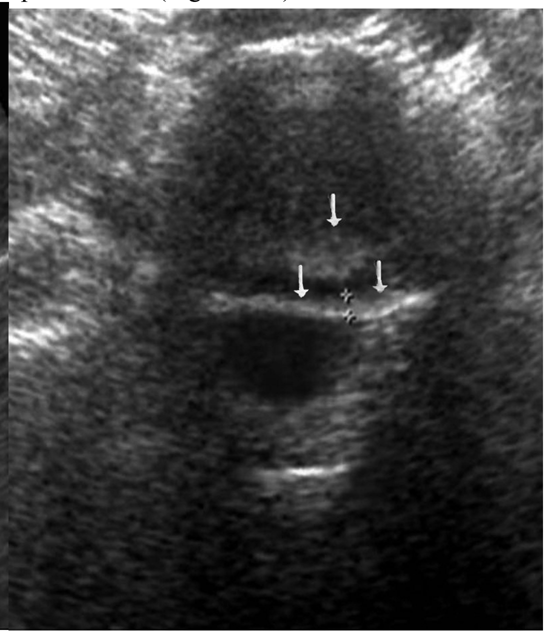

Figure 3

Figure 2. Median protrusion of the IVD (arrow).

Figure 3. Left paramedian protrusion of the IVD (lower arrows). Upper arrow shows displacement of the nucleus pulpous.

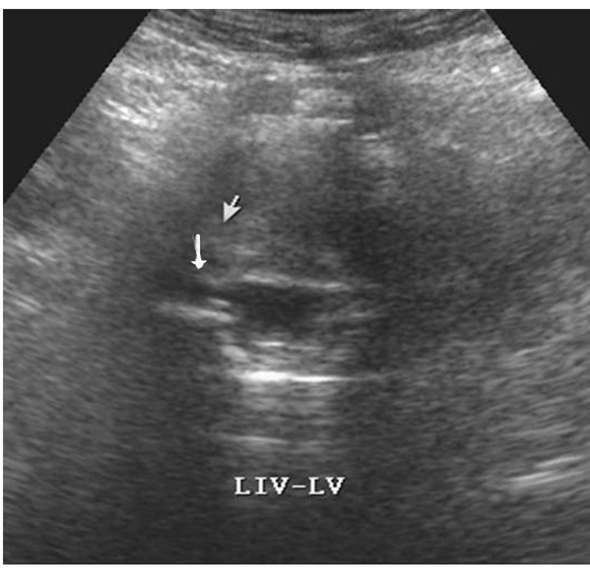

Figure 4

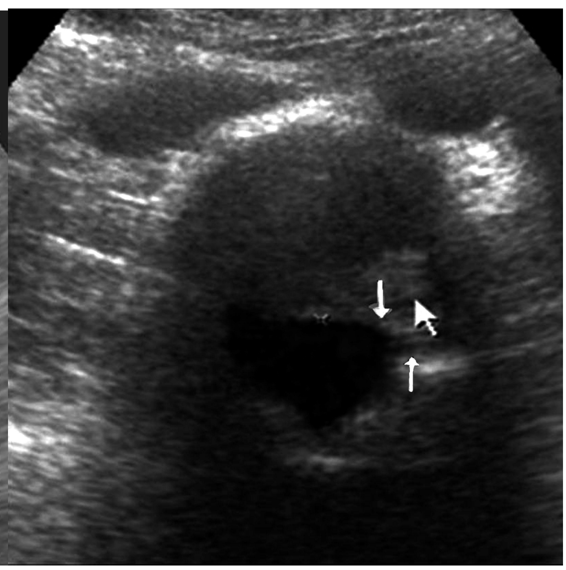

Figure 5

Figure 4. Right posterolateral protrusion of the IVD (lower arrow). Upper arrow shows displacement of the nucleus pulpous.

Figure 5. Left posterolateral protrusion of the IVD (left upper arrow). Upper right arrow shows displacement of the nucleus pulpous, lower arrow–narrowing spinal nerve canal.

Discussion

As a result of the study, echographic features of lumbar intervertebral discs protrusion in children 16–18 years old were established. Mean parameters of the sagittal dimensions of the intervertebral discs, spinal canal, the ratio of the sagittal dimensions of the disc and the spinal canal, the width of the spinal nerve canal were calculated. Different variants of localizations of protrusion are determined. Echographic parameters of healthy children without changes in the discs and with protrusion of the discs were compared.

