NEUROGENIC DYSFUNCTION OF THE LOWER URINARY TRACT IN INFECTIOUS AND INFLAMMATORY DISEASES OF THE SPINE: IS THERE A CORRELATION WITH CLINICAL AND RADIOLOGICAL VARIANTS OF MYELOPATHY?

Preliminary result of the analysis of a single-center cohort

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Objective. To study the relationship between clinical and radiation variants of myelopathy and types of the neurogenic dysfunction of the lower urinary tract in patients with infectious spondylitis.
Material and Methods. A single-center cohort observational study was conducted with the analysis of medical records and a prospective examination of 20 patients with infectious spondylitis complicated by neurogenic dysfunction of the lower urinary tract.
Results. Infectious spondylitis can be complicated by the development of various urodynamic disorders, including neurogenic detrusor hyperactivity (30 %), its combination with detrusor-sphincter dissinergia (30 %) and a decrease in detrusor contractility (40 %). In 50 % of patients, an urodynamic examination revealed an increase in detrusor pressure of more than 40 cm water. There was no connection between the development of any type of lower urinary tract dysfunction and MRI types of myelopathy according to Vendatam, as well as between the level of spinal cord compression and the severity of neurological disorders according to AIS.
Conclusion. The results of the study do not confirm the existence of a relationship between the various characteristics of myelopathy in infectious spondylitis and the results of urodynamic examination. The limitation of the reliability of the results is the small number of observations. Studies with a larger sample are required to assess the relationship between the clinical and radiation characteristics of myelopathy and variants of neurogenic dysfunction of the lower urinary tract in patients with infectious spondylitis.
Key Words: infectious spondylitis, neurogenic lower urinary tract dysfunction, urodynamic.
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Myelopathy in inflammatory infections of the spine is usually associated with spondylogenic compression of the spinal cord [1] or secondary myeloischemic disorders. The direct factors of compression in this case are epidural abscesses, granulomas, sequestration of discs and damaged vertebrae. Secondary spondylogenic epidural abscess is most often formed as a consequence of contact generalization from the bone lesion in the vertebral body to the anterior epidural space and accounts for 10 to 30 % of all spinal epidural abscesses [2]. While the simplest mechanism for the development of myelopathy is direct mechanical compression of nerve structures, its other causes (local venous stasis associated with thrombosis and thrombophlebitis of the epidural venous plexus, as well as ischemia associated with spinal artery thrombosis [3]) not only complicates the course of the disease but also makes the prognosis of its outcome less predictable.

The criterion of neurogenic lower urinary tract dysfunction (NLUTD) is an impairment of the function of the bladder and urethra associated with a verified neurological condition [4]. It is impossible to assess the global incidence of NLUTD in infectious spondylitis due to the small number of studies devoted to this issue. In most papers, such conditions are only implied in the collective concept of "pelvic organ dysfunction" [5–8]. Moreover, the incidence of NLUTD in patients with verified tuberculous spondylitis reaches 50 % [6].

Nowadays, the only objective technique to evaluate the type of urodynamic disorder is a comprehensive urodynamic study. In some cases, neurogenic disorders of urination are oligosymptomatic. For a long time, they do not cause subjective manifestations of severe urodynamic disorders that, without adequate correction, result in recurrent urinary infections, vesicoureteral reflux, the formation of urinary tract con-

cretions and renal failure. These complications progressively result in a significant decrease in quality of life and disability of patients, often remaining unknown for a long time for specialists in spinal abnormalities who follow patients after the procedure. In this context, it is crucial to evaluate the potential for the earliest possible prediction of the surgical outcomes of inflammatory infections of the spine, including considering the likelihood of the emergence of NLUTD and its consequences.

Only a small number of studies with a small sample are devoted to searching for the correlation between the nature of MRI changes and NLUTD in patients with tuberculous spondylitis and none in non-specific infectious spinal lesions [6–8].

The objective is to study the correlation between clinical and radiologic variants of myelopathy and types of NLUDT in patients with infectious spondylitis.

Design: a single-center observational cohort retrospective with a prospective part.

