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ASSESSMENT OF THE QUALITY OF PRE-HOSPITAL CARE IN PRIMARY WOUND TREATMENT IN RELATION TO INFLUENCE ON THE OUTCOMES OF TREATMENT OF NON-GUNSHOT WOUNDS OF SOFT TISSUE

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Abstract: The study assessed the quality of a newly developed method for primary treatment of non-gunshot soft tissue wounds and its impact on treatment outcomes at the pre-hospital and specialized stages of medical care. The research included 455 patients divided into two groups: the main group (treated with a multi-stage antiseptic gel application) and the comparison group (treated with standard wound care protocols). Stepwise microbiological monitoring was performed to analyze wound colonization dynamics and the association between intraoperative microbiological status and postoperative complications. The findings demonstrated that the presence of microbial contamination during surgery significantly increased the risk of postoperative microbial growth (56.5% vs. 20.8%) and complication rates (48.4% vs. 12.5%). Military personnel showed a higher rate of early microbial colonization compared to civilians. These results highlight the critical role of high-quality primary antiseptic wound care and early decontamination in preventing complications, supporting the need for improved pre-hospital care approaches for non-gunshot injuries.

Keywords: non-gunshot wounds, soft tissue injuries, pre-hospital care, antiseptic treatment, microbial contamination, postoperative complications, military medicine, wound infection prevention.

Introduction. The wound healing process is a complex set of biological reactions in response to tissue injury, typically resulting in healing. From the perspective of general pathology, the healing of any wound is considered an inflammatory process, which sequentially goes through the stages of alteration, exudation, and proliferation. The complex pathogenesis of wound healing necessitates a multifaceted local treatment approach. Such treatments must correspond to the phase of the wound process and possess several essential properties to create and maintain a specific microenvironment within the wound cavity [1,5].

At present, the problem of wound infection remains extremely relevant due to the growing number of technogenic and natural disasters, military conflicts, and terrorist acts. High rates of infectious complications associated with wounds continue to be recorded, often resulting in sepsis. In modern conflicts, the overall incidence of wound infections ranges from 5.5% to 30%, depending on the type of study, wound location, and severity. Among all surgical patients, wound infections occur in 35–45% of cases [12,18].

Infectious wound complications are observed in 4.9% of gunshot wounds, 7.3% of shrapnel wounds, and up to 53.0% of abdominal gunshot injuries. Even primary surgical management of gunshot wounds is accompanied by postoperative suppuration in 5.3% of cases. Furthermore, purulent-septic complications of gunshot wounds account for 15.0% of deaths at the early surgical care stage and 70.0% of deaths at the hospital stage of specialized medical care [4].

According to Weintrob A.C., the share of infectious complications in the wars in Iraq and Afghanistan, from the moment of injury to initial hospitalization in the United States, reached 34.0%, with half of those being infections of the skin, soft tissues, and bones [2,22]. During these conflicts, the most common infection-related complications associated with combat injuries were skin and soft tissue infections (41%), transmissible infections (13%), osteomyelitis (6%), and sepsis (4%) [21]. Penetrating injuries may result in both superficial and deep tissue infections, with infection rates reaching as high as 15.7% [15]. Civilian hospitals and military medical facilities are characterized by the presence of a group of microorganisms collectively referred to as ESKAPE pathogens. This acronym includes the following bacteria: Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae (and Escherichia coli), Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter spp. [17]. This microflora is noted for its high virulence, pathogenicity, and antibiotic resistance.

Effective prevention of wound complications remains one of the key challenges in trauma surgery, especially in the treatment of non-gunshot wounds. A critical aspect is the objective assessment of wound microflora at the stage of initial care, which allows for forecasting the risk of infectious complications and developing prevention strategies. Studying microbial contamination of wounds at patient admission and during early treatment stages is essential for justifying the importance of high-quality initial wound care and a systematic approach, both in civilian trauma cases and military field surgery.

Research Objective. To evaluate the effectiveness of the developed method of primary treatment of non-gunshot soft tissue wounds in terms of its impact on treatment outcomes at the pre-hospital and specialized stages of primary medical care.

