THE ROLE OF SPINE ADIPOSE INDEX IN PREDICTING THE RISK FOR SEPTIC SPONDYLODISCITIS AFTER LUMBAR PERCUTANEOUS LASER DISC DECOMPRESSION

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ABSTRACT

The aim. *To analyze the role of the spine adipose index (SAI) in predicting the risk of septic spondylodiscitis after lumbar percutaneous laser disk decompression (PLDD).*
Material and methods*. A retrospective observational single-center study was performed. Various clinical and instrumental parameters have been studied, including the spine adipose index, which are potential risk factors for the development of post-procedural septic spondylodiscitis.*
Results. *The study included 219 patients who underwent PLDD for degenerative lumbar disk disease. The mean post-operative follow-up period for the respondents was 30.8 ± 13.3 months. Signs of septic spondylodiscitis were detected in 5 (2.28 %) cases. Multivariate analysis showed that III degree of anesthesiological risk by the American Society of Anesthesiologists (ASA) scale (p = 0.021), a high value of body mass index (more than 25 kg/m^2) (p = 0.043) and a high value of SAI (over 0.7) (p = 0.037) are statistically significantly associated with the development of septic spondylodiscitis in patients who underwent lumbar PLDD.*
Conclusion. *The value of SAI is statistically significantly associated with the development of spondylodiscitis in patients who underwent PLDD for degenerative lumbar disk disease.*

Key words: *septic spondylodiscitis, spine adipose index, risk factors, percutaneous laser disk decompression*

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РОЛЬ СПИНАЛЬНОГО ЖИРОВОГО ИНДЕКСА В ПРОГНОЗИРОВАНИИ РИСКА РАЗВИТИЯ СЕПТИЧЕСКОГО СПОНДИЛОДИСЦИТА ПОСЛЕ ВЫПОЛНЕНИЯ ЧРЕСКОЖНОЙ ЛАЗЕРНОЙ ДЕКОМПРЕССИИ ПОЯСНИЧНЫХ МЕЖПОЗВОНКОВЫХ ДИСКОВ

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РЕЗЮМЕ

Цель исследования. *Изучить роль спинального жирового индекса (СЖИ) в прогнозировании риска развития септического спондилодисцита после выполнения чрескожной лазерной декомпрессии (ЧЛДД) поясничных межпозвонковых дисков.*

Материал и методы. *Выполнено ретроспективное наблюдательное одноцентровое исследование. Изучены различные клинико-инструментальные параметры, в том числе спинальный жировой индекс, потенциально являющиеся факторами риска развития постпроцедурного септического спондилодисцита.*

Результаты. *В исследование включено 219 пациентов, которым выполнена процедура ЧЛДД по поводу дегенеративного заболевания поясничных межпозвонковых дисков. Средний период послеоперационного наблюдения за респондентами составил 30,8 ± 13,3 месяца. Признаки септического спондилодисцита выявлены в 5 (2,28 %) случаях. Многофакторный анализ показал, что III степень операционно-анестезиологического риска по шкале Американского общества анестезиологов (ASA, American Society of Anaesthesiologists) (p = 0,021), высокое значение индекса массы тела (более 25 кг/м^2) (p = 0,043), а также большое значение СЖИ (свыше 0,7) (p = 0,037) статистически значимо связаны с развитием септического спондилодисцита у пациентов, перенёсших процедуру ЧЛДД на поясничном уровне.*

Заключение. *Значение СЖИ статистически значимо связано с развитием спондилодисцита у пациентов, перенёсших процедуру ЧЛДД по поводу дегенеративного заболевания поясничных межпозвонковых дисков.*

Ключевые слова: *септический спондилодисцит, спинальный жировой индекс, факторы риска, чрескожная лазерная декомпрессия межпозвонковых дисков*

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INTRODUCTION

Septic spondylodiscitis is the most common type of vertebral column infection, affecting the intervertebral cartilage with its adjoining endplates and vertebral bodies [1, 2]. The incidence of spondylodiscitis varies widely and ranges from 0.2 to 2.4 cases per 100,000 of population annually [3]. A number of authors claim that the frequency of occurrence of purulent forms of spondylodiscitis has increased significantly in the last two decades [4–6]. In their opinion, the reasons for such an increase in the prevalence of purulent discitis are: an increase in the average life expectancy of the population, a high incidence of various immunodeficiency conditions, uncontrolled use of antibacterial drugs, as well as an imminent increase in the percentage of performing diagnostic manipulations [5, 6].

