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Risk Factors for the Surgical Field Infections After the Osteosyntheses of Tibia Diaphysis

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ABSTRACT

Introduction: Infections occurring in the wound as a consequence of the surgery represent the surgical field infections (SFI). Tibia diaphysis fractures are common due to its exposure to the external force. Clinical signs include: pain, swelling, lower leg deformity and skin changes. Tibia in the lower extremities has an eccentric position - from the front inner side it is covered only with the skin and from the back and the outer by muscle mass. The most common pathogens are: Staphylococcus aureus, Coagulase negative Staphylococcus aureus or S. Epidermitis, Escherichia coli, and other. For the fracture fusion process, it is important that the skin and subcutaneous tissue above the fracture are well supplied with the blood. The American Association of Anesthesiologists defined the so-called ASA score, based on which all patients are divided into five categories according to health status before surgery. **Goal:** The goal of the study is to demonstrate the influence of risk factors on the occurrence of infection following osteosynthesis of tibial diaphysis, comparing emergency surgical interventions with elective. **Material and methods:** The study was conducted at the Clinic for Orthopedics and Traumatology of the Clinical Center of Sarajevo University during 2015 and 2016, with a total of 68 patients. **Results:** The age of the patient as risk factor is evident in our study, because deeper infections have had patients at the age over 60 with accompanying diseases such as Diabetes mellitus. Most of the hospitalized patients had a good health status prior to surgery, or they had ASA 1 or ASA 2 score. Surgical field infections were more common in men than in women, but the difference was not statistically significant ($p > 0.05$). Patients who are operated as an elective surgery have longer hospitalization and more frequent surgical field infection. Also, infections are more common among smokers.

Keywords: surgical field infection, tibial osteosynthesis, risk factors.

1. INTRODUCTION

Infections occurring in a wound created as the consequence of surgery are called surgical field infections (SFI). SFI are associated with considerable morbidity and may range from infection without complications to life threatening conditions (1, 2).

The number of surgical interventions in orthopedics and traumatology, where implants are used, are increasing steadily over the past few decades. In the future, more and more patients with implanted implants are expected.

The fractures of the tibia diaphysis are common due to exposure to external forces of any kind, such as traffic accidents, at impact, direct contact sport, fall from the high place etc. Clinical signs include: pain, swelling, skeletal deformity and short after, skin changes. "Weak point" of the lower limb is at the transition from the middle third into

the distal, so that the fractures are most common at this area. About 70% are closed fractures, and about 30% are open. In the treatment of fractures there are basic principles: repositioning, retaining the position of the fragments until the rigid callus is formed and early rehabilitation (3, 4, 5).

AO classification of lower limb fractures:

- Type A - simple fractures: sideling, transverse, longitudinal, spiral
- Type B fractures with triangular bone fragments
- Type C multiple chips (multi-fragmented) with a large number of free fragments

The accepted method of stable osteosynthesis is the AO method, the extremity function is rapidly established, with the anatomical repositioning of fragments and their stable fixation (6, 7).

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Tibia in the lower limbs has an exogenous position - from the frontal inner side it is covered only with the skin, and from the posterior and the outer by muscle mass. After the repositioning of the fractures, for the occurrence of the osteogenesis process is significant: stable osteosynthesis of the fracture and vascularization around the fractures. The metal cannot cause infection, but can promote the development of infection; it is a suitable substrate for bacterial growth and disables drainage. The surface of the implant is rapidly covered with proteins and cells. Necrotized or poorly vascularized wound tissue as well as extracellular fluid in the area between implants and healthy tissues create a suitable habitat for bacterial adhesion and growth (7, 8).

The causes of SFI are: *Staphylococcus aureus*, Coagulase negative *Staphylococcus* or *S. epidermidis*, *Escherichia coli*, *Enterobacter* spp, *Klebsiella* spp., *Pseudomonas aeruginosa*, *Acinetobacter baumani*. More and more bacteria (MRSA, MRSE, VRE, ESBL strains, multi-resistant *Acinetobacter*) show resistance to antimicrobial drugs, which is a significant therapeutic problem. *S. aureus* is present in the nose among 20-30% of healthy persons. So, the persons with this bacteria in the nose have a higher risk of SFI (1, 9, 10).

According to the tissue or organ involved, SFI are divided into: surface infection of the surgical site (incision, cut) involving only the skin and subcutaneous tissue of the incision (cut), deep infection of the surgical site (incision, cut) and involving deep subcutaneous tissue of the incision site (including any part of the body, except skin, fascia, or muscular logs that have been opened or manipulated with them during the surgery). The bony periosteus is exposed to a direct traumatic effect, especially on the front and the inside, where it directly has contact with the tibia.