Research and methods. As part of this scientific research, a total of 455 patients were included in the study. These individuals received emergency medical care between 2022 and 2024 in regional, city, and district medical institutions of the Andijan region (civilian population) and in medical units of the Armed Forces of the Republic of Uzbekistan (military personnel). The patients were divided into two groups depending on the method of primary wound treatment used.

The main group consisted of 164 patients (in 2024) who were treated using a proposed method involving the multi-stage application of an antiseptic gel: during pre-medical assistance, surgical wound treatment, and dressing changes in the postoperative period.

The comparison group included 291 patients (treated in 2022–2023) who received care according to traditional protocols. Additionally, a subgroup of 49 military personnel with non-penetrating wounds was included in the study (23 in the comparison group and 26 in the main group), in which the microbial profile of wounds and complication rates were analyzed separately.

The most common type of injury in both groups was stab-incised wounds, observed in 67 patients (40.9%) of the main group and 125 patients (43.0%) of the comparison group. These were followed in frequency by incised wounds, registered in 25.0% and 27.1% of patients respectively. Stab wounds occurred in 26 patients (15.9%) of the main group and 36 (12.4%) in the comparison group. Lacerations were seen in 14.0% of the main group and 14.8% of the comparison group, showing almost identical frequency. Chop wounds, being the rarest type, were registered in 7 patients (4.3%) of the main group and in 8 (2.7%) of the comparison group.

Among civilian patients, who made up the majority in both the main group (86.0%) and the comparison group (91.1%), most injuries resulted from domestic, industrial, or traffic-related accidents. Meanwhile, military personnel, accounting for 14.0% of the main group and 8.9% of the comparison group, predominantly sustained wounds in field conditions – during training, exercises, or tactical operations.

Out of the total 291 patients with non-firearm soft tissue injuries in the comparison group, 86 patients were included in microbiological analysis. The inclusion criterion was the availability of comprehensive microbiological data – results from wound cultures taken at all key stages: pre-hospital phase, during surgical intervention, and dynamically post-operation. This selection ensured the reliability of comparing wound microflora across different stages of the healing process and tracking changes in the microbial landscape within a single clinical case.

The study focused on non-firearm wounds sustained in open environments (workplace, household, road injuries, etc.), including both penetrating and non-penetrating wounds. These types of injuries are often contaminated with polymicrobial flora – originating from the skin surface or external sources such as soil, water, dust, and objects.

To assess wound microbial contamination, stepwise microbiological monitoring was conducted with consideration of the clinical progression. The study involved sequential sampling of wound material at critical stages: directly at the site of injury (pre-hospital phase) and during surgical intervention. All samples were placed in a transport medium and delivered to the bacteriology laboratory within no more than 2 hours.

For the initial assessment, the method of inoculation onto nutrient media was used: blood agar, bile agar, MacConkey agar, Sabouraud agar, and others. After incubation at a temperature of 36–37 °C for 24–48 hours, the isolated colonies were identified based on morphological, cultural, and biochemical characteristics. If necessary, standard identification panels were used (such as API, VITEK, or manual tests), including tests for enzymatic activity and Gram staining.

The antimicrobial susceptibility of microorganisms was determined using the disk diffusion method (Kirby–Bauer) on Mueller-Hinton agar with commercial discs containing standard antibiotic concentrations. The zone of growth inhibition was evaluated according to current EUCAST or CLSI standards. In cases of ambiguous results, the Minimum Inhibitory Concentration (MIC) method was used. Sensitivity was recorded across key groups of antibiotics: β-lactams, aminoglycosides, fluoroquinolones, carbapenems, glycopeptides, and others.

For the statistical analysis of the results and objective evaluation, parametric and non-parametric statistical methods were applied depending on the type of data and their distribution [3,6–11,13,14,16,19,20]. For quantitative indicators, the arithmetic mean, standard deviation (SD), and sample size (n) were calculated. Before comparing quantitative data between groups, the distribution of the data was assessed. The choice of statistical test was justified by testing for normality. For small samples, the Shapiro–Wilk test could be used, but in this study, independent samples were analyzed using the Student’s t-test. When comparing the mean values between the two independent groups (main and control), the Student’s t-test for independent samples was used (applying Welch’s correction when variance equality was not assumed). Results were presented as mean ± standard deviation, with p-values specified. A p-value < 0.05 was considered statistically significant. For categorical data, the Pearson’s chi-square (χ^2) test was used to compare proportions between groups. If needed, degree of freedom (df=1) correction was applied for 2×2 tables. For multicomponent comparisons, χ^2 with df > 1 was used.

