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ORIGINAL ARTICLE

# Assessment of the possibilities of B-Mode ultrasonography in the diagnosis of cervical intervertebral discs hernia in adolescents

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## ABSTRACT

**Objective:** To improve the efficiency of cervical intervertebral discs hernia by determining the ultrasound biomarkers.

**Materials and Methods:** The study included 38 healthy adolescents with normal intervertebral discs and neurologic status and 21 person with the disc hernia. Ultrasonography (USG) was performed at the level of disks C2-C3, C3-C4, C4-C5, C5-C6, C6-C7, C7-Th1 in longitudinal and transverse projections. In axial section was performed the sagittal intervertebral disc and spinal canal sizes, the anterior dural space size, the width of spinal nerve canals.

**Results:** In 9 (42.9 ± 10.8% ) cases, the hernia was localized at the level of C5-C6, in 7 (33.3 ± 10.3%) - C4-C5, in 2 (9.5 ± 6.4%) - at the level of C2-C3 and C6-C7 C7, in 1 (4.8 ± 4.7%) – at the level of C3-C4 respectively. In 13 (61.9 ± 10.6%) cases the hernia had paramedian, in 5 (23.8 ± 9.3%) cases – median, in 3 (14.3 ± 7.6) cases – posterolateral localization. The paramedian hernia was significantly more frequently recorded than the posterolateral (P<0,05) and median hernia (p <0.001).

**Conclusions:** In adolescents in the cervical spine, paramedian hernia are most commonly found, which are most often localized at the level of both C5-C6 and C4-C5. The greatest narrowing and deformation of the spinal nerve canal is observed by posterolateral and paramedian hernia, dural space–by median hernia respectively..

***Keywords**: cervical intervertebral discs hernia; spinal canal; ultrasound diagnostics; adolescents*

## Introduction

Cervical degenerative disc disease is a common cause of neck pain and radiating arm pain. It develops when one or more of the cushioning discs in the cervical spine starts to break down due to wear and tear. There may be a genetic component that predisposes some people to more rapid wear. Injury may also accelerate and sometimes cause the development of the degenerative changes. In children, the discs are about 85% water. The discs begin to naturally lose hydration during the aging process. Some estimates have the disc's water content typically falling to 70% by age 70, but in some people the disc can lose hydration much more quickly. As the disc loses hydration, it offers less cushioning and becomes more prone to cracks and tears[1].

A herniated disc in the neck can cause severe pain and symptoms that disrupt a person's quality of life. However, most symptomatic herniated discs end up resolving on their own. Some studies indicate that cervical radiculopathy from a herniated disc can to start feeling better within 4 to 6 weeks, although some symptoms may last up to 6 months, and more than 80% of cases are symptom-free within 2 to 3 years. When cervical radiculopathy is caused by a herniated disc, the pain can be even worse than when it is caused by a cervical osteophytes (bone spur) or bony overgrowth. This is because when a disc herniates, its inner layer (nucleus pulposus) contains inflammatory proteins that can leak all the way onto the sensitive nerve root. The chemical reaction that is created when these proteins flow onto the nerve root can cause both pain and damage[2].


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Studies show that a plurality of adults have no symptoms related to degenerative disc disease, even though a high percentage of these adults still shows signs of disc degeneration on an MRI somewhere on the spine. One study found that about half of people start showing some signs of disc degeneration on an MRI by their early 20s[3].

When degenerative disc disease develops in the cervical spine, it can occur in any of the cervical discs but is slightly more likely to occur at the C5-C6 level[4]. A small-sample study examining the cervical spine in symptom-free volunteers has found focal disc protrusions in 50% of participants, which suggests that a considerable part of the population can have focal herniated discs in their cervical region that do not cause noticeable symptoms[5].

Traditional plain X-rays does not allow visualizing intervertebral discs, ligamentous apparatus of the spinal column. Currently, magnetic resonance imaging (MRI) is the main method of visualization of intervertebral discs, ligamentous apparatus, spinal cord however, considering the lower costs, accessibility, high resolution and real-time imaging, the ultrasonography can be the relevant alternative for screening[6–8].

