RISK FACTORS FOR SURGICAL SITE INFECTION IN THORACIC AND LUMBOSACRAL SPINE SURGERY: RETROSPECTIVE STUDY RESULTS

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Objective. To specify risk factors for the development of surgical site infection in patients operated on for injuries and degenerative diseases of the thoracic and lumbosacral spine through the posterior median approach.

Material and Methods. The study included formalized case histories of 415 patients (207 men, 208 women) who were operated on for degenerative diseases (n = 385) or unstable injuries (n = 30) of the spine. The average age of patients was 47 ± 18 years. Out of them, 230 patients had concomitant chronic diseases requiring constant drug treatment. Before statistical processing, the data obtained in the study were classified according to a generally accepted method to determine the possibility of using different statistical methods when comparing groups. The patients were divided into two groups: Group I included patients with pyoinflammatory complications, and Group II — without pyoinflammatory complications.

Results. It was revealed that the following factors significantly affect the development of postoperative wound suppuration: the use of metal fixation, external drainage of the wound for more than four days, the use of monocoagulation from the level of subcutaneous fat, the installation of a retractor for a period of more than 1 hour, blood loss of more than 300 ml, leaving absorbable hemostatic materials in the wound, suturing of muscles in the area of laminectomy, and applying intradermal (cosmetic) sutures. Patient age, preoperative bed day number, skin isolation technique (or lack thereof), duration of surgery, and surgeon experience do not affect the risk of the surgical site infection.

Conclusion. Despite the fact that most of the identified risk factors for postoperative wound suppuration are reduced to more complex and prolonged intervention which is more difficult for a patient to tolerate, some of the identified risk factors are potentially removable.

Key Words: suppuration of a postoperative wound, purulent complications, surgical risk factors for suppuration of postoperative wound, surgical site infection.

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The number of patients operated on to treat spine injuries and degenerative diseases grows every year due to social, demographic, medical, and other reasons. According to the Moscow Department of Health, the number of surgeries performed in patients with spine pathology from 2007 till 2017 has doubled (from 4,252 to 8,032 patients). Modern spine surgery techniques employ various implants, thus inevitably increasing the rate of purulent complications. Such factors as chronic somatic disorders (e.g., hypertension, diabetes mellitus, obesity, smoking, infectious diseases, etc.) contribute to that. Emergency surgeries in patients with spinal cord injury can increase the rate of postoperative pyoinflammatory complications as minimal examination is performed in this case and the time taking to prepare the patient for surgery is very short [1].

Suppuration of postoperative wounds is one of the most severe complications in spine surgery. It negatively affects length of stay and duration of patients' rehabilitation. This complication may aggravate the general well-being of patients having it and even cause death [2]. As reported by different authors [2–4], the number of patients with postoperative wound suppuration ranges from 2 to 13 %; therefore, prevention, diagnosis, and treatment of suppuration is an urgent problem in managing patients with injuries and diseases of the spine.

According to their location, postoperative wound suppurations can be subdivided into the superficial and deep ones. Superficial suppuration is the one confined to skin and subcutaneous tissue, which does not penetrate beyond the fascia. Deep suppuration is that spreading beyond the fascia. According to the time of onset, suppuration can be subdivided into early (developing within 3–4 weeks after surgery) and late ones (developing within > 4 weeks after surgery) [5].

All the risk factors for the development of postoperative wound suppuration can be conditionally divided into three groups: the microbiological ones (neither preoperative nor intraoperative antibiotic prophylaxis is used; a patient is repeatedly admitted to the hospital; a patient receives intensive care; a patient with a permanent catheter installed; long-term antibiotic prophylaxis, etc.), the surgical ones (extensive surgery; extensive tissue dissection; the use of retractors traumatizing wound edges; significant blood loss; tissue response to implanted materials; leaving various hemostatic agents in the wound; wound suturing procedure being used; applying wound

drainage, etc.), and those associated with aggravated patient's somatic status (smoking, obesity, advanced age, diabetes mellitus, severe spinal cord injury, infectious diseases, etc.) [6, 7].

