PECULIARITIES OF CHANGES IN THE SAGITTAL BALANCE OF THE CERVICAL SPINE IN CERVICOBRACHIAL SYNDROME

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Objective. To analyze clinical manifestations of cervicobrachial syndrome and identify their relationship with sagittal imbalance using data of MRI and radiological examination.

Material and Methods. Clinical manifestations of cervicobrachial syndrome associated with degenerative changes in the spine were studied in 22 patients. Clinical examination, radiography of the cervical spine, electroneuromyography of the upper extremities, and MRI study were performed. The intensity of the pain syndrome was assessed by VAS, and the quality of life – by the NDI questionnaire. The sagittal balance of the cervical spine was evaluated according to the following characteristics: angle of T1 slope, atlantoaxial (C1–C2) angle, degree of shift of the center of gravity of C2–C7, and Cobb angle.

Results. The pain intensity in cervicobrachial syndrome correlates with sagittal balance changes in the C2–C7 Cobb angle ($r = 0.656$; $p < 0.05$), the angle of T1 vertebra slope ($r = 0.520$; $p < 0.05$), and in the degree of shift of the center of gravity of C2–C7 ($r = 0.756$; $p < 0.02$). Differences between MRI and radiological results of the sagittal balance measurement are not significant ($p < 0.04$).

Conclusion. The study of the sagittal balance can be included in the algorithm for diagnosing osteochondrosis of the cervical spine. The MRI, along with spondylography, can be used to assess the state of sagittal balance. Understanding the identified relationships can help in determining the program of etiopathogenetic treatment of patients with cervicobrachial syndrome with obligatory including the sagittal balance correction in the program.

Key Words: osteochondrosis, cervical spine, sagittal balance, MRI.

Please cite this paper as: *Damdinov BB, Sorokovikov VA, Larionov SN, Koshkareva ZV, Sklyarenko OV, Zhivotenko AP, Kiriyenko AN. Peculiarities of changes in the sagittal balance of the cervical spine in cervicobrachial syndrome. Hir. Pozvonoc. 2019;16(2):42–48. In Russian.*
DOI: http://dx.doi.org/10.14531/ss2019.2.42-48.

Cervicobrachial syndrome is a consequence of various diseases of the nervous system; it is characterized by pain in combination with motor and sensory impairments [1]. The pathogenic basis of the syndrome is osteochondrosis of the cervical spine.

One of the clinical manifestations of the cervicobrachial syndrome that plays a crucial role in the pathogenesis of pain is the reflex myotonic spasm of the paravertebral and rotator cuff muscles. This pathological condition causes the antalgic position of the vertebral column and manifests in the form of sagittal balance abnormalities that are seen on radiographs [2] and characterized by frequent exacerbations and long-term disability, which determines the need for studying this problem [3].

The results of sparse studies indicate the relationship of the degree of shift in the spatial location of the head and neck assessed using spine radiography with clinical and neurological manifestations of the pathology. There is a correlation between an increase in pain intensity and an increase in the degree of the cervical spine deformity [4, 5].

The aim of the study is to analyze clinical manifestations of cervicobrachial syndrome and identify their relationship with sagittal imbalance using MRI and radiological examination data.

Material and Methods

In this pilot study, the sagittal balance of 22 patients was analyzed in the standing position during X-ray radiography of the cervical spine and in the supine position during MRI scanning. The study was approved by the local ethical committee of Irkutsk Scientific Center of Surgery and Traumatology.

In 2016, a total of 22 patients with cervicobrachial syndrome were treated for degenerative changes in the spine in the neurosurgical department. There were an equal number of males and females in the group (according to the international classification of diseases, ICD-10, code M53.1). The patients were divided into two groups based on clinical and radiological manifestations depending on the onset of osteochondrosis: 8 (36 %) and 14 (64 %) patients, respectively. Follow-up period was 2 years.

Inclusion criteria were patients with degenerative changes in the cervical spine (stages II and III osteochondrosis), vertebral pain syndrome with neurological deficit in the upper extremities.

Exclusion criteria were traumatic injuries of the cervical spine, specific and non-specific infectious diseases, cancer pathology, previous surgical interventions on the cervical spine, and pregnancy.

Examination was performed according to the same algorithm in all cases, which included evaluation of clinical and neurological status, cervical spine radiography in frontal and lateral projections, and electroneuromyography of the upper extremities [6]. Evaluation of the sagittal balance was carried out based on the results of radiological examination of the cervical spine in the standing position and MRI scanning in the supine position. Pain intensity was assessed using VAS.

