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Preventing and managing port site infections in minimally invasive surgeries: A review of causes and best practices

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Abstract
Port site infections are a common complication in minimally invasive surgeries, including laparoscopic procedures, leading to increased patient morbidity and healthcare costs. This paper aims to review the incidence, risk factors, prevention strategies, and management of port site infections in minimally invasive surgeries. By examining current literature and guidelines, this review highlights the importance of proper surgical techniques, peri operative care, and postoperative monitoring in reducing the risk of port site infections. Additionally, the paper discusses the role of antimicrobial prophylaxis, wound care protocols, and patient education in optimizing outcomes for patients undergoing minimally invasive surgeries. The findings of this review provide valuable insights for healthcare providers to enhance patient safety and improve surgical outcomes in the management of port site infections in minimally invasive surgeries.

Keywords: Invasive surgeries, managing port, site infections

Introduction
A port site infection in minimally invasive surgeries refers to an infection localized at one or more of the incision sites where access ports or trocars were inserted during the procedure. Minimally invasive surgeries, which include laparoscopic and robotic-assisted procedures, involve making small incisions rather than larger, traditional incisions. These smaller incisions are used for the insertion of specialized instruments and a camera, enabling the surgeon to perform the surgery with reduced trauma to surrounding tissues.

Minimally invasive surgeries have become increasingly popular due to their numerous benefits, including shorter hospital stays, faster recovery times, and fewer complications. However, port site infections remain a significant concern and can lead to prolonged hospitalization, increased healthcare costs, and patient morbidity. This paper aims to review the causes of port site infections in minimally invasive surgeries, as well as the best practices for preventing and managing them. The paper will explore preoperative measures, intra-operative practices, postoperative care, and emerging technologies and innovations aimed at reducing the incidence of port site infections. By examining the latest research and evidence-based practices, this paper seeks to provide clinicians with the necessary tools and knowledge to prevent and manage port site infections in minimally invasive surgeries effectively.

Causes of port site infections in minimally invasive surgeries
Primary sources of infection in port site infections
Port site infections (PSIs) are a common occurrence following laparoscopic surgery. The most frequently affected port site is the umbilical port, where PSIs are more common than in other ports. While non-mycobacterial infections are the primary source of port site infections, non tuberculous mycobacteria (NTM) have emerged as a cause of concern for hospital settings. These bacteria are commonly found in soil and water and can cause nosocomial infections by contaminating equipment and disinfectant solutions used in hospitals. NTM persistence in hospital water systems can also be a source of infection for port site infections [1]. Geographical variation in reported cases of NTM port site infections may be linked to environmental conditions such as humidity, water exposure, and substandard infection prevention practices [1].

NTM port-site infections can involve single or multiple port sites [1], and the infection rate may depend upon the port through which the specimen is extracted [2]. The perceived increase in NTM port-site infections is likely multifactorial, influenced by greater awareness, better diagnostics, changes in medical practice, increased prevalence of immunosuppression, and potential pathogen spread [1]. On the other hand, non-mycobacterial infection is the most common presentation of port site infections, which usually occur within a week or after month of the surgery and are characterized by wound discharge and erythema around the port site [2].

Factors contributing to the development of port site infections;

Factors such as surgical technique and patient characteristics play a significant role in the development of port site infections (PSIs) in laparoscopic surgery (LS) [2]. Suppression of host systemic immunity due to disease, medications or disruptions of skin or mucous membranes can increase the risk of infection [2]. On the other hand, the immune functions are less affected in LS when compared to open surgery [2]. The technique of primary port entry to the peritoneum does not show any difference in umbilical PSIs in patients undergoing laparoscopic cholecystectomy [2]. However, incidence of SSI after elective laparoscopic cholecystectomy is less than that after open elective cholecystectomy due to shorter length of incision [2]. PSIs in LS manifest in the form of seropurulent discharge from the port sites with surrounding skin inflammation or symptoms related to the organ/space infection [2]. Surgical procedures done by laparoscopy are most commonly associated with Classes 1 and 2 wounds [2]. PSI erodes the advantages of LS and causes a significant increase in morbidity, hospital stay, and financial loss to the patient [2]. Furthermore, PSI can have a serious impact on the quality of life of patients, turning the purpose of achieving utmost cosmesis into an unsightly wound [2]. Although antibiotics may seem like an easy solution to prevent PSIs, irrational use can result in the emergence of multidrug-resistant microbes, posing a new threat to the surgical community [2]. To avoid PSIs, strict adherence to cleaning and sterilization of laparoscopic instruments with appropriate sterilizing agents is crucial [2].