Because of the urgency of the problems related to postoperative wound suppuration problems and the increasing number of patients having non-modifiable risk factors, it is believed that surgical risk factors are particularly important as they can potentially be eliminated.

The objective of this study was to refine the risk factors for developing surgical site infection in patients operated on through the posteromedial access to treat the injury and degenerative dystrophic disorders of the thoracic and lumbosacral spine.

Material and Methods

We have analyzed the literature focused on risk factors of postoperative wound suppuration and identified the most common ones: patient's age and sex, severe chronic conditions, the number of preoperative inpatient days, skin incision length, method used for skin isolation, spinal instrumentation, blood loss, wound drainage and its duration, application of wound retractors, suture type, procedure used for layerwise suturing, using or leaving absorbable hemostatic material in the wound, surgery duration, the number of surgeons involved in the surgery, surgeon's experience, and period of patient activation. Our own clinical data were analyzed with allowance for these risk factors.

In 2014–2016, 1939 patients with spine injuries and diseases received medical care at the N.V. Sklifosovsky Research Institute for Emergency Medicine (Moscow, Russia). In compliance with the study objective, the inclusion and exclusion criteria were determined to be as follows.

The inclusion criteria for study enrollment were:

(1) daytime elective surgery;

(2) surgery was performed within the same operating room;

(3) only the posteromedial approach was used to perform the surgery;

(4) the surgical intervention was performed at the thoracic and lumbosacral levels;

(5) antibiotic prophylaxis according to the unified regimen.

All the patients were operated on in the same operating room and received antibiotic prophylaxis according to the unified regimen (the Order of the Sklifosovsky Research Institute for Emergency Medicine about the Rational Use of Antimicrobials): second-generation cephalosporin 2 g (3 g for patients having body mass ⩾ 120 kg) intravenously dropwise (20 min) 30 min prior to surgery. Repeated dose of the antimicrobial was administered intraoperatively for surgical interventions lasting longer than two its half-life periods. If the intervention lasted longer than 4 hrs, 2 g of the antimicrobial was infused. During the postoperative period, patients with inserted metal instrumentation received antibiotic prophylaxis with second-generation cephalosporin (1 g, twice daily, administered intravenously dropwise) within 5 days after surgery. Personalized therapy was selected for patients with severe multiple trauma and concomitant diseases.

The exclusion criteria for study were:

(1) any prior surgery at the thoracic and lumbosacral levels;

(2) verified diagnosis of patient's mental illness making it impossible for them to follow the recommendations;

(3) systemic or local pyoinflammatory processes before the primary surgery;

(4)inability to obtain information on patient's condition after hospital discharge;

(5) patient's refusal to participate in the study.

The enrollment criteria were met in 415 patients. Therefore, this study was a full-design retrospective cohort study.

Formalized medical records of 415 patients (207 males and 208 females) with degenerative spine diseases (n = 385) and unstable spine injuries (n = 30) who had undergone surgeries were the study material. The mean patients' age was 47 ± 18 years. A total of 230 patients had concomitant chronic illnesses requiring permanent pharmacotherapy (essential hypertension, diabetes mellitus, gastric ulcer, obesity, infectious diseases, etc.)

Patients operated on to treat degenerative disorders were admitted on an elective basis and underwent outpatient examination: laboratory blood tests, CT and MRI of the spine were performed at the pre-hospital stage. The number of patients with multifactorial spinal canal stenosis requiring decompression and stabilization was 245; the number of patients with multifactorial spinal canal stenosis requiring decompression surgery only and patients with spinal disc herniation was 140.

Most (23 out of 30) patients having spinal cord injury (SCI) were delivered to the N.V. Sklifosovsky Research Institute for Emergency Medicine by ambulance teams within the first three days after the injury. The reasons for spinal cord injury were as follows: catatrauma, road accident, fall from a height, etc. In order to rule out cervical spine injury, all the patients with spinal cord injury admitted to intensive care unit underwent CT. Radiological examination of the extremities, pelvic bones, and ribs; abdominal and pleural ultrasound, echoencephaloscopy, brain CT, and lumbar puncture were performed to diagnose multiple injuries. Laboratory blood tests (complete blood count, blood chemistry test, coagulation test, and analysis of acid–base balance), cardiovascular and respiratory monitoring, central venous and urinary catheterization, and gastric intubation were also performed. All the patients were examined by a surgeon, a neurosurgeon, and a trauma surgeon and, if necessary, by a vascular surgeon, a toxicologist, and a psychiatrist. Female patients also underwent a gynecologic examination.

