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Ultrasonographic diagnosis of lumbar disc protrusion in adolescents: comparison with MRI results

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The intervertebral disc (IVD) is a fibrocartilage structure, the main function of which is to mitigate the load that occurs between the vertebral bodies, as well as to provide flexibility. It consists of 3 main structures: pulpal nucleus (PN), fibrous ring (FR) and cartilaginous closing plate. IVD differs from other connective tissues of the body in that age-related changes (aging) develop in it at an earlier age. Age-related changes in IVD, indicating the onset of degeneration, are observed in adolescents aged 11 years, as evidenced by histological studies [8, 15].

PN is a gel-like structure that is located in the center of the IVD and provides flexibility to the spine. It consists of 66-86 % water, mainly type II collagen. FR is a disc of fibrous connective tissue in the form of a ring that surrounds the PN. It is a 15-25 stacked sheets with a "radial layer" of collagen, proteoglycans, glycoproteins and elastic fibers. The total content of proteoglycans in IVD decreases with age, which leads to a decrease in its hydrophilicity, as well as to changes in the biomechanical properties of the fibers. Type II collagen is replaced by type I collagen fibers within FR and PN. Yellow pigmentation accumulates in PN, which also makes it less distinct from FR [13].

Disc degeneration begins with dehydration of the PN, which leads to an increase in pressure on the FR. The resistance of FR to compression forces by PN increases its stiffness and reduces elasticity. Excessive stress reduces IVD homeostasis. Imbalance in anabolic and catabolic processes often leads to an inflammatory reaction, which further contributes to the development of degenerative phenomena [9].

It is known, there is another reason to waste human working hours on the back because of the infection of the upper dickheads. There will be 5 million young people with disabilities through osteochondrosis.

Back pain is known to be the second leading cause of lost work time after an upper respiratory tract infection. More than 5 million young people are disabled due to osteochondrosis. The L5-S1 spine segment is the most common site of low back pain. Due to the range of movements and forces acting on this segment, degenerative processes develop and progress in it more often [4]. Magnetic resonance imaging (MRI) revealed degenerative changes in girls less than 20 years of age with lower back pain. After 10 years, at re-examining the progression of the degenerative process was found in 31 % of patients [7].

The results of MRI [11] suggest the following sequence of changes in IVD, indicating its degeneration: (1) decrease and/or change in signal intensity from PN; (2) loss of the difference between PN and FR; (3) convexity of the disc; (4) reduction of the disk height.

Along with MRI, which is the main method of IVD imaging, ultrasound (US) may be an appropriate alternative, considering its low cost, availability and well-known recognition of the possibility to obtain high-quality soft tissue images [2, 3].

The purpose of the study is to compare the diagnostic capabilities of ultrasonography (USG) and MRI in determining the localization of lumbar IVD protrusion in adolescents.

Material and investigation methods

A comparative analysis of USG and MRI results obtained in 74 adolescent patients with IVD protrusion of the lumbar spine. Among investigated persons were 25 girls

and 39 boys aged 17 to 21. All patients complained of lower back pain. During the examination by a neurologist, some clinical signs of osteochondrosis were found. Patients with a history of spinal injuries. with spinal pathologies according to radiological examination and the presence of low back pain were not included in the study. USG of the lumbar spine was performed at levels L1-L2 to L5-S1 in sagittal and axial projections. In the sagittal slice, the height of the IVD was measured, the condition of the apophyseal zones was assessed, in the axial section – the structures of the discs and spinal canal, the nature of disc changes and protrusion location were determined.

At the level of the lumbar discs USG was performed with a convex probe (2-5 MHz) on a Philips HD-11. MRI was performed on a Magnetom Aera 1.5T according to standard study protocols.

Results and discussion

According to the results of MRI in 1 (1.4±1.4 %) case protrusion was localized at the level of L1-L2, in 5 (6.7±2.9 %) – at the level of L2-L3, in 16 (21.6±4.8) – at the level of L3-L4, in 27 (36.5 ± 5.6%) – at the level of L4-L5 and in 25 (33.8±5.5 %) cases – at the level of L5-S1. Lumbar disc protrusion at the levels L4-L5 and L5-S1 occurs significantly more often than at the level L3-L4 ($p < 0.05$) and L2-L3 ($p<0.001$) (Table 1).