Role of bacterial colonization and biofilm formation in causing port site infections

While bacterial colonization and biofilm formation can cause port site infections, mycobacteria are a unique cause of these infections. Mycobacterial infections can cause persistent multiple discharging sinuses or lumps/nodules, pigmentation, and induration at the port site, which can spread to other ports [2]. Bacterial colonization and biofilm formation can lead to delayed presentation of these infections, making them difficult to treat [2]. Additionally, antibiotics may not be effective in treating mycobacterial port site infections, further complicating treatment options [2].

Preoperative measures to prevent port site infections

Perioperative measures play a significant role in reducing the risk of port site infections (PSIs) in minimally invasive surgeries. Some of these measures are supported by strong evidence, such as proper perioperative care at every stage of the process, from the operating theater to postoperative care [4]. Preoperative antiseptic showers have been shown to effectively reduce the incidence of postoperative infections [5]. The presence of bacterial pathogens on nails poses a significant infection hazard, but there are no established protocols for addressing this issue [5]. The use of preoperative measures to reduce *Staphylococcus aureus* nasal colonization has been shown to be effective, along with proper wound closure and postoperative care to optimize host defenses against infection [7]. PSIs can be prevented by taking appropriate measures preoperatively, intraoperatively, and postoperatively, and can often be treated non-surgically with early identification and intervention [2]. One such measure is high perioperative oxygen fraction, which has been shown to reduce surgical site infection and pulmonary complications [8]. It is essential to remember that surgical sites that do not harbor purulent fluid are not necessarily free of infection, and that control measures must extend into the immediate postoperative period [9].

Maintaining skin integrity during surgery can play a pivotal role in minimizing the incidence of port site infections (PSIs). Disruptions to the skin or mucous membranes due to surgical insult can lead to an increased risk of PSIs [2].Using a preoperative skin preparation solution containing 2% chlorhexidine gluconate and 70% isopropyl alcohol before inserting the central venous catheter significantly decreased the incidence of catheter-related bloodstream infections [2].

Use of sterile drapes, proper instrument handling, and maintaining aseptic conditions impact port site infections

A breach in sterilisation protocol of laparoscopic instruments is the most common cause of PSI with atypical mycobacteria [2]. The contaminated instrument can deposit endospores in subcutaneous tissue, which can cause PSI [2]. Contamination with organisms like atypical mycobacteria can occur due to frequent use of laparoscopic instruments without optimal cleaning [2]. Laparoscopic instruments are not autoclavable because of the heat-sensitive outer insulation sheath, which makes proper cleaning even more critical [2]. In addition, orthophthaldehyde and peracetic acid can substitute glutaraldehyde for high-level disinfection with good efficacy [2]. Therefore, it is important for healthcare providers to adopt proper preoperative skin preparation protocols to minimize the risk of postoperative PSIs.

Intra operative techniques and practices can be employed to minimise the risk of port site infections

To minimise the risk of port site infections in minimally invasive surgery, various intrao perative techniques and practices can be employed. These measures focus on maintaining aseptic conditions, reducing bacterial contamination, and promoting optimal wound healing. Here are key intra operative techniques to mitigate the risk of port site infections:

Aseptic Technique

Ensure strict adherence to aseptic principles throughout the entire surgical procedure.

Use sterile draping, gowns, gloves, and instruments to minimise the introduction of bacteria.

Proper skin preparation

Thoroughly clean and disinfect the patient's skin at the site of trocar insertion.

Use an appropriate antiseptic solution (e.g., chlorhexidine or iodine-based solutions) and allow sufficient drying time.

