Overview of the Risk Factors and the Application of Major Surgical Site Infections Preventive Strategies

Eris Nepravishta[1]

Skender Topi[2]

Ervin Toçi[3]

Ervin Nepravishta[4]

Armela Kapaj[2]

[1]Department of Medical Sciences,
Aleksander Moisiu University,
Durres, Albania
[2]Faculty of Technical Medical Sciences,
Aleksander Xhuvani University,
Elbasan, Albania
[3]Department of Public Health,
Faculty of Medicine,
University of Medicine,
Tirana, Albania
[4]Trauma University Hospital,
Tirana, Albania

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Abstract

Introduction. Surgical site infections (SSIs) have been a clearly defined nosology since many decades, and despite all the efforts towards their prevention and control, they still account for the majority of burden within Healthcare Associated Infections (HAI). SSIs are clearly proved to increase both morbidity and mortality of the affected individuals, and their treatment is challenging and costly at the same time. Purpose. Following the literature review, our goal is to determine the main preventive strategies for SSI and risk factors, as well as to analyze the level of implementation of these strategies in our study center Trauma University Hospital in Tirana. Methodology. A literature review on the PubMed search engine for articles with the keywords "surgical wound infection" and "risk factors for surgical wound infection" revealed the main risk factors and four key preventive strategies for SSI in accordance with the World Health Organization (WHO) guidelines for the prevention of SSIs. Subsequently, we retrospectively analyzed the level of awareness and implementation of these four preventive strategies for SSI in the surveillance database of preventive measures for elective surgeries at the Trauma University Hospital in Tirana. Results. The top four policies most widely accepted internationally from almost all concerned entities are antibiotic prophylaxis, proper preparation of surgical field, normothermia and local hair removal. Our local institutional protocols and ongoing surveys are reassuring regarding implementation of only two of the above, the antibiotic prophylaxis and hair removal strategies. Conclusion. While the antibiotic prophylaxis and hair removal application strategies appear to satisfy our current expectations, the implementation of intraoperative normothermia and a standardized surgical site preparation are absent to deficient, and possible reasons might include insufficient knowledge distribution, and improper adherence with such knowledge.

Keywords: *normothermia, risk factors, surgical infections, site, strategies*

1. Introduction

Surgical site infections (SSIs) are infections that emerge on the site of the surgical wound within 30 days after the intervention. The time period is extended till 90 days (ECDC, 2021) or sometimes even a year (Owens & Stoessel, 2008), if any orthopedic or other prosthetic device has been implanted, during the surgical procedure.

Several classification and diagnostic criteria protocols have been proposed for SSIs by various authorities; however, in general, SSIs are classified as superficial, deep or in organs, depending on the layers of soft tissue involved (WHO, 2018; Balkan & Çelebi, 2020). If the infection has reached only to subcutaneous level, it is named superficial. It may show laboratory findings but local inflammatory finding like redness, swelling and temperature increase can confirm the diagnosis.

Deep infections extend till fascia and muscles, and usually are associated with the presence of puss drainage, which may sometimes be found in the closed form of abscess. It should be accompanied by laboratory findings, histopathological findings and sometimes even radiological findings.

The involvement of organs and deep spaces is generally related to areas accessed, examined, involved somehow in the process of surgery and such spaces may not have direct contact with the incision but may have been open and manipulated. Such tableau with plenty of radiological, histopathological and laboratory findings can even be life threatening under certain scenarios.

Owing to the enormous difficulties faced during their control and the significant cost of treatment, SSIs are still considered a major public health issue and the prevention of such complication, a priority! Efficient preventive strategies might be beneficial in reducing many adverse outcomes including economic burden, lengthening of hospitalization, disabilities, resistance to antibiotics, and overall morbidity and mortality (Eckmann et al., 2022).

According to the infection survey analysis of many health centers, SSI incidence is reported to vary from 3 to 5% of all surgical procedures per center per year, significantly associated with an increasing of both morbidity and mortality (Eckmann et al., 2022). The global pooled average incidence of SSIs was reported to be 2.5%, the highest on average 7.2% was observed in the African region (Mengistu et al., 2023).

The European Center for Disease Prevention and Control (ECDC) reported the highest cumulative incidence of SSI to be 9.5% for colon surgery, followed by 3.5% for coronary artery bypass graft, 2.9% for caesarean section, 1.4% for cholecystectomy, 1.0% for hip prosthesis, 0.8% for laminectomy and 0.75% for knee prosthesis (Eckmann et al., 2022; ECDC, 2013). Statistically SSIs are accounted for being the primary death cause during the postoperative period, before and after discharge (Fuglestad et al., 2021).