Table 1.

Distribution of MRI and USG results for the diagnosis of protrusion considering the level of lumbar intervertebral discs.

Level of lumbar disks	Disc protrusion (n=74)	
	MRI n =74	USG n =72
L1-L2	1 (1,4 ± 1,4 %)	1 (1,4 ± 1,4 %)
L2-L3	5 (6,7 ± 2,9 %)	5 (6,8±2,9 %)
L3-L4	15 (20,3 ± 4,6 %)	15 (21,6±4,8 %)
L4-L5	27 (36,5 ± 5,6 %)	26 (35,1±5,5 %)
L5-S1	26 (35,1 ± 5,5 %)	24 (32,4 ± 5,4 %)

Coincidence of MRI and USG results was noted in 72 (97.3 %) cases. In two patients USG picture of protrusion L4-L5 and L5-S1 was interpreted as a possible hernia, since the fragmentary image of the refined FR was registered (Table 1).

According to the results of MRI, the central localization of lumbar disc protrusion was registered in 31 (41.9±5.7 %), paramedial – in 29 (39.2±5.7 %) and foraminal – in 14 (18.9±4.5 %) cases. On US, protrusion was assessed as medial in 30 (40.5±5.6 %), paramedial – in 28 (37.8±5.6 %) and foraminal – in 14 (18.9±4.5 %) patients. In one case, medial protrusion at USG was regarded as paramedial, in another case, paramedial protrusion – as foraminal. In one case, paramedial protrusion at the level of L4-L5 and foraminal at the level of L5-S1 at USG was assessed as a disc herniation (Table 2).

Table 2.

Localization of lumbar disc protrusion inside the spinal canal according to MRI and USG.

Localization of protrusion	Disc protrusion (n=74)	
	MRI (n=74)	USG (n=72)
Medial	31 (41,9± 5,7 %)	30 (40,5± 5,6 %)
Paramedial	29 (39,2± 5,7 %)	28 (37,8± 5,6 %)
Foraminal	14 (18,9± 4,5 %)	14 (18,9± 4,5 %)

The most correct comparison of MRI and USG results is observed on axial slices. For this purpose, T1 MRI images are better suited, as strong signals from different structures of the vertebromotor segment are registered in light, and weak – in dark tones. Lumbar discs were visualized with convex probes (2-5 MHz) through the anterior abdominal wall. At the navel level, the L3-L4 disk was visualized, above the navel – L2-L3 and L1-L2, and below – L4-L5 and L5-S1, respectively. At USG and MRI in the center of IVD PN is visible, behind its perimeter – FR. Both have a homogeneous structure without additional signals (Fig. 1-3).

