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Review Article

Study to determine the factors related to patient and surgical procedures influencing the rate of postoperative surgical wound infections

Sandeep Bhoyar[1], Atul R Rukadikar[2,*]

[1]*Medstar Diagnostics Clinical Laboratory, Nagpur, Maharashtra, India*
[2]*Dept. of Microbiology, All India Institute of Medical Sciences, Gorakhpur, Uttar Pradesh, India*

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ABSTRACT

Wound infections continue to be a substantial contributor to postoperative morbidity, responsible for around one-fourth of all nosocomial infections. The human bacteria from the endogenous organ microflora and the extrinsic environment continue to have a role in the development of wound infections. The development of postoperative wound infection has been linked to several different perioperative variables that have been studied in detail. Numerous studies have shown that several surgical procedures are more susceptible to postoperative infection complications because of individual risk factors. The majority of patient- and procedure-related variables have been identified to influence the likelihood of surgical site infections in univariate or multivariate analysis. Preexisting infection, older age, *Staphylococcus aureus* and other dangerous pathogens, smoking, and diabetes is also possible patient-related variables. Procedure-related variables include the length of the surgery, the quality of preoperative skin preparation and poor surgical skill. The goal of this study was to recognize the incidence of postoperative surgical wound infections, which is influenced by patient and surgical technique parameters.

1. Introduction

Infection occurs when pathogens penetrate tissues, multiply, and cause host tissues to respond to the infectious agent and the toxins it produces. When a person becomes unwell as a consequence of contracting an infection, it is referred to as an infectious disease. Bacteria and viruses are two of the most common pathogens that cause infections.[1] Hosts' immune systems may help them combat infections. Mammalian hosts respond to infections by first passing through an innate reaction, which often involves inflammation, and then passing through an adaptive response. Most microorganisms become persistent "colonists," living in complex colonies within and on human bodies. Microorganisms are successful because of their extraordinary adaptability.[2] Natural selection causes organisms that are genetically more compatible with their environment to reproduce more frequently and pass on their favorable traits to succeeding generations. When compared to humans, the microbial world is where this mechanism works far more effectively. A new generation of humans often arises every 20 to 30 minutes for bacteria and even more frequently for viruses. Microorganisms may congregate in huge numbers and with a wide variation in their communities because of how rapidly they replicate. The genetic diversity throughout the group increases the likelihood that some members will survive if their environment suddenly changes.[3] Because of this, bacteria have a major evolutionary benefit over humans in terms of adaptation for survival. In elective surgery, wound infection is a crucial clinical outcome indicator.

* *Corresponding author*.
E-mail address: atulruks@gmail.com (A. R. Rukadikar).

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There are several methods to describe wound infection. Numerous research has made use of the World Health Organization definition: "a rupture in the skin or mucous membrane, owing to surgery, burns, or trauma, which is releasing pus"[4–6] The need for a visible suppuration, however, could lead to unnaturally low detection rates. In investigations of health services research, surgical audit, normal hospital monitoring, and nosocomial surveillance systems, surgical wound infection is documented as a postoperative outcome. It is common practice to compare postoperative wound infection rates across and within healthcare facilities, with infection rates serving as a gauge of the quality of surgical treatment received. A significant comparison may only be performed if wound infection is evaluated using uniform criteria and reliable data collecting techniques.[7,8] One of the primary causes of morbidity and a less common cause of death in surgical patients continues to be postoperative wound infections.

There are various risk factors for postoperative wound infection, and they may be classified into patient-related and procedure-related categories.[9] In nationally representative research that was broadly cited and published more than three decades ago, the overall incidence of postoperative wound infection was revealed to be 7.4 percent.[10] In the survey that took place for a year from 1975–1976, it was predicted that wound infections comprised around 24% of all nosocomial infections.[11] More than 500,000 wound infections, or around 2.8 per 100 procedures, were represented by this number. The intensity of wound infection differs from one surgical method to another, from one surgeon to another, from one hospital to another, and most importantly, from one patient to another. In the middle of the 1970s, it was observed that when postoperative wound infection developed after some surgeries, the average stay in hospital doubled, and the cost of hospitalization enhanced proportionally. Most surgical procedures are now done as outpatient procedures or need just a short postoperative stay, resulting in much-decreased costs and stays in hospitals.[12]

Table 1: Some recent studies on wound infection.