Material and Methods

The initiative cohort observational study performed at the St. Petersburg Research Institute of Phthisiopulmonology from November 2022 to March 2023 included 20 patients selected in accordance with the inclusion/non-inclusion/exclusion criteria.

Inclusion criteria: age from 18 to 75 years; bacteriologically and/or morphologically verified infectious and inflammatory lesions of the spine; a full-fledged record of radiologic findings, including digital MRI scans performed on a single device (Toshiba Excelart Vantage 1.5T MRI machine) using standard sequences and views for the study of the spine; performance of urodynamic examination during hospital stay; indication in the patient's medical records of information concerning the neurological status in accordance with the AIS scale.

Non-inclusion criteria: urinary and other organs diseases that could affect the examination findings (urethral stricture, prostatic hyperplasia, bladder stones); pelvic tumors; other neurological and mental diseases (multiple sclerosis, Parkinson's disease, spinal cord injury, etc.) that make an adequate urodynamic examination impossible.

Exclusion criteria: refusal of the patient to perform tests as part of the study, as well as verified urinary tract tuberculosis.

Patients

In accordance with the above criteria, the final group included 20 patients (15 men and 5 women) with the mean age of 47 ± 10 years (31; 68), with the diagnosis of "spondylitis complicated by NLUTD". The median duration of clinical manifestations of spine disorders from the onset of the first symptoms of inflammatory infections of the spine (back pain, fever, hypoesthesia or muscle weakness) before the examination was 11.5 months (5.25; 16.75).

Techniques

Biopsy specimen sampling for the verification of an infectious agent from the disruption zone of the spine was performed by puncture, bone marrow sampling or during decompressive surgery followed by bacteriological examination and/or in vivo microscopic examination. Thus, 12 (60 %) patients had nonspecific spondylitis and 8 (40 %) had tuberculous spondylitis.

The neurological status of patients was registered in accordance with the standard evaluation of the severity of motor and sensory disorders entered in the patient's medical record according to the AIS scale of the international standard ASIA/ISNCSCI (revision 2015). The distribution of patients according to the standard is presented in Fig. 1, while an equal number of patients had flaccid or spastic lower paraparesis/plegia; 2 patients had tetraparesis/plegia (upper – mixed, lower – spastic), corresponding to AIS types A and C.

The most cranial levels of segmental lesions of the spinal cord, identified within the neurological examination, demonstrate the most frequent lesions of the lower thoracic segments (Fig. 2).

The median number of involved vertebrae was 3 (2; 4); angular deformity was noted in 17 (85 %) patients; and the epidural component was noted in 15 (75 %) patients.

Considering the objective of the study, the possibility of visualization, as well as the commonly known variability of the location of the lumbar enlargement (LE) of the spinal cord relative to vertebral structures, the following levels of changes in the signal of its structures indicated in the research protocols or established during the review of the radiologic findings were identified during the analysis of MRI: above LE (spinal tracts), LE, epiconus, conus medullaris and cauda equina. Considering these zones, the structure of spinal cord compression levels appeared as follows: spinal tracts above LE – 13 (65 %), LE – 1 (5 %), cauda equina – 1 (5 %), spinal tracts above LE + LE – 3 (15 %), and spinal tracts above LE + LE + epiconus + conus medullaris – 1 (5 %).

The Vedantam and Rajshekhar classification originally suggested for cervical spondylogenic myelopathy was used [10–12] in order to differentiate the radiologic manifestations of myelopathy. According to this classification two qualitative types of changes in the MRI signal were identified:

type 1: its diffuse increase with fuzzy or blurred borders on T2-WI with an iso-/hypointensive signal on T1-WI, morphologically corresponding to the edema/Wallerian degeneration/demyelination/myeloishemia/gliosis;

type 2: a pronounced (bright) clearly defined increase on T2-WI with a hypointensive signal on T1-WI, having a morphological correlation with myelomalacia/cavitation of spinal cord tissue.

According to this classification, signal changes corresponded to type 1 in 9 (45 %) cases, to type 2 in 6 (30 %), and there were no changes in the MR signal of the spinal cord revealed in 5 (25 %).

