OBESITY AND SPINAL SURGERY: A SYSTEMATIC REVIEW

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Objective. A systematic review of the outcomes of surgical treatment of patients with spinal pathology in obesity.
Material and Methods. A search was conducted in the Pubmed, EMBASE, ELibrary and Google databases for studies assessing the impact of obesity on the results and outcomes of spinal surgeries, the frequency and type of complications, and clinical and functional outcomes. The type of articles of interest was a systematic review and meta-analysis; the search period was 10 years. The literature search was performed by three researchers. The study was conducted in accordance with the international PRISMA guidelines for writing systematic reviews and meta-analyses. The levels of evidence reliability and recommendation strength gradations were assessed according to the ASCO guidelines.
Results. A total of 1,695 articles were found in the databases using keywords, of which 1,618 were with full-texts, 1,161 — over the last 10 years, and 62 — systematic reviews and meta-analyses. The inclusion criteria were met by 17 articles. One article by domestic authors was additionally included in the sample by agreement of the authors of this publication. Thus, the study included 18 articles. Risk factors in obese patients undergoing spinal surgery include insulin resistance, arterial hypertension, atherogenic dyslipidemia, prooxidant and inflammatory activity, and muscle oxidative stress. Comparative analysis of surgical interventions in obese patients showed significantly higher duration of surgery, volume of blood loss, infectious and thromboembolic complications, and frequency of repeated interventions. According to all studies, the functional outcome of treatment in the long-term follow-up period does not differ in groups of obese and non-obese patients. Minimally invasive surgical interventions in obese patients showed advantages in terms of lower blood loss and shorter length of hospital stay without significant differences in functional outcomes. Technical difficulties in surgical interventions in obese patients are associated with surgical access, requiring additional traction of soft tissues and special instruments, which affects the duration of surgery, the volume of blood loss and, possibly, infectious complications.
Conclusion. Obesity is a significant risk factor for perioperative complications in elective spinal surgery, the most important of which are blood loss, duration of surgery, surgical site infection, thromboembolism and repeated interventions. It is the operating surgeon who, based on all the initial data, determines the possibility of performing the intervention during the period of the patient's visit, taking into account the risk factors, technical capabilities and features of surgical manipulations.
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Obesity is defined by the World Health Organization as a body mass index (BMI) equal to or greater than 30 kg/m^2. There are three stages of obesity: the first – BMI = 30.0–34.9 kg/m^2; the second – BMI = 35.0–39.9 kg/m^2; and the third – morbid obesity, BMI ⩾ 40 kg/m^2 [1].

Obesity is a global health challenge affecting a significant proportion of adults worldwide. In 2016, the prevalence of obesity was 13% of individuals aged over 18 years old. The correlation between obesity and numerous diseases has been proven (type 2 diabetes, hypertension, cardiovascular diseases and some types of cancers); furthermore, higher mortality rates have been reported in obese patients [1].

Obesity is a multifactorial condition involving consumption of highly processed and high-calorie foods, limited physical activity, and other nonmodifiable genetic factors. Bariatric surgery is indicated for obese patients, and they are at increased risk of postoperative complications as well as longer periods of hospital stay, thus contributing to the overall increase in the cost of health care [2].

Obesity predisposes to disc degeneration and low back pain and potentially increases the frequency of indications for surgical treatment. Obese patients who underwent spinal surgery have a higher risk of postoperative complications, especially surgical site infection and venous thromboembolism [3].

A preliminary literature search showed that systematic reviews on the outcomes of elective spinal surgery in obese patients are controversial. There is no unified concept regarding the specific features and technical challenges associated with spine surgery in obesity, whether obesity is a contraindication for elective surgery, and whether preoperative weight loss is required.

The objective is to perform a systematic review of surgical treatment outcomes of patients with spinal pathology in obesity.

Material and Methods

Search and selection strategy for literature data. We performed a search for publications in Pubmed, EMBASE, ELibrary, and Google databases evaluating the effect of obesity on the results and outcomes of spine surgery, incidence and type of complications, as well as clinical and functional outcome. Three researchers were involved in the literature search. The study was performed in accordance with the PRISMA international protocol (Fig., Table 1).