The following parameters were used for evaluation of the sagittal balance [7]: T1 slope angle, i.e. the angle between the line drawn through the superior endplate of the T1 vertebra and the horizontal axis (T1-slope); the degree of shift of the gravity center position of C2–C7 determined by the distance between the superior posterior edge of C7 and the vertical line crossing the center of C2 (SVA C2–C7, Fig. 1); atlanto-axial angle in neutral position of C1–C2, i.e. the angle between the line drawn through the C1 tubercle and the apex of the C1 spinous process and the line drown through the C2 inferior endplate; C2–C7 Cobb angle (CL – cervical lordosis; Fig. 2).

Lateral spine radiographs revealed sagittal imbalance: in patient V. (Fig. 1), despite the fact that the C2–C7 lordosis angle equals 16°, and no shifting of gravity center position is noted (d = 2.8 cm), a negative angle (-13°) is determined upon measuring the lordosis angle at the C5–C7 level, which indicates the presence of a kyphotic deformity. Patient R. (Fig. 2) has a negative lordosis angle at C2–C7 (antalgic posture).

Parameters of the spatial location of the head and neck (sagittal balance) in the analyzed patients are presented in the Table.

Statistical analysis was performed using Statistica 10.0 software and by evaluating Spearman's rank correlation using the non-parametric method for the following sections: comparison of VAS data with sagittal balance parameters (the Cobb angle of the cervical spine, angle between C1–C2, SVA C2–C7 parameters, and T1-slope value obtained by radiography). A comparative analysis of the sagittal balance parameters obtained by radiography in the standing position and by MRI in the supine position using the aforementioned statistical method was also performed. The results were considered reliable at $p < 0.05$. Calculation of pain intensity values was performed by determining the median with an interquartile range.

Results and Discussion

The median pain intensity measured using VAS was 73 mm with an interquartile range (52; 81): significant levels of pain (70–99 mm) were found for 13 patients, median 80 (75; 83); 9 patients suffered from moderate pain (40–69 mm), median 51 (50; 56).

Analysis of clinical and neurological symptoms revealed unilateral cervicobrachialgia in 19 patients, concomitant cranialgia in 4 of these patients, myotonic syndrome in 15 cases (the pain was moderate in 4 patients and pronounced in 11 cases, mainly on the side of pain syndrome). Radiculopathy of the nerve roots was diagnosed in three patients, bilateral lesion was found in two of these cases.

According to radiography, osteochondral nodes were found in 4 patients, impaired cervical lordosis [7] was observed in 16 cases, with the pain intensity being more pronounced in 13 of them (VAS 71–91 mm) than in patients without impairments in the natural curvature of the cervical spine.

Changes in the intervertebral discs were determined by MRI, which demonstrated disc protrusions located at the same level in 8 patients, extrusions at two different levels in 4 cases, and multilevel protrusion in 10 patients.

As a clinically significant parameter, C2 was considered as the gravity center of the cervical spine [8]. Analysis of correlation between pain syndrome and SVA C2–C7 parameter revealed a close relationship ($r = 0.756$; $p < 0.02$), while analysis of the lordosis angle with the VAS values demonstrated a moderate correlation ($r = 0.656$; $p < 0.05$), which is indicative of an antalgic change in the spatial correlations of the head and neck, which is confirmed by literature data [9]. Analysis of the statistical parameters of the interdependence between the T1 slope angle and severity of the pain syndrome also showed a moderate relationship ($r = 0.52$; $p < 0.05$).

Fig. 1
Radiograph of the patient V., lateral projection: α –T1 slope angle; β – atlanto-axial angle; d – the degree of shift of the gravity center position in the cervical spine (the distance is denoted in yellow)

Fig. 2
Lateral projection of patient R. radiograph: C2–C7 Cobb angle

T1 slope was used as a constant for comparative analysis of the sagittal balance parameters of the cervical spine obtained by MRI and radiography (Fig. 3).

Analysis of the degree of shift of gravity center position and changes in the parameters of cervical lordosis revealed slight differences in the sagittal balance data in the horizontal and vertical positions of the patient ($p < 0.04$), which indicates a highly informative value of the cervical spine MRI in the diagnosis of sagittal balance disorders.

Based on the obtained results, we performed a search for the relationship between the parameters of cervical lordosis obtained by radiography and MRI. A high degree of correlation between these parameters ($r = 0.79$; $p = 0.01$) was found, which is demonstrated in the graph (Fig. 4).

The obtained correlation of spine radiography and MRI data for shifting of C2–C7 gravity center position revealed a moderate correlation for the degree of displacement of C2–C7 gravity center: $r = 0.63$ at $p < 0.05$ (Fig. 5).