For better visualization of the results, the following were used: Bar charts showing mean values and SD; Significance labels (p-value, χ^2, df) above the graphs; Internal labels with values inside the bars; Color differentiation between the main and control groups for improved clarity.

Results and Discussion. At later stages – particularly after surgical intervention – the initial wound sanitation effect may be neutralized due to other influencing factors. The formation of the microbial landscape in the wound at this stage is influenced not only by the nature and depth of the injury but also by several medical and organizational factors, including: The type and extent of the surgical intervention (e.g., simple debridement, wound suturing, laparotomy with revision and closure of a hollow organ); The quality and biocompatibility of the suture material; Compliance with aseptic and antiseptic protocols in the healthcare facility, including during dressing changes; The type and duration of prescribed antibiotic therapy; And the individual immune response of the patient.

Thus, microbiological monitoring after surgery allows for an assessment not only of the effectiveness of initial prophylaxis but also of the quality of comprehensive surgical and therapeutic management of the patient.

On days 2–3 after surgery, in patients with penetrating wounds (n=21), the most commonly isolated pathogens were: Staphylococcus aureus (14.3%), Klebsiella spp. and Escherichia coli (each 9.5%), Enterococcus spp. (9.5%) and Pseudomonas aeruginosa (4.8%). The share of mixed flora was 14.3%, and the share of sterile cultures was 28.6%. By days 4–5, there was a clear trend toward reduced microbial load: S. aureus persisted in only 9.5% of patients, Klebsiella spp. and E. coli in 4.8% each, Enterococcus spp. and P. aeruginosa were not detected at all. The proportion of sterile cultures significantly increased to 66.7%, indicating the effectiveness of surgical debridement and the initiated antibacterial therapy (Table 1).

Table 1. Wound Microflora in Penetrating Injuries After Surgical Intervention (n=21)

The causative agent	2-3 days		4-5 days	
	Detection frequency (n, %)	Average portion (COM/ml)	Detection frequency (n, %)	Average portion (COM/ml)
Staphylococcus aureus	3 (14,3%)	$9{,}5\times10^4$	2 (9,5%)	$9{,}0\times10^4$
Klebsiella spp.	2 (9,5%)	$1{,}2\times10^5$	1 (4,8%)	$1{,}1\times10^5$
Escherichia coli	2 (9,5%)	$1{,}0\times10^5$	1 (4,8%)	$7{,}0\times10^4$
Enterococcus spp.	2 (9,5%)	$7{,}8\times10^4$	-	-
Pseudomonas aeruginosa	1 (4,8%)	$9{,}1\times10^4$	-	-
Combined microflora	3 (14,3%)	$1{,}6\times10^5$	2 (9,5%)	$1{,}4\times10^5$
Another microflora	2 (9,5%)	$8{,}7\times10^4$	1 (4,8%)	$8{,}5\times10^4$
Sowing without height	6 (28,6%)	-	14 (66,7%)	-

Table 2 Wound microflora for non -minute wounds after surgery (n = 65)

The causative agent	2-3 days		4-5 days	
	Detection frequency (n, %)	Average portion (COM/ml)	Detection frequency (n, %)	Average portion (COM/ml)
S. Epidermidis	6 (9,2%)	$6{,}8\times10^4$	3 (4,6%)	$6{,}4\times10^4$
Staphylococcus aureus	5 (7,7%)	$9{,}6\times10^4$	3 (4,6%)	$8{,}9\times10^4$
Proteus mirabilis	3 (4,6%)	$8{,}3\times10^4$	-	-
Pseudomonas aeruginosa	2 (3,1%)	$9{,}9\times10^4$	-	-
Enterococcus spp.	3 (4,6%)	$7{,}1\times10^4$	2 (3,1%)	$7{,}2\times10^4$