S.no.	Author	Observation	References
1.	Sattar F et al., 2019	Patients hospitalized at Ayub Teaching Hospital have a significant incidence of SSIs. Comorbidities, advanced age, obesity, the length of operation, major surgeries, and anemia were key risk factors found. There should be action made to reduce SSIs in these high-risk populations.	13
2.	Sandy-Hodgetts K et al., 2015	Surgical wound dehiscence (SWD) has a direct effect on the emotional stress that patients and their families face as a consequence, affects mortality and morbidity rates, and significantly prolongs hospital stays.	14
3.	Tan DJ et al., 2021	Diabetes mellitus has often been linked to unsuccessful surgical procedures. Anastomotic leakage and a greater re-admission rate were among the surgical complications that the meta-analysis and comprehensive review revealed to be more common.	15
4.	Chacón-Quesada T et al., 2021	They investigated the impact of increased hygiene precautions on the incidence of surgical site infections (SSI) after neurosurgical operations.	16

2. Infection in the Postoperative Patient

2.1. Nosocomial Pneumonia

As the second most prevalent nosocomial infection after urinary tract infection, hospital-associated pneumonia (HAP) has become a significant cause of postoperative infection. Nosocomial pneumonia is a particular danger to surgical patients since many surgical procedures include general anesthesia and intubation. Intubation enhances the risk of developing ventilator-associated pneumonia (VAP) by encouraging aspiration and colonization of the endotracheal tube with endogenous and multi-drug resistant, healthcare-associated bacteria, particularly as the length of intubation rises. VAP risk may be reduced if patients are weaned off mechanical ventilation quickly. Surgeons and other patients who are unable to move are at a greater risk of getting pneumonia because of their immobility, which increases atelectasis as well as inadequate secretion clearance.[17]

3. Catheter-Related Urinary Tract Infection

The majority of nosocomial infections, or around 40% of all infections acquired in hospitals, are urinary tract infections (UTIs).[18] A urinary catheter will almost always be inserted during surgery and soon after, making it a frequent site of contamination and infection. By itself, catheterization poses a risk of developing bacteriuria, and that risk rises as the catheterization lasts longer. The majority of bacteriuria patients have no symptoms; however, up to 30% of cases may be worsened by a fever or other symptoms.[19] Long-term catheterization is more likely to cause fever than short-term catheterization. A catheterized patient's fever may also be a sign of problems, including urethritis, epididymitis, prostatitis, or pyelonephritis. Catheterized urine cultures are not required or helpful unless there are symptoms present, which may or may not be assessable depending on the patient's state of sedation. Asymptomatic bacteriuria is prevalent in catheterized patients.[20]

3.1. Surgical site infection

According to estimates, surgical site infections (SSIs) account for around 3% of all surgical operations and are the most prevalent nosocomial infection among surgical patients.[21] A surgical site infection (SSI), assuming no implants were used, is now defined as an infection that appears within 30 days of surgical treatment. Most SSIs appear 5 to 10 days after surgery, although others may take up to 30 days or more.[22] The majority of SSIs involve the introduction of microorganisms during the surgical process. These infections often come from the skin or gut flora of the patient.

The risk of developing an SSI depends on the patient's overall health and the kind of surgery performed. Historically, surgical operations have been categorised based on the likelihood of contamination. It has been shown that the amount of pollution in the wound corresponds to an increased risk of acquiring an SSI. A risk index has also been created by the National Nosocomial Infections Surveillance System (NNIS). Patient characteristics and the procedure's potential impact on SSI development.

If there are indications of local inflammation, such as erythema, warmth, or discomfort, surgical site infection should be considered. Following additional testing or surgical re-examination, the infection may be categorised as superficial, affecting only the skin and subcutaneous tissue, deep, affecting the fascia and muscle, or organ/space infection, affecting organs far from the incision but still directly connected to the procedure.

It is particularly challenging and dangerous to get a culture from an SSI due to the presence of the indigenous flora. If a suspected SSI is not accompanied by symptoms of systemic toxicity, such as fever or leukocytosis, wound cultures are not advised. In contrast to typical wound drainage swabs, an aspirate of pus in a syringe or a tissue specimen will offer the most useful information if a culture is collected.