Clinical case. Female patient A., aged 43, was admitted to the clinic with complaints of pronounced intermittent pain in the cervical spine radiating to the right hand up to the fingers. The patient also complained of limited mobility in the cervical spine, occasional numbness in the fingers I–IV of the right hand, occasional dizziness.

Patient history. The patient suggests that pain in the cervical spine, which she has been suffering from for the period of 10 years, is due to physical load on the spine. In 2015, she underwent a course of conservative therapy under the supervision of a neurologist on an outpatient basis. The exacerbation has been noted during the last month, when the pain began to radiate to the right hand; numbness of the fingers I–IV of the right hand appeared, which are caused by physical and emotional stress in the patient's opinion.

Neurological status. The patient is fully conscious; cranial nerves are intact. Tendon reflexes are as follows: brisk from *m. biceps* D = S; brisk from *m. triceps* D = S; hypoactive D, brisk S carporadial reflexes; patellar reflexes D = S are hypoactive; brisk Achilles S = D; brisk abdominal (upper, medial, lower) reflexes D = S. Protective reflexes are absent. No pathological reflexes are noted. Her muscle tone was normal. The range of motion in the extremities was full. Amyotrophy is absent. Atrial fibrillation is absent. Romberg's test was positive; the patient is able to perform finger-to-nose test properly. Examination of the sensorium revealed the following impairments: painful hypesthesia in the area of C6 and C7 dermatomes on the right. Kinaesthesia is preserved. No muscular rigidity is noted in the neck area. Kernig's and Brudzin-

Table

Parameters of spatial location of the head and neck (sagittal balance) in the analyzed patients

Patient, No	Radiography (standing position)				MRI (lying position)			VAS, mm
	T1-slope, deg	CL, deg.	SVA C2–C7, mm	C1–C2, deg.	CL, deg.	SVA C2–C7, mm	C1–C2, deg.	
1	25	14	27.8	39	-4	29.4	32	91
2	19	1	23.6	48	3	25.0	31	75
3	23	4	35.7	36	0	25.0	35	76
4	19	-19	51.5	37	-9	21.9	38	95
5	16	-12	16.9	40	-5	30.0	39	88
6	19	10	23.1	33	5	23.0	32	56
7	14	-9	16.9	39	0	16.0	36	73
8	15	12	31.7	35	11	28.1	41	49
9	26	27	20.9	20	27	16.9	24	59
10	15	-1	27.2	36	4	34.4	39	71
11	19	6	20.3	35	7	20.6	29	50
12	13	-9	28.1	36	-1	20.0	20	82
13	20	0.	35.7	37	0	35.0	27	80
14	18	5	51.5	40	5	40.0	20	51
15	23	10	16.9	33	7	15.0	17	59
16	21	6	23.1	39	4	13.0	25	45
17	13	-6	16.9	35	-2	17.0	19	83
18	15	3	31.7	20	3	21.0	25	73
19	17	7	20.9	36	5	15.0	31	50
20	17	-1	27.2	35	0	25.0	23	81
21	22	2	20.3	24	2	20.0	20	79
22	24	8	28.1	33	7	28.0	27	51

T1-slope —T1 slope angle; CL — C2–C7 Cobb angle; SVA — the degree of shift of the gravity center of C2–C7; C1–C2 — atlanto-axial angle in neutral position.

ski's signs are absent. Vegetative nervous system is without pathological changes. Higher cerebral functions are preserved. Speech disorders are absent.

Local status. Palpation of the C4, C5 and C6 spinous processes is painful, pain radiates along the outer surface of the right shoulder, the inner surface of the forearm to the right. The volume of active and passive movements in the cervical region is sharply limited and painful. Palpation reveals grade III muscular defense of the paravertebral muscles of the cervical spine and the muscles of the right shoulder.

VAS pain intensity is 87 mm in the cervical spine and 84 mm in the right upper extremity. NDI equals 42 %.

Radiographs obtained in two projections demonstrate degenerative changes. Aberrations in the spatial relationships of the spinal motion segments in the sagittal projection are shown in Fig. 6

The results of spinal MRI are as follows: degenerative changes in the cervical region, dorsal osteochondral overgrowth at the C5–C6 spinal motion segment, dorsal protrusions of C4–C5 and C6–C7, intervertebral discs, spondylosis, spondyloarthritis (Fig. 7).

ENMG of the upper extremities revealed a decrease in the M-response amplitude on the right, a moderate decrease in the velocity of the right radial and median nerves.