Combined microflora	4 (6,2%)	$1,3\times10^5$	2 (3,1%)	$1,2\times10^5$
Another microflora	2 (3,1%)	$9,0\times10^4$	2 (3,1%)	$9,1\times10^4$
Sowing without height	40 (61,5%)	-	53 (81,5%)	-

In the subgroup with non-penetrating injuries (n=65), days 2–3 were characterized by moderate microbial contamination, with the most common pathogens being: S. epidermidis (9.2%), S. aureus (7.7%), Proteus mirabilis, Pseudomonas aeruginosa, and Enterococcus spp. (each 3.1–4.6%). The share of sterile cultures was 61.5%. By days 4–5, the microbial profile became significantly more favorable: Only isolated cases of S. aureus, S. epidermidis, and Enterococcus spp. were detected (each 3–4.6%), Pathogens such as P. aeruginosa and Proteus completely disappeared. The share of sterile cultures increased to 81.5% (Table 2).

In both subgroups, a clear reduction in both the number of positive cultures and the diversity of microflora was observed by days 4–5, which directly reflects the successful management of patients after surgical intervention. The decrease in the frequency of detection of polymicrobial associations and hospital-relevant pathogens (Klebsiella spp., P. aeruginosa, Enterococcus spp.) indicates the positive impact of the comprehensive treatment approach: wound sanitation, antibacterial therapy, and dressing care.

The following analysis reflects the impact of the quality of primary wound treatment on the frequency of positive cultures in the postoperative period. The effect of the initial culture results on microflora dynamics in the early postoperative period is demonstrated by a direct correlation between the results of microbiological testing performed during surgery and the frequency of positive cultures in the early days after the operation.

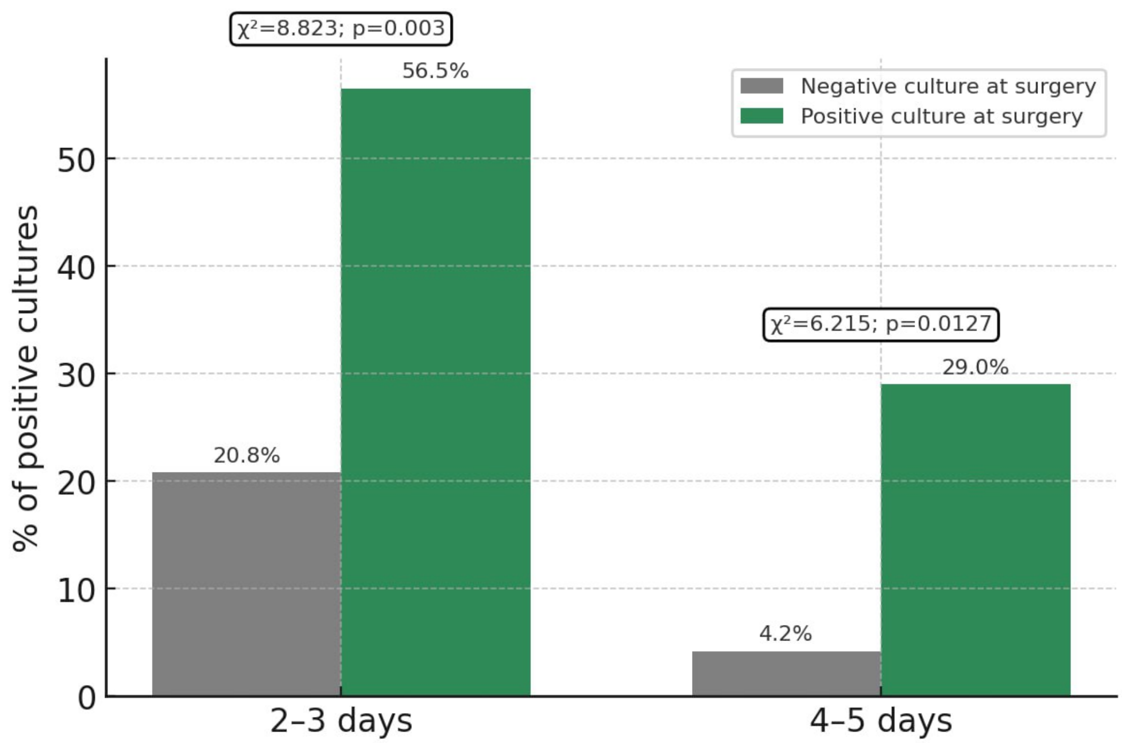

Fig. 1. Impact of the quality of initial wound debridement on the frequency of positive cultures in the early postoperative period.