The treatment and prevention of septic spondylodiscitis after surgical procedures on the lumbar spine represents a promising area of modern spinal surgery and orthopaedics. Thus, the development of bacterial spondylodiscitis in the early postoperative period is associated with a high incidence of adverse clinical outcomes, an increase in the time of hospitalization of patients and, as a consequence, with an increase in the economic costs of practical healthcare [7]. For this reason, the search for new methods that can predict and prevent the development of septic spondylodiscitis after surgical procedures on the lumbar spine is an extremely urgent problem.

We are aware of a study conducted by V.K. Gupta et al. [8] devoted to the study of the role of the spinal adipose index (SAI) when predicting the risk of development of deep surgical infections after posterior rigid lumbar stabilisation surgery. SAI is the ratio of the thickness of subcutaneous fatty tissue in the lumbar area to the distance between the skin and the vertebral arch [8] (Fig. 1). The authors of this study have clearly demonstrated that SAI plays an important role in predicting the risk of the development of deep surgical site infections among patients who have undergone posterior lumbar fixation surgery.

A literature search of national and international scientific databases revealed a lack of reports devoted to the study of the role of SAI in predicting the risk of septic spondylodiscitis after lumbar percutaneous laser disc decompression (PLDD), which induced the present study.

THE AIM OF THE STUDY

To study the role of spinal fat index in predicting the risk of septic spondylodiscitis after lumbar percutaneous laser disk decompression.

MATERIAL AND METHODS

Study design

A retrospective observational single-centre study was conducted in accordance with international guidelines that govern the conduct and reporting of observational studies in Epidemiology (STROBE, The Strengthening the Reporting of Observational Studies in Epidemiology) [9].

Eligibility criteria

The study included the medical records of patients who had undergone a lumbar PLDD procedure for a degenerative disease of the latter.

The inclusion criteria for the study were:

1) the age of respondents is between 18 and 70;
2) the duration of pain in the lower part of the back and/or lower limbs is at least 6 months;
3) patients' quality of life as measured by the Oswestry Disability Index (ODI) is less than 30 %;
4) ineffectiveness of ongoing conservative treatment for at least 4–6 weeks.

The exclusion criteria for medical records from the study covered:

1) a previous medical history of spinal surgical procedures;
2) a severe neurological impairment;
3) spodylolysis or degenerative spondylolisthesis;
4) central spinal canal stenosis;
5) pregnancy;
6) the history of chronic infectious foci in the body;
7) the failure to provide a full range of clinical and instrumental data from the respondent study;
8) the loss of communication with respondents in the postoperative period.

Proper environment

The study was performed on the basis of the Center for Minimally Invasive Surgery of the Kharlampievskaya Clinic (Irkutsk).

Duration of the study

The study was conducted between March 2021 and April 2022.

Medical intervention description

The lumbar spine LBDD procedure was performed according to generally accepted procedures, with the patient lying on his stomach with lumbosacral flexion, under intravenous sedation and fluoroscopic monitoring by means of a Philips BV Pulsera C-arm (Royal Philips Electronics, The Netherlands). The skin and subcutaneous adipose tissue were tightly infiltrated with a local anaesthetic solution, followed by paraphorominal insertion of a Complete Chiba biopsy needle (Sterylab, Italy), 18 G in diameter and 20 cm long, towards the centre of the nucleus pulposus of the intervertebral cartilage. The next stage was the discography using the X-ray contrast agent Omnipack (GE Healthcare, Ireland) in order to identify structural changes in the fibrous ring. Discography was followed by laser decompression of the intervertebral cartilage using a Mediola Compact diode laser device (Mediola, Belarus). The parameters of the laser radiation were as fol-

lows: wavelength 960 nm, power 7 W, pulse duration 0.6 s, pause duration 1 s, absorbed energy value 1500 J.

