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# Operation time and body mass index are significant risk factors for surgical site infection in laparoscopic sigmoid resection: a multicenter study

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**Abstract**
*Background* Surgical site infection (SSI) in patients who underwent colorectal surgery is a common complication associated with increased morbidity and costs. The aim of this study was to assess risk factors for SSI in laparoscopic sigmoid resection for benign disease.
*Methods* Using a multicenter database of the Swiss Association of Laparoscopic and Thoracoscopic Surgery, we prospectively identified 4,488 patients who underwent laparoscopic colorectal surgery between 1995 and 2008; of these, 2,571 patients who underwent sigmoid resection for benign disease were included. Uni- and multivariate analyses were used to determine risk factors for SSI.
*Results* The incidence of SSI was 3.5% (90/2,571). Among SSI patients, incisional superficial infections were found in 71%, incisional deep infections in 22%, and organ–space infections in 7%. Patients' age, underlying disease, and surgeons' experience had no impact on SSI. Multivariate analyses showed that operation time >240 min (odds ratio [OR] 1.7; 95% confidence interval [CI] 1.0–2.8), BMI $\geq$ 27 kg/m$^2$ (OR 2.3 [1.3–4.5]), organ lesions (OR 7.9 [2.0–31.8]), and male gender (OR 2.3 [1.2–4.5]) were significant risk factors for SSI. Reoperations in the SSI group were significantly more frequent than in the Non-SSI group (30% vs. 3%; $p < 0.001$). SSI was associated with a significantly longer median hospital stay (15 days, range = 2–69 vs. 8 days, range = 1–69; $p < 0.001$) and higher mortality rate (2.2% vs. 0.4%; $p = 0.019$).
*Conclusion* Significant risk factors for SSI were operation time >240 min, BMI $\geq$27 kg/m$^2$, organ lesions, and male gender. SSI was significantly associated with more reoperations, longer hospital stay, and higher mortality rate.

**Keywords** Surgical site infection · Risk factors · Laparoscopic surgery · Sigmoid resection

Surgical site infection (SSI) is a common complication in patients who underwent colorectal surgery [1–5]. SSI is significantly associated with the length of the hospital stay, mortality, and higher costs [2, 6, 7]. Similar to open surgery, laparoscopic colon surgery is associated with an increased incidence of SSI compared to laparoscopic surgery in other organs [1, 8]. Thus, factors that are not associated with the length of incision seem to critically impact the incidence of SSI.

The aim of this study was to evaluate the incidence of and risk factors for SSI in a prospective cohort study of patients who underwent laparoscopic sigmoid resection for benign disease. To assess these outcome parameters in a general nonselected population, we used data from a registry of teaching and nonteaching hospitals: the database of the Swiss Association of Laparoscopic and Thoracoscopic Surgery (SALTS).

## Patients and methods

From the prospective SALTS database, 4,488 patients who underwent laparoscopic colorectal surgery in Switzerland between February 1995 and February 2008 were identified. The SALTS database contains all patients who underwent

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consecutive laparoscopic and thoracoscopic surgeries in up to 73 hospitals all over Switzerland. The primary aim of this database is to provide data for performing quality control of laparoscopic and thoracoscopic procedures. Using standardized questionnaires, data are collected prospectively from admission until 30 days after discharge and kept in a centralized database. Questionnaires contain information about patients' demographic information (no comorbidities), operative procedures, intraoperative complications, local and general postoperative complications, and discharge information (at discharge and at readmission).

The present study focused on a subset of 2,571 patients who underwent sigmoid or rectosigmoid resection for benign diseases. Antibiotic prophylaxis was used in 92% of the patients. Antibiotic agent and exact time of application were not recorded by the questionnaire. Bowel preparation also was not noted in the questionnaire.

Surgical site infections were assessed according to the criteria developed by the Centers for Disease Control and Prevention [5]. Infections were categorized as incisional (superficial or deep) or organ–space infections. Superficial SSI involved only the skin and subcutaneous tissues and excluded stitch abscesses. Deep SSI involved the deeper soft tissues at the site of incision. Organ–space SSIs were defined as infections in any organ or space. The diagnosis of SSI was made by physicians at clinical follow-up visits.