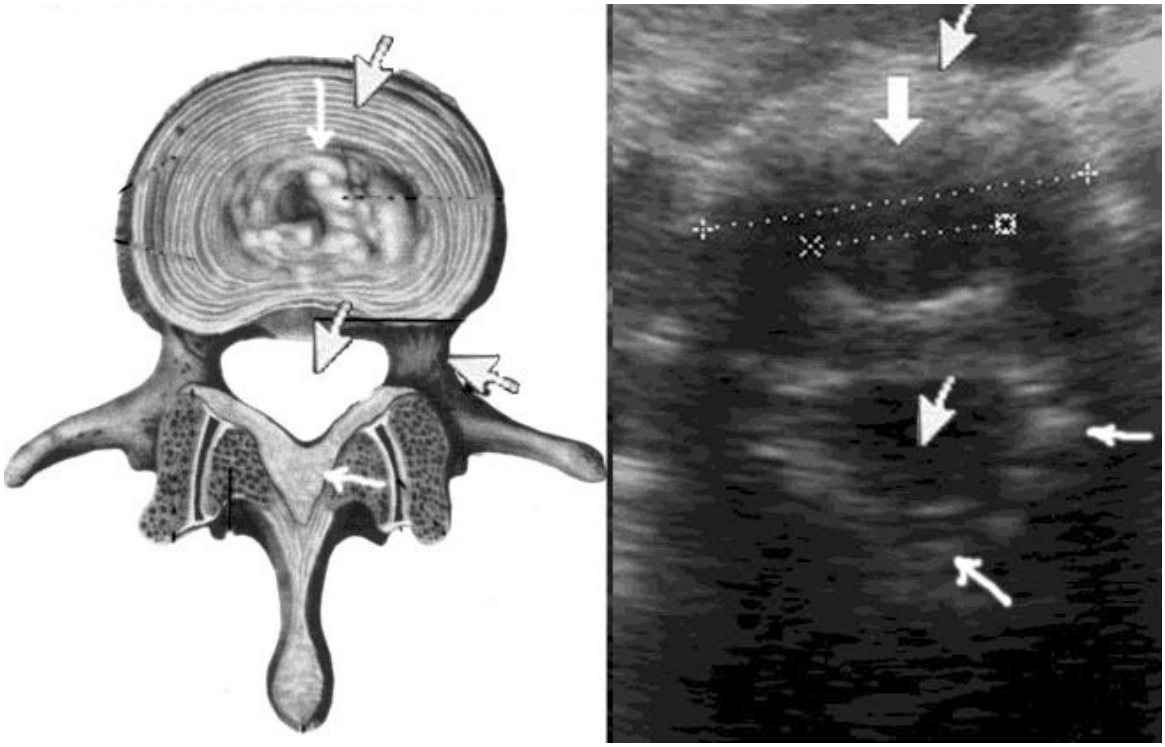

Fig. 1. *Schematic and USG image of the lumbar disc L3-L4. The arrows from top to bottom show: fibrous ring, pulpal nucleus, spinal cord, spinal nerve (lateral arrow), yellow ligament.*

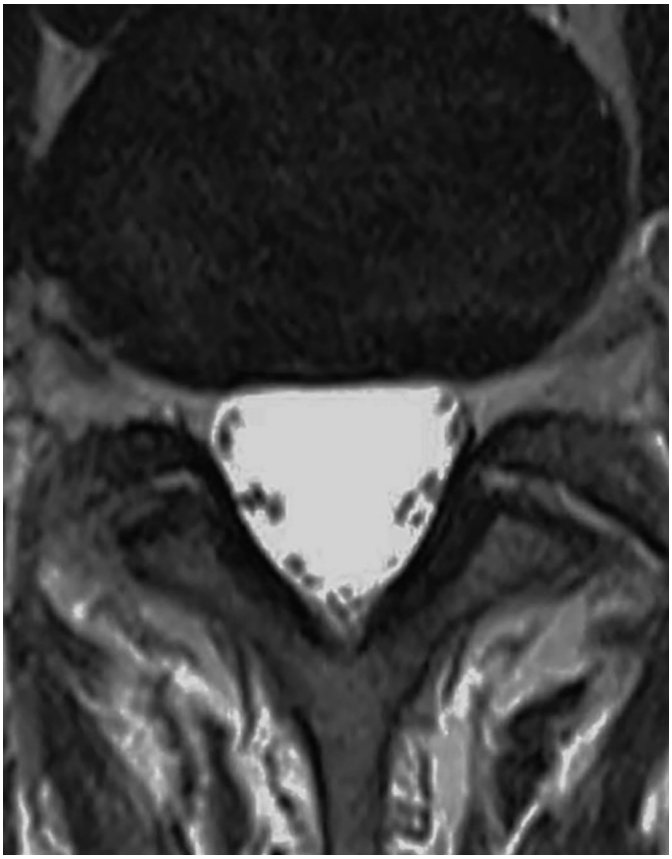

Fig. 2. *MRI image of the normal lumbar disc L4-L5.*

Fig. 3. *The same. USG image of a normal lumbar disc L4-L5.*

Table 3.
Indicators of degenerative disk changes of according to MRI and USG.

Indicators of degenerativedisk changes	**MRI (n=74)**	**USG (n=72)**
Enhancement of signals (or increase of echogenicity) from PN	61 (82,4 ± 4,4 %)	56 (77,8 ± 4,9%)
PN microcalcification	32 (43,2 ± 5,8 %)	35 (48,6 ± 5,7 %)
PN displacement towards FR	31 (41,9 ± 5,7 %)	43 (59,7±5,6 %) p<0,05
FR thinning	56 (75,7 ± 5,9 %)	53 (73,6±5,3 %)
Reduction of spinal channel sagittal size	17 (23,0±4,9 %)	18 (25,0±5,1 %)

In the comparative assessment of degenerative changes of the discs by MRI and USG we took into account: 1) echogenicity of PN; 2) presence of calcification areas and their size; 3) shift of hyperechoic PN towards FR; 4) thinning of FR; 5) narrowing of the spinal canal on the protrusion side (Table 3).