Ultrasound is usually most effective with tissues that have high collagen content such as tendons, ligaments, joint capsules, and fascia[9–11]. 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[12–15].

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[16]. In previous studies, the herniated lumbar discs for screening programs in the late childhood and teenage are presented[17]. Development of ultrasound semiotics of the cervical discs hernia is an actual task.

Objective: To improve the efficiency of cervical intervertebral discs hernia by determining the ultrasound biomarkers.

## Materials and Methods

Among 258 children aged 16–18 years, examined for cervicogenic and occipital pain, 21 cases of cervical intervertebral discs hernia, confirmed by magnetic resonance imaging, were detected. All patients had clinical signs of cervical radiculopaty. In the studied persons dominated the occipital localization of pain (83.6%). The pulsating type of pain was observed in 17.9% of patients, bursting - in 62,7%, their combination - in 20.9%.

The results of ultrasonography of intervertebral disks of 21 children with hernias and 38 children without any changes in the discs and complaints were analyzed. Ultrasonography of the cervical spine held on the levels from C2-C3 to C7-Th1.

Changes in intervertebral discs were characterized followed:

- within the nucleus pulpous (NP);
- within the pulpous nucleus and fibrous ring (FC) without disturbing its integrity;
- Violation of the integrity of the fibrous ring with involvement in the pathological process of the spinal canal (SC).

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 anterior dural space or spinal nerve canals.
6) interruptent imaging of the fibrous ring.

In all cases of hernia of cervical discs the changes within the pulpous nucleus, in the fibrous ring (FC) with non-uniform thinning and protrusion, of accompanyed with its interrupting imaging were registered.

## 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 9 (42.9 ± 10.8%) cases, the hernia was localized at the level of C5-C6, in 7 (33.3 ± 10.3%) - C4-C5, in 2 (9.5 ± 6.4%) - at the level of C2-C3 and C6-C7, in 1 (4.8 ± 4.7%) – at the level of C3-C4 respectively (table 1). In 13 (61.9 ± 10.6%) cases the hernia had paramedian, in 5 (23.8 ± 9.3%) cases – median, in 3 (14.3 ± 7.6%) cases – posterolateral localization (table 2). The paramedian hernia was significantly more frequently recorded than the median hernia ($p < 0.05$)

and posterolateral (p <0.001).

Table 1. The cervical intervertebral discs levels with hernia.

| The level of IVD | | Hernia, n = 21 |
|---|---|---|
| 1 | C2-C3 | 2 (9.5 ± 6.4%) |
| 2 | C3-C4 | 1 (4.8 ± 4.7%) |
| 3 | C4-C5 | 7 (33.3 ± 10.3%) |
| 4 | C5-C6 | 9 (42.9 ± 10.8%) |
| 5 | C6-C7 | 2 (9.5 ± 6.4%) |
| 6 | C7-Th1 | - |

Table 2. Localization of hernia in cervical intervertebral discs.

| The type of hernia | | Hernia, n = 21 |
|---|---|---|
| 1 | Paramedian | 13 (61.9 ± 10.6%)<br>P <0.05 |
| 2 | Posterolateral | 5 (23.8 ± 9.3%) |
| 3 | Median | 3 (14.3 ± 7.6%) |

In healthy children without degenerative changes of the intervertebral discs, the anterior dural space on the ultrasonogram looks like a hypo-anechogenous zone with even edges - the anterior contour of which is bordered by the posterior edge of the fibrous ring and the posterior edge by the anterior margin of the spinal cord (Figure 1, 2).