In the course of the study, it was found that the most frequently observed

paramedian (45.6 ± 6.0%) protrusions. The greatest sagittal size is observed with median protrusions–in 19.1 ± 4.8% of cases. The same leads to the greatest decrease in the sagittal size of the spinal canal. The greatest decrease in the width of the spinal nerve canals occurs with posterior-lateral and paramedian hernias.

It is known that the most common method of examining the spine is radiography. However, the method does not allow visualizing intervertebral discs, spinal cord, spinal nerves, ligamentous apparatus.

Magnetic resonance (MR) imaging of the lumbar spine is a frequently performed procedure[14]. Several studies have been undertaken to assess the concordance of different physicians in reporting findings such as disk degeneration, Modic changes, annular tears, disk bulges, protrusions and herniations, and spinal stenosis at MR imaging. In general, the concordance found in those studies ranged from moderate to excellent, depending on the MR imaging fi nding that was being evaluated[15–17].

But when using high-frequency microconvex transducer in children, the echographic image of intervertebral discs and the spinal canal is not inferior in quality to magnetic resonance imaging (Figure 6). Ultrasonography is easy to perform, cheap, non-invasive. This indicates a great opportunity for echography, especially in pediatrics and use it not only as a screening test, but also for peer review.

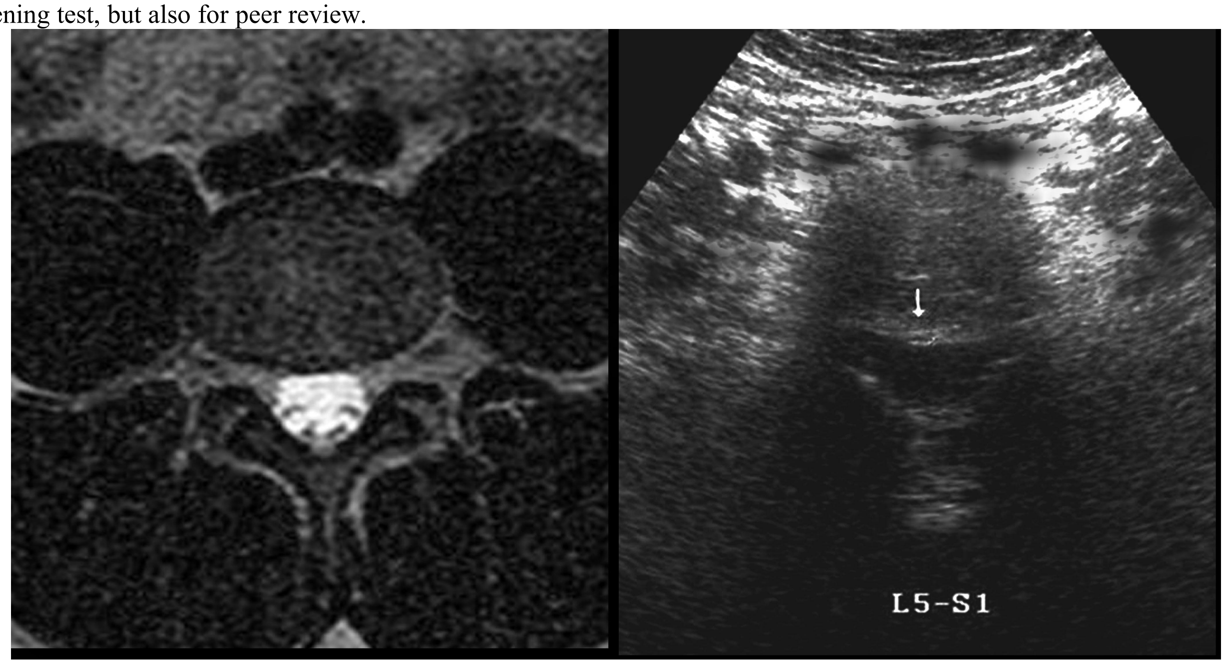

Figure 6. MRI and USG view of circular protrusion of the IVD (arrow)

Conflict of interest

The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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