Among patients with negative intraoperative cultures (n = 24), microbial growth was recorded only in 20.8% of cases (5 out of 24) within 2–3 days after surgery. In contrast, for those with a positive culture during surgery (n = 62), the microbial growth rate at days 2–3 was 56.5% (35 out of 62). The differences between the groups were statistically significant ($\chi^2 = 8.823$; $p = 0.003$), indicating a strong influence of the microbial status at the time of surgery on subsequent infection dynamics (Figure 1).

A similar trend was observed on days 4–5: among patients with a negative culture during surgery (n = 24), microbial growth by days 4–5 was detected in only 1 case (4.2%). Meanwhile, in patients with a positive culture at the time of surgical intervention (n = 62), microflora persisted in 29.0% of patients (18 out of 62). These differences were also statistically significant ($\chi^2 = 6.215$; $p = 0.0127$), confirming the importance of the initial microbial status in assessing the risk of infection and progression of the wound process.

The next important stage of analysis was the assessment of how the presence of microbial contamination in the wound during surgery affects the frequency and structure of postoperative complications. This is especially relevant because the moment of surgery is considered the "infection control point": the effectiveness of debridement, aseptic techniques, the choice of antibiotic therapy, and other interventions directly impact the outcome.

Within the conducted analysis, patients were categorized based on the presence of a leading complication – i.e., the condition that determined the clinical course and necessitated additional treatment. This is important because complications can occur sequentially. For example, wound suppuration may develop on the background of a seroma or hematoma, and wound dehiscence is often the result of purulent tissue disintegration or suture failure due to other causes (tension of wound edges, ischemia, infected suture material, etc.). In this sample (86 patients), hematoma accumulation was not observed; however, there were cases of seroma, wound suppuration, and suture dehiscence.

Complications were classified based on the dominant clinical event, which helped avoid duplication and allowed for a more accurate assessment of the impact of microbial contamination on outcomes. The results confirm: the higher the bacterial load at the time of surgery, the higher the risk of subsequent complications – both in frequency and severity.

Among patients with a negative culture during surgery, complications developed in only 12.5% of cases (3 out of 24). In contrast, in the group with a positive culture, complications were observed in 48.4% of cases (30 out of 62) ($\chi^2 = 9.423$; $p = 0.0021$) (Figure 2).

At the same time, not only the frequency but also the structure of complications changes. Among patients with positive intraoperative cultures, the most frequently recorded complications were seromas (19.4%), wound suppuration (17.7%), and suture dehiscence (11.3%). In contrast, in the absence of microbial growth during surgery, seromas were observed in only 8.3% of cases, suppuration in 4.2%, and suture dehiscence was not observed at all ($\chi^2 = 9.902$; $p = 0.0432$) (Figure 3).