The following diagnosis was made: osteochondrosis, spondylosis, severe spondyloarthritis of the cervical spine; osteochondral node at C5–C6; intervertebral disc protrusions at C4–C5, C6–C7; radiculoneuritis of C6, C7 on the right; pronounced pain and myotonic syndromes.

The following treatment was carried out in the hospital: vascular and nootropic therapy, non-steroidal anti-inflammatory drugs, gastroprotective therapy, centrally acting muscle relaxants, group B vitamins, massage of the cervical-collar region and right upper extremity, electrophoresis with novocaine in the cervical spine area, acupuncture, weight-offloading orthosis to the cervical spine, physical therapy.

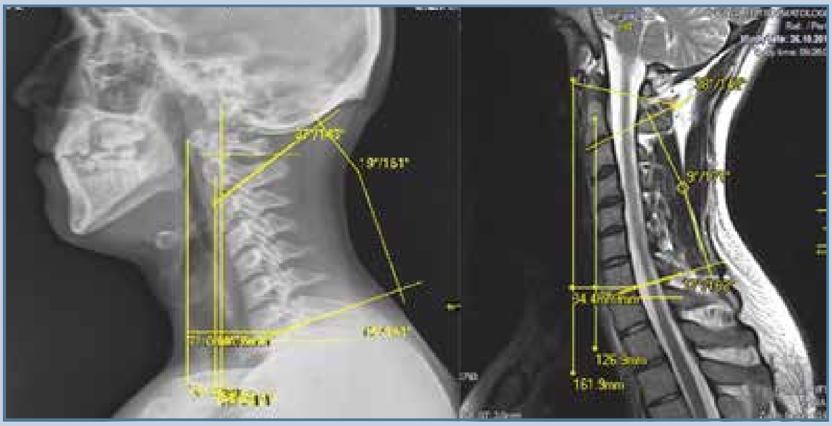

Fig. 3
Lateral projection of patient R. spodylogram (standing position) and MRI (lying position)

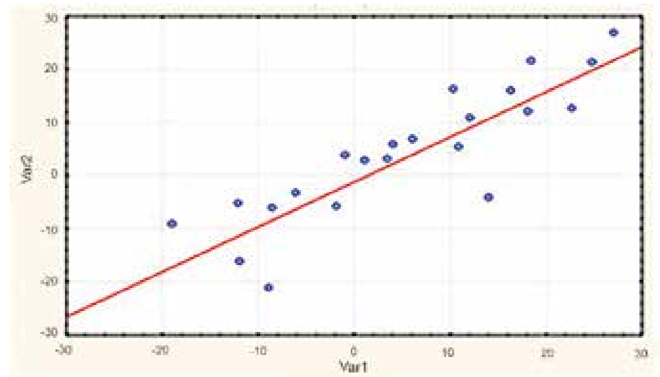

Fig. 4
Graphical representation of linear correlation of cervical lordosis value measured by MRI and spine radiography

After treatment, improvement was noted in the form of decreased pain intensity (VAS in the cervical spine equaled 6 mm, VAS in the right upper extremity reached 6 mm), regression of neurological symptoms in the form of sensory recovery in the innervation area of C6 and C7 dermatomes. The range of motion in the cervical spine was recovered. NDI equaled 10 %.

Improvement in the sagittal balance is determined on the lateral spine radiograph after treatment (Fig. 8): Cobb angle of the cervical spine (C2–C7) is reduced to 8°, SVA equals 25 mm.

Conclusion

Pain intensity in cervicobrachial syndrome correlates with such parameters of changes in the sagittal balance as C2–C7 Cobb angle ($r = 0.680$; $p < 0.05$), T1 slope angle ($r = 0.520$; $p < 0.05$) and the degree of shift of the C2–C7 gravity center ($r = 0.726$; $p < 0.02$). This relationship allows clinicians to include analysis of the sagittal balance state in the algorithm for diagnosing cervical osteochondrosis.

A correlation between the parameters of cervical lordosis ($r = 0.79$) obtained

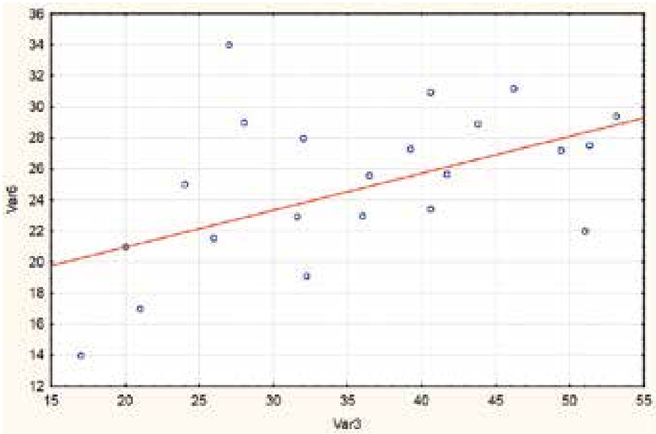

Fig. 5
Graphical representation of linear correlation of shift of the center of gravity measured by MRI and spine radiography