The nutrition of the skin, including vascular network, is relatively poor, especially the front part which is most exposed to trauma. The tibia fracture is followed by bleeding and the swelling. The skin becomes ischemic; a regional paralysis of the capillary is formed, followed by the appearance of bulla-flint. They pose a threat to the appearance of soft and bone tissue infections, which slow down the osteogenesis process. The time for the formation of a swelling at the closed type of the fracture of the lower leg is: first half hour 1%, after one hour 2%, after three hours 12% and after 6 hours 28%, after 24 hours 43%, then the appearance frequency decreases (5, 7).

For the fusion process, it is important that the skin and subcutaneous tissue above the fracture are well supplied with blood. Entry sites for microorganisms may be: surgical wound, intravenous/arterial catheter, drain, urinary catheter, prolonged use of antibiotics, impaired immune system due to other chronic diseases, contact with infectious material, poor patient hygiene habits, other skin lesions such as decubitus or cuts, the preoperative health condition of patients significantly influences SFI's emergence (8, 9).

The American Association of Anesthesiologists defined the so-called ASA score based on which all patients are divided into five categories according to health status

prior to surgery (9, 10). The score classifies patients from one (healthy) to five (a patient who is not expected to survive 24 hours).

Most authors agree that patients with a worse health condition than two have a higher risk of developing SFI.

- ASA 1 - Healthy person. A patient with mild illness.
- ASA 2 - A patient with a severe illness that does not disable it.
- ASA 3 - A patient with a severe illness that disables it and endangers its life.
- ASA 4 - Sick patient who will not survive without surgery.
- ASA 5 - Sick patient who is not expected to survive for 24 hours with or without surgery.

2. GOAL

The aim of the study was to demonstrate the influence of risk factors on the occurrence of post-osteosynthesis of tibial diaphysis, comparing emergency surgical procedures with elective ones.

3. MATERIAL AND METHODS

This is a retrospective study. The study was conducted at the Clinic for Orthopedics and Traumatology of the Clinical Center of Sarajevo university during 2015 and 2016, and involved a total of 68 patients. Patients with closed isolated fracture of tibia diaphysis were included and divided into two groups:

- Patients who were operated as an elective surgery, including a total of 36 patients;
- Patients who have been operated as an emergency surgery during the first 24 hours, including a total of 32 patients.

All patients received preoperative antibiotics, analgesics and thromboprophylaxis. ASA was used to evaluate the overall health status of the patients before the surgery. The SFI diagnosis was set during hospitalization. Data were derived from the protocol and history of illness.

4. RESULTS

The results are presented forms of tables by the number of patients, percentages, mean with standard deviation and range of values. Comparison was performed using Chi-square test and Student's t test. The results of all tests were considered significant at 95% confidence level or at $p < 0.05$. The analysis was performed using the

	N	%
Elective	36	52.9
Emergency	32	47.1
Total	68	100.0

Table 1. Studied group of patients

IBM Statistical SPSS v23.0 Statistical Package.

5. DISCUSSION

Tibia has its own specificity from the anatomy-physiological aspect, which makes it more vulnerable in terms

		Group		Total	
		Elective	Emergency		
Gender	Male	N	22	17	39
		%	1.1	53.1	57.4
	Female	N	14	15	29
		%	38.9	46.9	42.6
Total	N	36	32	68	
	%	100.0	10.0	100.0	

Table 2. Distribution according to gender. $\chi^2=0.442$; $p=0.338$

	N	Mean	Std. deviation	Std. error of mean	Minimum	Maximum
Elective	36	47.64	13.994	2.332	8	70
Emergency	32	45.03	12.943	2.288	22	68
Total	68	46.41	13.473	1.634	8	70

Table 3. Mean age according to studied groups. $t=0.631$; $p=0.430$

		Group		Total	
		Elective	Elective		
ASA	ASA 1	N	20	22	42
		%	55.6	68.8	61.8
	ASA 2	N	16	10	26
		%	44.4	31.3	38.2
Total	N	36	32	68	
	%	100.0	100.0	100.0	

Table 4. Analysis according to ASA score, $\chi^2=1.249$; $p=0.193$

	N	Mean	Std. deviation	Std. error of mean	Minimum	Maximum
Elective	35	12.71	4.750	.803	7	25
Emergency	32	10.53	4.158	.735	6	22
Total	67	11.67	4.577	.559	6	25

Table 7. Mean hospitalization duration. $t=3.974$; $p=0.042$

of the osteogenesis process and the possibility of secondary bone tissue infection after osteosynthesis.

In our study we divided the patients into two groups as emergency and elective surgical procedures. The SFI frequency is lower among emergency surgeries primarily due to the position of tibia and skin injuries. Our results correspond to the ones from the literature. In case of emergency surgery, preoperative preparation has been shortened, while during the extended preoperative hospitalization colonization of the patient’s skin with hospital flora, which represents a significant risk for the SFI emergence (8).

The average age of patients in sample is 46.4 years, which also corresponds to the mechanism of injury. The age risk factor is evident in our study because deeper infections have had patients at the age of over 60 with accompanying diseases such as Diabetes mellitus (5, 7).