Inclusion criteria: available full-text articles in English and Russian, systematic reviews and meta-analyses of the surgical outcomes of obese patients at any level of the vertebral column, of any age, using various techniques.

Exclusion criteria: systematic reviews and meta-analyses on the diagnosis of diseases of the spine in obese patients; articles that do not provide data on perioperative and postoperative follow-up of patients; case reports; articles without full-text versions available.

The first step of the PRISMA protocol involved a literature search using the keywords "Obesity and Spine Surgery". The depth of the search was 10 years. At the second stage, we excluded articles that did not meet the research criteria. In the third step, we reviewed the full texts of the selected articles for compliance with the inclusion criteria and the reference list for relevant studies.

The main research questions were formulated to analyze the papers:

1) risk factors for spine surgery in obese patients;

2) a comparative analysis of complications in obese and non-obese patients;

3) functional outcomes of surgery in obese and non-obese patients;

4) a comparative analysis of open and minimally invasive surgeries in obese patients;

5) technical difficulties in surgery in obese patients: anesthesia, position on operating table, instrumentation, approach;

6) if obesity is a contraindication for elective spine surgery;

7) patient selection, preparation for surgery.

Results

1,695 articles were found in databases using the keywords "Obesity and Spine Surgery"; among them: 1,618 articles with full text, 1,161 articles in the last 10 years, and 62 systematic reviews and meta-analyses. Seventeen papers met the inclusion criteria. One article by Russian authors [4] did not meet the inclusion criteria for timing of publication and the requirements for systematic reviews at the present time. Nevertheless, this is the only Russian-language review article on the given topic; it was included in the sample by agreement of the authors of this study. Consequently, 18 articles were included in the study.

It should be mentioned that the selected articles analyze elective surgeries for degenerative disc diseases. Lumbar spine surgery outcomes were analyzed most frequently (Table 2). The authors use various statistical unified parameters and coefficients as the basis for comparative analyses. At the same time, the selected articles are conditionally divided into two groups: the first – comparative analysis of the surgeries of obese and non-obese patients; the second – comparative analysis of open and minimally invasive procedures in obese patients. Since some of the articles cover both topics, the distinction is conditional.

Risk factors for surgeries in obese patients

Obesity is an independent risk factor for complications during any surgery, including spine surgery. A correlation has been established between obesity, especially abdominal obesity, and insulin resistance because of increased secretion of some adipokines [1, 3]. Hypertension and atherogenic dyslipidemia promote the prothrombotic state [1, 3]. The close correlation between the condition of skeletal muscles and systemic insulin resistance develops prooxidant and inflammatory activity. Ectopic lipid deposition disrupts muscle protein metabolism, contributing to systemic and muscle oxidative stress. Blood glucose concentrations may also have a significant effect on immunologic/cellular mechanisms and form an increased infection risk. Despite there is still being no consensus on glycemic control in the perioperative period, the effects of acute hyperglycemia on neutrophil activity, cytokine pattern and microvascular reactivity have been proven [1].

In the general population, obesity is an independent risk factor for both deep vein thrombosis and pulmonary embolism resulting from chronic inflammation associated with obesity, impaired fibrinolysis, increased thrombin generation, and increased platelet activation. A higher risk of venous thromboembolism has been reported in obese patients who underwent elective spine surgery [3].

Obesity is associated with a higher incidence of musculoskeletal system disorders, chronic back pain and disc degeneration [6, 18]. Obesity also increases the risk of cervical myelopathy and radiculopathy [18].

Comparative analysis of surgical complications in obese and non-obese patients

Anterior approach for degenerative diseases of the cervical spine: no significant differences in clinical outcomes in the immediate and late postoperative periods were found [1, 18].

Posterior approach for degenerative diseases of the cervical spine: there were more infectious complications and instrumentation instability in obese patients [1], prolonged duration of surgery and hospital stay, higher mortality rate, and more frequent thromboembolic complications [18].