The urodynamic disorders were specified under the results of a comprehensive urodynamic study performed using the Pico Smart SNYC0022 system of Menfis Biomedica in accordance with the recommendations of the International Continence Society (ICS). Patients able to perform verticalization were examined in a standing or sitting position, in other cases – in a lying position. All patients underwent filling cystometry with an initial infusion rate of 20 ml/min. Due to the impossibility of verticalization of some patients, as well as limitations of the mobility due to the spine instability, the pressure-flow study was performed in full in 6 (30 %) patients. Electromyography of the pelvic floor muscles with surface electrodes was performed

in all patients during the filling and emptying phases of the bladder. The amount of residual urine was detected by urinary catheterization. Meanwhile, clinically, urine evacuation at the time of the study was done as follows: the urinary bladder was drained by an indwelling urethral catheter in 9 (45 %) patients; there was cystostomy drainage in 3 (15 %) patients; voluntary urination was preserved in 4 (20 %) patients; and urination was uncontrolled (involuntary urination) in 4 (20 %) patients.

Statistical analysis

Statistical analysis was performed using the SPSS Statistics v.22 software. The normality of the distribution of quantitative parameters was evaluated using Kolmogorov-Smirnov tests. The distribution was considered normal at the value of bilateral significance $p > 0.05$. The results are given as $M \pm \sigma$ (where M is the mean value and σ is the standard deviation) for normal and Me (Q25; Q75) for abnormal data distribution. The relationships of categorical variables were assessed using the construction of contingency tables and the evaluation of the criterion χ^2 and degrees of freedom (df), the Fisher's test with a value in cells less than 5, as well as the Bonferroni correction depending on the structure of the contingency tables. The correlation was considered statistically significant at the value of $p < 0.05$.

Results

Depending on the variant of lower urinary tract dysfunction and according to the urodynamic examination, patients were divided into 3 groups: hypo- and acontractility of the detrusor were found in 8 patients; hyperactivity of the detrusor was found in 6 patients; a combination of detrusor hyperactivity and detrusor-sphincter dyssynergia was found in 6 patients that corresponds to 40 %, 30 %, and 30 %, respectively (Fig. 3).

A detailed analysis of the urodynamic examination indicators revealed an increase in detrusor pressure in the filling phase of more than 40 cm water in 10 (50 %) patients (median: 55.50 cm water; 48.75; 71.25). A clinically significant boost in the volume of residual urine was revealed in 13 (65 %) cases; the median indicator was 275.00 ml (172.75; 477.00). A reduction in compliance was found in 8 (40 %) patients. Among the patients who underwent the pressure-flow test in full (n = 6), the mean maximum urination rate was 9.95 ml/s (6.55; 11.28) and the mean volume of urination was 244.50 ml (111.00; 261.00).

The outcomes of the statistical analysis of the correlation between the urodynamic disorder of the lower urinary tract and the complex of assessed indicators is shown in the Table.

The table data indicate that none of the assessed indicators – the type and level of disruption of the spinal cord MR signal, the depth of neurological disorders and their variants (spastic or paretic), gender, the presence of an angular deformity of the spine or the epidural component of the vertebral process, the possibility of verticalization of the patient or the etiological variant of spondylitis (tuberculous or nonspecific) – has a statistically significant association with the type of lower urinary tract dysfunction.

Discussion

Infectious spondylitis is marked by a severe course and a high frequency of complications, including neurological ones, resulting in the disability of patients [13]. Nevertheless, only isolated clinical studies, primarily in spinal tuberculosis, are aimed at determining the correlation between the severity of neurological disorders and the radiologic (neuroimaging) features of spondylitis. For example, Dunn et al. [9] in their retrospective study of 82 patients suffering from tuberculous spondylitis noted a statistically significant association of an increase in the spinal cord MR signal on T2-WI with the development of neurologic impairment, while Kalita et al. [6] in their prospective study of 15 similar patients found the association of the development of NLUTD with the severity of motor dysfunction ($p = 0.02$), the sensory level of spinal cord injury ($p = 0.0001$) and the change in the intensity of the signal from the spinal cord during the MR study ($p = 0.001$).

