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**Original Research Article**

# Incidence of surgical site infection in elective inguinal hernia surgery and factors affecting it

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## ABSTRACT

**Background:** Surgical site infections (SSIs) are a significant concern in surgical patients. The present study aims to estimate the incidence and evaluate the risk factors, microbiology, prevention strategies, and management of SSIs in patients undergoing elective inguinal hernia repair.
**Methods:** This prospective observational study included 1053 patients who underwent elective inguinal hernia repair at our institution. Patient demographics, surgical characteristics, and outcomes were collected and analysed. Independent risk factors for SSI were identified by univariate and multivariate analyses.
**Results:** Thirty-one patients developed SSIs within 30 days after surgery, resulting in an overall SSI rate of 2.94%. The most common microorganism isolated from SSI was *Staphylococcus aureus*. Identifiable risk factors associated with SSIs included age ≥65 years, body and mass index (BMI) >24.6 kg/m$^2$, current smoking and diabetes mellitus.
**Conclusions:** The study highlights the importance of identifying high-risk patients and implementing preventive measures to reduce the incidence of SSIs in elective inguinal hernia surgery. The findings suggest that age ≥65 years, BMI >24.6 kg/m$^2$, current smoking and diabetes mellitus are risk factors for SSIs. The study also emphasizes the importance of proper skin preparation and antibiotic prophylaxis in reducing the risk of SSIs.

**Keywords:** Surgical site infections, Elective inguinal hernia surgery, Risk factors, Microbiology, Prevention strategies, Management

## INTRODUCTION

Inguinal hernia repair is one of the most commonly performed surgical procedures globally.[1] The repair in adults includes reduction of the hernia contents followed by posterior wall reinforcement by suturing (herniorraphy) or by the use of non-absorbable mesh (hernioplasty). Laparoscopic approach has also recently shows good results.[2]

Surgical site infections (SSIs) are infections that occur at the site of incision for surgery and implants. That can occur within 30 days after the surgical procedure is over.[3] SSIs significantly impact patient outcomes and healthcare resources, necessitating an understanding of their incidence and management.

Pre-existing health conditions like increased age (>55 years) and diabetes mellitus lead to a significantly higher incidence of SSIs than others.[4] Other patient-related risk factors found to be associated significantly with higher occurrence of SSIs are: obesity, smoking and a low serum albumin concentration.[5] The major sources of infection, however, are the microorganisms present on the patient's own skin and, less commonly gastrointestinal or genitourinary tract.[6]

There are multiple techniques for the prevention of SSI have been recommended including preoperative factors (showering with soap, antimicrobial prophylaxis), intra-operative factors (skin preparation with an alcohol-based antiseptic, normothermia, aseptic precautions), and postoperative factors (shortening duration procedure,

avoiding use of drain, sterile regular dressings).[7] In 2007 one meta-analysis published in which 6 randomised clinical trials (RCT) were done in which the rate of SSI came out to be 2.89% following inguinal hernia surgery with mesh repair.[8] In 2018 one latest Cochrane meta-analysis published in which the rate of SSI was 2.59%.[9]

This paper aims to comprehensively review the incidence, risk factors, microbiology, prevention strategies, and management of SSIs in elective inguinal hernia surgery.

## METHODS

### *Patients and study design*

This prospective observational study was conducted in the department of general surgery, JIIU'S Indian Institute of Medical Science and Research, Jalna, Maharashtra, India after approval by institutional ethical committee. The study included all elective adult inguinal hernioplasty cases (n=1053) performed between July 2022 and May 2024 (2 years) and excluded patients below 18 years of age, cases where mesh was not used, cases where gross contamination was present such as breach of gastrointestinal tract. There was one chief surgeon attending in every operation as required. One the day of surgery, the skin prepared by hair on surgical site and cleaned using ioprep. Lichtenstein repair was applied for open approach by the standardized technique.[10] Patients were examined daily till discharge from hospital (usually post op day 3) for any local signs of infection with alternate day follow up on OPD basis till suture removal. Thereafter patients were followed up on post op day 15 and 30. Any presence of infection was managed accordingly and its details recorded. Details of hospitalization, subsequent visit and any additional hospital visits within 30 days after surgery were recorded. Patients who underwent another concomitant surgery were excluded.

