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Diagnostic potential for detecting upper limb arthropathy in ischemic stroke patients with RRS score of 4–6 points

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Abstract

Aim – to identify the features of the formation of upper limb arthropathy in patients with ischemic stroke with 4-6 points on the rehabilitation routing scale (RRS) depending on the type of treatment and rehabilitation procedures.
Material and methods. Ninety-eight patients with ischemic stroke were examined in two periods: Period 1, 13.2±0.8 days and Period 2, 189.2±2.1 days. Ultrasound and X-ray examinations were performed to determine the nature of damage to the joint complex of the upper limb. The severity of the neurosomatic status was assessed using the NIHSS, MRS, MMSE, VAS, and RRS scales.
Results. Post-stroke hemiparesis in the acute period of ischemic stroke was registered in 86 patients (88%), and upper limb arthropathy in 36 (37%) of the examined patients. In 12 (32%) patients with ischemic stroke the arthropathy of the shoulder joint combined with damage to other joints. In the majority of patients with ischemic stroke with arthropathy, according to the ultrasound data of the joints, synovitis was detected in 27 (76%), and tendon tendinitis in 17 (47%) that form the structure of the shoulder joint. In dynamics, contracture of the upper limb was revealed in 12 (26%) of the examined and was combined with a more pronounced cognitive defect, which required development of preventive and corrective methods.
Conclusion. It is proposed to introduce into the diagnostic standard of patients with ischemic stroke with paresis of 0-3 points ultrasound of the affected joint to identify early markers of arthropathy in order to promptly prevent contracture of the upper limb.
Keywords: ischemic stroke, arthropathy, contracture, ultrasound examination of the joint.
Conflict of interest: nothing to disclose.

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Диагностические возможности выявления артропатии верхней конечности у больных ишемическим инсультом с ШРМ 4–6 баллов

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Аннотация

Цель – выявить особенности формирования артропатии верхней конечности у больных ишемическим инсультом с 4–6 баллами по шкале реабилитационной маршрутизации (ШРМ) в зависимости от характера лечебно-реабилитационных мероприятий.
Материал и методы. Обследовано 98 больных ишемическим инсультом в два временных периода: первый период – 13,2±0,8 дня и второй период – 189,2±2,1 дня. Характер поражения суставного аппарата верхней конечности оценивали при помощи ультразвукового и рентгенологического исследования. Выраженность нейросоматического статуса оценивали по шкалам NIHSS, MRS, MMSE, ВАШ, ШРМ.
Результаты. Постинсультные гемипарезы в остром периоде ишемического инсульта зарегистрированы у 86 пациентов (88%), при этом артропатия верхней конечности выявлена у трети – 36 (37%) обследованных. У 12 (32%) больных ишемическим инсультом артропатия плечевого сустава сочеталась с поражением других суставов. У большинства больных ишемическим инсультом с артропатией – 27 (76%), согласно данным УЗИ суставов, выявлено наличие синовита, у 17 (47 %) – тендиниты сухожилий, формирующих каркас плечевого сустава, что в динамике проявилось формированием контрактуры верхней конечности у четверти – 12 (26%) обследованных и сочеталось с более выраженным когнитивным дефектом, что требует разработки превентивных методик их коррекции.
Выводы. Предложено внедрение в диагностический стандарт больных ишемическим интсультом с парезом 0–3 балла УЗИ заинтересованного сустава как убедительного метода исследования для выявления ранних маркеров артропатии с целью своевременной профилактики контрактуры верхней конечности.
Ключевые слова: ишемический инсульт, артропатия, контрактура, ультразвуковое исследование сустава.
Конфликт интересов: не заявлен.

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Список сокращений
ИИ – ишемический инсульт; ШРМ – шкала реабилитационной маршрутизации; MRS – Medical Research Council Weakness Scale; ВАШ – визуально-аналоговая шкала; УЗИ – ультразвуковое исследование; ЭНМГ – электронейромиография; NIHSS – National Institutes of Health Stroke Scale.

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INTRODUCTION

According to modern concepts, the clinical notion of arthropathy includes the presence of the pain syndrome and restricted articular movement of varied amplitude. Development of post-stroke arthropathy is regarded as highly important in the course of formation of contractures of the upper limb, resulting not only in deteriorating quality of life, but in disablement regardless of age [1–3]. Therefore, the effort of the medical community is focused on searching for early diagnostic criteria of the risk of formation of post-stroke contracture and medical and rehabilitation technologies of its correction.