The features of neurogenic urination disorders in this pathology remain almost unstudied. The analysis of a few articles points to a variety of urodynamic disorders in infectious spondylitis, including detrusor hyperactivity, detrusor-sphincter dyssynergia, disruption of detrusor contractility, decreased compliance, etc. [6–8]. During the comparison of clinical, radiologic, and urodynamic parameters in patients suffering from tuberculous spondylitis with NLUTD (n = 16) and without it (n =

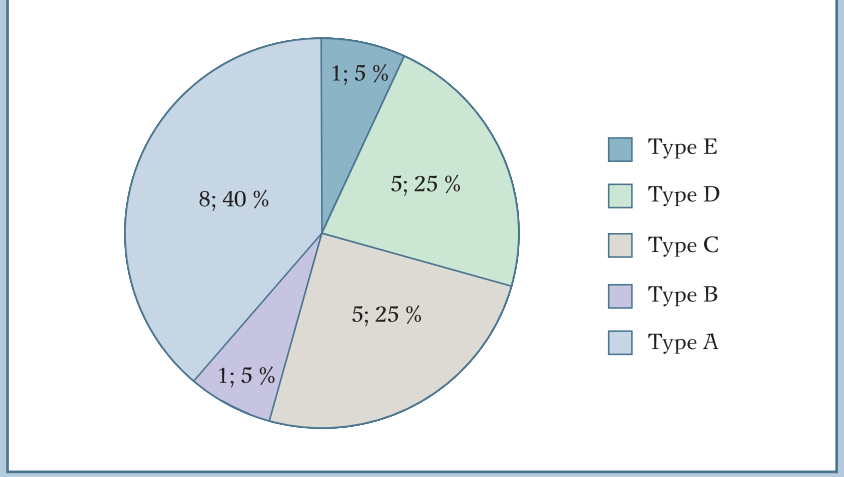

Fig. 1
Types of neurological disorders according to the AIS scale

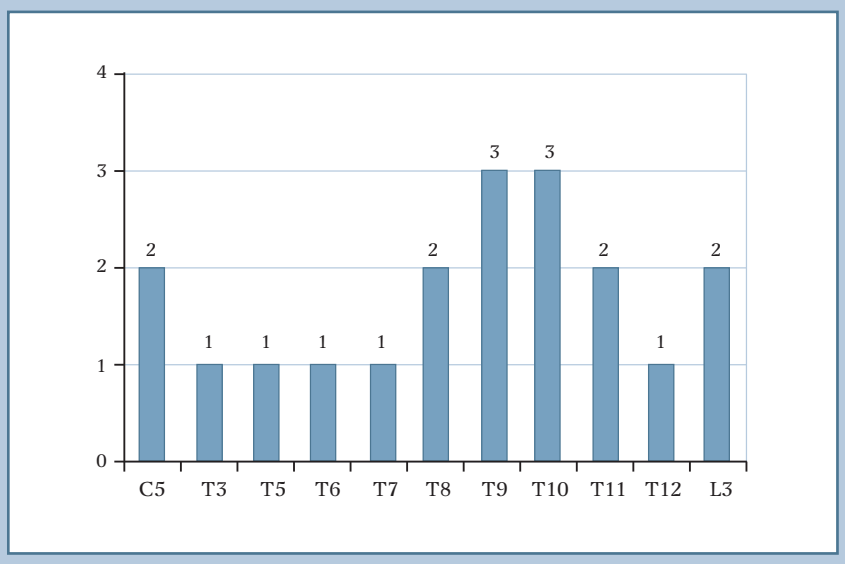

Fig. 2
The most cranial segmental level of spinal cord injury according to neurological examination