Fig. 6
Radiograph of the cervical spine of the patient A. in the lateral projection before treatment: sagittal imbalance in the form of kyphosis of the cervical spine up to -13°, the shift of the center of gravity is 27 mm

Fig. 7
MRI of the cervical spine of the patient A. in a horizontal position before treatment, lateral projection: the center of gravity is displaced 22 mm, the Cobb angle is 12°

by MRI and cervical spine radiography methods has been shown. A significant dependence was also revealed for the degree of shift of the gravity center of the cervical spine (r = 0.63) when using both approaches. Thus, MRI can be used to assess the degree of sagittal imbalance of the cervical spine. Understanding of the identified relationships can help in determining the strategy for etiopathogenetic treatment of patients with cervicobrachial syndrome with mandatory inclusion of the sagittal balance correction in the program.

The study had no sponsorship. Authors declare no conflict of interests.

Fig. 8
Lateral cervical spine radiograph of the patient A. after treatment

References

1. **Levin OG.** Diagnosis and treatment of pain in the neck and upper limbs. Russian Med J. 2006;9:71–73. In Russian.
2. **Passias PG, Segreto FA, Bortz CA, Horn SR, Frangella NJ, Diebo BG, Hockley A, Wang C, Shepard N, Lafage R, Lafage V.** Fatty infiltration of cervical spine extensor musculature: is there a relationship with cervical sagittal balance? Clin Spine Surg. 2018;31(10):428–434. DOI: 10.1097/BSD.0000000000000742.
3. **Sorokovikov VA, Koshkareva ZV, Sklyarenko OV.** Osteochondrosis: some aspects of the problem. Sibirskij Medicinskij Zurnal (Irkutsk). 2016;141(2):22–28. In Russian.
4. **Zaborovskiy NS, Ptashnikov DA, Mikhaylov DA, Smekalenkov OA, Masevnin SV, Lapaeva OA.** The effect of spinal deformity correction on the quality of life of elderly patients. Zh Vopr Neirokhir Im N.N. Burdenko. 2016;80(3):58–65. In Russian. DOI: 10.17116/neiro201680358-65.
5. **Schwab FJ, Smith VA, Biserni M, Gamez L, Farcy JP, Pagala M.** Adult scoliosis: a quantitative radiographic and clinical analysis. Spine. 2002;27(4):387–392. DOI: 10.1097/00007632-200202150-00012.
6. **Sklyarenko OV, Zhivotenko AP, Koshkareva ZV, Ippolitova EG, Verkhozina TK, Tsyslyak ES.** Cervicobrachial syndrome in patients with spinal osteochondrosis. Acta Biomedica Scientifica. 2018;3(5):66–71. In Russian. DOI: 10.29413/ABS.2018-3.5.10.
7. **Scheer JK, Tang JA, Smith JS, Acosta FL** Jr, Protopsaltis TS, Blondel B, Bess S, Shaffrey CI, Deviren V, Lafage V, Schwab F, Ames CP. Cervical spine alignment, sagittal deformity, and clinical implications: a review. J Neurosurg Spine. 2013;19(2):141–159. DOI: 10.3171/2013.4.SPINE12838.
8. **Ames CP, Smith JS, Eastlack R, Blaskiewicz DJ, Shaffrey CI, Schwab F, Bess S, Kim HJ, Mundis GM Jr, Klineberg E, Gupta M, O'Brien M, Hostin R, Scheer JK, Protopsaltis TS, Fu KM, Hart R, Albert TJ, Riew KD, Fehlings MG, Deviren V, Lafage V.** Reliability assessment of a novel cervical spine deformity classification system. J Neurosurg Spine. 2015;23(6):673–683. DOI: 10.3171/2014.12.SPINE14780.
9. **Tang JA, Scheer JK, Smith JS, Deviren V, Bess RS, Hart RA, Lafage V, Shaffrey CI, Schwab FJ, Ames CP.** The impact of standing regional cervical sagittal alignment on outcomes in posterior cervical fusion surgery. Neurosurgery. 2012;71(3):662–669. DOI: 10.1227/NEU.0b013e31826100c9.

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Received 12.02.2019
Review completed 29.03.2019
Passed for printing 01.04.2019

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