Prophylaxis to prevent surgical site infections was performed according to clinical guidelines [10] and included intravenous administration of cefazolin at a dose of 1 g.

The procedure was performed by three neurosurgeons in one operating theatre with the same instrumental equipment.

Study outcomes

The following clinical and instrumental parameters that could potentially be risk factors for septic spondylodiscitis after lumbosacral PLDD were assessed in the study group of patients: gender; age; level of surgical and anaesthetic risk as measured by the American Society of Anaesthesiologists (ASA) scale; body mass index (BMI) value; smoking; diabetes mellitus; number of intervertebral cartilages being operated on; duration of surgical intervention; amount of blood loss; thickness of subcutaneous fatty tissue; and SAI value.

Outcome recording methods

The diagnosis of septic spondylodiscitis has been made according to the clinical, instrumental and laboratory studies, as recommended by the clinical guidelines of the Ministry of Health of the Russian Federation [10]. Subcutaneous adipose tissue thickness and TJI values were calculated on standard T1- and T2-weighted images in sagittal mode using Radiant DICOM Viewer program (Medixant, Poland) using the method of V.K. Gupta et al. [8] (Fig. 1).

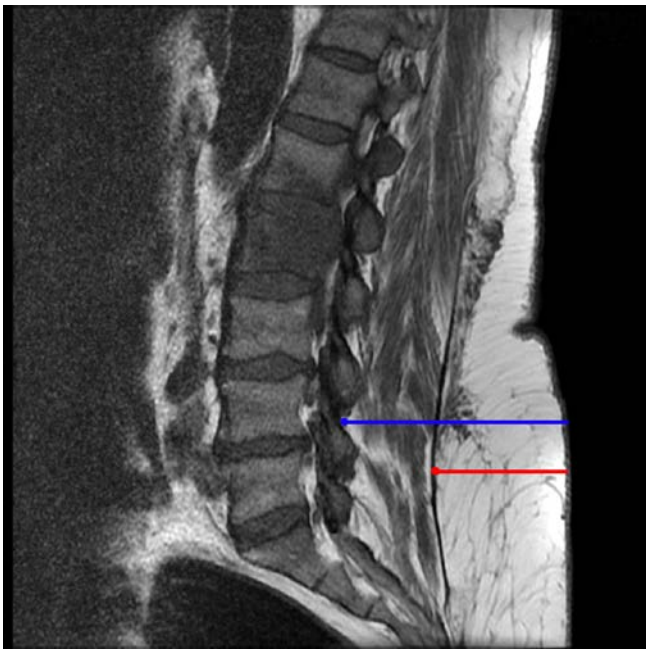

FIG. 1.

An example of the calculation of SAI using the method of V.K. Gupta et al. [8] based on a T2-weighted image of the lumbar spine with signs of septic spondylodiscitis at L_{III}–L_{IV} in the sagittal plane after PLDD

Ethical review

The study protocol was approved by the Ethics Committee of the Irkutsk State Medical University of the Ministry of Health of Russia. The study was conducted in accordance with the principles of good clinical practice and the Declaration of Helsinki [11].

Statistical data analysis

Continuous variables are represented as mean values (M) and their standard deviations (SD), categorical variables are represented as their number (*n*) and frequency of occurrence (%). A single-factor analysis was performed with the intention of identifying an unadjusted association between the analysed patient parameters and the risk of poor clinical outcomes. The intergroup comparison of categorical variables was performed using Fisher's exact test, continuous variables – using Student's t-test. The collinearity of the covariates was analyzed using the Pearson correlation coefficient. Covariates with a statistically significant effect in a single factor analysis are included in a binary logistic regression model used to identify reliable risk factors for septic spondylodiscitis in patients who underwent a lumbar LBDD procedure. An overall assessment for the consistency of the model and the data obtained was assessed using the Hosmer – Lemeshow test. Statistical data processing was carried out using software Microsoft Excel 2016 (Microsoft Corp., USA) and SPSS 22.0 (IBM Corp., USA). The statistical significance threshold *p* was chosen to be 0.05.

