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Research Article

Ultrasonographic Evaluation of Lumbar Intervertebral Discs Hernia Detected by MRI in High School Aged Children

Rizvan Yagubovich Abdullaiev*, Igor A Voronzhev, Roman R Abdullaiev and Nataly S Lisenko

Kharkov National Medical University, Ukraine

***Corresponding Author:** Rizvan Yagubovich Abdullaiev, Department of Ultrasound Diagnostics of Kharkov National Medical University, Ukraine.

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Abstract

Objective: The aim of this study was to determine the ultrasonographic features of lumbar intervertebral disc herniation in older school-aged children detected by MRI.

Materials and Methods: A retrospective analysis of ultrasonography results was conducted on 95 lumbar intervertebral discs in 19 children aged 13 to 18 years. All patients had clinical and neurological signs of degenerative disc disease-discomfort and chronic lower back pain of mild and moderate severity, aggravated by heavy lifting and awkward body positions. Radiographically, a decrease in intervertebral space height and osteophytes at the level of the discs involved in the degenerative process were recorded in all cases.

Ultrasonography (USG) was performed at the level of disks L1-L2 - L5-S1, in sagittal and axial sections. In axial section was performed the anteroposterior size of central spinal canal and spinal nerve canal.

Results: Hernia was diagnosed only at the level of L4-L5 and L5-S1 - in 9 (9.5 ± 3.0%) and 10 (10.5 ± 3.1%) discs out of 95 examined in 19 children.

Median hernia localization was recorded in 8 (8.4 ± 2.8%) discs, paramedian - in 9 (9.5 ± 3.0%) discs, and posterolateral - in 2 (2.1 ± 1.5%) discs, respectively. The median and paramedian protrusions was significantly more frequently recorded than the posterolateral ($P < 0,05$) types.

Conclusion:

1. Ultrasonography is as effective as magnetic resonance imaging in diagnosing lumbar disc herniations in older school-aged children. Only in interpreting paramedian and median herniation locations is there a slight difference between the two methods.
2. In high school aged children in the lumbar spine, median and paramedian hernia are most commonly found, which are most often localized at the level of both L4-L5 and L5-S1.
3. Ultrasonography can be used to screen children with low back discomfort or pain to detect lumbar disc degeneration in its early stages.

Keywords: *Lumbar Intervertebral Discs Hernia; Spinal Canal; Ultrasonography; High School Aged Children; Magnetic Resonance Tomography*

Introduction

In most cases, the causes of back pain are several, it is difficult to determine the main one. In such cases, the intensity and nature of the pain, the zone of their distribution, is important. Often the degree of damage and intensity of pain do not match. An analysis of clinical symptoms in 70 young patients with degenerative changes in the lumbar intervertebral discs showed that in 54% of cases the pain was localized in the lower back, in 46% it had the character of sciatica spreading to the lower limb. The most common levels of damage were L4-L5 in 54% of patients and L5-S1 in 34% of patients [1].

Radiculopathy is one of the variants of pain in the back and it is caused by mechanical compression of the nerve root in the foramen. More often, radiculopathy develops as a result of degenerative disc disease, intervertebral joint, hypertrophy of the ligamentous apparatus, spondylolisthesis or a combination of these factors [2].

Degenerative disc disease (DDD) in the lumbar spine is the most common cause of pain. A study by J. P. G. Urban., *et al*. showed the role of biomechanical factors and gene phenotypes in the development of degenerative changes in IVD at a young age [3]. The link between low back pain and degenerative changes in the discs, the role of improper loading and trauma in their development is noted in many publications [4].

Low back pain due to lumbar spondylolysis is a common condition in adolescent athletes, and epidemiological studies have shown that the incidence is significantly higher in young athletes (8.8% - 47%) compared to the general population (4.4% - 6%). Often a multifactorial condition, low back pain can be classified by its origin. Common causes of back pain are primarily nociceptive and neuropathic in nature [5].

The appearance of pain syndrome is explained by the increase in ectopic irritability of nerve fibers during their direct damage or the presence of the main factor near it. It should be noted that “spinal pain” or “nerve root pain” is not the same thing. They are more often found in place of, but can be seen separately without the other. For radiculopathy, symptoms such as paresthesia, hypoesthesia, loss of motor function and pain are inherent. Radicular pain is this as one symptom that can arise from one or more spinal nerve roots. Lumbar radiculopathy is a disease in which pain occurs in the lower back and spreads into the leg. This is caused by damage to one of the lower intervertebral discs and the compression of the nerve roots [6].