Polytraumas were diagnosed in 25 (83 %) patients; spine trauma including injury to the spinal cord and spinal nerve roots, in 20 (67 %) patients. Seventeen patients had A3 and A4 fractures according to the AOSpine classification [8]; six patients, type B fractures; and seven patients, type C fractures. Eighteen

patients were operated on within two days and five patients, within three days after admission.

In all the patients enrolled in the study, indications for surgery and the extent of surgery complied with the approved clinical practice guidelines [9].

The data obtained during clinical and instrumental examination of patients were analyzed on a PC using the Statistica software (version 8). Prior to statistical analysis, the data were classified using the conventional procedure for determining whether it is possible to apply various statistical methods for intergroup comparison. The patients were divided into two groups: Group I – patients with pyoinflammatory complications and Group II – patients without pyoinflammatory complications. The Mann–Whitney U-test was used to determine the statistical significance of intergroup differences; the χ^2 test with Yates' correction was used to analyze binary features. The results were interpreted with respect to the p value (the possibility of erroneous rejection of zero hypothesis that there is no intergroup difference): if $p > 0.05$, the zero hypothesis that there is no intergroup difference was not rejected; if $p < 0.05$, there were differences between the groups under study.

Group I consisted of 25 patients (10 males and 15 females). The mean age was 44 ± 18 years. Fifteen patients had degenerative spine disorders; ten patients had complicated and uncomplicated unstable spine injuries. Early suppuration was observed in 23 patients; late suppuration, in two patients. Deep wound suppuration was revealed in 23 (92 %) patients; superficial suppuration, in 2 (8 %) patients. Twelve (48 %) patients had concomitant chronic conditions (essential hypertension, diabetes mellitus, gastric ulcer, obesity, infectious diseases, etc.)

Group II consisted of 390 patients (207 males and 183 females). The mean age was 47 ± 18 years. A total of 370 patients had degenerative spine disorders; 20 patients had complicated and uncomplicated unstable spine injuries. Eighty (20.5 %) patients had concomitant chronic conditions (essential hypertension, diabetes mellitus, gastric ulcer, obesity, infectious diseases, etc.). Table 1 summarizes the demographic data for patients in the two groups.

Results and Discussion

Most of the studies focused on suppuration of postoperative wounds aimed at revealing the risk factors whose effect needs to be minimized to prevent infectious wound complications. Prophylaxis of the development of wound infection should obviously be supplemented with correction of patient's general condition (treating shock, hypovolemia, protein and electrolyte imbalance, nutritional disturbances, etc.). However, studies focused on surgical risk factors are of the greatest interest.

During the follow-up period, the annual rate of postoperative wound suppuration among patients having spinal pathology ranged from 5.4 to 6.1 % (mean rate, 6 %). Fig. 1 shows the distribution of patients with pyoinflammatory complications across years. The greatest number of complications was observed in 2015.

Fig. 2 shows the graph illustrating the time of detecting early suppuration of postoperative wounds, which ranged from 1 to 12 postoperative days (mean time, 8 ± 2 days).

Seventeen potential risk factors were analyzed in this study (Table 2).

The group of patients having postoperative wound suppuration contained more individuals with inserted metal instrumentation. Thus, surgeries using various instrumentation systems were conducted in 21 (84 %) Group I patients and 136 (35 %) Group II patients. The analysis revealed statistically significant intergroup differences in such parameters as intraoperatively inserted metal instrumentation ($p = 0.00001$; $p = 0.00001$). These findings are consistent with the data reported by other authors who have shown that the risk of postoperative wound suppuration increases in patients who have undergone instrumentation insertion. Thus, the rate of suppuration after microsurgical discectomy was 0.6–5.0 % [10], while being 6.6–8.7 % in patients after metal instrumentation insertion [11, 12]. It has been assumed that there are several mechanisms explaining why the risk of postoperative wound suppuration increases after instrumentation insertion: the implants may cause local tissue irritation resulting in aseptic inflammation, seroma formation and infection. Furthermore, the implants act as an avascular surface for the bacterial glycocalyx, thus protecting bacteria against the penetration of antibiotics [10, 13].