An uncommon but dangerous subtype of surgical site infections is necrotizing soft-tissue infections. Although other Clostridium species have also been implicated, the most frequent cause of clostridial myonecrosis, often known as gas gangrene, is *Clostridium perfringens.* Within a few hours of surgery, clostridial myonecrosis might happen and is characterized by immense pain that radiates beyond the surgical site. Hemorrhagic bullae and skin darkening ensue from the surrounding muscle, and tissue becomes necrotic. A thin, serous discharge is more frequent, and purulent drainage is often missing. Additionally, postoperative reports of necrotizing fasciitis brought on by group A *Streptococcus* have been made. This condition has been linked to hypotension, renal failure, and respiratory failure. Both situations are regarded as surgical emergencies, necrotic tissue removal requiring immediate surgical intervention. Although parenteral penicillins and clindamycin are regarded as the therapy of choice and may have a role in preventing the spread of infection, antibiotics are secondary in significance to surgical resection.[23,24]

3.2. Risk factors for surgical site infections

The risk of surgical site infections (SSIs) has been associated with a variety of patient and procedure-related factors, either alone or in combination. Preexisting conditions such as advanced age, *S. aureus* colonization, smoking, diabetes, and other dangerous infections are additional probable patient-related factors. Poor surgical technique, insufficient sterilization of surgical tools, the quality of preoperative skin preparation, and the length of the procedure are all procedure-related issues.[25] According to a study by Dominioni L et al., 2006, the most important patient-related variables were low blood albumin concentrations and age, whereas the most significant procedure-related factor was the quality of surgical technique. This analysis also concluded that the majority of SSIs are caused by patient-related factors as opposed to procedure-related factors. The NNIS SSI Risk Index may be used to determine a patient's risk of SSI. There are three factors that influence the calculation of this index, and each one is given a single point:

1. Surgical procedures often take substantially longer than the 75th percentile of the time predicted to finish the treatment at hand.
2. The existence of a filthy, infected, or contaminated wound
3. An American Society of Anesthesiologists (ASA) Physical Status Classification score of >2 (i.e., mild systemic illness).[26]

Numerous studies were conducted to identify risk factors for SSIs following breast surgery, but these studies had several limitations. For example, Sørensen LT et al., 2002; Xue DQ et al., 2012 studies only focused on one or a small number of potential risk factors, and the varied criteria of some risk factors made it difficult to conclude them.[27,28] The findings of several research may have been skewed because the sample size was so small (patients' total number of SSIs was under 20). Additionally, some findings are still inconclusive rather than contradicting. For example, Mangram AJ et al., 2000 in their study, smoking and prolonged use of surgical drains were both identified as risk factors for SSIs; however, other results did not show a statistically significant correlation between them.[29] Breast reconstruction, Preoperative chemotherapy and the prescription of antibiotic prophylaxis were alleged to have an effect on the incidence of SSIs[30–32] Two cohort studies by Vilar-Compte D et al., 2006; Felippe WA et al., 2007 on the SSI risk variables were also carried out. Patients were included in each research, although they were all pretreated with unique influencing variables. Therefore, a meta-analysis using the data from these three investigations was not appropriate.[33,34]

Table 2: Overall risk factors for surgical site infection (SSI)

S.no.	Category	Factors
1.	Patient-related	Increasing age, diabetes, obesity, smoking, immunosuppression, malnutrition.
2.	Preoperative	Preoperative length of stay, antibiotic prophylaxis, hair removal technique.
3.	Operative	Wound classification, operative technique, degree of tissue trauma, prolonged duration of surgery, presence of the foreign body, and need for blood transfusion.

3.3. Rates of infection

The work of Gottrup F et al. 2005 is commonly recognized as the benchmark for infection rates in the four surgical classes (clean, clean-contaminated, contaminated, and filthy wounds). Before the widespread use of prophylactic antibiotics, infection rates in clean wounds varied from 1 to 2 percent, 6 to 9 percent for clean-contaminated wounds, and 40 percent for filthy wounds. Contaminated wound infection rates ranged from 13 to 20 percent. Prophylactic antibiotic treatment has greatly decreased the number of people in the most polluted groups contracting infections. SSIs are among the main causes of illness and death in India. The SSI rate in India varies greatly and, depending on the circumstances, might be anywhere between 1.6 and 38 percent. However, the kind of surgery done has a significant impact on the diversity in each class.[35,36]

3.4. Pathogenesis of surgical site infection

Understanding the pathophysiology of SSIs is essential for assessing and creating prevention measures for SSIs. Skin flora and inherent immunity are delicately balanced in the healthy condition. There are two types of skin flora: transitory and resident. Microbes that are permanently present make up resident flora, while transitory flora is only present briefly. Skin health depends on a regulated and managed relationship between microbial flora and skin. When this is interfered then SSI may occur. Therefore after surgery, the wound must be infected, and the pathogenicity and inoculum of the bacteria presence must be balanced against the host's immune response. If the bacteria that cause SSIs come through a patient's skin or an open viscus, they are known as "endogenous" infections. Exogenous infection may be caused by microorganisms from surgical instruments or the operating room environment, as well as those from the environment contaminating a traumatic incision, or they can get entrance to the surgical site before the skin has fully healed. An SSI may be caused by germs from a distant source of infection adhering to a prosthesis or other implant left in the surgical site, most often by hematogenous dissemination. SSI may be prevented by limiting the number of bacteria that enter the surgical site, for example, by using sterilization techniques:

1. Eliminating skin-colonizing germs.
2. By using prophylactic antibiotics, for instance, one may prevent the formation of microorganisms at the surgical site.
3. Enhancing the patient's resistance to infection, for instance, by minimizing tissue damage and keeping body temperatures normal.
4. Using a wound dressing to stop bacteria from getting into the incision after surgery.