The main outcome measure was the presence of an SSI within 30 days after the operation. The secondary outcome measures were median operation time, intraoperative complications, repeated operation, length of hospital stay, and mortality.

### Statistical analysis

Categorical variables were compared using Fisher's exact test. Continuous variables were presented as medians with ranges and compared using Student's *t*-test. Logistic regression analysis was performed to analyze risk factors for SSI. $p$ values were two-sided, and $p < 0.05$ was used as the threshold for statistical significance (NCSS 2004 for Windows; NCSS, Kaysville, UT).

## Results

We found a total of 2,571 patients in the SALTS database who underwent laparoscopic sigmoid and rectosigmoid resection for benign disease between February 1995 and February 2008. The incidence of SSI was 3.5% (90/2,571). In 87.7%, the operation was performed for diverticular disease; the remaining 12.3% had surgery for inflammatory bowel disease and other benign diseases. The demographic characteristics and the technical details of the operation are given in Table 1. Procedures were performed electively in 97.6% and as emergencies in 2.4%. Emergency surgery had no impact on SSI ($p$ = n.s.). The conversion to open surgery was significantly higher in the SSI group compared to the Non-SSI group (22.2% vs. 11.3%; $p = 0.015$).

Intraoperative complications are given in Table 2. In the SSI group, 8 patients had intraoperative complications, whereas 61 patients had them in the Non-SSI group (8.9% vs. 2.5%; $p < 0.001$). The incidence of intraoperative hemorrhage in the abdominal cavity was significantly

**Table 1** Demographic and surgical characteristics

| | SSI group ($n = 90$) | Non-SSI group ($n = 2,481$) | $p$ value* |
|---|---|---|---|
| Age (years)[a] | 60.5 (17–88) | 61 (17–97) | 0.76** |
| Sex | | | |
| Male | 45 (50) | 967 (38.9) | 0.037 |
| Female | 45 (50) | 1,514 (61.1) | |
| BMI (kg/m$^2$)[a] | 27.4 (17.3–44.6) | 25.8 (12–50.4) | 0.017** |
| ASA score[a] | 2 (1–4) | 2 (1–4) | 0.04 ** |
| Exitus | 2 (2) | 11 (0.5) | 0.019 |
| Approach | | | |
| Sigmoid colectomy | 78 (86.7) | 2,171 (87.5) | 0.8 |
| Sigmoid and low anterior resection | 12 (13.3) | 310 (12.5) | |
| Operation time (min)[a] | 240 (90–270) | 180 (60–270) | 0.005** |
| Surgeon's experience | | | |
| ≤100 operations | 11 (12.2) | 312 (12.6) | 0.9 |
| >100 operations | 79 (87.8) | 2,169 (87.4) | |
| Conversion to open surgery | 20 (22.2) | 280 (11.3) | 0.015 |

*BMI* body mass index, *ASA* American Society of Anesthesiologists

Values in parentheses are percentages unless indicated otherwise

[a] Values are median (range)

* Fisher's exact test unless indicated otherwise

** Student's *t*-test

**Table 2** Univariate analysis of intraoperative complications and reoperation

| Intraoperative complications | SSI group ($n = 90$) | Non-SSI group ($n = 2,481$) | $p$ value* |
|---|---|---|---|
| Puncture of stomach and intestine | 1 (1.1) | 3 (0.1) | 0.01 |
| Puncture of urinary bladder | 0 (0) | 5 (0.2) | 0.6 |
| Puncture of blood vessels | 0 (0) | 2 (0.08) | 0.8 |
| Puncture of solid organs | 0 (0) | 1 (0.04) | 0.8 |
| Organ lesion | 4 (4.4) | 23 (0.9) | 0.001 |