Amplification of signals (or increase in echogenicity) from PN was detected on MRI in 61 (82.4±4.4 %), on USG – in 56 (77.8±4.9 %) cases; calcification of PN – in 32 (43.2±5.8 %) and 35 (48.6 ± 5.7%); displacement of hyperechoic PN – in 31 (41.9±5.7 %) and 43 (59.7±5.6 %) (p<0.05); thinning of FR – in 56 (75.7±5.9 %) and 53 (73.6±5.3 %); reduction of the sagittal size of the spinal canal – in 17 (23.0±4.9 %) and 18 (25.0±5.1 %) cases, respectively. On MRI and USG, protrusion of the disc toward the spinal canal or spinal nerve root canal more than 2 mm without violation of the integrity of the FR image from the conditional demarcation line between the posterior disc contour and spinal canal was the main sign of disc protrusion (Fig. 4-8).

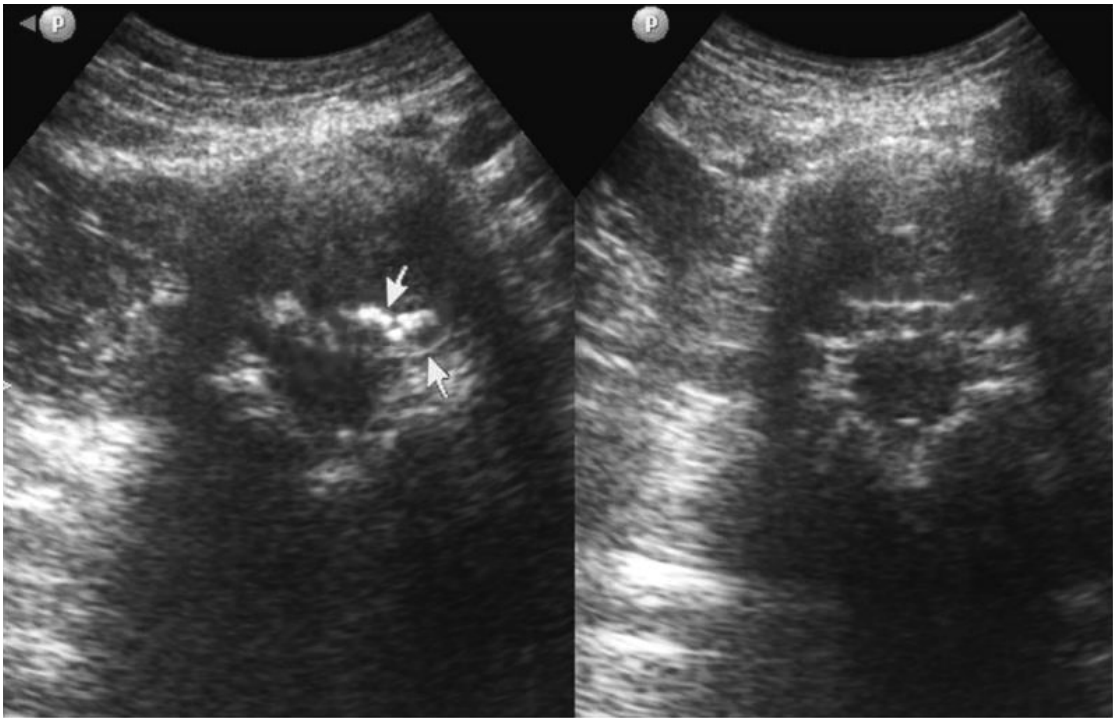

Fig. 4. *USG-visualization of L5-S1protrusion. Displacement of the hyperechoic pulpal nucleus posteriorly (upper arrow), thinning and left paramedial-foraminal protrusion of the fibrous ring together with the disc (on the left). The unaltered disk L3-L4 is visualized on the right.*