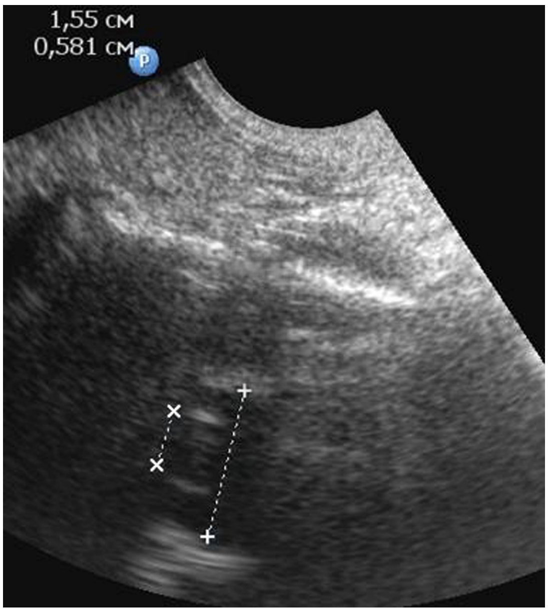



Figure 1

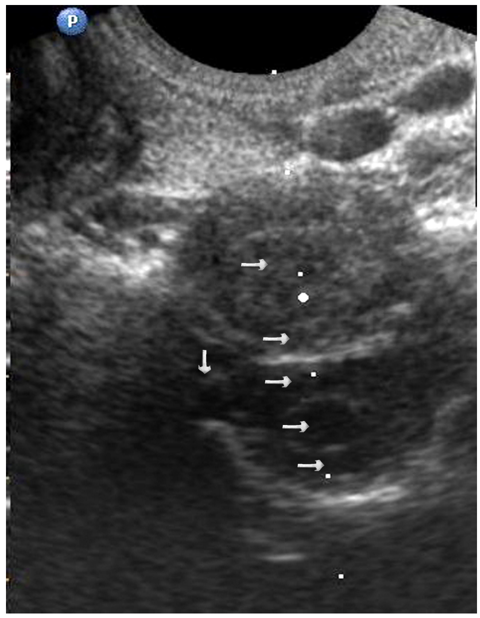


Figure 2

Figure 1. Sagittal section of the spinal motor segment at the level of C4-C5. Closer to the transducer, the front contour of the vertebral bodies looks like hyperechoic linear structures.
Anteroposterior size of the spinal canal is 1.55 cm, the spinal cord is 0.581 cm

Figure 2. Axial section of the IVD and SC. Top-down the horizontal arrows show the nucleus pulposus, fibrous ring, anterior dural space, spinal cord, posterior dural space; the vertical arrow shows the right spinal nerve canal.

The sagittal size of the intervertebral disc (IVD), spinal canal (SC), spinal nerve canal (SNC), the ratio IVD/SC was calculated (Table 3). The sagittal size of the C2-C3 disc in healthy children averaged 16.4 ± 0.9 mm, C3-C4 – 15.9 ± 0.8 mm, C4-C5 – 15.4 ± 0.8 mm, C5-C6 – 15.3 ± 0.7 mm, C6-C7 – 14.9 ± 0.6 mm and C7-Th1 –15.1 ± 0.6 mm respectively. The average sagittal size for all discs is 15.5 ± 0.7 mm.

The sagittal size of the SC at level of the C2-C3 disc in healthy children averaged 17.3 ± 0.8 mm, C3-C4 – 16.8 ± 0.7 mm, C4-C5 – 15.3 ± 0.8 mm, C5-C6 – 15.4 ± 0.7 mm, C6-C7 – 15.1 ± 0.6 mm and C7-Th1 –15.2 ± 0.7 mm respectively. The average sagittal size for all level of spinal canal is 15.9 ± 0.7 mm.

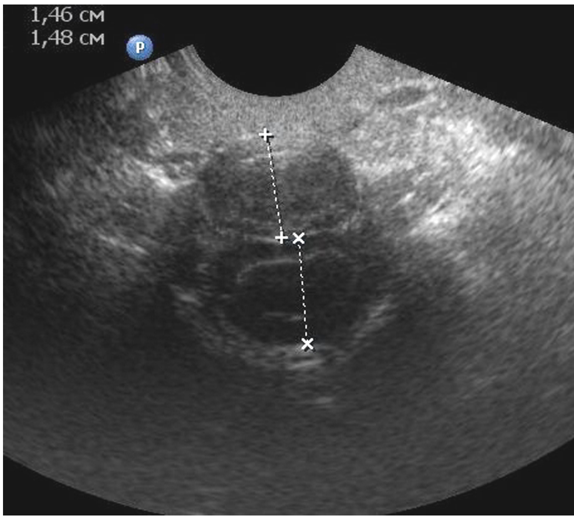
The ratio IVD/SC is variated from 0.93 to 1.08 in different level of cervical discs. The average ratio of IVD/SC at level of the C2-C3 – 0.95; C3-C4 – 0.95; C4-C5 – 1.01; C5-C6 – 0.99; C6-C7 – 0.99; C7-Th1 –0.99 respectively. The sagittal size of the spinal nerve canals in healthy children averaged 4.37 ± 0.32 mm (Figures 3, 4).