RESULTS

Study participants

According to the eligibility criteria, the present study included 219 patients who had undergone a PLDD procedure for degenerative lumbar intervertebral cartilage disease. The mean post-operative follow-up period for the respondents was 30.8 ± 13.3 months. Signs of septic spondylodiscitis were diagnosed among 5 (2.28 %) patients. In 4 cases, the causative agent was *Staphylococcus aureus* and in 1 case, the etiological agent was *Escherichia coli*. The general characteristics of the patients included in this study are presented in Table 1.

Univariate data analysis

An univariate analysis showing the effect of different parameters on the risk of infective spondylodiscitis among patients with degenerative lumbar intervertebral cartilage disease after PLDD was performed demonstrate the following results. A high degree of surgical and anesthetic risk on the ASA scale (grade III) ($p = 0.029$), the presence of diabetes mellitus ($p = 0.037$), a high BMI value (more than 25 kg/m^2) ($p = 0.024$), as well as a significant subcutaneous adipose tissue thickness (more than 40 mm) ($p = 0.032$) and a high value of SAI (over 0.7) ($p = 0.025$) were associated with the development of spondylodiscitis in the study group of respondents (Table 2).

TABLE 1
GENERAL CHARACTERISTICS OF THE RESPONDENTS INCLUDED IN THE CLINICAL STUDY

Parameters	*n*	%
Gender: male/female	115/104	52.5/47.5
Age (M ± SD)	53.7 ± 8.1	–
Smoking: yes/no	107/112	48.8/51.2
Presence of diabetes mellitus: yes/no	36/183	16.4/83.6
Body mass index value, kg/m^2 (M ± SD)	25.3 ± 12.1	–
Surgical and anaesthetic risk according to the ASA scale		
I degree	177	80.8
II degree	31	14.1
III degree	11	5.1
Number of operated intervertebral cartilages		
1	166	75.7
2	44	20
≥ 3	9	4.3
Duration of surgical intervention, min (M ± SD)	21.4 ± 14.8	–
Volume of blood loss, ml (M ± SD)	11.5 ± 4.2	–
Subcutaneous adipose tissue thickness, mm (M ± SD)	39.7 ± 16.6	–
SAI value (M ± SD)	0.5 ± 0.3	–

Results of multivariate data analysis

A univariate analysis was used to construct a binary logistic regression model including parameters that were statistically significantly associated with the development of infective spondylodiscitis in the patient group under study (Table 3).

According to the constructed model, the III degree of surgical and anesthesiological risk on the ASA scale ($p = 0.021$), a high BMI value (more than 25 kg/m^2) ($p = 0.043$), as well as a high value of SAI (over 0.7) ($p = 0.037$) were statistically significantly associated with the development of septic spondylodiscitis in patients, who underwent the PLDD procedure for a degenerative intervertebral cartilage disease of the lumbar spine. Hosmer – Lemeshow test demonstrated a high degree of consistency between the constructed model and the data obtained ($\chi^2 = 4{,}118$; $p = 0.576$).

DISCUSSION

The conducted study clearly demonstrated that a high value of SAI is a statistically significant risk factor

TABLE 2
RESULTS OF UNIVARIATE ANALYSIS

Parameters	*p*
Male	0.61
Female	0.74
Age (60 years and older)	0.51
Smoking	0.23
The presence of diabetes mellitus	0.037
Body mass index value (more than 25 kg/m^2)	0.024
Surgical and anaesthetic risk according to the ASA scale	
I degree	0.26
II degree	0.18
III degree	0.029
Number of operated intervertebral cartilages	
1	0.74
2	0.48
≥ 3	0.35
Duration of surgical intervention (more than 20 minutes)	0.85
Volume of blood loss (more than 15 ml)	0.97
Subcutaneous adipose tissue thickness (over 40 mm)	0.032
SAI value (over 0.7)	0.025