Post-stroke pain syndrome may be related to several underlying factors including local damage of paraarticular tissue, myogenic pain from the scalene muscles, neuropathic pain, including complex regional pain syndrome, central post-stroke pain, or may be stem from spasticity. In order to measure the intensity of pain, the visual analog scale (VAS) is used. Instrumental assessment of condition of peripheral nerves in the course of formation of neuropathis pain syndrome involved ultrasonic investigation (US) and electroneuromyography (ENMG). Assessment of tone and turgor of spasmed muscles is performed using the Ashworth scale. The measurement of articular movement is performed by goniometry on the Tardieu scale [4–6].

Combined methods of diagnostics, treatment and rehabilitation allow not only decrease of the pain syndrome but also restoration of the motor function of the extremity, as well as positive prevention of contractures in patients with ischemic stroke (IS) with early spasticity. To improve the motor control and restore the sensorimotor function of extremities, both pharmacological and non-pharmacological methods are used (injections of botulinum A-toxin in the subscapular and/or greater pectoral muscle, injections of glucocorticoids in the shoulder and/or subacromial joint, block anesthesia of the suprascapular nerve). From the first day of the patient's stay in the intensive care unit, positioning should be performed. Besides, in patients with spastic paresis, sparing mobilization techniques for shoulder muscles are recommended, as well as exercising of the upper extremities including target-oriented movements with lots of repetitions, massage and acupuncture therapy, use of postural positioning, kinesio tape, thermal procedures, tapes, braces, and frames [7–10].

The current organizational mechanisms of routing and consideration of severity of comorbid pathologies in patients with IS and 4 to 6 points on the rehabilitation routing scale (RRS) are far from being perfect. Therefore, at the end of inpatient care within the department of vascular surgery (DVS) only half of examined patients are timely diagnosed in the most acute period of causes of deep motor disorders, and successive medical rehabilitation of stages 1 to 3 is performed. The remaining IS patients face severe disablement in the early period of recovery [11, 12].

AIM

To identify the features of the formation of upper limb arthropathy in patients with ischemic stroke with 4-6 points on the rehabilitation routing scale depending on the type of treatment and rehabilitation procedures.

MATERIAL AND METHODS

A clinical study of the neurosomatic status of 90 IS patients was performed in two periods. First period: 13.2±0.8 days (Group 1). Second period: 189.2±2.1 days including dynamic follow-up of IS patients depending on the presence (Group 1A) or absence (Group 1B) of stage 2 medical rehabilitation within 1-2 months of the disease. The subjects were IS patients over 18 of age with RRS score of 4–6 points. The exclusion criteria were IS patients with RRS score of 1–3 points, with hemorrhagic stroke, oncological and mental diseases, as well as inflammatory or demyelinating diseases of the central nervous system (CNS).

Part from the standard neurological examination method, the following was assessed: neurological deficiency using the NIHSS scale, muscular strength using the five-point quantitative muscular strength assessment scale MRC. The intensity of the pain syndrome was assessed using the VAS, the degree of loss of self-care capability, using the RRS scale. The nature of damage to the articular apparatus of the upper extremity was assessed using ultrasonic and radiological diagnostics of the joint in question. The level of cognitive deficiency was assessed using the MMSE scale.

Treatment and rehabilitation procedures included basic pharmacological treatment (antiplatelet or anticoagulant drugs, anti-hypertension, lipid lowering and anti-arrhythmic drugs. etc.) and a complex of device-assisted rehabilitation and kinesiotherapy within stage two of medical rehabilitation.

The obtained quantitative and qualitative findings of the examinations were collected in Excel spreadsheets. The data was then processed using StatSoft STATISTICA 10.0.1011.0 Russian Portable and included identification of average and sampled shares, assessment of statistical significance of variance between groups, methods of variation statistics and correlation analysis. In the description of investigated groups, the absolute and the relative number of carriers of the qualitative findings was indicated, n (%), the mean value and

the standard deviation (M ± SD) in normal distribution of the quantitative variable, or the median value and the interquartile interval (Me [Q1; Q3]) in deviation of the distribution from the normal. The results of statistical analysis were considered significant in the probability of alpha error below 5% ($p < 0.05$).

RESULTS

The assessment of deterioration of self-care capability showed that among the studied IS patients, the prevailing RRS score was 4 points: 56 patients (57%, p = 0.004); less frequent RRS values were 5 points, in 40 patients (41%), and RRS of 6 points in 2 patients (2%). The severity of neurological deficit on the NIHSS scale in the acute period was moderate at 10.9 [10.0; 11.8] points, white the share of moderate stroke (5–15 points) was seen in 77 patients (79%), and severe (≥16 points) in 21 patients (21%, p =0.03). A direct correlation was identified (r=0.77) between the NIHSS and RRS levels.