Hemostatic materials left in the wound may have a harmful impact similar to that of metal instrumentation; these materials were used in 22 (88 %) Group I patients and in 282 (72 %) Group II patients. No statistically significant intergroup difference was found (the χ^2 test with Yates' correction, $p = 0.49$). The hemostatic materials were not removed from the surgical wound in 20 (80 %) Group I patients and 170 (44 %) Group II patients. Statistical analysis was performed using the Fisher's exact test ($p = 0.0004$) and the χ^2 test with Yates' correction for binary features ($p = 0.0009$). There was a statistically significant intergroup difference for the parameter 'hemostatic materials left in the surgical wound.'

Duration of the exposure to wound retractors plays a negative role during surgeries on the thoracic and lumbar spine performed through the posterior

Table 1
Patients' demographic data in the study groups

Parameter	Group I	Group II
Number of patients, n	25	390
Sex: male/female, n	10/15	207/183
Age, years	44 ± 18	47 ± 18
Patients with injuries of the spine and spinal cord	40	5

approach as it leads to tissue ischemia. Muscle compression causes ischemia and partial tissue necrosis, followed by poor wound healing and diastasis of the wound edges, thus opening way for infection.

In this study, the median duration of application of wound retractors in Group I and Group II patients was 138 and 40 min, respectively. Fig. 3 shows the distribution of this parameter in the study groups. Statistical analysis using the Mann–Whitney test yielded the value p = 0.000003; i.e., the groups differed significantly for the parameter 'duration of application of a wound retractor.' Furthermore, wound retractor was applied for more than 65 min in most patients in Group I and less than 65 min in most patients in Group II; this value can be used as a certain threshold.

In our study, paravertebral drains were inserted in 21 (84 %) patients in Group I and 142 (36 %) patients in Group II. The mean time of draining was 4 ± 2 days. In most (97 %) Group II patients, the drains were removed no later than on day 4, while in Group I patients, on day 4 and later. Fig. 4 shows the patient distribution depending on time when the drain was removed.

A statistical test to determine if drain insertion affects the development of postoperative wound suppuration was also used, and the value p = 0.00001 was obtained; i.e., there was a statistically significant intergroup difference for this parameter. These findings demonstrate that both prolonged (for longer than 4 days) wound drainage and insertion of surgical drain are the risk factors. Drain insertion increases the likelihood of wound suppuration threefold. According to the literature data [14], postoperative wound drainage is one of the putative causes of suppuration.

In this study, the median blood loss volume was 500 mL in Group I patients and 50 mL in Group II patients. The distribution of values in the study groups is shown in Fig. 5.

An analysis using the Mann – Whitney test yielded the value p = 0.0000001; i.e., the groups differed statistically significantly for such parameter as intraoperative blood loss. Furthermore, blood loss volume was > 350 mL in 75 % of Group I patients and < 300 mL in 75 % of Group II patients. Therefore, the blood loss volume of 300 mL can be used as the threshold value.