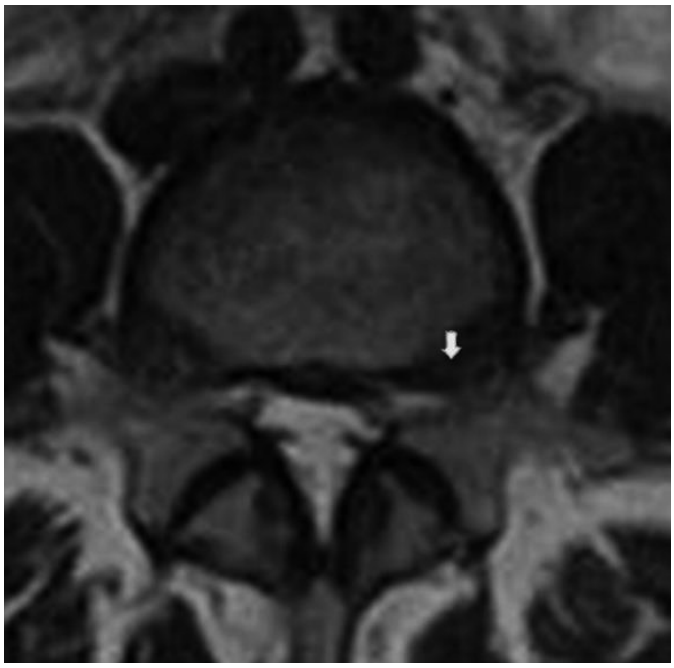

Fig. 5. *MRI visualization of the L4-L5 left-side paramedial-foraminal protrusion (arrow).*

Fig. 6. *The same. USG-visualization of the L4-L5 left-side paramedial-foraminal protrusion (arrow).*

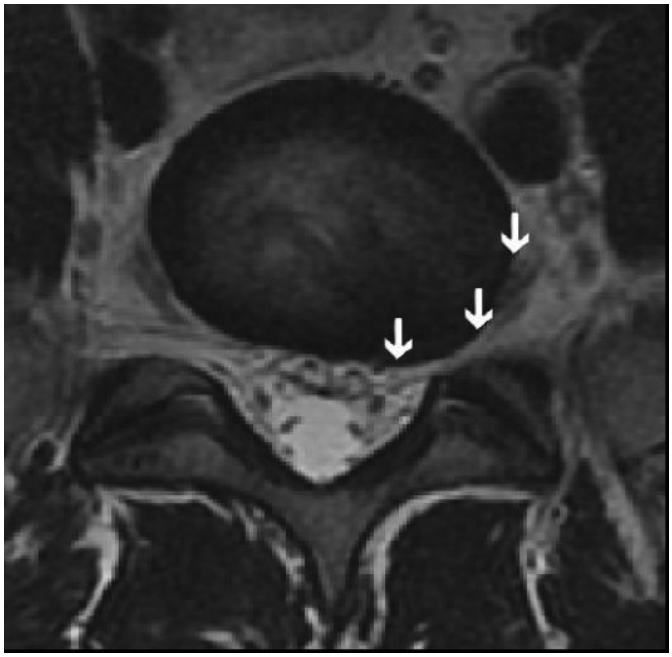

Fig. 7. *Axial MRI image. Left-side foraminal protrusion of the disc L5-S1 (arrows).*