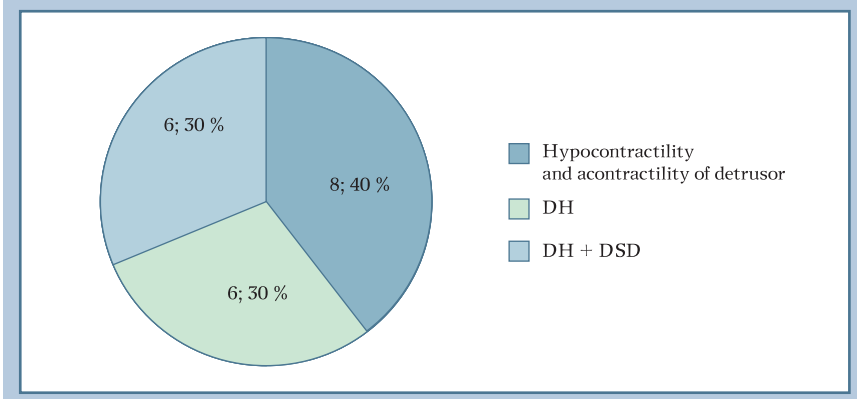

Fig. 3
The structure of neurogenic dysfunction of the lower urinary tract in patients with infectious spondylitis: DH – detrusor hyperactivity; DSD – detrusor-sphincter dyssynergia

14), Singh et al. [7] suggest the development of NLUTD when the nerve roots and posterior spinal cord are involved in the pathological process, while such patients had the worst outcomes of functional recovery after 6 and 12 months of treatment.

Our study also indicated different variants of urinary tract dysfunction with a predominance of neurogenic detrusor hyperactivity (12 (60 %) patients) combined with detrusor-sphincter dyssynergia in half of cases. It is typical that in 10 (50 %) patients during the study, an increase in detrusor pressure of more than 40 cm water was recorded in the phase of filling and/or emptying of the bladder that indicates a high risk of developing vesicoureteral reflux and, correspondingly, damage to the upper urinary tract [14].

Schrivatsava et al. [8] and Kalita et al. [6] point to the lack of a significant correlation between the type of lower urinary tract dysfunction and the level of spinal cord lesions evaluated by MRI. We were also unable to identify a similar correlation both with respect to this parameter and with respect to the MRI features of myelopathy (according to Vendatam), and that was more surprising, with respect to the severity of motor neurological disorders. Moreover, this corresponds to the Gupta and Taly data [15] obtained in 79 patients with non-traumatic myelopathy, including 8 patients with infectious spondylitis and with no correlation between the functional state of the bladder and the level of spinal lesion and the severity of neurological disorders evaluated by ASIA.

Significant and new (to our opinion) aspect is the absence of the influence of the etiology of spondylitis (tuberculous or nonspecific) on the development of NLUTD.

Conclusion

NLUTD in inflammatory infections of the spine includes several forms of urodynamic disorders. The currently available data on the absence of any association between the types of neurogenic lower urinary tract dysfunctions and topical spinal cord lesion reflect their complex and multilevel innervation.

There was no correlation between the development of a certain type of lower urinary tract dysfunction and the MRI types of myelopathies and the level of spinal cord compression assessed by Vendatam. The type of urodynamic disorders is not associated with the severity of neurologic impairment, and the disorders themselves may develop both in patients with profound neurological disorders and with their minimal severity.

It is probable that the obtained data (that do not contradict the previously published ones) make it unfavorable to search for both prognostic factors for the outcomes of NLUTD associated with the localization of myeloischemic changes. Confirmation or rebuttal of such a hypothe-

Table
Outcomes of the statistical analysis of the associative correlation between neurogenic lower urinary tract dysfunction and the complex of assessed categorical variables

Parameters	χ^2 value	df	p
Pattern of change in the MR signal (Vedantam)	0.704	4	0.951
Zone of MR signal changes	10.726	10	0.379
Neurological disorders according to the AIS scale	11.000	8	0.202
Gender	2.889	2	0.236
Angular deformity	1.699	2	0.747
Epidural component of the process	4.889	2	0.087
Possibility of verticalization	0.382	2	0.826
Spastic/paretic variant	2.184	2	0.336
Variant of inflammatory infections of the spine	4.549	2	0.103

df — degrees of freedom.

sis requires more number of observations. Nonetheless, any result, including a negative one, is important both for spinal surgeons and for specialists involved in the treatment of complications of inflammatory infections of the spine.

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The study was approved by the local ethical committees of institutions.
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