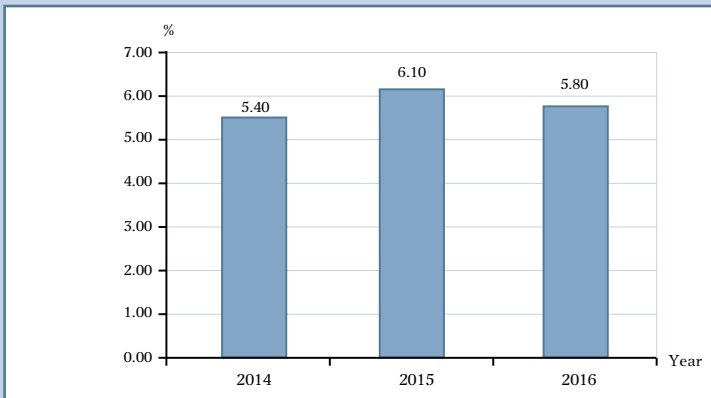

Fig. 1
Patients with pyoinflammatory complications in 2014–2016

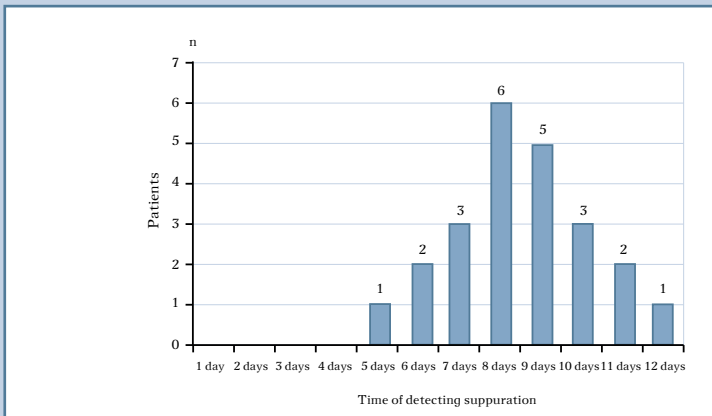

Fig. 2
Distribution of patients with early pyoinflammatory complications according to time of detection of postoperative wound suppuration (n = 23)

Although no direct proof of dependence between the rate of postoperative wound suppuration and the coagulation type was found in the literature, we also analyzed this parameter. Monopolar coagulation was used starting from the aponeurosis level in 5 Group I patients and 191 Group II patients and from the level of subcutaneous fat, in 20 Group I and 199 Group II patients. Statistical analysis was performed using the Fisher's exact test (p = 0.0037) and the χ^2 test with Yates' correction for binary features (p = 0.0092). Statistically significant intergroup difference was revealed; i.e., the groups differed significantly in terms of using monopolar coagulation when performing the approach from the aponeurosis or subcutaneous fat levels.

Muscle and skin compression with too tight sutures may cause marginal tissue necrosis, while inadequate apposition of the wound edges may lead to diastasis. Currently, there is no general

Table 2
Factors affecting the postoperative wound suppuration in patients with degenerative spine disorders and injury to the spine and spinal cord

Factors being analyzed	Significance level, p	Statistical test
Sex (males)	0.57	χ^2
Age	0.54	M-U
Metal instrumentation	0.00001	χ^2
Using monocoagulation at the level of subcutaneous fat	0.0092	χ^2
Application of a wound retractor for more than 1 hr	0.000003	M-U
Blood loss volume > 300 mL	0.0000001	M-U
Using absorbable hemostatic material	0.49	χ^2
Hemostatic materials left in the wound	0.0009	χ^2
Closure of muscles in the laminectomy site	0.0001	χ^2
Application of intradermal sutures	0.0036	χ^2
Incision length	0.96	M-U
Skin insulation (or none)	0.51	M-U
Intraoperative wound irrigation with antiseptic agents	0.9	χ^2
Surgery duration	0.43	M-U
Wound drainage for more than 4 days	0.00001	χ^2
Number of physicians engaged in the surgery	0.48	M-U
Experience of the operating surgeon	0.79	M-U

χ^2 – χ^2 test with Yates' correction; M–U – Mann–Whitney test

consensus about the method for postoperative wound suturing. We took the following wound suturing parameters into account: the wound layers being opposed, suture material, and the procedure used for suturing each layer. An analysis of these data revealed statistically significant intergroup differences for only two parameters: muscle suturing and the use of intradermal sutures. Thus, apposition sutures were applied to muscles in 14 (56 %) Group I patients and 65 (17 %) Group II patients (Fisher's exact test, p = 0.0001; the χ^2 test with Yates' correction, p = 0.0001). Intradermal sutures were applied in 13 (52 %) Group I patients and 95 (24 %) Group II patients (Fisher's exact test, p = 0.0016; the χ^2 test with Yates' correction, p = 0.0036).