The data are controversial when analyzing surgeries on the lumbar spine: both the lack of reliable differences between patient groups and critical differences in the parameters considered are reported. The main types of complications considered are infectious complications, thromboembolism, injury to the dura mater and spinal nerves. Blood loss volume, duration of surgery, length

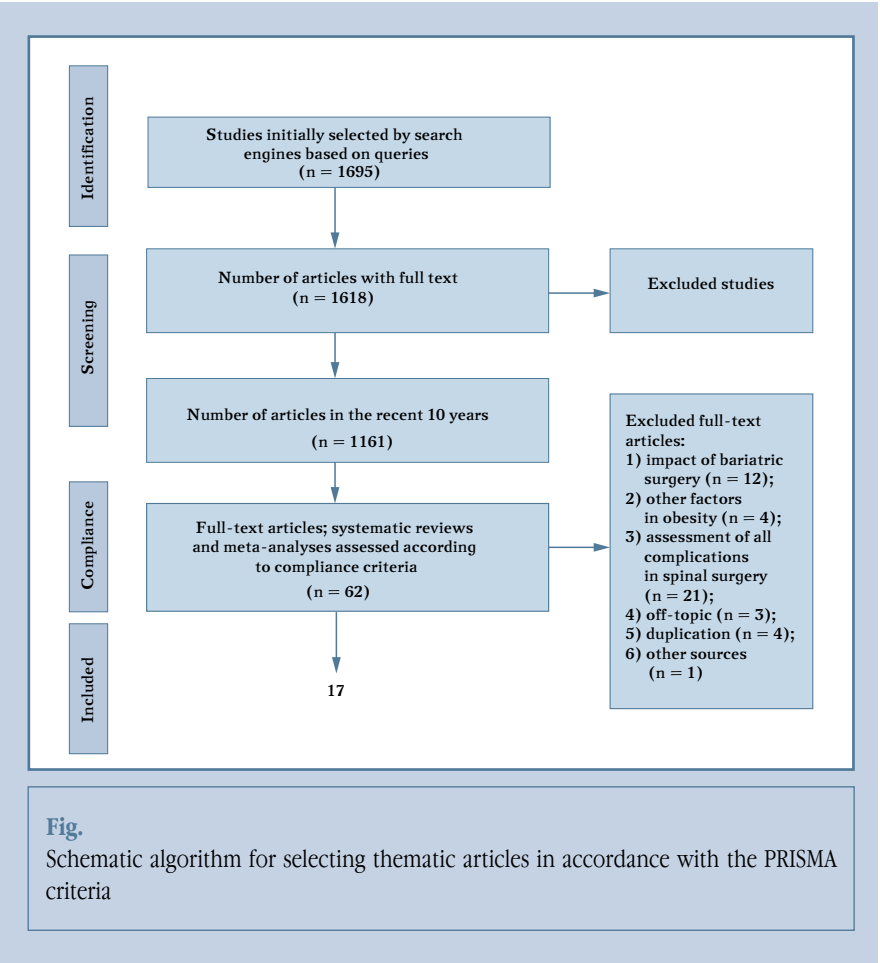

Fig.
Schematic algorithm for selecting thematic articles in accordance with the PRISMA criteria

of hospital stay, repeated surgery rate, and mortality are also parameters to be assessed (Table 3).

The duration of surgery was evaluated in 12 articles: according to their data, the parameter was significantly higher in obese patients.

Intraoperative blood loss (12 articles): higher in all studies except Ghobrial et al. [9].

Length of hospital stay (10 articles): the results are controversial; authors have reported both a higher value of this parameter (n = 6) [1, 2, 6, 14, 15, 17] and similar admission periods in patients with and without obesity (n = 4) [5, 8-10]. Delayed wound healing and difficulties with mobilization and rehabilitation of patients in the postoperative period are considered to be factors determining the increased length of hospital stay [14].

Infectious complications (9 articles) are definitely found more often in obese patients (8 studies).

Thromboembolic complications (6 articles): most articles (n = 4) reported a higher incidence of thromboembolic complications in obese patients.

Comparative analyses of dura mater injury were performed in five studies, whereas in three of them the differences between the patient groups were insignificant, and in two of them it was more frequent in obese patients.

The frequency of repeated surgeries (7 articles) was definitely more frequent in obese patients (n = 5).

The postoperative mortality rate has been evaluated in two studies [2, 6], and there were no differences between the patient groups.