Since herniated discs are the most common cause of radiculopathy, their diagnosis is important. A qualitative study of the diagnosis of radiculopathy requires a comparison of clinical symptoms and MRI or CT results, which allow direct visualization of the affected discs, the central spinal canal, the spinal nerve canal, the intervertebral foramen, the ligamentous apparatus, and the presence of inflammation in the epidural space [7].

The most widely accepted classification of degenerative disc disease staging is the grading of changes in the intervertebral disc on MRI images using the Pfirrmann grading system. The staging system for osteochondrosis includes five stages based on disc structure, the distinction between the PU and FC, signal intensity, and disc height on axial T2-weighted images. This classification allows for the early diagnosis of degenerative processes in the intervertebral disc, allowing for timely referral of patients for regenerative treatment [8].

In recent years, ultrasonography has been actively used in the diagnosis of musculoskeletal disorders, particularly to determine the causes of low back pain. Some authors have used ultrasound to assess abdominal muscle thickness in adolescents with low back pain. Accurate anatomical localization of lumbar motion segment structures is essential for interventional procedures in the treatment of low back pain [9-11].

Objective of the Study

The aim of this study was to determine the ultrasonographic features of lumbar intervertebral disc herniation in older school-aged children detected by magnetic resonance tomography.

Materials and Methods

A retrospective analysis of ultrasonography results was conducted on 95 lumbar intervertebral discs in 19 children aged 13 to 18 years. All patients had clinical and neurological signs of degenerative disc disease-discomfort and chronic lower back pain of mild and moderate severity, aggravated by heavy lifting and awkward body positions. Radiographically, a decrease in intervertebral space height and osteophytes at the level of the discs involved in the degenerative process were recorded in all cases.

Ultrasonography (USG) was performed at the level of disks L1-L2 - L5-S1, in sagittal and axial sections. In axial section was performed the anteroposterior size of central spinal canal and spinal nerve canal. At the level of lumbar discs ultrasound was performed with a convex probe 2 - 5 MHz (Philips HD-11).

Results

According to the results of MRI hernia was diagnosed only at the level of L4-L5 and L5-S1 - in 9 (9.5 ± 3.0%) and 10 (10.5 ± 3.1%) discs out of 95 examined discs in 19 children. In one case, an L5-S1 hernia was diagnosed as a protrusion by ultrasound (Table 1).

Level of lumbar disks	Disc hernia	
	MRI	US
L1-L2	-	-
L2-L3	-	-
L3-L4	-	-
L4-L5	9 (9.5 ± 3.0%)	9 (9.5 ± 3.0%)
L5-S1	10 (10.5 ± 3.1%)	9 (9.5 ± 3.0%)

Table 1: *Distribution of MRI and USG results for the diagnosis of hernia considering the level of lumbar intervertebral discs.*

In four patients, MRI and ultrasound revealed not only herniated discs but also protrusions. In two cases of L5-S1 herniation, a protrusion of the L4-L5 disc was detected; in one case of L4-L5 herniation, a protrusion of the L5-S1 disc was detected; and in another case, a protrusion of the L3-L4 disc was detected.

In total, among 95 discs, 19 children were diagnosed with 19 herniations and 4 protrusions using MRI, and 18 herniations and 5 protrusions using ultrasonography (Table 2).

Type of degenerative disc disease	MRI	US
Protrusion	4 (4.2 ± 2.0%)	5 (5.3 ± 2.3%)
Hernia	19 (20.0 ± 4.1%)	18 (18.9 ± 4.0%)
Total number of examined lumbar discs	n = 95	

Table 2: *The number of detected protrusions and herniations of lumbar intervertebral discs using MRI and ultrasonography.*

Median hernia localization was recorded in 8 (8.4 ± 2.8%) discs, paramedian - in 9 (9.5 ± 3.0%) discs, and posterolateral - in 2 (2.1 ± 1.5%) discs, respectively. In one case, a posterolateral hernia was assessed as a protrusion by ultrasonography (Table 3). As can be seen from table 3, with MRI and ultrasonography, median and paramedian hernias were registered reliably ($P < 0.05$; $P < 0.01$) more often than posterolateral hernias.

The type of hernia		MRI	Ultrasonography
1	Median	8 (8.4 ± 2.8%) P 2-3< 0,05	8 (8.4 ± 2.8%) P 2-3< 0,05
2	Paramedian	9 (9.5 ± 3.0%) P 2-3< 0,05	9 (9.5 ± 3.0%) P 2-3< 0,01
3	Posterolateral	2 (2.1 ± 1.5%)	1 (1.1 ± 1.1%)

Table 3: *The level of localization of the hernia inside of lumbar spine canal by MRI and ultrasonography.*

Degenerative changes in the intervertebral discs were as follows:

1. Increased echogenicity and heterogeneity of the nucleus pulposus;
2. Displacement of the nucleus pulposus;
3. The appearance of hyperechoic inclusions in the nucleus pulposus;
4. Increased echogenicity and thinning of the fibrous ring;
5. Protrusion of the fibrous ring by more than 2 mm;
6. Disruption of the fibrous ring;
7. A decrease in the sagittal diameter of the central spinal canal and the spinal nerve canal.