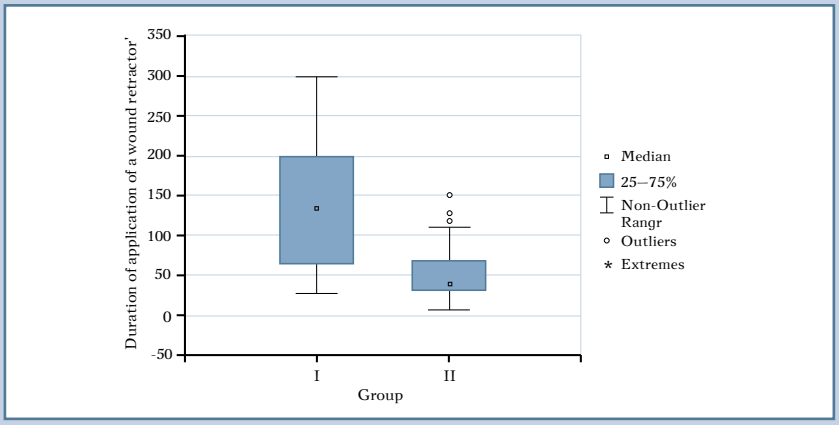

Fig. 3
Comparison of study groups for the parameter 'duration of application of a wound retractor'

Conclusion

Although most of the revealed risk factors of postoperative wound suppuration refer to more complex and prolonged surgical interventions that are less well tolerated by patients (because of the inserted metal instrumentation, greater blood loss volume, and wound drainage), some identified risk factors can potentially be eliminated (e.g., the use of monopolar coagulation at the subcutaneous fat level, wound retractor insertion for longer than 1 hr, muscle suturing and the use of intradermal suture, and leaving the hemostatic material in the wound.)

Such factors as patient's age, the number of the day before surgery, the procedure used for skin insulation (or none), duration of surgical intervention and surgeon's experience have no effect on the development of infection within the surgical site. Using monopolar coagulation at the aponeurosis level, removing the hemostatic material from the wound,

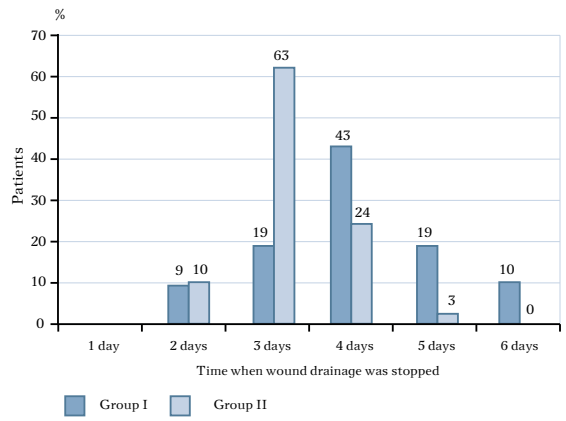

Fig. 4
Patient distribution according to the time of wound drainage

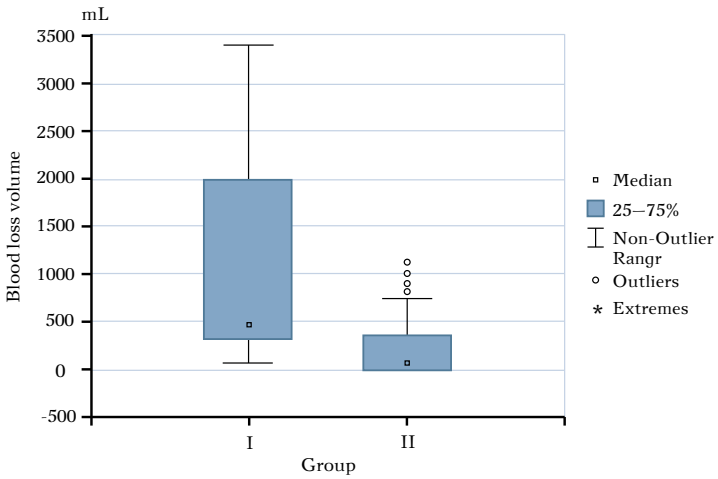

Fig. 5
Comparison of study groups for the parameter 'blood loss volume'

loosening the wound retractor every hour, not using muscle suturing within the laminectomy site, and not using the intradermal sutures make it possible to reduce the risk of postoperative wound suppuration.

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