Risk factors for SSIs are classified as patient-related (endogenous) and process/procedural-related (exogenous) variables that affect a patient's risk of developing an SSI. Also, they can be classified as not modifiable (i.e. age, gender), or other controllable factors that if modified can yield a positive surgical outcome (nutritional status, tobacco, proper use of antibiotics and the intraoperative techniques) (Eckmann et al., 2022; 9. Buggy, 2019).

The WHO SSI prevention guidelines encourage the adoption of 29 recommendations covering 23 topics for the prevention of SSI in the pre-, intra- and postoperative periods. For each recommendation, the quality of evidence was graded as "very low", "low", "moderate" or "high". The development group classified the strength of each recommendation by considering the quality of evidence and other factors, including the balance between benefits and harms (Balkan & Çelebi, 2020). Difficulties have been faced regarding the comprehensive adoption of these guidelines by the responsible entities in order to develop preventive policies, and these strategies implementation in the diversity of characteristics of the patient population.

In this context, initially it is necessary to describe the key strategies for preventing SSI through a recent literature review regarding the SSI risk factors, and the adoption and maintenance of recommended preventive strategies according to WHO guidelines.

Secondly, through a retrospective analysis in the surveillance database of SSI preventive measures at our study center, we aim to assess the level of awareness and application of these preventive strategies in our healthcare personnel's medical practice. By identifying the main preventive strategies that are poorly understood and underused, it will be possible to raise awareness among healthcare personnel towards the inclusion and proper implementation of these strategies in daily surgical practice.

2. Methods

Using scientific article search engines such as ResearchGate and PubMed we identified a set of last five years papers from diverse geographical regions (10-18), that explore SSIs risk factors, and integration of WHO SSI prevention guidelines in the routine surgical practice.

After determining the risk factors, the adoption of WHO strategies and recommendations for preventing SSI was analyzed. Four strategies were identified as the most commonly accepted and applied by the majority of the entities involved.

Subsequently, the practice and duration of antibiotic prophylaxis strategy implementation, hair removal recommendations, intraoperative normothermia application, and proper surgical field preparation elements, were retrospectively analyzed on the SSI preventive measures Surveillance Database at the Trauma University Hospital. Database data were collected through questionnaires investigating the level of acceptance and implementation of SSI preventive strategies (WHO update 2018), and were analyzed using MS Analysis ToolPak. The participating medical personnel were doctors, 3rd-4th year medical residents, and operating room nurses, respectively according to departments: surgery, orthopedics, neurosurgery, and maxillofacial surgery. We excluded from the database, other physicians of the respective departments who were not actively practicing surgical procedures at the time of data collection.

3. Results

The identified risk factors that directly influence surgical wound healing and determine the potential for SSI include:

Chronic diseases are proved to affect and directly impair the immunological response of the body, by different mechanisms on different levels (Fuglestad et al., 2021; Kolasiński, 2018; Shao J et al., 2018; Alkaaki et al., 2019). The rise in blood viscosity in diabetes mellitus patient impairs the movement of immune cells towards the desired infection site, or the primary site of bacterial contamination (Balkan & Çelebi, 2020; Chávez-Reyes J et al., 2021).

The ageing process stimulates such physiological changes known to specially affect the regeneration capabilities of soft tissue and organs, and also the immune response and together with a neurovascular support deficiency, they lead to a very inadequate healing process of the wounds and therefore making these sites more vulnerable to infection.

Smoking is well known to directly contribute to a less efficient inflammatory response. It is proven to cause multisystem metabolic changes. Its peripheric vasoconstrictive effect can lead to a decrease in blood circulation to the affected area of the intervention, therefore predisposing the site to infection (Fuglestad et al., 2021; Kolasiński, 2018; Shao J et al., 2018; Alkaaki et al., 2019).

Corticosteroid therapy, or any other kind of immunosuppressive treatment is obviously predisposing the whole body to more critical and severe infection scenarios. Taking into account the reasons for patients to undergo such treatment, it is clear that the body healing process is too slow and prone to bacterial colonization (Gómez-Romero et al.,2017).

Malnutrition, has direct effect on slowing the process of cell growth, and hence wound healing. Many authors advise that special formulas should be administered to patients having a BMI of less than 18 prior to any planned invasive procedure that might suffer from delayed wound healing and infection (Gómez-Romero et al., 2017; Alkaaki et al., 2019). Another hypothesis is that the immune system may be modulated by the use of specific types of nutritional support (WHO, 2018; Culebras-Fernandez et al., 2013).

The use of prosthetic materials specially in cardiovascular, orthopedic and other similar types of surgeries, that require the use or placement inside the body of foreign implants, increases significantly the risk for SSI.

The contamination can occur hematogenously, from organisms that originate from another area in the body and travel through the blood and attach to the surface of such implants or from contamination before implantation to the body during the preoperative period. The hematogenous contaminants tend to be bacteria of low virulence, but the contamination during the preoperative period tends to be from very hardly controllable organisms.