The evaluation of the motor function revealed post-stroke hemipareses of various severity in 86 examined IS patients (88%).

The study of muscle strength of the upper limb on the MRC scale showed that the share of patients with plegia was 21 cases (25%); number of cases of 1 point was 14 cases (16%), cases of 2 points, 13 (15%), cases of 3 points, 20 (23%), and cases of 4 points, 18 (21%). The data is shown in **Fig. 1**.

Thus, the share of severe disorders (0-2 points) in 55 cases (56%) prevailed over the mild motor disorders (3-4 points) in 43 cases (44%).

The analysis of condition of the musculoskeletal apparatus showed that during the acute period of IS arthoropathy of the upper limb was identified in 36 (37%) of investigated patients. Among them, the visual inspection by the neurologist identified not only restriction of movement in all patients, but the pain syndrome of various severity in the joint under consideration in the prevailing number of patients (31 (86%)), as well as muscular hypotrophy of the upper limb and the edema of the joint capsule in 16 (45%) patients. Isolated damage of the shoulder joint was found in all 36 (100%) patients, and its combination with arthropathies of other joints (knee, elbow, wrist), in 12 (32%) patients. Left-sided arthropathy of the shoulder join was registered more frequently, in 21 (22%) cases, than the right-sided in15 (15%) cases. Its features were more frequently identified in women, in 22 (61%, p = 0.005) cases, than in men, in 14 (39%) cases.

In order to specify the nature of the bone defect, X-ray examination of the joints was performed. In the presence of clinical manifestations of the shoulder joint arthropathy, the signs of shoulder periarthritis were found in16 (46%) IS patients with the RRS score of 4-6 points. At the same time, according to the data of additional examination, US of the joint of practically all patients with arthropathy (27 patients (76%)) revealed synovitis of various severity, and the tendonitis of the tendons forming the shoulder joint complex was found in 17 patients (47%). We believe that ultrasonic examination of the joint in question to be necessary for patients in the acute phase of IS with paresis of 0-3 points in order to identify early markers of arthropathy and provide timely prevention of contracture of the upper limb; since this method provides finer data as compared to the routine X-ray examination of the joint.

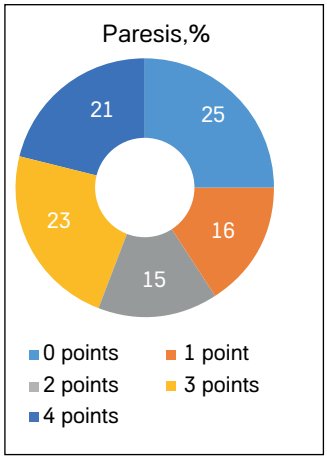

Figure 1. *The structure of paresis on the MRS scale.*
Рисунок 1. *Структура выраженности пареза по шкале MRS верхней конечности.*

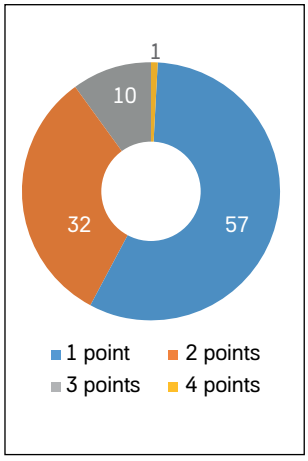

Figure 2. *Structure of paresis severity on the MRS scale in stroke patients with arthropathy.*
Рисунок 2. *Структура тяжести пареза по шкале MRS у больных ИИ с артропатией верхней конечности, %.*

In all 36 IS patients (100%) with arthropathy of the upper limb, signs of paresis of various severity were identified, which had a negative relation to the severity of the pain syndrome of the joint in question on the VAS scale (r = -0.72) (**Fig. 2**). The comparison of pain severity on the VAS scale demonstrated its prevalence in patients with arthropathy: 4.8 ± 0.3 and 2.8 ± 0.1, respectively.

Besides, the presence of shoulder joint arthropathy was related to formation of severe paresis of the upper limbs in 32 cases (89%, p=0.002), predominantly with 0-1 points on the MRC scale. Such disorders form a determining criterion of disablement of IS patients.

The analysis of neurological deficiency on the NIHSS scale registered a credible difference in patients with and without signs of arthropathy, 14.0 [13.0; 15.0], p = 0.00001 and 9.0 [8.0; 10.0], respectively, which could be accounted for by the contribution from pyramidal disorders and by the symptom complex of sensitive disorders. Thus, in the IS patients with signs of arthropathy it was identified in 19 (53% p= 0.005) of patients, and in IS patients without signs of arthropathy, only in 11 (31%) cases. Often this relates to the formation of a vicious circle of pathological interaction of motor, sensitive and cognitive disorders and ultimately may lead to decrease of motivation of patients to recover.