TABLE 3
RESULTS OF BUILDING A BINARY LOGISTIC REGRESSION MODEL

Parameters	OR (95% CI)	*p*
Smoking	1.69 (0.65–4.31)	0.75
The presence of diabetes mellitus	1.18 (0.33–3.53)	0.42
Body mass index value (more than 25 kg/m^2)	0.81 (0.28–2.29)	0.043
Surgical and anaesthetic risk according to the ASA scale (III)	0.97 (0.96–1.17)	0.021
Subcutaneous adipose tissue thickness (over 40 mm)	0.85 (0.67–1.12)	0.54
SAI value (over 0.7)	0.99 (0.92–1.06)	0.038

Note. OR – odds ratio; 95% CI – 95% confidence interval.

for the development of septic spondylodiscitis after performing lumbosacral PLDD. A literature search of the PubMed, Medline, EMBASE, Cochrane Library and eLibrary scientific databases revealed several reports supporting the effect of SAI values on the risk of surgical infection among patients undergoing posterior stiffening lumbar surgery [12], anterior fixation cervical discectomy [13], and knee and hip endoprosthetics [14]. No similar studies were found regarding the risk of developing dyscitis after the PLDD procedure.

Other studied risk factors for the development of septic spondylodiscitis among patients who have undergone PLDD include a high degree of surgical and anesthetic risk on the ASA scale and a high BMI value. Similar results have been obtained in the clinical series A. Marquez-Lara et al. [15], J.J. Lee et al. [12], as well as in the study of A.O. Mehta et al. [16]. However, these studies also examined groups of respondents who had undergone open decompression-stabilisation surgery on the cervical and lumbar spine. Authors of the aforementioned studies believe that patients with high BMI values and marked subcutaneous fatty tissue thickness are at high risk of surgical infections, including deep localization [15, 16]. The reason for this is the peculiarities of performing surgical access and creating the necessary manipulative tissue corridor to the structures of the spine. Generally, a wide skin incision is then performed in this group of patients, followed by a prolonged insertion of a wound dilator. All this can lead to the contamination of the surgical wound with skin microflora, and a retractor installed causes long-term ischaemia of the tissue mass with the formation of necrosis foci, which subsequently only increases the activity of the infection process [17].

The pathogenesis of septic spondylodiscitis after PLDD is closely related to several factors. For example, inadequate antiseptic preparation of the skin prior to the lumbar PLDD procedure stimulates direct entry of the infective agent into the intervertebral cartilage and, in patients with thick subcutaneous fatty tissue, further spread of micro-organisms and consequently generalisation of the inflammatory process [18]. Haematogenous spread from primary sources of acute or chronic infection also appears to be one of the most important ways for micro-organisms to enter the tissue of the intervertebral cartilage. Blood supply disturbances to the endplates with reduced diffusion of nutrients into the fibrous ring and nucleus pulposus inevitably lead to impaired immune surveillance and the immediate development of an infection process when bacteria and/or fungi penetrate the intervertebral cartilage [19].

Study limitations

Obviously, this study is not free from shortcomings. Firstly, the study is retrospective in nature and includes a small number of patients, which could not but affect the results of statistical analysis of the data obtained. Secondly, the authors have not studied the microbiological characteristics of the identified cases of septic spondylodiscitis after the lumbar spine PLDD procedure. And thirdly, several MRI images in the sagittal plane with artefacts, which may have affected the results of subcutaneous adipose tissue thickness calculations and, consequently, SAI, were included in the analysis.

CONCLUSION

The study showed that a high BMI value (more than 25 kg/m^2), as well as a high SAI value (over 0.7), were statistically significantly associated with the development of spondylodiscitis in patients had undergone a PLDD procedure for degenerative lumbar intervertebral cartilage disease. We believe that patients who have the above risk factors for dyscitis should be treated preoperatively with antibiotic prophylaxis, with careful treatment of the skin with antiseptic solutions, and that the puncture of the intervertebral cartilage should be performed with a slight retraction of the skin to create a "broken" surgical corridor. There is no doubt that large multicentre prospective studies including more respondents will be necessary to evaluate more objectively the proposed preventive measures for septic spondylodiscitis in patients who have undergone a lumbar PLDD.

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Conflict of interest

The authors declare the absence of a conflict of interest.

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Beloborodov V.A. – development of the study design; definition of the purpose and objectives of the research; scientific editing; approval of the manuscript for publication.