In a systematic review by Wang et al. [15], there was a comparative analysis of the outcomes of minimally invasive surgeries (discectomy and tranforaminal spinal fusion) in obese and non-obese patients. No significant differences

Table 1
Criteria for inclusion/exclusion and selection of articles in accordance with PRISMA principles

PRISMA elements	Exclusion criteria	Exclusion criteria
Participants	Obese patients undergoing spinal surgery	Patients undergoing surgery for reasons other than spinal disease
Surgical intervention	Surgical treatment of spinal diseases	–
Comparison	Research groups in the selected articles	
Outcome	The impact of obesity on the outcomes of spinal surgeries, intraoperative and postoperative complications, clinical and functional outcomes	
Study design	Systematic review	Randomized and non-randomized, retrospective, prospective studies. Clinical cases, clinical case series
Articles	In Russian, English, full text	In any other languages, without access to the full text

Table 2
Articles complied with the selection criteria and included in the review

Authors	Year	Study design	Included articles, n	Search strategy	Patients' features	Follow-up period	Type and level of surgery	Assessment parameters
Golovin et al. [4]	2013	Literature Review	64	–	–	–	Degenerative diseases, lumbar spine	General frequency of complications, technical aspects
Bansal et al. [5]	2023	Systematic review and meta-analysis	8	Prisma	n = 566; mean age – 39.05 years; obese men – 56.6%, non-obese men – 63.4%	–	Degenerative diseases, lumbar spine	Complications (DM injury), duration of surgery, blood loss, length of hospital stay, recurrence rate, clinical outcomes, functional outcomes
Cao et al. [6]	2016	Meta-analysis	12	Prisma, assessment of articles – Newcastle Ottawa Scale	n = 8,066; with obesity – 2,412	–	Degenerative diseases, lumbar spine	Infectious complications, thromboembolism, spinal nerve injury, DM injury, blood loss, duration of surgery, functional outcomes, mortality rate
Chen et al. [7]	2022	Systematic review and meta-analysis	6	Prisma	n = 654; 267 (40.8 %) men, 387 (59.2 %) women	–	Comparative analysis of open and minimally invasive transforaminal spinal fusion techniques in obese patients	Complications (DM injury, surgical site infection), blood loss, duration of surgery, length of hospital stay, clinical outcomes, functional outcomes
Cofano et al. [1]	2022	Systematic review	130	Prisma, assessment of articles – Sacket	–	–	Spinal fusion, degenerative diseases, cervical and lumbar spine	Infectious complications, thromboembolism, blood loss, duration of surgery, functional outcomes, repeated surgeries
Feng et al. [8]	2024	Systematic review and meta-analysis	4	Prisma	n = 258; 99 – with obesity, 159 –without obesity	–	Degenerative diseases, lumbar spine	Duration of surgery, duration of approach, rate of general and late complications, length of hospital stay, clinical outcomes, functional outcomes
Ghobrial et al. [9]	2022	Systematic review	14	Prisma	n = 13,653; mean age – 52.6 years; 46.4 % – women	24 month	Degenerative diseases, lumbar spine, decompression surgeries without instrumental fixation	Clinical outcomes: pain syndrome, limitation of life activities, satisfaction with surgery, DM injury, infectious complications, morbidity and mortality rate
Goyal et al. [10]	2019	Systematic review	32	Prisma	n = 23,415, including 7,274 with obesity; 62.7 % – women	–	Degenerative diseases, lumbar spine	Blood loss, duration of surgery, length of hospital stay, repeated surgeries, DM injury, functional results
Jackson и Devine [3]	2016	Systematic review	54	–	–	–	Degenerative diseases, lumbar spine	Infectious complications, thromboembolism, functional outcomes
Jiang et al. [2]	2014	Systematic review and meta-analysis of randomized controlled trials	32	Prisma	n = 97,326	–	Degenerative diseases, cervical, thoracic, lumbar and sacral spine	Infectious complications, blood loss, mortality rate, repeated surgeries, duration of surgery
Lingutla et al. [11]	2015	Systematic review and meta-analysis	17	Newcastle-Ottawa Scale	n = 12,984 with obesity (men age – 56.9 years); n = 293,542 without obesity (mean age – 56.8 years)	–	Spinal fusion (open and minimally invasive techniques), lumbar spine, back pain syndrome	Blood loss, duration of surgery, length of hospital stay, leg and back pain, functional outcomes