Trocar Placement

Choosing port sites that avoid abdominal wall nerves can minimise the risk of nerve injury and associated complications [15]. Select appropriate trocar sizes based on the procedure and patient anatomy. Avoid excessive force during trocar insertion to prevent tissue damage and reduce the risk of contamination.

Wound Protectors
Consider using wound protectors or sleeves over the trocars to minimize contact between the trocar and external tissues, reducing the risk of contamination.

Maintain pneumoperitoneum sterility
Minimize the introduction of bacteria during insufflation and maintain the sterility of the pneumoperitoneum.
Use filters on insufflation devices to filter out contaminants.

Surgical glove change
Change surgical gloves if there is any breach or contamination during the procedure.

Optimal Hemostasis
Achieve meticulous hemostasis to minimize the risk of hematoma formation, which can serve as a potential source of infection.

Proper handling of instruments
Handle instruments with care to avoid any damage or contamination.
Regularly inspect and replace instruments as needed.

Minimize operative time
Efficient and well-planned surgical techniques can help minimize the duration of the procedure, reducing the patient's exposure to potential sources of infection.

Use of antimicrobial coatings
Consider using trocars or instruments with antimicrobial coatings to reduce the microbial load at the incision sites.

Gentle tissue handling
Minimize tissue trauma and manipulation to reduce the likelihood of introducing bacteria from the operative field into the port sites.

Optimal closure technique
Use an appropriate closure technique for trocar sites, ensuring the proper approximation of tissue layers.
Consider subcuticular sutures or skin adhesive for skin closure.

Intraoperative irrigation
Use sterile saline or antimicrobial solutions for intraoperative irrigation to minimize bacterial load in the surgical field.

Surgeon and Staff education
Ensure that the surgical team is educated and trained in infection prevention practices.
Regularly update the team on the latest guidelines and best practices.

PSI Presentation and Staging
Port site infections (PSIs) are a potential complication of laparoscopic surgery that can negatively impact postoperative quality of life and aesthetics [2]. PSIs usually present as wound discharge and erythema around the port site within a week of surgery [2].

There are five clinical stages of atypical mycobacterial PSI.

- **First stage:** A tender nodule appears in the vicinity of the port site, and its usual timing of appearance is around four weeks following the surgery.
- **Second stage:** Increase in the size of the nodule, and increased tenderness of the site along with other signs of inflammation with eventual formation of a discharging sinus.
- **Third stage:** Reduced pain sensation following discharge of the purulent material and necrosis of the skin surrounding the port site.
- **Fourth stage:** Chronic sinus discharging white or serous fluid.
- **Fifth stage:** Hyper-pigmentation of the skin surrounding the sinus and appearance of multiple nodules at different places

Postoperative Care and Management of Port Site Infections
The infection is usually limited to the skin and subcutaneous tissue [2]. PSIs are more common in the umbilical port [2]. Thorough irrigation and cleaning of the port site before wound closure is a key component to manage and prevent PSIs [2]. Drainage and debridement may sometimes be required to assist in wound healing, and wound exploration and removal of retained stones may be necessary for the healing of wounds presenting as discharging sinus months after surgery [2]. Specific antibiotics should be given subsequently as per the culture and sensitivity report. *Staphylococcus aureus* strains are usually isolated from clean wounds, and their status of β-lactamase production and methicillin resistance needs to be assessed [2]. Daily dressing, cleaning of the wound, and a course of empirical antibiotic should be started [2]. However, antibiotics may not be the answer to prevent postoperative PSIs, as using antibiotics irrationally can result in the emergence of multidrug-resistant microbes [2]. Thus, swabs obtained should be processed aerobically and anaerobically to find non-mycobacterial isolates. Gram stains and culture sensitivity of the pus from port site wounds should be taken for early diagnosis [2]. If significant erythema and wound discharge around the port site along with fever are present, it may be a sign of necrotising fasciitis, which requires a high grade of suspicion and aggressive management [2].