The investigation of the level of intellect and memory disorders on the MMSE scale in patients with arthropathy showed that among them, the most severe cognitive defects were registered at 15.8 [14.7; 17.0] points vs. patients without signs of artropathy at 20.3 [19.3; 22.1] points, p = 0.01.

The analysis of the structure of the rehabilitation routing scale showed that the degree of deterioration of self-care capacity in arthropathy patients was more severe as compared to the general sampling. Among patients with arthropathy, the RRS score of 5 points was twice as high (30 (80%, p

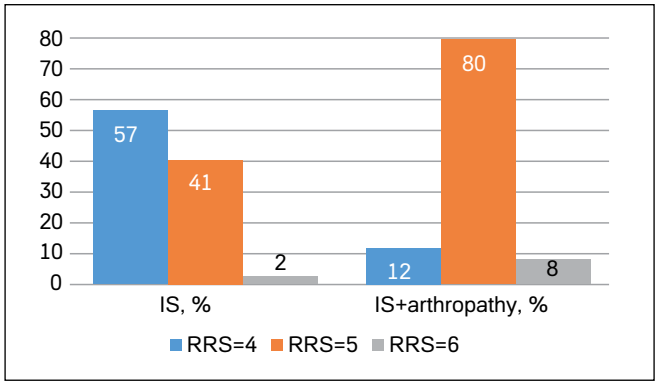

Figure 3. *The structure of the routing scale in stroke patients with upper limb arthropathy, %.*

Рисунок 3. *Структура ШРМ у больных ИИ с артропатией верхней конечности, %.*

=0.005)) vs. general group, and RRS score of 4 points only in 4 patients (12%, p = 0.04), RRS of 6 points, in 2 patients (8%). The data is shown in **Fig. 3**.

The evaluation of the degree of deterioration of self-care capacity in the IS patients in the course of dynamic follow-up (**Table 1**) among patients in the 1A group identified improvement of the neurosomatic status. This occurs not only due to prevalence of RRS of 4 points (31(60%, p = 0.004); the number of patients with RRS of 3 points also increased to 12 persons (23%). At the same time, among patients of the 1B group there still prevailed patients with RRS of 5 points: 25 persons (53%, p= 0.005).

As expected, follow-up assessment revealed a significant reduction in NIHSS scores to 6.1 [5.6; 7.0] points (p=0.04) among patients who received the second-stage comprehensive rehabilitation within the first 1–2 months after IS. In contrast, NIHSS scores in the group deprived of second-stage medical rehabilitation remained significantly higher at 9.0 [8.4; 9.8] points. Analysis of the dynamic severity structure of neurological deficit using the NIHSS revealed that while in the acute phase of IS, the main cohort of patients with RRS scores of 4-6 points consisted of individuals with moderate impairments (77 (79%, p=0.004)), and no cases of mild stroke manifestations were identified, the follow-up assessment showed a more favorable severity distribution. In Group 1A, patients with mild acute cerebrovascular events appeared (22 (42%, p=0.05)); consequently, the proportion of patients with a moderate course of ACVE significantly decreased (30 (58%, p=0.05)). However, in Group 1B, no significant dynamic changes were recorded, and patients with moderate impairments prevailed (44 (95%, p=0.004)). The data is presented in **Table 2**.

The incidence of arthropathy during follow-up was identified in 28 patients (28%). Among patients in Group 1A, it was found in only 8 individuals (16%), whereas in Group 1B it was 2.5 times more frequent, occurring in 20 patients (44%, p=0.04). Contracture of the affected upper limb had developed in 15 patients (15%). While it was present in only 3 patients (5%) from Group 1A, it was observed in 12 patients (26%) from Group 1B. This inevitably affected the cognitive status of the IS patients. Specifically, among patients without arthropathy, cognitive status showed significant recovery to 25.4 [23.4; 26.2] points (p=0.01), whereas among patients with established contracture, it remained significantly depressed at 19.4 [18.2; 22.1] points.

The identified pattern emphasizes the necessity of implementing early preventive diagnostic technologies for detecting and characterizing arthropathy in order to prevent contractures.

DISCUSSION

Recent scientific literature focused on evaluating the relationship between the severity of pyramidal tract impairments, the degree of limitations in self-care capacity and the extent of cognitive deficits. This is based on the concept that *barriers to rehabilitation can include cognitive disorders, 'higher-level' motor impairments, fall risk, depression, chronic fatigue, pain syndromes, and comorbidities* [13–16]. Our study identified a direct correlation between NIHSS and RRS scores (r=0.77), which supports this assertion.