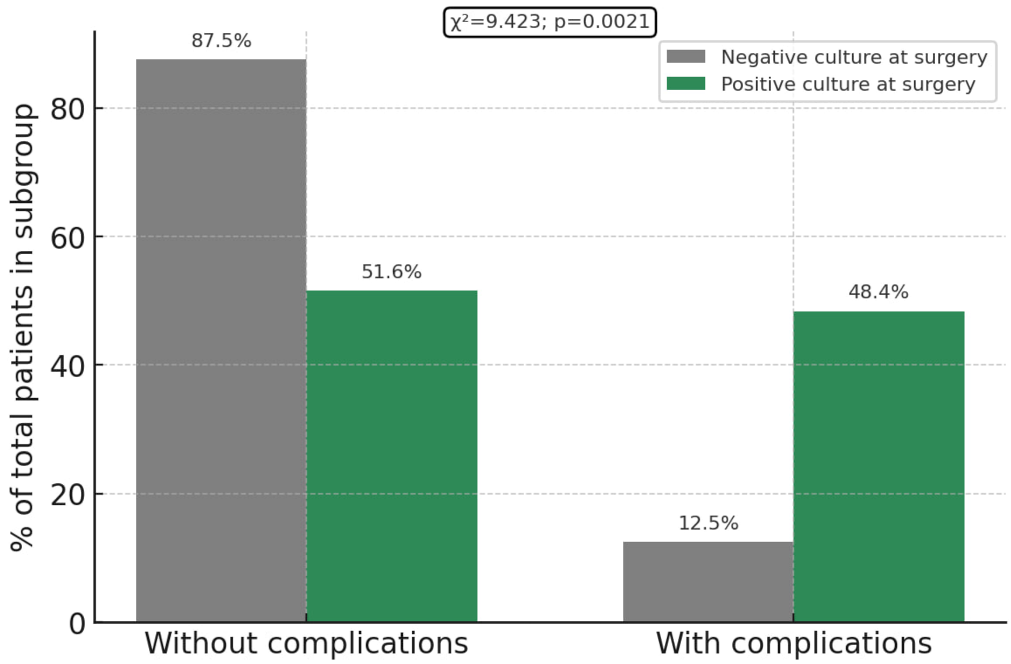

Figure 2. Distribution of patients with and without wound complications.

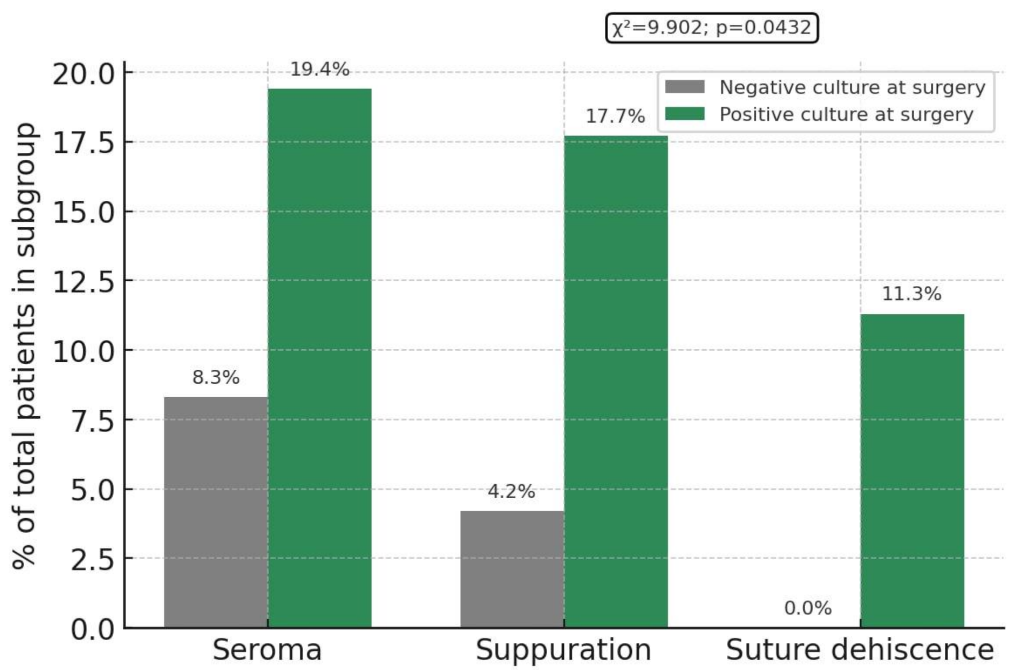

Fig. 3. Frequency and Structure of Complications Depending on Wound Cleanliness at the Time of Surgery

The higher frequency of complications observed in patients with a positive intraoperative smear is likely associated with several key factors:

Firstly, the mere presence of microbial flora in the wound during surgery suggests insufficient effectiveness of primary antiseptic measures or initial surgical debridement.

Secondly, the existence of bacteria at the time of tissue closure creates favorable conditions for the development of a closed purulent focus, particularly when suture material is used, which may serve as a nidus for infection.