The greatest increase in the sagittal size of the discs was observed with a median hernia (18.6 ± 0.7 mm), respectively, the largest value of the IVD/SC index (1.54 ± 0.08). This indicator was significantly higher than in healthy children and also in children with paramedian and posterolateral localization of a hernia (P <0.001). As can be seen from Table 3, the smallest sagittal size of the canal of the spinal nerve was among children with posterolateral localization of the hernia

(2.31 ± 0.35 mm), which is significantly less than in healthy children (P <0.001) and in the group of children with a median hernia
(P <0.05).

Table 3. Ultrasound parameters of IVD, SC and SNC in healthy adolescents and in patient with hernia

| **Ultrasonographic parameters** | **The healthy children (n = 38)** | **Discs hernia** | | |
|---|---|---|---|---|
| | | **Paramedian (n = 13)** | **Posterolateral (n = 5)** | **Median (n = 3)** |
| Sagittal size IVD, mm | 15.5 ± 0.7 mm | 17.2 ± 0.7 | 15.9 ± 0.8 | 18.6 ± 0.7 mm |
| Sagittal size SC, mm | 15.9 ± 0.7 mm | 14.5 ± 0.9 | 14.5 ± 0.9 | 12.1 ± 0.8 mm |
| IVD/SC | 0.97 ± 0.07 | 1,19 ± 0.07 P<0.05 | 1.08 ± 0.07 | 1.54 ± 0.08 P<0.001 |
| Sagittal size of SNC | 4.37 ± 0.32 mm | 3.12 ± 0.26 mm P<0.01 | 2.31 ± 0.35 mm P<0.001 | 3.34 ±.0.39 mm P<0.05 |



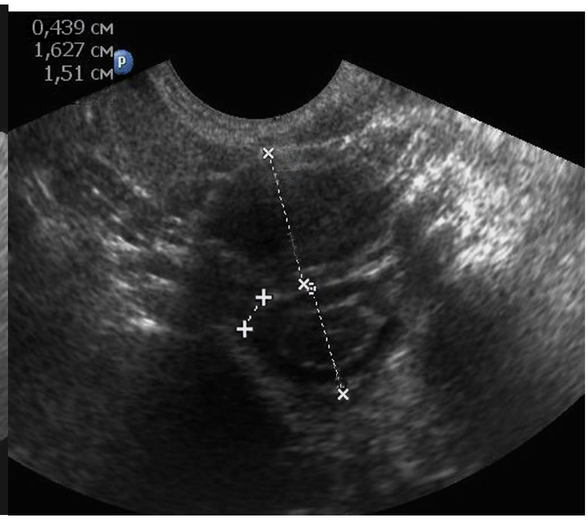




Figure 3 Figure 4

Figure 3. Axial section of the intervertebral disk with spinal canal at the level of C2-C3. The sagittal size of the disk is 1.46 cm, of the SC – 1.48, the IVD/SC ratio – 0.99

Figure 4. Axial section of the intervertebral disk with spinal canal at the level of C6-C7. The sagittal size of the disk is 1.627 cm, of the SC – 1.51cm, the IVD/SC ratio –1.08. The sagittal size of spinal nerve canal is 0.439 cm.