### *Data collection*

Details of postoperative SSIs within 1 month of surgery were collected. Besides, we included variables with the aim to explore the risk factors related to SSI. Demographic factors (at the time of surgery) included age, gender, body mass index (BMI), smoking status, status of alcohol consumption. Accompanied diseases including diabetes mellitus, hypertension, pulmonary disease (chronic obstructive pulmonary disease, asthma and chronic bronchitis) and any evidence of immune compromised state. Chronic drug therapy that may have an effect on the development of SSI including current glucocorticoid use (oral and inhaled) and statins use were recorded.[11]

The following operative data were collected: American Society of Anaesthesiologists (ASA) score, hernia type (direct, indirect, and combined), hernia characteristics (left, right, and bilateral), duration of inguinal hernia presentation (reflected in number of years), prior history of inguinal hernia repairs, lengths of preoperative hospital stay and operative time (from the start of incision to completion of skin closure). SSI was diagnosed by the surgeons adapted from guidelines by the U.S. Centres for Disease Control and Prevention (CDC). Superficial SSI was defined as an infection that arose within 30 days postoperatively and involved only skin or subcutaneous tissue.[12]

### *Statistical analysis*

We compared the patient and surgical factors and relation between the patients with SSI and the other patients who did not have SSI. All data are reported as mean value±standard deviation. Patient variables were evaluated initially using univariate logistic regression.[13] Those variables significantly associated with surgical site infection were then evaluated using multiple logistic regression to identify variables independently associated with surgical site infection. A p value of less than 0.05 was set as statistically significant.

## RESULTS

Patient characteristics of the total 1053 patients were included in the final analysis based on the inclusion and exclusion criteria. Demographic data and surgery-related information are (Tables 1-3 and Figures 1 and 2).

**Table 1: Age and gender.**

| Variables | Mean±SD |
|---|---|
| **Age (in years)** | 51.4±16.0 |
| Range | 18-85 |
| **Gender** | |
| Male | 1040 (98.8) |
| Female | 13 (1.2) |

**Table 2: Body mass index.**

| Variables | Mean±SD |
|---|---|
| **BMI** | 24.6±3.1 |
| **Range** | 19.6-33.2 |

BMI: body mass index

**Table 3: ASA score.**

| ASA grade | Score |
|---|---|
| **I** | 257 (24.4) |
| **II** | 746 (70.8) |
| **III** | 48 (4.6) |
| **IV** | 2 (0.2) |

ASA: American society of anaesthesiologists

### *Univariate logistic regression*

By evaluating each variable in isolation with univariate logistic regression gives the following as associated with an increased incidence of SSI: age >65 years, BMI ≥24.6 kg/m$^2$, diabetes, ASA classes 3 and 4, and longer

duration of surgery (Table 4). All other variables were excluded from further analysis.

***Multivariate logistic regression***

Variables identified by univariate logistic regression which were statistically significantly associated with SSI in isolation were analyzed together, to rule out any associations between variables. Results suggest that age, smoking status, diabetes mellitus, and surgery duration are significant predictors of SSI risk, while BMI and ASA score may also play a role although with less certainty due to their non-significance at the traditional level of $p<0.05$.

There were 31 SSIs that were recorded in the total 1053 patients within 30 days after mesh repair of Inguinal hernia, revealing a 2.94% (31/1053) overall SSI rate. All of the recorded infections were superficial SSIs. SSIs were observed within a mean interval of 4.6 (4.0) days postoperatively (range, 1–18 days) during the original admission, with most (77.4%, 24 of 31) found within the first post-operative week. The most common microorganism isolated (Figure 3) was *Staphylococcus aureus* (17). The other microorganisms included *Staphylococcus epidermidis* (6), *Pseudomonas aeruginosa* (5), *Enterococcus faecalis* (2) and methicillin-resistant *Staphylococcus epidermidis* (1) (Figure 6). All these patients recovered with use of intravenous antibiotic treatment and/or local wound management by dressings and if required drainage (16.1%, 5/31), without removal of the mesh.