Furthermore, we established that in patients with severe limitations in self-care capability, beyond assessing the degree of motor impairments, attention must be paid to the presence of upper limb arthropathy, which was recorded in over one-third (37%) of patients in the ischemic stroke cohort.

Presence of the shoulder joint arthropathy is related to the formation of deep paresis of the upper limbs (predominantly, 0-1 points on the MRS scale), and to the more manifested sensitive (19 (53%)) and cognitive disorders (15.8 [14.7; 17.0]), that constitute the prevailing criterion of disablement of ischemic stroke patients [12].

Analysis of the impact of timely implementation of treatment and rehabilitation measures for preventing severe disabling motor impairments in ischemic stroke patients showed that arthropathy during follow-up was observed in 8 patients (16%) in Group 1A, but 2.5 times more frequently in Group 1B, in 20 cases (44%, p=0.04). The contracture of the affected upper limb developed in half of the cases, 15 patients (15%), which is a marker of severe patient disability. The identified pattern emphasizes the necessity of implementing

RRS	Group 1 (n=98)	Group 1A (n=52)	Group 1B (n=46)
3 points		12 (23%)	2 (5%)
4 points	56 (57 %, p= 0.005)	31 (60 %, p= 0.004)	17 (38 %)
5 points	40 (41%)	9 (17 %, p = 0.004)	25 (53%, p= 0.005)
6 points	2 (2%)	–	2 (4%)

Note. Accuracy of variance between studied groups in dynamic follow-up: p ≤ 0.05.

Table 1. *Dynamic structure of the routing scale in stroke patients, abs. (%)*

Таблица 1. *Динамическая структура уровня ШРМ у больных ИИ, абс. (%)*

NIHSS	Group 1 (n=98)	Group 1A (n=52)	Group 1B (n=46)
0–4 points	–	22 (42%, p = 0.05)	2 (5%)
5–15 points	77 (79%)	30 (58%, p = 0.05)	44 (95%, p = 0.004)
≥16 points	21 (21%, p = 0.03)	–	–

Note. Accuracy of variance between studied groups in dynamic follow-up: p ≤ 0.05.

Table 2. *Dynamic structure of NIHSS in stroke patients, abs. (%)*

Таблица 2. *Динамическая структура уровня NIHSS у больных ИИ, абс. (%)*

early preventive diagnostic technologies for detecting and characterizing arthropathy to prevent contractures.

CONCLUSION

Development of novel preventive clinical and diagnostic technologies for identifying early markers of arthropathy necessitates the timely implementation of a recommended complex of therapeutic and rehabilitative measures to prevent contractures. Moreover, the early and active initiation of rehabilitation itself constitutes a crucial stage in preventing contractures as a significant factor contributing to disability in ischemic stroke patients, regardless of age.

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Ethical expertise. Minutes No. 202 of the meeting of the Committee on Bioethics at TGMU dated 7.12.2023.	***Этическая экспертиза.*** Протокол №22 заседания ЛЭК при ТГМУ от 07 декабря 2023 г.
Study funding. The study was the authors' initiative without external funding.	***Источник финансирования.*** Работа выполнена по инициативе авторов без привлечения финансирования.
Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Contribution of individual authors. Chichanovskaya L.V.: development of the study concept, detailed manuscript editing and revision. Bakhareva O.N., Ganzya D.V.: scientific data collection, systematization and analysis, writing of the first draft of the manuscript; manuscript editing. Menshikova T.V.: editing of the text. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** Л.В. Чичановская – разработка концепции исследования, редактирование текста. О.Н. Бахарева, Д.В. Ганзя – сбор и обработка научного материала, написание текста. Т.В. Меньшикова – редактирование текста. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.
Statement of originality. No previously published material (text, images, or data) was used in this work.	***Оригинальность.*** При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, иллюстрации, данные).
Data availability statement. The editorial policy regarding data sharing does not apply to this work.	***Доступ к данным.*** Редакционная политика в отношении совместного использования данных к настоящей работе не применима
Generative AI. No generative artificial intelligence technologies were used to prepare this article.	***Генеративный искусственный интеллект.*** При создании настоящей статьи технологии генеративного искусственного интеллекта не использовали.
Provenance and peer review. This paper was submitted unsolicited and reviewed following the standard procedure. The peer review process involved 2 external reviewers.	***Рассмотрение и рецензирование.*** Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали 2 внешних рецензента.

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