Time of surgery is statistically shown to directly increase the incidence of surgical site infections. The longer the time of surgery, the longer the disruption of the skin barrier, the longer the exposure of tissues to external contaminated environment. A longer than 2 hours' exposure to such environment significantly increases the risk for SSI (Kolasiński, 2018; Shao J et al., 2018; Alkaaki et al., 2019).

Hospitalization duration, as a risk factor during the preoperative period directly extends the time of exposure of the patient, and during the postoperative period also the exposure of the surgical wound to the contaminated hospital

environment. In cases when the hospitalization is prolonged for more than 24 hours, the exposure and the risk for such bacterial colonization increases significantly (Bolton, 2021; Shao et al., 2018).

The preexisting degree of contamination of the wound to be treated is another issue that exponentially increases the risk for surgical site infections. Such infections whenever improperly administered can lead to serious site infections of same pathogen if isolated, or the extend of tissue damage itself can lead to a higher probability of occurrence of SSI.

The WHO SSI preventive measures or strategies, as mentioned during the introduction, could be in different grades of quality of evidence, in the form of either strong or conditional recommendations.

Nevertheless, their building process is triggered by all the above risk factors but not limited to, and is elaborated to the most efficient and updated form by a continuous evidence-based body of research. Based on our research, the most frequently adopted SSI prevention guidelines are antibiotic prophylaxis, hair removal with trimmer from the surgery site, usage of alcohol based chlorhexidine solutions for preparation of the surgical site, and preserving normal body temperature during whole duration of surgery or normothermia (Mengistu et al., 2023; Liu et al, 2018). The surveillance of preventive measures for SSI at the Trauma University Hospital (TUH) includes 108 data entries according to departments: General Surgery, Maxillofacial Surgery, Neurosurgery, and Orthopedics, and the participants position as surgeon, resident doctor, and operating room nurse (See Table 1).

Table 1. The distribution of data from the Surveillance of Preventive Measures for SSI at TUH according to department and position.

Variable	***Absolute No***	***Percentage***
Total	*108*	*100.0*
Department		
General Surgery	*40*	*37*
Maxillofacial Surgery	*10*	*9.3*
Neurosurgery	*11*	*10.2*
Orthopedics	*47*	*43.5*
Position		
Prep Nurse	*11*	*10.2*
Resident	*10*	*9.3*
Surgeon	*87*	*80.5*

The analysis of the survey data conducted among healthcare personnel regarding the WHO strategies revealed that the rate of antibiotic prophylaxis application before and after surgery is 88%, while the strategy of hair removal in the surgical area is applied in 84.5% of cases. (See Figure 1).

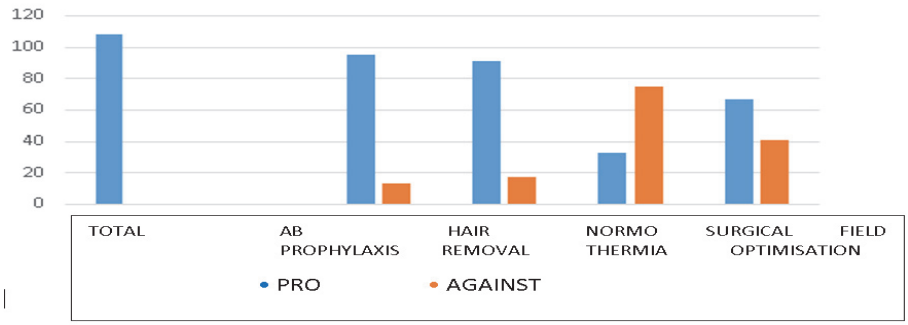

Figure 1. Graphical presentation of the data of the analyzed preventive strategy applications

Unfortunately, in 50 out of 91 data points, thus in 55% of cases favoring hair removal, the recommended technique was incorrect, recommending the use of razors instead of trimmers. (See Figure 2)

The data in favor of preserving normothermia were discouraging. Maintaining the patient's body temperature seemed to

lack as a priority, with only 33 data points out of 71 favoring its routine application, and there was no appropriate standardization of surgical site preparation, with only 62% of participants confident about the standard quality of the applied methods.