Staphylococcal agents are the most common cause of SFI. In both groups the most common cause is Staphylococcal aureus, more in the group with elective surgery - 4 deep infections and one superficial, followed by Staphylococcus epidermidis as superficial infection. Most epidemiological studies put staphylococci in the first place

		Group		Total	
		Elective	Emergency		
Smoking status	Smoker	N	30	16	46
		%	88.2	50.0	69.7
	Nonsmoker	N	4	16	20
		%	11.8	50.0	30.3
Total	N	34	32	66	
	%	100.0	100.0	100.0	

Table 5. Smoking as risk factor. $\chi^2=11.411$; $p=0.001$

		Group		Total	
		Elective	Emergency		
Infection	No	N	26	26	52
		%	72.2	81.3	76.5
	Yes	N	10	6	16
		%	27.8	18.8	23.5
Total	N	36	32	68	
	%	100.0	100.0	100.0	

Table 6. Presence of infections according to studied groups. $\chi^2=0.775$; $p=0.279$

		Group		Total	
		Elective	Emergency		
DM	Diabetic	N	6	2	8
		%	16.7	6.3	11.8
	Non- diabetic	N	30	30	60
		%	83.3	93.8	88.2
Total	N	36	32	68	
	%	100.0	100.0	100.0	

Table 8. Diabetes mellitus as a risk factor for infection. $\chi^2=1.771$; $p=0.171$

among the pathogens, the only difference is the proportion of S. aureus and S. epidermidis among other causes (10, 11).

Adhesion of bacteria to implants and transfer between exposed surfaces during surgery is a complex process. The source of infection may be contaminated implants, surgeon’s gloves, wound healing disorders, hematogenic disinfection and the most important skin of the operated patient. Staphylococcus can be found on the skin of the baby several hours after birth. In adult patients, staphylococcus inhabits the skin and mucous membranes of the upper respiratory system. Infections associated with osteosynthesis implants are usually exogenous due to penetrating trauma (preoperative), during osteosynthesis implant placement (intraoperatively) or during wound healing (postoperatively) (12, 13). In case of planned surgeries, we need to identify and cure all infections prior to surgery - it has been noted that patients with a remote infection have two to three times higher risk of developing SFI. S.epidermidis is the most commonly isolated coagulase-negative staphylococci associated with infected orthopedic implants (11, 12).

Smoking as a risk factor. From our study it is evident that SFI is more common among tobacco smokers. Smoking - Nicotine slows wound healing – so it is advis-

able to encourage the patient to stop smoking at least 30 days before the planned surgery (13).

The surgical methods becoming more and more sophisticated and the hospital stay shorter, SFIs are one of the most common localization in all countries. Our results, as well as the results of the above-mentioned studies, indicate that higher ASA score, or presence of some disease, is a risk for an infection of surgical field. Most of hospitalized patients had a good health condition prior to surgery, or they had a ASA score 1 or 2 (1,14).

In diabetes mellitus, it is recommended that hyperglycemia should be avoided preoperatively - elevated glycaemic values in the first 48 hours after surgery are associated with higher risk for SFI formation (15). SFI were more common in men than in women but the difference was not statistically significant ($p > 0.05$). Cephalosporins are the most commonly used antibiotics for surgical fracture treatment. Antimicrobial prophylaxis - short-term administration of an antimicrobial medication immediately before surgery, best 30 minutes before incision, to ensure adequate antibiotic therapy level was present in the tissue at the earliest stage of the surgery (16). SFI can also be influenced by: the conditions at the operating room, the clothing of the team members, the respect of aseptic and surgical techniques.

Surgeons emphasize that surgical technique is one of the most important risk factors for SFI. Adequate hemostasis with the aim of preventing hematoma and seroma formation, a properly debrided with the removal of devitalized tissue and foreign bodies, the prevention of additional tissue injuries during surgery, are just some of the tools that contribute to SFI prevention (16). The length of hospitalization as a risk factor is evident in our study. Patients who are operated as an elective surgery have longer hospitalization and more frequent operative infection (17).

6. CONCLUSION

The data obtained through our study are significant as the evidence of the relationship between risk factors and SFI after osteosynthesis of tibial diaphysis in patients who were surgically treated as an emergency or as an elective surgical procedure.

The results obtained does not differ significantly from previous known data on surgical field infections.

It is necessary to apply measures of SFI prevention, which has already been proven in developed countries. Surgical field infection, after surgery of tibial diaphysis an urgent surgical procedure should be a standard.

The capabilities for prevention and control of surgical field infections are great. We need to develop clinical guidelines for treating SFI, and identify the cause as soon as possible.

It is recommended in the hospitals, within the Commissions for Hospital Infections, gather the experts from

this field, and create procedures for the selection of antimicrobial prophylaxis for each type of surgical intervention.

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- **Authors contribution:** All authors participated in every step of research and gave final approval of the version to be submitted.

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