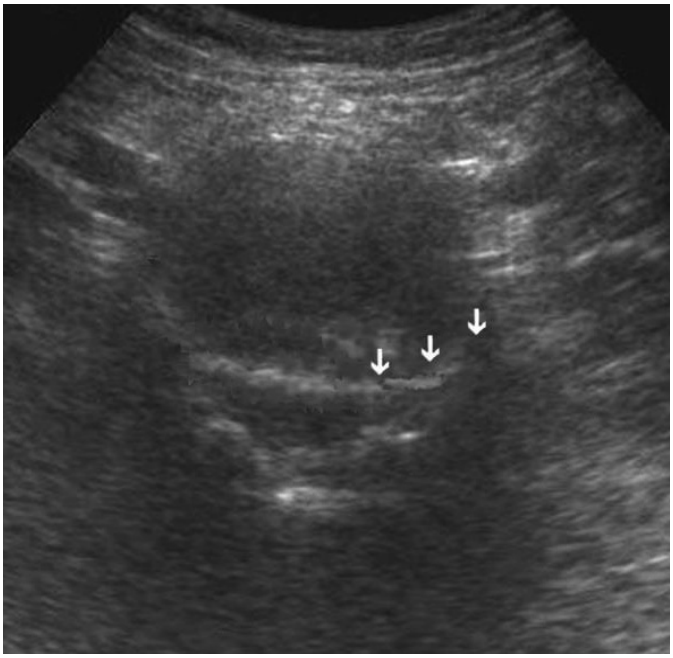

Fig. 8. *The same. Axial USG image. Left-side foraminal protrusion of the disc L5-S1 (arrows).*

As the most common method of radiological diagnosis, X-ray allows to assess mainly bone structures, but does not visualize IVD, spinal cord, spinal nerves and ligaments. Currently, MRI is the main diagnostic method of degenerative changes in IVD. It should be noted that high-frequency microconvex probes provide a high-quality image of the motor segment of the spine.

Studies [1, 14] conducted with MRI in the athletes who participated in the Summer Olympic Games demonstrated a high in-

cidence of degenerative changes in lumbar IVD. The clinical significance of these studies suggests that Olympic athletes have more severe lumbar spine osteochondrosis than non-athletes, who may have long-term signs of early degenerative changes in the discs, namely pain, vertebral instability, neurological disorders [1, 14]. Previously published scientific studies indicate a high frequency of degenerative changes L4-5 and L5-S1 in athletes. This is due to the high intensity of training, the presence of a large axial load on these parts of the spine [12].

Literature analysis on the ultrasound application for the diagnosis of spinal pathologies demonstrates that so far there are very few publications on this topic in peer-reviewed journals [6]. Most of the publications are devoted to the ultrasound imaging of the spine in newborns, the use of ultrasound for navigation and administration of drugs at chronic back pain [10].

Our investigations demonstrated that discs L3-L4, L4-L5, L5-S1 most often undergo degenerative changes. At the L3-L4, L4-L5 level, the image quality of the discs with high-frequency microconvex probe was better than with MRI. In obese patients, the image of the discs was slightly worse than in thin patients.

Conclusion

USG is a cheap, non-invasive and informative method of primary screening in young patients with back pain, and this study can be applied to diagnose degenerative lumbar disc disease along with MRI, especially when it is not available.

The research was conducted in accordance with the principles of bioethics set out in the WMA Declaration of Helsinki – "Ethical principles for medical research involving human subjects" and "Universal Declaration on Bioethics and Human Rights" (UNESCO).

Conflict of interest information. The authors declare no conflicts of interest related to the publication of this article.

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ULTRASONOGRAPHIC DIAGNOSTIC OF LUMBAR DISC PROTRUSION IN ADOLESCENTS: COMPARISON WITH MRI RESULTS

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Degenerative changes in the discs begin already in childhood, as evidenced by histological studies.

Purpose – to compare the diagnostic capabilities of US and MRI in identifying and determining the localization of protrusion of the lumbar intervertebral discs in adolescents.

Materials and methods. The study involved 74 patients with protrusion of the lumbar intervertebral discs aged 17-21 years: 25 (33.8 %) girls and 39 (66.2 %) boys. All patients complained of pain in the lower back, and when examined by a neuropathologist, some clinical signs of osteochondrosis were revealed. USG of the lumbar spine was performed with a convex transducer with a frequency of 2-5 MHz at levels from L1-L2 to L5-S1 in sagittal and axial projections. MRI was performed on a Magnetom Aera 1.5T apparatus with standard research protocols.

Results. According to the results of MRI at the L4-L5 level, protrusion was localized in 27 (36.5 ± 5.6%) cases, at the level of L5-S1 – in 26 (35.1 ± 5.5 %) cases – significantly (P <0, 05) more often than at the level of L3-L4, L2-L3 i L1-L2 (P <0.001), respectively. The coincidence of the results of MRI and USG took place in 72 (97.3 %) cases. In two cases of USG, the picture of L4-L5 and L5-S1 protrusion was interpreted as a hernia.