Thirdly, the microbial flora detected intraoperatively is often represented by hospital-acquired and antibiotic-resistant strains. These strains may not respond adequately to standard antibacterial therapy, thereby increasing the risk of persistent infection.

Lastly, polymicrobial associations – especially when combined with tissue ischemia and trauma – create optimal conditions for superinfection and a delayed inflammatory response. This scenario heightens the risk of postoperative complications.

Thus, the findings reinforce that the microbial “cleanliness” of the wound at the time of surgery is a key prognostic factor. Routine intraoperative microbiological assessment and its interpretation as a predictive indicator can significantly enhance wound management strategies and reduce postoperative risks.

The data clearly demonstrate that proper primary wound management, sanitation, and sterility during surgery are positively correlated with improved outcomes. In cases with negative intraoperative cultures, the likelihood of microbial regrowth within 2–5 days post-surgery is extremely low. In contrast, the presence of active microbial flora during surgery substantially increases the risk of microbial persistence and recurrence in the postoperative period.

Conclusion. Several characteristic differences were identified concerning microbial contamination of wounds in military personnel. Among service members, positive microbial cultures were recorded in 73.9% of cases (17 out of 23), whereas among civilians, the rate was significantly lower – only 38.1% (16 out of 42). Accordingly, the proportion of sterile cultures in military patients was 26.1%, while among civilians it was 61.9% (χ^2=7.628; df=1; p=0.0057), indicating a significantly higher rate of early microbial contamination in military wounds.

Further analysis of bacteriological cultures collected during specialized care for patients with non-penetrating injuries revealed marked differences between military and civilian patients. Among service members, microbiota growth was observed in 87.0% of cases, whereas among civilians, positive cultures were found in only 52.4%. The rate of sterile cultures among civilians reached 47.6%, compared to only 13.0% in military patients (χ^2=7.771; df=1; p=0.0053).

These findings support the conclusion that military personnel experience a significantly higher microbial burden in wounds, potentially necessitating more rigorous antiseptic and antibiotic protocols in combat or field settings. Despite the antibacterial therapy, the presence of microflora in the wound already at the time of surgical intervention significantly increases the likelihood of its subsequent growth. This emphasizes the importance of effective antiseptic treatment at the early stage, timely insulation of the wound and reduce delivery time to the medical institution as key factors that form the further course of the wound process. The analysis showed that in patients with positive sowing with surgical intervention, the frequency of the subsequent growth of microflora on 2-3 days was 56.5%, while with initially sterile sowing - only 20.8% (χ^2 = 8.823; p = 0.003). By the 4–5 days, the difference becomes even more pronounced: the positive growth of microflora was observed in 29.0% of patients, while in the absence of microflora at the time of the operation - only in 4.2% of cases (χ^2 = 6.215; p = 0.0127).

The presence of microbial contractions of the wound during the operation is statistically reliably associated with a higher frequency of postoperative complications. So, in patients with positive sowing, complications developed in 48.4% of cases, while in a group with negative sowing - only 12.5% (χ^2 = 9.423; p = 0.0021). In addition, in the structure of complications against the background of positive sowing, clinically more significant forms were more often revealed: seroma (19.4% versus 8.3%), suppuration (17.7% versus 4.2%) and the divergence of seams (11.3% versus 0%) ($\chi^2 = 9.902$; $p = 0.0432$).

The data obtained confirms that the microbial state of the wound at the time of surgical intervention is formed primarily at the stage of primary assistance, where the effectiveness of antiseptic treatment, timeliness of delivery and conditions of the dressing are of the main importance. This serves as the basis for further improvement of the system of assistance to victims with open non-gunshot wounds and justifying approaches to the prevention of complications, starting with the first aid stage.

Based on the results on the established connections between the microbial contamination of the wound, primary assistance and the frequency of complications, the need to improve approaches to the primary processing of the Russian Academy of Sciences during non -aggregate injuries in the conditions of the civil and military medical service is justified. Particular attention should be paid to the development and implementation of new methods of antiseptic treatment, including the use of complex antiseptic agents with a prolonged effect, which is already used at the stage of prehospital assistance. To confirm the effectiveness of the proposed approach, experimental research is required, with the subsequent stage of clinical testing in practical health care conditions.

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