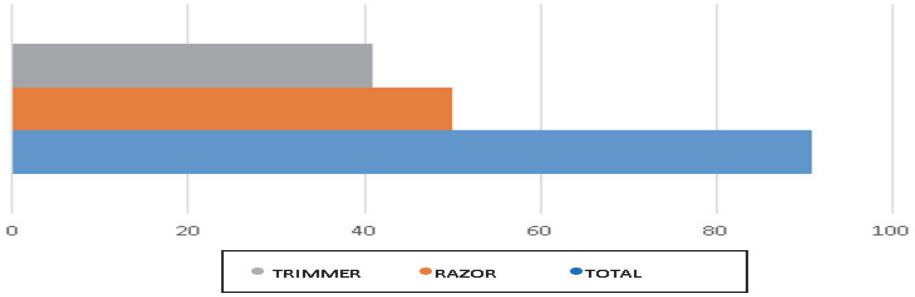

Figure 2. Graphical presentation of application methods of the hair removal preventive strategy

4. Discussion

SSIs have been a vastly investigated entity, and due to its debilitating potential, the high cost of treatment, and the overall poor outcome of such treatment, most of the current health policies are mainly directed to the prevention of these infections. And they have proven efficient and beneficial. But still there is a lot of controversy between institutions regarding the routine application of such measures. We concluded that, four primary recommended polities were accepted and integrated by the majority of the researched institutions or entities: *1. Antibiotic prophylaxis beginning at least 30 min before incision, 2. Hair removal with trimmer from the surgery site, 3. Usage of alcohol-based chlorhexidine solutions for preparation of the surgical site, and 4. Preserving normal body temperature during whole duration of surgery or normothermia* (Liu et al., 2018; Riojas, 2022). Trials investigating the effect of the application technique with similar antiseptic compounds showed no difference in surgical site infection rates. (Korol et al., 2013; Segal & Anderson, 2002).
There was not enough documented supporting evidence to encourage the usage of transparent drapes and plastic incision fields, and sutures soaked in antibiotic.

The WHO guidelines strongly recommend the usage of Mupirocin ointments to decolonize mucosa from Methicillin Resistant Staphylococcus Aureus (MRSA) in the preoperative period, (WHO, 2018), but still this measure has been considered controversial. The American Society of Healthcare Epidemiology recommends screening for *S. aureus* and decolonizing surgical patients for high-risk procedures (Anderson et al., 2014) and mupirocin can be used for the eradication of both methicillin-sensitive *S. aureus* (MSSA) and MRSA (Francois et al., 2003) but still, many opinion leading authorities consider the routine screening for MSSA and MRSA unjustified.
We found no data regarding past strategies for screening and and/or any reports of any foreseen degree of colonization with MSSA and MRSA in our population, in our case such recommendation is out of place.

Returning to the acceptance and implementation of these strategies in our practice, our data showed satisfactory compliance with WHO strategies for preventing SSIs regarding antibiotic prophylaxis.

Nevertheless we noticed diversities in data favoring different timings of onset of therapy ranging from 1 day before to 30 minutes before the incision, and unfortunately, despite the fact that most guidelines discourage the continuation of postoperative antibiotic prophylaxis for more than 24 hours (IHI, 2012), more than half of the date entries at our survey continued the therapy until the fifth day after surgery.

As stated in the latest update of the guidelines, the hair should be removed from the site of surgery only when necessary and using a trimmer. Shaving is discouraged at all times (WHO, 2018). In our survey the significant majority of the data were supportive for the hair removal recommendation, but more than half of the entries (55%) of participants favored the use of razors instead of the recommended trimmers.

Many different types of solutions have been demonstrated effectively prepare the skin for surgery including polyvidone, chlorhexidine and alcohol or a mixture of 2 or more of the previous, but no formula have been shown to be superior to the others and the panel of the guidelines with moderate evidence supports only the usage of alcohol-based antiseptic solutions with chlorhexidine WHO, 2018; Yang et al. 2024) The guidelines do not specify a recommended

formula or ratio, and regarding the recommendation of optimal surgical field preparation, unfortunately only 38% of our studies healthcare professionals believed that the solutions used for surgical site preparation met the expected standard.

Although in our review it resulted to be one of the most widely accepted and applied prevention strategy, we concluded that unfortunately, in our institution we are lacking the core supporting evidence and consequently there is no clear consensus on intraoperative normothermia, and only 46% of participants believed that this strategy has a scientifically proven impact on SSI incidence.

We found no similar studies within the country or region regarding the acceptance or practical application of preventive measures or strategies recommended by the WHO. This constitutes a limiting factor in assessing or comparing the results. The presence of other regional studies in institutions sharing similar characteristics, and environments, would produce more significant data interpretations. A reported high false positive rate of application of these strategies might be another limiting factor, that occurs due to the influence of present information, but that unfortunately cannot be applied objectively in practice.

5. Conclusion

Additional efforts are needed in order to promulgate among health professionals the role of normothermia and standardized surgical site preparation with alcohol based antiseptic solutions based on chlorhexidine. Shaving should be discouraged at all times, promoting trimmers usage whenever hair removal is considered a necessity.

In addition, we recommend a close continuous reviewing of the relevant international guidelines, to formulate even more effective approaches to routine preventive measures and applied policies.

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