According to the results of MRI, medial localization of disc protrusion was recorded in 31 (41.9 ± 5.7 %) cases, paramedial – in 29 (39.2 ± 5.7 %), and foraminal – in 14 (18.9 ± 4.5 %) cases, and with USG – in 30 (40.5 ± 5.6%), 28 (37.8 ± 5.6 %) and 14 (18.9 ± 4.5 %) cases, respectively.

Strengthening of signals (or increased echogenicity) of the nucleus pulposus (NP) was detected on MRI in 61 (82.4 ± 4.4 %) cases, on USG in 56 (77.8 ± 4.9 %) cases; calcification of the NP in 32 (43.2 ± 5.8 %) and 35 (48.6 ± 5.7%); mixing of hyperechogenic NP - in 31 (41.9 ± 5.7 %) and 43 (59.7 ± 5.6%) cases (P <0.05); FR thinning – in 56 (75.7 ± 5.9 %) and 53 (73.6 ± 5.3 %) cases; decrease in the sagittal size of the spinal canal – in 17 (23.0 ± 4.9 %) and 18 (25.0 ± 5.1 %) cases, respectively.

Conclusion. USG is a cheap, non-invasive and informative method for the initial examination of adolescent patients with back pain, and it can also be used to diagnose degenerative disc disease of the lumbar spine along with MRI, especially in cases where the use of the latter is not available.

USG can be an alternative method for diagnosing lumbar disc protrusion.

Keywords: Spine, Sonography, MRI, lumbar Disc Degeneration, protrusion.

УЛЬТРАСОНОГРАФІЧНА ДІАГНОСТИКА ПРОТРУЗІЇ ПОПЕРЕКОВОГО ДИСКА У ПІДЛІТКІВ: ЗІСТАВЛЕННЯ З РЕЗУЛЬТАТАМИ МРТ

Р.Я. Абдуллаєв, І.Г. Мамедов

Дегенеративні зміни в міжхребцевих дисках (IVD) починаються вже у дитячому віці, про що свідчать результати гістологічних досліджень.

Мета дослідження – порівняти діагностичні можливості ультрасонографії (УСГ) та магнітно-резонансної томографії (МРТ) у визначенні локалізації протрузії поперекових міжхребцевих дисків в осіб юнацького віку.

Матеріали і методи. Обстежено 74 осіб з протрузією поперекових IVD віком від 17 до 21 року: 25 (33,8 %) дівчат та 39 (66,2 %) хлопців. Усі пацієнти скаржилися на біль у нижній частині спини, під час огляду невропатологом у них було виявлено деякі клінічні ознаки остеохондрозу. УСГ поперекового відділу хребта проведено конвексним датчиком з частотою 2-5 МГц на рівнях від L1-L2 до L5-S1 у сагітальній та аксіальній проекціях. МРТ виконувалася на апараті Magnetom Aera 1,5T відповідно до стандартних протоколів дослідження.

Результати. За результатами МРТ на рівні L4-L5 протрузія локалізувалася у 27 (36,5±5,6 %) випадках, на рівні L5-S1 – у 26 (35,1±5,5 %), причому достовірно ($p<0,05$) частіше, ніж на рівні L3-L4 (у 15 (20,3±4,6 %) пацієнтів), L2-L3 і L1-L2 ($p<0,001$) відповідно. Збіг результатів МРТ та УСГ відзначався у 72 (97,3%) випадках. У двох випадках УСГ картина протрузії L4-L5 і L5-S1 трактувалася як грижа.

За результатами МРТ медіальна локалізація протрузії диска реєструвалася у 31 (41,9 ± 5,7 %) випадку, парамедіальна – у 29 (39,2 ± 5,7 %) та форамінальна – у 14 (18,9 ± 4,5 %) , а при УСГ – у 30 (40,5±5,6 %), у 28 (37,8±5,6 %) та у 14 (18,9±4,5 %) пацієнтів відповідно.

Посилення сигналів (або підвищення ехогенності) від пульпозного ядра (PN) виявлено на МРТ-зображенні у 61 (82,4±4,4 %), на УСГ – у 56 (77,8±4,9 %) випадках; кальцифікація PN – у 32 (43,2±5,8 %) та у 35 (48,6±5,7 %); зміщення гіперехогенного PN – у 31 (41,9±5,7 %) та 43 (59,7±5,6 %) ($p<0,05$); стоншення фіброзного кільця – у 56 (75,7±5,9 %) та 53 (73,6±5,3 %); зменшення сагітального розміру хребетного каналу – у 17 (23,0±4,9 %) та у 18 (25,0±5,1 %) відповідно.