The main sign of the herniated intervertebral disc was the presence of a hernial gates, which on the ultrasonogram looked like the intermittence of the fibrous ring images. The contents of the disc protruded toward the spinal canal through the hernial gates. In children, the hernia sequestration was never observed. In the presence of a median hernia, the greatest decrease in the sagittal size of the spinal canal was recorded, while a significant increase in the IVD / SC index in some cases to 1.6. Sometimes deformation of the anterior contour of the spinal cord was observed (Figure 5). In paramedian, especially posterolateral localization of disc herniation, the narrowing of the canal of the spinal nerve was observed (Figure 6). These children showed more pronounced clinical symptoms of cervical radiculopathy.

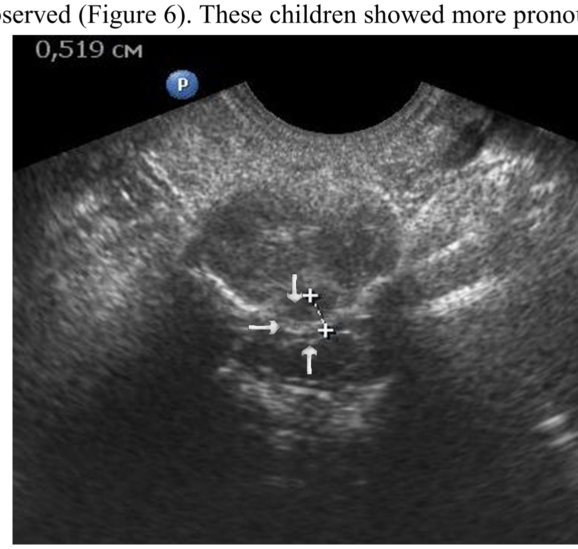



Figure 5 Figure 6

Figure 5. Axial section of the IVD and SC. Median hernia. The upper arrow shows the hernial gates, lower arrow-deformation of the anterior spinal cord contour, the horizontal arrow shows the discs hernia.

Figure 6. Left-side paramedian hernia. The upper vertical arrow shows the hernial gates, the horizontal arrow-narrowing anterior dural space, the black arrow-narrowing left spinal nerve canal together with the compressed nerve.

## Discussion

As a result of the study, echographic features of cervical intervertebral discs hernia in children 16–18 years old were established. Mean parameters of the sagittal dimensions of the intervertebral discs, spinal canal, anterior dural space, the ratio of the sagittal dimensions of the disc and the spinal canal, as well as the anterior dural space and the spinal canal were calculated. Different variants of localizations of hernias are determined. Echographic parameters of healthy children without changes in the discs and with hernia of the discs were compared.

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

paramedian (61.9 ± 10.6%) and posterolateral (23.8 ± 9.3%) hernias. The greatest sagittal size is observed with median and median-paramedian hernias, which together were observed in 38.1% of cases. The same leads to the greatest decrease in the sagittal size of the anterior dural space, its deformation. The greatest decrease in the anterior-posterior dimensions of the channels of the spinal cord nerves 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 imaging is the most accurate method for diagnosing the different stages of osteochondrosis in adults and children. It is proposed to carry out MRI with neck extension, which improves the visualization of the canal of the spinal nerve and to diagnose its stenosis[18,19]. But when using high-frequency microconvex transducer, the echographic image of intervertebral discs and the spinal canal is not inferior in quality to magnetic resonance imaging. This indicates a great opportunity for echography, especially in pediatrics and use it not only as a screening test, but also for peer review.

## Conclusions

1. In the senior childhood in the cervical spine the most common are paramedian hernias and they are more often localized at the level of C5-C6 and C4-C5.

2. The main sign of a herniated intervertebral disc is its protrusion with intermittent image of the fibrous ring.

3. Additional signs of the median hernia include the disappearance of the image of the anterior dural space, an increase in the ratio of anteroposterior dimensions of the IVD/SC ≥1.3, and deformation of the spinal cord.

4. Asymmetry of the spinal nerve canal and half of the intervertebral disc, as well as the inclination of its posterior contour, are indirect signs of a paramedian hernia. In this case, the sagittal size of the central SC decreases insignificantly.

5. Indirect signs of posterolateral hernia are a narrowing and an obvious asymmetry of spinal nerve canals more than 2/3 of their sagittal size.

## 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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