In all cases of lumbar disc herniation, changes were recorded within the nucleus pulposus and the fibrous ring with uneven thinning and protrusion, accompanied by its intermittent visualization, as well as a decrease in the size of the spinal canal or spinal nerve canal.

The greatest similarity between ultrasound and MRI images was observed on axial T1-weighted MRI slices. In images obtained by both methods, strong signals from dense structures were light, while those from soft structures were dark. At the level of the umbilicus, the L3-L4 disc was visualized, above the umbilicus - L2-L3 and L1-L2, and below - L4-L5 and L5-S1, respectively. Ultrasound and MRI show the nucleus pulposus in the center of the intervertebral disc, with the annulus fibrosus surrounding it. Both have a uniform structure without additional signals (Figure 1-4).

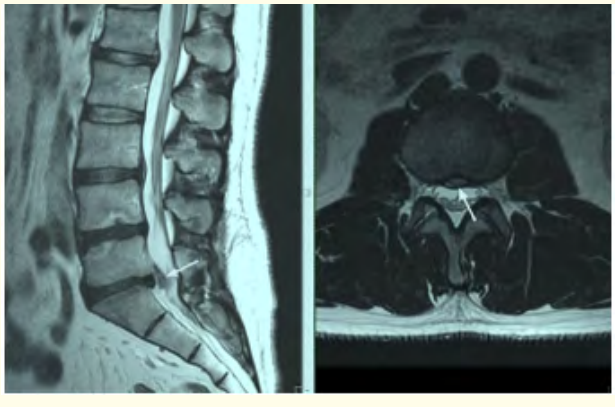

Figure 1: *MRI sagittal and axial scan of the lumbar spine. The arrow shows the median L5-S1 herniation.*

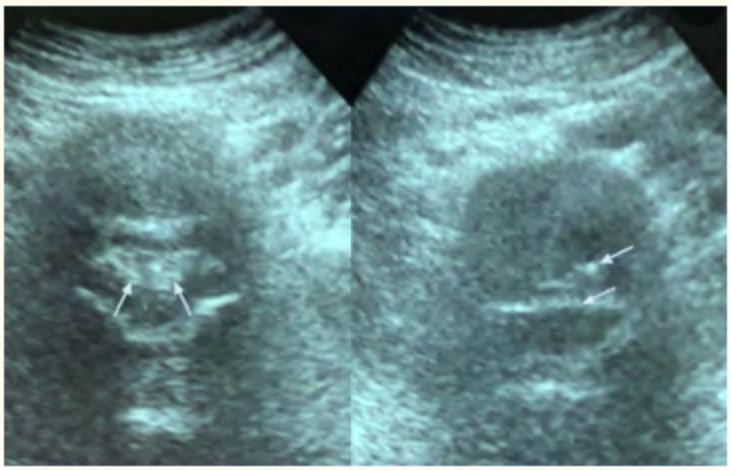

Figure 2: *Axial ultrasonograms of the same patient. On the right side of the screen, the arrows indicate a median herniation of L5-S1. Significant degenerative changes in the nucleus pulposus are visible. On the left side of the screen, the lower arrow indicates the posterior horizontal contour of L4-L5, and the upper arrow indicates small focal localized degeneration of the nucleus pulposus.*

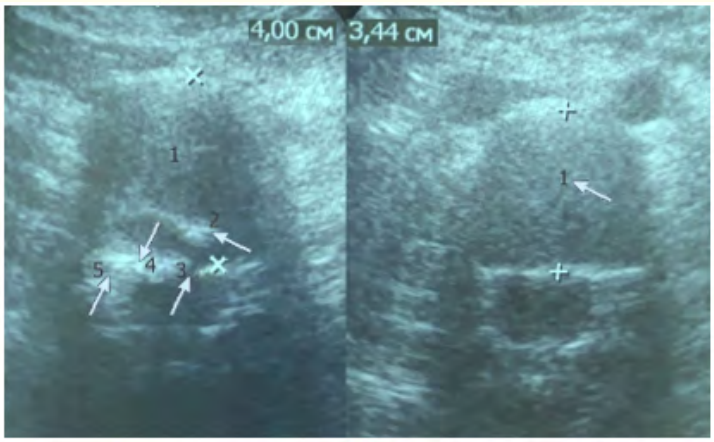

Figure 3: *Axial ultrasonograms of the lumbar intervertebral discs of a 17-year-old wrestler. On the right side of the screen, arrow 1 shows the central part of the nucleus pulposus L5-S1, arrow 2 - disc calcification near the fibrous ring, arrow 3 - rupture of the fibrous ring, arrow 4 - a large right-sided paramedian-posterolateral herniation, arrow 5 - stenosis of the right spinal nerve canal. On the left side of the screen, a normal disc L4-L5 is visualized. The anteroposterior dimension of L5-S1 is 40 mm, and L4-L5 is 34 mm.*