Висновки. УСГ є дешевим, неінвазивним та інформативним методом первинного обстеження пацієнтів юнацького віку з болем у спині, також це дослідження може бути використане для діагностики дегенеративної хвороби дисків поперекового відділу хребта поряд з МРТ, особливо у випадках, коли застосування останнього недоступне.

Ключові слова: хребет, ультрасонографія, магнітно-резонансна томографія, дегенерація диска поперекового відділу, протрузія.

УЛЬТРАСОНОГРАФИЧЕСКАЯ ДИАГНОСТИКА ПРОТРУЗИИ ПОЯСНИЧНОГО ДИСКА У ПОДРОСТКОВ: СОПОСТАВЛЕНИЕ С РЕЗУЛЬТАТАМИ МРТ

Р.Я. Абдуллаев, И.Г. Мамедов

Дегенеративные изменения в дисках начинаются уже в детском возрасте, о чем свидетельствуют результаты гистологических исследований.

Цель исследования – сравнить диагностические возможности ультрасонографии (УСГ) и магнитно-резонансной томографии (МРТ) в определении локализации протрузии поясничных межпозвонковых дисков (МПД) у лиц юношеского возраста.

Материалы и методы. Обследованы 74 пациента с протрузией поясничных МПД

в возрасте от 17до 21 года: 25 (33,8 %) девушек и 39 (66,2 %) парней. Все пациенты жаловались на боль в нижней части спины, при осмотре невропатологом у них были выявлены некоторые клинические признаки остеохондроза. УСГ поясничного отдела позвоночника проведена конвексным датчиком с частотою 2-5 МГц на уровнях от L1-L2 до L5-S1 в сагиттальной и аксиальной проекциях. МРТ выполнялась на аппарате Magnetom Aera 1,5T в соответствии со стандартными протоколами исследования.

Результаты исследования. По результатам МРТ на уровне L4-L5 протрузия локализовалась в 27 (36,5±5,6 %) случаях, на уровне L5-S1 – в 26 (35,1±5,5 %) достоверно ($p<0,05$) чаще, чем на уровне L3-L4, L2-L3 и L1-L2 ($p<0,001$) соответственно. Совпадение результатов МРТ и УСГ отмечалось в 72 (97,3 %) случаях. В двух случаях УСГ картина протрузии L4-L5 и L5-S1 трактовалась как грыжа.

По результатам МРТ медиальная локализация протрузии диска регистрировалась в 31 (41,9 ± 5,7%) случае, парамедиальная – в 29 (39,2 ± 5,7 %) и фораминальная – в 14 (18,9 ± 4,5 %), а при УСГ – у 30 (40,5±5,6 %), 28 (37,8±5,6 %) и 14 (18,9±4,5 %) пациентов соответственно.

Усиление сигналов (или повышение эхогенности) пульпозного ядра (PN) выявлено на МРТ в 61 (82,4±4,4 %), на УСГ – в 56 (77,8±4,9 %) случаях; кальцификация PN – в 32 (43,2±5,8 %) и в 35 (48,6±5,7 %); смещение гиперехогенного PN – в 31 (41,9±5,7 %) и в 43 (59,7±5,6 %) ($p<0,05$); истончение фиброзного кольца – в 56 (75,7±5,9 %) и в 53 (73,6±5,3 %); уменьшение сагиттального размера позвоночного канала – в 17 (23,0±4,9 %) и в 18 (25,0±5,1 %) соответственно.

Выводы. УСГ является дешевым, неинвазивным и информативным методом первичного обследования пациентов юношеского возраста с болями в спине, также это исследование может быть использовано для диагностики дегенеративной болезни дисков поясничного отдела позвоночника наряду с МРТ, особенно в случаях, когда использование последнего недоступно.

Ключевые слова: позвоночник, ультрасонография, магнитно-резонансная томография, дегенерация поясничного диска, протрузия.