Ending of the Table 2
Articles complied with the selection criteria and included in the review

Othman et al. [12]	2020	Systematic review and meta-analysis	4	Prisma	n = 430; mean age — 53.5 years; 153 men, 203 women	—	Comparative analysis of open and minimally invasive transforaminal spinal fusion techniques in obese patients	Surgical complications, blood loss, duration of surgery, length of hospital stay, clinical outcomes, functional outcomes
Tan et al. [13]	2018	Systematic review and meta-analysis	4	Prisma	n = 430; 194 (45.1 %) men, 236 (54.9 %) women; mean age 54.8 ± 12.0 years	—	Comparative analysis of open and minimally invasive transforaminal spinal fusion techniques in obese patients	Complications (DM injury), duration of surgery, blood loss, length of hospital stay, recurrence rate, clinical outcomes, functional outcomes
Tang et al. [14]	2024	Systematic review and meta-analysis	14	Prisma	n = 4,889; age from 37.8 to 64.6 years	from 6 weeks to 2 yearsт	Degenerative diseases, lumbar spine	Blood loss, duration of surgery, length of hospital stay, clinical outcomes, functional outcomes, rate of pseudoarthrosis
Wang et al. [15]	2018	Systematic review and meta-analysis	12	Prisma	n = 1,198	—	Comparative analysis of open and minimally invasive discectomy and transforaminal spinal fusion techniques in obese and non-obese patients	Blood loss, duration of surgery, length of hospital stay, clinical outcomes, functional outcomes
Xie et al. [16]	2018	Meta-analysis	7	Prisma	n = 638	—	Degenerative diseases, lumbar spine	Blood loss, duration of surgery, length of hospital stay, postoperative drainage, time to verticalization, clinical outcomes, functional outcomes
Xu et al. [17]	2022	Meta-analysis	16	Newcastle-Ottawa Scale	n = 6,453; with obesity — 2,467, with normal weight — 3,986 with obesity — 2,467, with normal weight — 3,986	12—48 months	Degenerative diseases, lumbar spine, open posterior spinal fusion in obese and non-obese patients	Complications (pneumonia, wound hematoma, urinary tract infection), DM injury, spinal nerve injury, blood loss, duration of surgery, thromboembolism, length of hospital stay, clinical and functional outcomes
Zhang et al. [18]	2020	Systematic review	7	Prisma	—	—	Degenerative diseases, cervical spine	Clinical outcomes: pain syndrome, limitation of life activities, satisfaction with surgery, DM injury, infectious complications, morbidity and mortality rate

DM — dura mater; CNS — central nervous system; CVS — cardiovascular system.

between the groups were found in the analysis of complications; differences were found in the parameters of surgery duration, blood loss volume and length of hospital stay.

In an analysis of surgical techniques, Cofano et al. [1] pointed out that there was no increased risk of complications in obese patients when performing LLIF. There was no difference in surgery duration, blood loss volume, length of hospital stay, and the total number of complications when performing ALIF. Nevertheless, the incidence of bone block formation was lower in obese patients.

Functional outcomes of surgeries in obese and non-obese patients

The functional outcome of surgeries on the cervical spine is shown in a study by Zhang et al. [18]: the differences between obese and non-obese patients are unreliable.

VAS, ODI, and the SF-36 questionnaire were most often used to evaluate the functional results of surgery for degenerative lumbar spine diseases. According to the results of 10 studies, functional outcomes were similar in the obese and non-obese groups and had no clinical significance (Table 3).

Meanwhile, the authors specify that obese patients have worse initial functional scores and less improvement with conservative treatment.

Functional outcomes of minimally invasive lumbar spine interventions showed no significant differences in obese and non-obese patients [15].

Comparative analysis of open and minimally invasive surgeries in obese patients

Open and minimally invasive procedures in obese patients were compared in five studies [1, 7, 12, 13, 16] using open and minimally invasive transforaminal spinal fusion techniques (Table 4).