Materials and Methods
This is a retrospective analysis of 15 patients' ASCOMS and HOSPITAL JAMMU between 2021 and 2023 and complained of persistent port-site infections after minimal invasive surgery.
Information was gathered on surgeries, pre-present treatment, imaging results, lab tests, and antibiotic therapy.
All of the patients' microbiological and pathological records were located. Microscopical evidence of acid-fast bacilli and the presence of non-tuberculous mycobacteria (NTM) on microbiological culture were tested for in microbiological records.
Clinically, chronic port-site infections were defined as wounds that did not heal, drainage that did not go away, or wound disintegration after laparoscopy surgery. Following the diagnosis of a persistent port-site infection, the patients were treated in accordance with a departmental procedure that was established beforehand, as shown in Figure 1. To determine the extent of the sinus tract collection, the patients had screening ultrasonography (USG), and magnetic resonance imaging (MRI) and computed tomography (CT) were saved for cases of diagnostic uncertainty. The patients' wounds were completely surgically removed, and the sinus canal was thoroughly dissected. The samples were sent for regular culturing of bacteria, fungi, and mycobacteria as well as routine histological investigation. Following debridement, the

surgical wounds were allowed to heal with secondary intention.

Results

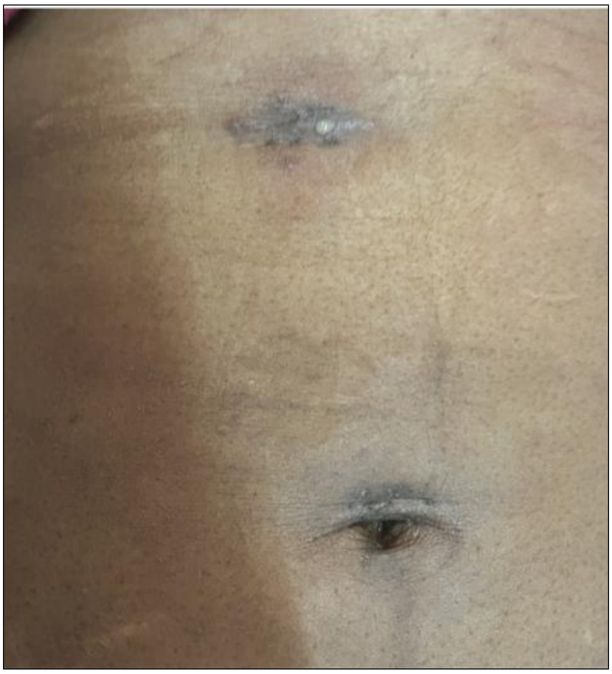
Table 1 Demographic and treatment details of the patients of port-site infections who presented to our hospital

Abbreviations used: ATT: Anti-tubercular therapy; HPE: histopathological examination; AFB: acid-fast bacillus; MRSA: methicillin-resistant *Staphylococcus aureus*;

Table 1: Patient characteristics and treatment modalities.