The bacteria that is most often cultivated from SSIs is *Staphylococcus aureus.* The tissues from a viscus, like the big bowel, are likely to be infected with a wide variety of microorganisms when it is opened. For instance, Enterobacteriaceae and anaerobes may be present after colorectal surgery and may work together to induce SSI. The number of pathogenic organisms required to cause an SSI is decreased by the presence of the foreign body during prosthetic surgery, such as a prosthetic joint during orthopedic surgery or a vascular graft during arterial bypass surgery. Under these circumstances, normally non-pathogenic bacteria like the coagulase-negative Staphylococcus epidermidis may cause an SSI. Contrary to procedures carried out on "contaminated" or "dirty" locations, where rates may exceed 10%, surgeries carried out in normally sterile settings have extremely low rates of SSI.[36]

4. Factors that Affect the Incidence of Wound Infection

4.1. Patient risk factors

4.1.1. Smoking

Infections at surgical sites and dehiscence of tissue and wounds were related to smoking and comorbidities, which included diabetes, lung disease and cardiovascular disease, corroborating earlier observations. There might be some pathogenetic processes at the action. Smoking, microvascular disease, and severe lung disease have been linked to peripheral tissue hypoxia, which elevates the risk of wound infection and dehiscence. Additionally, some research indicates that diabetes, smoking and hypoxia lower neutrophil oxidative killing mechanisms and collagen formation.[37–39]

4.1.2. Effects of malnutrition

Patients who are undernourished have a very high risk of developing spinal inflammatory infections. Malnutrition of protein and protein calories is linked to impaired wound healing, an increase in postoperative infections, and immunological suppression. Albumin, prealbumin, and total lymphocyte counts should be evaluated as part of a patient's nutritional condition. Malnutrition is indicated by a total lymphocyte count of 1500–2000 cells/mm^3 and a serum albumin level of less than 3.5 g/dl. Prealbumin levels may be utilized in the inpatient setting as a gauge of effective continuing nutritional placement since they react to the patient's nutrition more quickly. The nutritional state of a patient alters considerably after staged spinal surgery. According to Klein JD. et al. 2012, during their first hospitalization, 84 percent of patients having staged anterior-posterior spinal surgery developed malnutrition; 27 out of 28 postoperative infections were observed to occur in this impoverished group.[40]

4.1.3. Patient's skin

Various bacteria colonize the skin; however, *Staphylococcus aureus* makes up to 50% of this population. The patient's epidermis was found to be the primary source of wound contamination in investigations of contamination rates after cholecystectomy.[41]

4.2. Age

Ridgeway S et al. 2005; Neumayer L et al. 2007; Friedman ND et al. 2007 revealed that age was found as an independent risk factor for SSI in one prospective observational research that used logistic regression to analyse data gathered from 142 medical centres. [EL = 2+] In patients having general and vascular surgery, trained nurses collected information on preexisting and postoperative risk factors for SSI. 7035 of the 163 624 trial participants had SSI 17 within 30 days after surgery. Compared to patients under 40, those over 40 showed a statistically significant higher chance of having SSI. Patients who had general surgery in a community hospital in the USA were included in a retrospective observational research. [EL = 2−] The database was searched for demographic and clinical data, including relapse data up to 28 days after surgery. When SSI was detected early (between 2 and 7 days post-operatively), regression techniques were employed to identify independent risk factors for recurrence or death as well as SSI. There was a statistically significant correlation between a person's age and the likelihood of developing an early SSI.[42–44]

4.3. Obesity

Adipose tissue has inadequate blood flow, which affects the immune system working and the oxygenation of tissues, raising the possibility of SSI. Additionally, procedures on fat people may be more difficult and drawn out. In cardiac, spinal, and caesarean sections, the impact of obesity on the risk of SSI has been studied. According to Olsen MA et al. 2008, individuals with a body fat index of 35 kg/m^2 or more had ORs for SSI ranging from 2 to 7.[45]