Values in parentheses are percentages

* Fisher's exact test

**Table 3** Univariate analysis of postoperative complications

| Postoperative complications | SSI group ($n = 90$) | Non-SSI group ($n = 2{,}481$) | $p$ value* |
|---|---|---|---|
| Incisional superficial SSI | 64 (71) | – | – |
| Incisional deep SSI | 20 (22) | – | – |
| Organ space infection | 7 (8) | – | – |
| Hematoma in abdominal wall | 0 (0) | 3 (0.1) | 0.7 |
| Bleeding in abdominal cavity | 4 (4.4) | 25 (1.0) | 0.002 |
| Perforation | 3 (3.3) | 5 (0.2) | 0.002 |

Values in parentheses are percentages

* Fisher's exact test

**Table 4** Multivariate analysis of risk factors for SSI

| Risk factors | Odds ratio (95% CI) | $p$ value |
|---|---|---|
| Operation time > 240 min | 1.7 (1.0–2.8) | 0.03 |
| Male gender | 2.3 (1.2–4.5) | 0.02 |
| BMI $\geq$ 27 kg/m$^2$ | 2.3 (1.3–4.5) | 0.007 |
| Organ lesions | 7.9 (2.0–31.8) | 0.004 |
| Conversion to open surgery | 1.6 (0.9–2.7) | 0.10 |
| ASA score | 1.3 (0.9–1.7) | 0.13 |

Multivariate regression analysis

*BMI* body mass index, *ASA* American Society of Anesthesiologists

higher in the SSI group than in the Non-SSI group (4% vs. 1%; $p = 0.002$).

Postoperative complications are given in Table 3. Incisional superficial SSI was found in 64 patients (71%) and deep incisional SSI was found in 20 patients (22%). Organ–space infection occurred in 7 patients (8%). One patient developed superficial and organ–space infections. Significantly more paralytic ileus was found in the SSI group than in the Non-SSI group (3.3% vs. 0.9%; $p = 0.03$), whereas the incidence of mechanical bowel obstruction was not significantly different between the two groups (1.1% vs. 0.5%; $p = 0.45$). The number of repeated operations was significantly higher in the SSI group compared to the Non-SSI group (30% vs. 3%; $p < 0.001$). Intensive care surveillance was noted in 9 patients in the SSI group compared to 49 patients in the Non-SSI group (10.0% vs. 2.0%; $p < 0.001$). SSI was associated with a significantly longer median hospital stay (15 days, range = 2–69 vs. 8 days, range = 1–69; $p < 0.001$) and higher mortality rate (2.2% vs. 0.4%; $p = 0.019$). Significantly more hospitalizations in the 30-day post-discharge period were noted in the SSI group compared to the Non-SSI group (12.2% vs. 1.5%; $p < 0.001$).

For the univariate analysis, patients' age, underlying disease, type of operation (sigmoid or rectosigmoid resection), and surgeons' experience had no impact on the incidence level of SSI ($p$ = n.s.). Significant risk factors for SSI in multivariate regression analysis are given in Table 4. Figures 1 and 2 show the risk of SSI associated with operation time and BMI, respectively.

## Discussion

This study found an incidence of SSI of 3.5% in patients who underwent laparoscopic sigmoid resection for benign disease. Significant risk factors for SSI were operation time >240 min, BMI $\geq$27 kg/m$^2$, organ lesions, and male gender. SSI was associated with significantly more reoperations, longer hospital stay, and higher mortality rate.

Risk factors for SSI can be divided into various procedure- and patient-related factors. Procedure-related risk factors in our study group were operation time and intraoperative organ lesions (e.g., bowel perforation); patient-related risk factors were BMI and male gender.

One of the most important procedure-related risk factors for laparoscopic sigmoid resection was operation time. We showed that an operation time >240 min was a significant risk factor for SSI. Interestingly, the association between operation time and the risk of SSI seemed to be linear (Fig. 1). A similar relationship has been shown for open colorectal procedures [1, 8, 9]. The reason for such a linear increase in SSI risk with increasing operation time has not been explored in detail. In general, overall operation time depends on various parameters such as the surgeon's experience and technical or intraoperative problems (e.g., accidental puncture of an intra-abdominal organ, intraoperative hematoma, organ lesions, or conversion to open surgery).