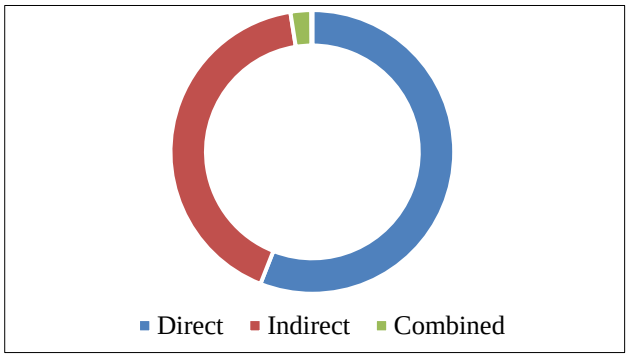


**Figure 1: Type of hernia.**

**Table 4: Univariate analysis of risk factors.**

| Variables | SSI (n=31, 2.94%) | No SSI (n=1022, 97.6%) | OR | 95% CI | P value |
|---|---|---|---|---|---|
| **Demographic factors, yes** | | | | | |
| Age≥65 years | 25 (80.6) | 200 (19.6) | 16 | 7.58, 33.58 | 0.001 |
| Gender (male) | 30 (96.8) | 1010 (98.8) | 0.356 | 0.044, 2.851 | 1 |
| BMI >24.6 kg/m$^2$ | 16 (51.6) | 243 (23.8) | 3.42 | 1.667, 7.030 | 0.009 |
| Current smoker | 20 (64.5) | 253 (24.7) | 6.64 | 1.12, 2.68 | 0.001 |
| Alcoholism | 4 (12.9) | 39 (3.8) | 3.73 | 1.67 ,8.33 | 0.001 |
| **Comorbidity, yes** | | | | | |
| Diabetes mellitus | 12 (38.7) | 121 (11.83) | 2.38 | 0.03, 1.71 | 0.01 |
| Hypertension | 7 (22.58) | 295 (28.9) | 0.719 | 0.523, 1.179 | 0.451 |
| Pulmonary disease | 2 (6.4) | 54 (5.2) | 1.236 | 0.624, 2.454 | 0.831 |
| **Chronic drug treatment, yes** | | | | | |
| Current steroid use | 1 (3.22) | 40 (3.9) | 0.818 | -2.2158, 1.8140 | 0.845 |
| Current statin use | 1 (3.22) | 52 (5.08) | 0.622 | -0.8914, -0.0644 | 0.791 |
| **Procedure-related factors, yes** | | | | | |
| ASA score (III-IV) | 10 (32.2) | 40 (3.91) | 11.67 | 3.69,33.9 | 0.02 |
| **Type of hernia** | | | | | |
| Direct | 9 (29.0) | 581 (56.8) | 0.31 | 0.14, 0.68 | 0.003 |
| Indirect | 20 (66.6) | 418 (40.9) | 2.63 | 1.25, 5.54 | 0.008 |
| Combined | 2 (6.4) | 23 (2.2) | 0.085 | 0.012,0.617 | 0.004 |
| **Hernia characteristics** | | | | | |
| Right | 11 (35.4) | 567 (55.47) | 0.441 | 0.209,0.931 | 0.042 |
| Left | 17 (54.8) | 443 (43.34) | 1.59 | 0.77, 3.25 | 0.27 |
| Bilateral | 3 (9.6) | 12 (1.17) | 9.02 | 2.41,33.79 | 0.007 |
| Duration of inguinal hernia presentation >3.5 year | 13 (41.9) | 255 (24.9) | 0.69 | 0.43, 1.12 | 0.01 |
| Preoperative stay >3 days | 5 (16.1) | 170 (16.6) | 0.06 | 0.02, 0.23 | 0.004 |
| Duration of surgery >77 min | 9 (29.0) | 408 (39.9) | 3.343 | 0.37, 1.024 | 0.018 |

Data are presented as the number with the percentage in parenthesis. *There were 31 infected cases among 1053 hernias which were surgically treated (1038 unilateral hernia and 15 bilateral hernia repairs); SSI: surgical site infection; BMI: body mass index; ASA: American Society of Anesthesiologists.

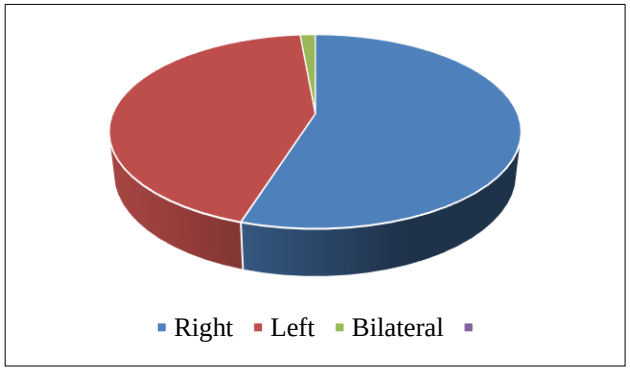


**Figure 2: Hernia characteristics.**

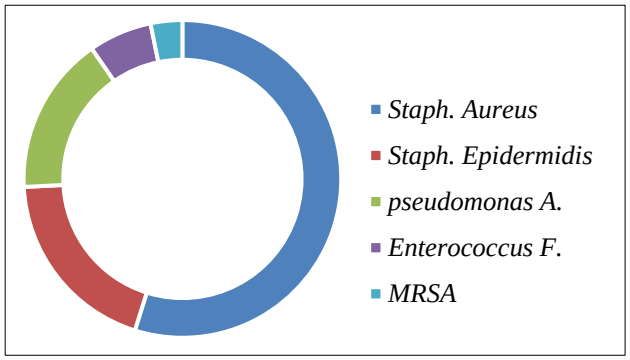


**Figure 3: Microorganism isolated.**

## DISCUSSION

SSI's are a common problem in surgical practice. Although relatively less common in elective cases, if present, greatly impacts the patient outcome. In elective inguinal meshplasty, if not managed appropriately may warrant the need for mesh removal. SSI's significantly impact patient outcomes and healthcare resources, necessitating an understanding of their incidence and management. It leads to unnecessary prolonged hospitalisation and on the other-hand inappropriate and indiscriminate use of prophylactic antibiotics may increase the cost with unnecessary drug use and may lead to growth of resistant organisms.[14]

The present study aims to investigate the incidence, risk factors, microbiology, prevention strategies, and management of SSIs in elective inguinal hernia surgery. The results provide valuable insights into the prevalence and predictors of SSIs in this patient population.