According to the data of the authors, just blood loss volume and length of hospital stay were higher in open procedures. Functional outcomes in these types of surgeries did not show any differences.

According to Goyal et al. [10], the influence of BMI on the incidence of complications in lumbar spine surgeries is associated with the invasiveness of the surgery. Minimally invasive surgeries are characterized by a smaller surgical wound required for the approach, thus avoiding the associated complications.

Technical challenges in surgery in obese patients

The thick adipose layer in obese patients requires additional retraction during surgical approach, which increases the duration of surgery. Injury to the soft tissues and increased time of surgery may result in additional hemorrhage [6].

Longer retractors are used to approach the spine in obese patients, which limits the view of the surgical area [9] and complicates the approach to necessary anatomical landmarks [16].

According to the literature [3], increased duration of surgery and blood loss volume in obese patients correlates with the incidence of postoperative complications by increasing the degree of soft tissue ischemia because of retraction, higher probability of contamination of sterile instruments, increased total anesthesia time and positioning risk. Large blood loss volumes can result in hematoma formation that has been identified as a risk factor for postoperative complications.

According to Feng et al. [8], the obese patient group showed higher rates of the number of intraoperative radiological examinations, time of approach and duration of the procedure compared to the group without obesity.

Postoperative mobilization of obese patients is complicated because of increased load on long back muscles and is the reason for postoperative leg and back pain [9].

Can obesity be a contraindication for elective spine surgery?

Obesity has not been determined as a contraindication to elective spine surgery in any of the reported studies. The presence of risk factors and complication rates requires the surgeon to take a balanced evaluation of indications for surgery and selection of surgical technique [1, 9, 11, 12].

Selection of patients and preparation for surgery

There are currently no protocols or guidelines for weight loss in obese patients before elective surgery. In the authors' opinion, future studies should be focused on evaluating the effect of weight loss before spine surgery instead of testing the risk of surgical complications in obese patients. The use of correct nutrition before elective surgery to reduce adipose mass while preserving/enhancing muscle mass and bariatric surgery options may be an effective strategy to reduce surgery-related complications and improve the chances of functional recovery after surgery [1].

One of the most crucial points in spine surgery in general and degenerative disease surgery in particular in obese patients is proper patient selection [4].

Discussion

Risk factors for spine surgery in obese patients have been identified as insulin resistance, hypertension, atherogenic dyslipidemia, prooxidant and inflammatory activities, and muscle oxidative stress [1, 3].

Comparative analysis of surgeries in obese patients shows that the duration of surgery, blood loss volume, and rate of infectious and thromboembolic complications were significantly higher. All of the above factors are interlinked and are caused by the technical challenges of surgical interventions in obese patients because of the need to perform a deeper approach with massive skeletonization of tissues and their traction, predetermining the prolongation of the surgery and forced position of the patient on operating table. This results in reduced tissue regenerative capacity and infectious complications associated with insulin resistance, prooxidant and inflammatory activity, and muscle oxidative stress. It is reasonable that minimally invasive surgeries in obese patients have shown advantages in blood loss volume and length of hospital stay with no reliable differences in functional outcomes.

Technical challenges in performing surgery on obese patients require the use

Table 3
Comparative analysis of surgical treatment of patients with degenerative diseases of the lumbar spine with and without obesity