4.4. Immunosuppression

Although it's crucial to keep in mind that the underlying reason a patient is receiving steroid therapy may raise the risk of SSI on its own, the use of steroids has been associated with an increased risk of SSI. For instance, several studies have linked SSI risk to COPD history, and many COPD patients are receiving long-term steroid therapy.[46] More research is required to fully understand these risk variables. In comparison to the general population, HIV-infected individuals had a twice greater prevalence of SSI. According to the research, additionally, individuals are more likely to get SSIs if their preoperative CD4 levels are lower.[47]

5. Risk Factors Related to the Surgery

The surgical risk is influenced by shaving before surgery as well. According to the study by Idé G et al. 2018, patients who did not shave their surgical site before surgery were more likely to develop an infection. A BIC razor was found to be an effective method of shaving the day before surgery by a patient who had already settled in. This was consistent with the findings of previous investigations. Several kinds of research using a hand razor to remove hair poses a higher danger than using an electric razor or other hair removal methods. Additionally, while using a hand razor, the risk was doubled if the shaving was done 24 hours before the procedure as opposed to just before. The duration of the postoperative stay is increased by surgical site infection. The duration of the postoperative stay raises the risk of site infection. They found that individuals who remained in the postoperative period for more than a week were more likely to acquire an infection at the surgical site than those who stayed for less than a week.[48] Over a two-hour surgery seems to provide a particularly high risk of surgical site infection. The probability of a surgery lasting more than two hours was 1.03 in our sample. This increased risk is attributed to a variety of variables, including an increase in the number of sutures, an increase in intensification of surgical trauma, wound contamination, an increase in blood loss, and a reduction in the effectiveness of preventive antibiotics. Additional risk factors notwithstanding, an extended preoperative stay increases the risk of infection. They searched for a relationship between the length of the preoperative stay and surgical site infection, but they were unsuccessful. Debarge et al. 2007 made the same observation.[49] This discrepancy may be understood by the difficulties in accurately determining the date of admission before the operative act of certain research.[50,51]

5.1. Surgical location

Staphylococcus, Micrococcus, Clostridium, Acinetobacter, Corynebacterium, Streptococcus, Enterobacter spp. and *Escherichia coli* are common bacteria found on the skin of animals. On hair and skin surfaces, in the superficial cornified layers and follicles, these organisms are found. An infection can only occur if there are too many germs present at the surgical site, which is why the aseptic preparation of the surgical site is so important. After the anesthesia is administered, the patient's hair is cut in a pre-operative area outside the operating room. Orthopedic draping should make it possible for the surgeon to handle the limb in various directions without fear of contamination. The patient's body is first draped with four pieces of cloth, one for each of the four corners of the limb. About 10 cm of double-thickness folds at the edges are used to hang these curtains. Backhaus towel clamps are used to hold them in place on the skin. It is not recommended that the clamps be relocated due to contamination of the clamp points after skin penetration. After that, a sterile adhesive drape material is applied to the foot. The limb emerges from a central aperture in a huge single sheet before being placed on top of a second layer. A third layer may be necessary on top of the second, depending on the kind of draping material being used. When moist, reusable cotton fabric drapes are ineffective in preventing bacterial penetration, resulting in an infection at the spot.[52]

5.2. Preparation of the surgical team

The surgical team's preparation is focused on minimizing both airborne and human skin contamination. Bacterial populations in the air may be increased by factors such as the number of individuals in the operating room, the degree of activity, and how much skin is exposed. Many of the germs that cause a postoperative wound infection are found under the nails and in the nail beds. A gown should be water-resistant and constructed of durable material. Surgeons should wear gowns that cover their backs. Assisting the surgeon in putting on the gown and ensuring that the surgeon's hands remain within the sleeves until the gloves are on reduces the risk of infection at the wound site. When talc or cornstarch enters a wound, it may cause inflammation, and starch can lead to synovial necrosis or joint tissue death. Therefore, a sponge soaked in sterile isotonic solution should be used to clean powdered gloves before skin incision.[53]

6. Conclusion

The high mortality and morbidity burden associated with SSIs places a significant demand on healthcare resources because of the lengthy hospital stays. Both host and perioperative variables are connected to the risks of SSIs. Variables like smoking, contamination of the surgical site, diabetes, lung illness and gender, as well as cardiovascular disease, blood loss and the surgical process itself, have been found to be independent predictors of wound and tissue complications. Therefore, additional research is required to assess additional areas that may be improved to lower the risk of SSI and eventually enhance the care given to surgical patients.

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None.

8. Conflict of Interest

None.

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Author biography

Sandeep Bhoyar, -

Atul R Rukadikar, -

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