Case	Age/sex	Presentation	Culture	Anti-microbial therapy	Surgery
1.	18/M	Persistent nodule	Negative	Clarithromycin 500 mg BID x 4 weeks and Ciprofloxacin 500MG BID x 4 weeks	None
2.	42/F	Discharging sinus at Epigastric port site	Negative	Clarithromycin 500 mg BID x 4 weeks and Ciprofloxacin 500MG BID x 4 weeks INJ Gentamicin L/A x 5 days	None
3.	64/M	Discharging sinus at umbilical port site	MRSA	Tab Linezolid 600MG Bid For 2 Weeks	None
4.	48/F	Multiple epigastric discharging sinuses and nodule in infraumbilical port sit	Afb positive	Standard first line antitubercular regimen Rifampicin, isoniazid, pyrazinamide and ethambutol for 2 mo followed by rifampicin and isoniazid for 6 mo	Surgical Tract Excision
5.	32/M	Persistent nodule	Negative	Clarithromycin 500 mg BID x 4 weeks and Ciprofloxacin 500MG BID x 4 weeks INJ Gentamicin L/A x 5 days	None
6.	25/M	Pus Discharge At Epigastirc Port	Afb positive	Standard first line antitubercular regimen Rifampicin, isoniazid, pyrazinamide and ethambutol for 2 mo followed by rifampicin and isoniazid for 6 mo	None
7.	54/F	PUS Discharge At Right ILIAC Port	MRSA	Tab linezolid 600MG bid For 2 Weeks	None
8.	36/F	Pus Discharge At Epigastirc Port	Gram Poistive Cocci	Tab Amoxyclav 625MG TDS	None
9.	26/M	Recuurent Sinus Tract Formation	Afb positive	Standard first line antitubercular regimen Rifampicin, isoniazid, pyrazinamide and ethambutol for 2 mo followed by rifampicin and isoniazid for 6 mo	Surgical Tract Excision
10.	58/M	Pus Discharge At Epigastirc Port	Enterococcus Species	Tab Linezolid 600mg Bid For 2 Weeks	None
11.	50/M	Pus Discharge At Ubilical Port	Staph Aureus	Tab ciprofloxacin 500 mg Bd for 2weeks	None
12.	30/M	Pus Discharge At Epigastirc Port And Iliac Port	Staph Aureus	Tab Linezolid 600mg Bid For 2 Weeks	None
13.	76/M	Pus Discharge At Epigastirc Port And Iliac Port	Staph Aureus and *E coli*	Tab doxycycline 100mg for 1 week Tab faropenem 300mg tds for 1 week	None
14.	36/F	Pus Discharge At Ubilical Port	Entero Bacteria Species	INJ amikacin 500mg l/a bd for 5 days Tab amoxy clauv 625 mg tds	None
15.	54/M	Pus Discharge At Epigastirc Port	Entero Bacteria Species	INJ amikacin 500mg l/a bd for 5 days Tab amoxy clauv 625 mg tds	None

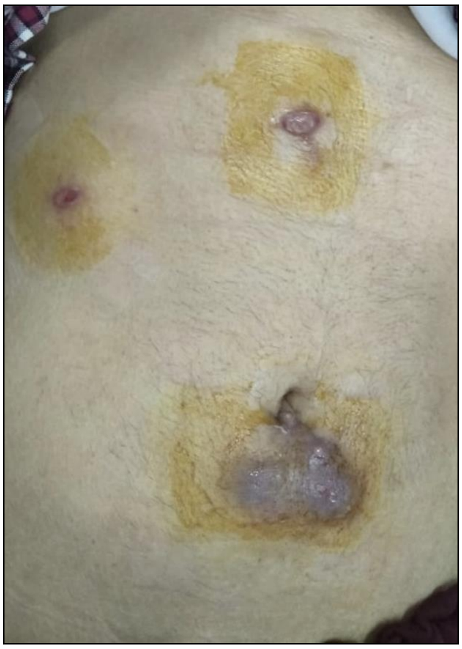
Nodule and discharging sinus at epigastric port