Authors	Surgery duration	Blood loss	Length of hospital stay	Dura mater injury	Surgical site infection	Thrombo-embolism	Repeated surgery	Functional outcome	Mortality
Golovin et al. [4]	Higher	Higher	–	–	Higher	–	–	VAS: unreliable difference	–
Bansal et al. [5]	Higher	Higher	Unreliable difference	–	–	–	Higher	VAS: unreliable difference	–
Cao J. et al. [6]	Higher	Higher	Higher	Unreliable difference	Higher	Unreliable difference	Unreliable difference	–	Unreliable difference
Cofano et al. [1]	Higher	Higher	Higher	–	Higher	Higher	Higher	ODI, VAS, SF-36: worse on SF-36	–
Feng et al. [8]	Higher	–	Unreliable difference	–	–	–	Higher	ODI, VAS: unreliable difference	–
Ghobrial et al. [9]	–	Unreliable difference	Unreliable difference	Unreliable difference	Higher	–	–	ODI, VAS, SF-36, EQ 5D: unreliable difference	–
Goyal et al. [10]	Higher	Higher	Unreliable difference	Higher	Higher	Higher	Higher	ODI, VAS: unreliable difference	–
Jackson et al. [3]	Higher	Higher	–	–	Higher	Higher	–	ODI, SF-36: unreliable difference	–
Jiang et al. [2]	Higher	Higher	Higher	–	–	–	Higher	–	Unreliable difference
Lingutla et al. [11]	Higher	Higher	–	–	Higher	–	–	ODI, VAS: unreliable difference	–
Tang et al. [14]	Higher	Higher	Higher	–	–	–	–	PROMIS-PF: worse in case of obesity, ODI, VAS: unreliable difference	–
Wang et al. [15]	Выше	Выше	Higher	Unreliable difference	Unreliable difference	Unreliable difference	–	ODI, VAS: unreliable difference	–
Xu et al. [17]	Выше	Выше	Higher Higher	Higher	Higher	Higher	Higher	ODI, VAS, SF-36: unreliable difference	–

of special instrumentation and manual skills of the operating surgeon, affecting the duration of the procedure, blood loss volume, and possibly infectious complications.

Length of hospital stay, dura mater and spinal nerve injury were unreliably higher in obese patients.

According to all studies, the functional outcome of treatment in the long-term follow-up period did not differ between obese and non-obese patient groups.

Obesity is not a contraindication for elective spine surgery but requires consideration of all risk factors and, preferably, the patient's preoperative weight loss preparation.

Nevertheless, despite reports of the lack of functional differences in the long-term follow-up period, there is a logical question about biomechanical interactions in the spinal motion segment in people with increased body weight. It is logical to presume that rigid fixation on the lumbar spine under conditions of increased body weight in the presence of a degenerative process is associated with an increased load on both the operated and adjacent segments. Conversely, it is possible that the skeletal muscles of patients adapted to increased body weight respond similarly to muscles of patients with normal body weight without critical overload. The literature presented here unfortunately does not contain any studies on the effect of rigid fixation on the course of the degenerative process at adjacent levels (adjacent segment disease) and on the integrity of the fixation systems under conditions of an increased load on the spinal motion segments because of high body weight.

In order to answer the questions about the treatment outcomes of patients with increased body weight with clarification of the degree of degenerative process progression in the long-term follow-up, it is necessary to conduct a randomized multicenter study with wide coverage of the results in the academic press and implementation of the obtained results in clinical guidelines.

Table 4
Comparative analysis of open and minimally invasive surgeries in obese patients with degenerative diseases of the lumbar spine

Authors	Surgery duration	Blood loss	Length of hospital stay	Dura mater injury	Surgical site infection	Thrombo-embolism	Repeated surgery	Functional outcome
Chen et al. [7]	Higher	Higher	Higher	–	Unreliable difference	–	–	ODI, VAS: unreliable difference
Cofano et al. [1]	–	Higher	Higher	Higher	–	Unreliable difference	–	ODI, VAS: unreliable difference
Othman et al. [12]	Higher	Higher	Higher	Higher	Unreliable difference	–	Higher	ODI, VAS: unreliable difference
Tan et al. [13]	–	Higher	Higher	Higher	Higher	–	–	ODI: early is better in case of MI-TLIF, late ODI, VAS: unreliable difference
Xie et al. [16]	Higher	Выше	Выше	–	–	–	–	ODI, VAS: unreliable difference

Conclusion

Obesity is a considerable risk factor for perioperative complications in elective spinal surgery, the most important of which are blood loss volume, duration of surgery, surgical wound infection, thromboembolism and repeated procedures being of most significance.

It is the operating surgeon who, based on all initial data, defines the possibility and type of procedure for the period of the patient's treatment, considering risk factors, technical capabilities and features of surgical manipulation. Randomized multicenter studies on this issue is required.

The study had no sponsors. The authors declare that they have no conflict of interest.
The study was approved by the local ethics committee of the institution.
All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication

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