BMI seemed to be the most relevant patient-related risk factor (Fig. 2) [1, 2, 4, 10]. Superficial incisional infection was the most common type of infection in our study group and was associated with obesity. In addition to BMI, we

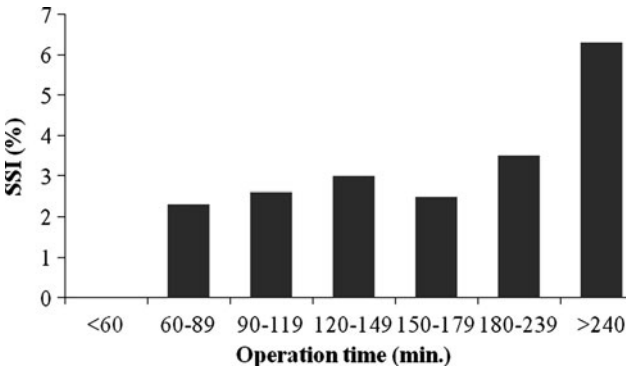


**Fig. 1** Operation time and risk of SSI

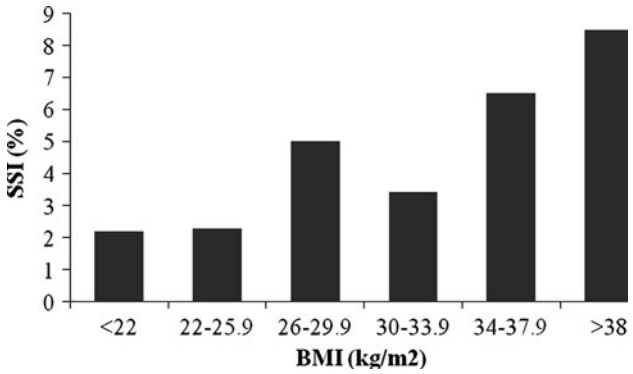


**Fig. 2** BMI and risk of SSI

identified male gender as an independent risk factor for SSI. Increased fractions of visceral fat, higher incidence of the metabolic syndrome, and a narrow pelvis may explain this finding in part. A further explanation for the association of BMI and SSI is a modified immune response in the obese that is enhanced during surgical procedures [11–13].

Long operation time, high BMI, and male gender are all potentially associated with increased difficulty of an operation. Difficult operations are associated with reduced adherence to rules of asepsis and antisepsis by members of the surgical team [14]. Such interrelationships between patient- and procedure-related factors and the surgical team may explain the increased incidence of SSI associated with operation time and BMI. These effects, however, are impossible to assess in a registry-based study.

In this prospective cohort study, we found an incidence of SSI of 3.5%, which was relatively low compared to the published literature [1–5]. The incidence of SSI in published series of patients who underwent open or laparoscopic colorectal surgery varied between 5 and 30% [1–5]. However, most previous studies focused on cohorts of patients that included both open and laparoscopic colorectal surgery [1–4, 10]. The relatively low incidence of SSI in our study may be explained in part by the fact that the study population was relatively healthier than those in other studies as it included only patients with benign disease, without previous radiotherapy, and few patients who underwent emergency procedures. However, the Centers for Disease Control and Prevention guidelines, which require a 30-day follow-up for the assessment of SSI, were potentially not fulfilled in this study [5]. The criteria of the classification of SSI according to the guidelines of the Centers for Disease Control and Prevention have been shown to be reproducible in clinical practice and therefore homogeneous distributions throughout the various institutions were assumed [5].

In conclusion, this prospective multicenter study identified risk factors for SSI after laparoscopic sigmoid resection. Our data suggested that risk factors for SSI were operation time, higher BMI, male gender, and the technical details of the procedure. Further analyses using active surveillance data could help to further identify various risk factors of SSI.

**Disclosure** Drs. Anita Kurmann, Stephan A. Vorburger, Daniel Candinas, and Guido Beldi have no conflicts of interest or financial ties to disclose.

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