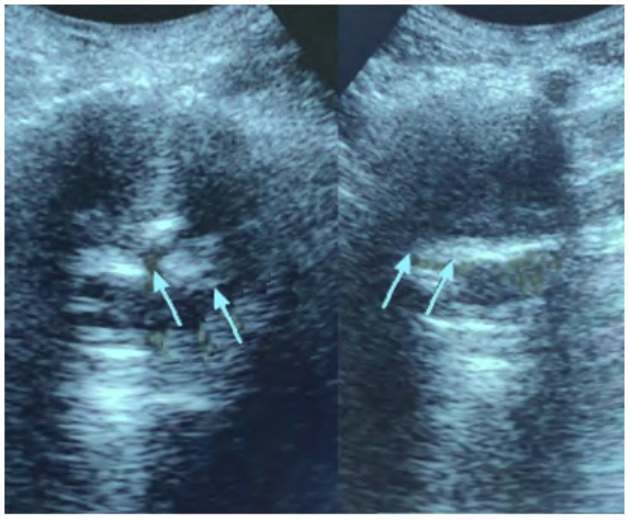

Figure 4: *Axial ultrasonograms of the lumbar intervertebral discs of a 17-year-old patient who has been lifting weights since the age of 11. On the right side of the screen, the left arrow shows a rupture of the fibrous ring, and the right arrow shows a left-sided paramedian herniation of L5-S1. On the left side of the screen, the arrows show a right-sided protrusion of L4-L5.*

Discussion

Progression of disc degeneration, coupled with prolonged spinal overload, ultimately leads to rupture of the annulus fibrosus and the formation of a disc herniation. According to Fjeld OR., *et al*. (2019), lumbar disc herniation occurs twice as often in men as in women [12].

Numerous factors contribute to decreased proteoglycan production, which leads to disc dehydration, increasing stress on the annulus fibrosus, which in turn leads to ruptures and fissures, and, as a consequence, disc herniation. Therefore, when the disc is exposed to repeated mechanical stress, symptoms gradually develop, eventually becoming chronic [13]. On the other hand, axial loading places a large biomechanical stress on a healthy disc, which can lead to extrusion of disc material through a rupture of the annulus fibrosus. These injuries usually result in severe acute symptoms [14].

Low back pain due to lumbar spondylolysis in adolescent athletes is a common condition, and epidemiological studies have shown that the incidence is significantly higher in young athletes (8.8% - 47%) compared to the general population (4.4% - 6%). Most lumbar spondylolysis in adolescent athletes is considered to be stress fractures in the intervertebral disc [15].

In recent years, platelet-rich plasma has become an important therapeutic intervention for the treatment of lumbar pain associated with degenerative disc disease. Recent studies have demonstrated the clinical efficacy of these agents due to their anti-inflammatory properties [16]. Treatment can be highly effective in the early stages of degenerative disc disease, while degeneration is still confined to the nucleus pulposus. Therefore, timely diagnosis is essential. As is known, X-rays are perceived by discs as intervertebral space, and MRI is an expensive method. In recent years, ultrasonography has been widely used to determine the causes of low back pain [10].

Our examinations show that the quality of axial ultrasound images in children is comparable to that obtained with MRI. Even with ultrasonography, small focal degenerations in the nucleus pulposus are more clearly visible. Posterolateral disc herniations are less visible

with ultrasonography, but they are significantly less common than median and paramedian disc herniations. Currently, some portable devices produce high-quality images comparable to those obtained with stationary devices. This allows for screening for childhood osteochondrosis, even in schools, long before overt clinical symptoms appear, when a disc herniation with spinal nerve compression has already formed.

Ethics Statement

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

Conclusion:

1. Ultrasonography is as effective as magnetic resonance imaging in diagnosing lumbar disc herniations in older school-aged children. Only in interpreting paramedian and median herniation locations is there a slight difference between the two methods.
2. In high school aged children in the lumbar spine, median and paramedian hernia are most commonly found, which are most often localized at the level of both L4-L5 and L5-S1.
3. Ultrasonography can be used to screen children with low back discomfort or pain to detect lumbar disc degeneration in its early stages.

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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