Multiple discharging sinus at umbilical and epigastric port

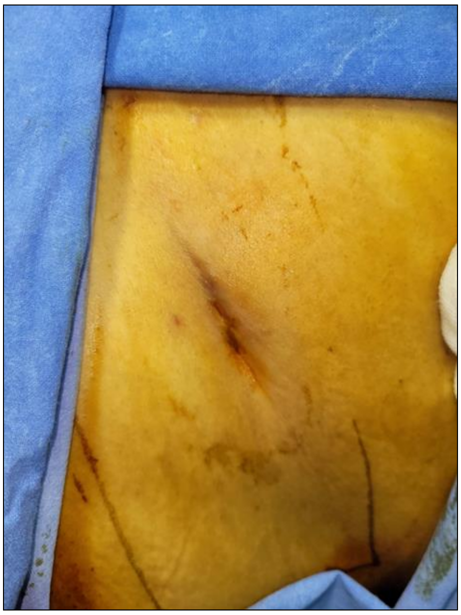
Discharging sinus at right iliac port

Nodule and Discharging

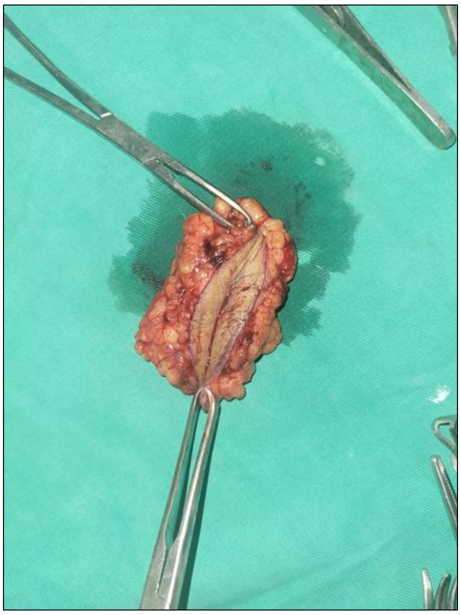


Sinus at epigastric and umbilical port
Green pus discharge at port

Figure recurrent multiple pus discharging sinus after primary sinus tract excision in a patient of laparoscopic cholecystectomy healing by secondary attention



Sinus tract excision after laparoscopic cholecystectomy



Discussion

One annoying side effect of laparoscopic surgery is port-site infection. As defined by the CDC [9, 10], the majority of laparoscopic procedures are conducted on surgical wounds that are either clean or clean-contaminated. The literature reports a port-site infection rate ranging from 2% to 6%, even though these surgical incisions are often sterile [9]. An infection might have an external or endogenous cause. Reducing endogenous sources of infection can be achieved through appropriate intestinal preparation prior to surgery and by controlling spills during the procedure. The latter can be accomplished by employing endobags to retrieve specimens and reducing damage to the hollow viscus [11, 12]. Conversely, sedulous sterilization may be used to achieve external source decrease.

According to recent data, non-tuberculous mycobacteria-related PSIs are most frequently caused by a sterilizing process violation [5]. Because NTMs are so common in nature-found in dirt and flowing water, for example-they can easily contaminate medical equipment. NTM infections have mostly been documented following laparoscopic procedures [13]. There are two main causes that could explain this. First of all, the insulating layer on laparoscopic equipment restricts the amount of autoclaving that can be done to sterilize them, leaving some NTM endospores unaccounted for. Second, biological soil, burned tissue, and grime can collect in the numerous joints and moving portions of laparoscopic equipment.

Laparoscopic instruments are submerged in a 2-2.5% glutaraldehyde solution for 20 minutes in between procedures at some Indian centers [5]. Glutaraldehyde functions as a high-level disinfectant but not a sterilant at the previously specified concentration and contact period, allowing the bacterial endospores to endure [14]. The chemical can only be used for a maximum of 100 cycles over 14 days (2.5% glutaraldehyde) or 28 days (3.4% glutaraldehyde) according to current standards [5]. Avoid using tap water to rinse out the glutaraldehyde as this will introduce NTM endospores back into the instrument, where they will subsequently settle in the subcutaneous tissue of the patient. Laparoscopic equipment must be fully disassembled and then properly cleaned to guarantee the elimination of biological soil in order to achieve successful sterilization [15].

For sporicidal activity, glutaraldehyde used for sterilization needs to have a long contact duration (8–12 hours) and a sufficient strength (3.4%) [5]. Lastly, when the laparoscopic instruments have been exposed to glutaraldehyde, only autoclaved or sterile water should be used to rinse them. Given its many drawbacks, it is wise to restrict the extensive use of glutaraldehyde in the sterilizing of laparoscopic tools. Low-cost and efficient alternatives to low-temperature sterilization are provided by plasma sterilization devices like STERRAD [5, 16]. With differing degrees of success, other methods including formalin gas chambers and ethylene oxide gas sterilization can also be employed [5]. Using disposable laparoscopic equipment would be the most efficient method of preventing PSIs.

Conclusion

- Port-site infections, are seldom life-threatening.
- They are set of irksome complications that curtail the benefits of laparoscopic surgery.
- >early psis due to skin commensals are easy to treat
- >delayed psis caused by multidrug-resistant mycobacteria are treatment refractory.
- >robust sterilisation, from conventional glutaraldehyde-techniques towards plasma and gas sterilisation, may reduce their Incidence.
- >Clinicians Must Not Initiate Empirical Antibiotic Therapy Before Investigating The patient as it may lead to the emergence of antimicrobacterial resistance.

Conflict of Interest
Not available

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Not available

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