The overall SSI rate of 2.94% in our study is comparable to the reported rates in previous studies.[15]

Haley et al have shown that surgical wound infection prolongs hospitalization for approximately 1 week and adds 20–30% cost to the hospital bill.[16]

The most common microorganism isolated from SSI in our study was *Staphylococcus aureus*, followed by *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and methicillin-resistant *Staphylococcus epidermidis*. This is consistent with the literature, which suggests that *S. aureus* is the most common pathogen responsible for SSIs.[17]

Our study identified several risk factors associated with an increased risk of SSIs, including age ≥65 years, BMI>24.6 kg/m$^2$, current smoking and diabetes mellitus.

These findings are supported by previous studies, which have shown that older age, obesity, smoking, diabetes, and pre-existing medical conditions are all independent risk factors for SSIs.

In 2022, Kohno et al concluded that the incidence of postoperative SSI after hernia surgery has recently been reported to be 3.1–4.5%. A large cohort analysis of predictive factors for SSI after inguinal hernia surgery in clean wounds revealed a significant association between a history of diabetes, BMI≥35 kg/m$^2$, and current smoking.[18]

Sereysky et al collected all the data of the American College of Surgeons national surgical quality improvement program (NSQIP). It included patients older than 18 years old with elective initial open inguinal hernia repair. They reported SSI for 0.4% patients. After multiple logistic regression, only 3 factors (out of 17) were independently associated with SSIs: diabetes, BMI ≥35 kg/m$^2$, and current smoking.[19]

In 2004, Taylor et al included data with 2,665 patients who had groin hernia surgery. Overall, 5.2% had SSI. The study pointed out after two multivariate analyses, two SSI risk factors: absence of antibiotic prophylaxis (p=0.002) and an national nosocomial infections surveillance system (NNIS) local score of 1 or 2 (p=0.021). The NNIS score is calculated by assigning one point to each of the following risk factors present: ASA score of 3 or more, operation classified as contaminated or dirty, and operation lasting less than 55 min.[20]

The results of our study highlights the importance of various factors in the development of SSIs. Patients with ASA scores of III-IV were found to have a higher risk of developing SSIs, consistent with previous studies that have shown that patients with higher ASA scores are at increased risk of complications. Additionally, patients with indirect or combined hernias had a higher risk of developing SSIs, which may be attributed to the increased complexity of these procedures.

Our study also emphasizes the importance of proper skin preparation and antibiotic prophylaxis in reducing the risk of SSIs. The use of topical antimicrobial agents and antibiotic prophylaxis has been shown to reduce the incidence of SSIs in various surgical settings.[21] However, further research is needed to determine the optimal duration and type of antibiotic prophylaxis for inguinal hernia repair.

***Limitations***

Demerits of the study include exclusion of paediatric patients, patients in whom mesh was not used (herniorrhaphy) and failure of long term follow up (to look for deep SSI).

## CONCLUSION

This prospective observational study aims to comprehensively review the incidence, risk factors, microbiology, prevention strategies, and management of SSI's in elective inguinal hernia repair. A total of 1053 patients undergoing meshplasty were included in the study, of which 31 patients developed SSIs within 30 days after surgery, resulting in an overall SSI rate of 2.94%.

The findings highlight the importance of identifying high-risk patients and implementing preventive measures to reduce the incidence of SSIs. Future studies should focus on developing effective strategies for preventing SSIs in this patient population.

The study identified several risk factors associated with SSIs, including: age ≥65 years, BMI>24.6 kg/m$^2$, current smoking, diabetes mellitus, ASA score (III-IV), patients with indirect/combined type of hernia, and bilateral hernias.

It may be noted that apart from above mentioned patient factors preventive strategies are also of utmost important and may lead to higher risk of SSI if not implemented judiciously, such as skin preparation, antibiotic prophylaxis, sterilisation of operating room, linen and instruments, complete sterile technique by surgeon and assisting staff, sterile dressing and appropriate wound care post operatively. Use of World Health Organization (WHO) surgical safety checklist must also be ensured.

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*Ethical approval: The study was approved by the Institutional Ethics Committee*

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