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ORIGINAL ARTICLE

Additional surgical procedure is a risk factor for surgical site infections after laparoscopic cholecystectomy

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Abstract
Purpose Surgical site infections (SSI) are associated with increased costs and length of hospital stay, readmission rates, and mortality. The aim of this study was to identify risk factors for SSI in patients undergoing laparoscopic cholecystectomy.
Methods Analysis of 35,432 laparoscopic cholecystectomies of a prospective multicenter database was performed. Risk factors for SSI were identified among demographic data, preoperative patients' history, and operative data using multivariate analysis.
Results SSIs after laparoscopic cholecystectomy were seen in 0.8 % (n=291) of the patients. Multivariate analysis identified the following parameters as risk factors for SSI: additional surgical procedure (odds ratio [OR] 4.0, 95 % confidence interval [CI] 2.2–7.5), age over 55 years (OR 2.4 [1.8–3.2]), conversion to open procedure (OR 2.6 [1.9–3.6]), postoperative hematoma (OR 1.9 [1.2–3.1]), duration of operation >60 min (OR 2.5 [1.7–3.6], cystic stump insufficiency (OR 12.5 [4.2–37.2]), gallbladder perforation (OR 6.2 [2.4–16.1]), gallbladder empyema (OR 1.7 [1.1–2.7]), and surgical revision (OR 15.7 [10.4–23.7]. SSIs were associated with a significantly prolonged hospital stay (p<0.001), higher postoperative mortality (p<0.001), and increased rate of surgical revision (p<0.001).
Conclusions Additional surgical procedure was identified as a strong risk factor for SSI after laparoscopic cholecystectomy. Furthermore, operation time >60 min, age >55 years, conversion to open procedure, cystic stump insufficiency, postoperative hematoma, gallbladder perforation, gallbladder empyema, or surgical revision were identified as specific risk factors for SSI after laparoscopic cholecystectomy.

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Keywords Laparoscopic cholecystectomy · Surgical site infection · Risk factor · Morbidity · Mortality

Introduction

Surgical site infections (SSI) are associated with increased costs and readmission rates [1, 2]. The incidence of postoperative SSI has decreased with the introduction of laparoscopic procedures in comparison to open procedures [3–5]. Several risk factors to develop SSI after laparoscopic gastrointestinal surgery were identified in previous studies including long operation time, obesity, age, emergency procedure, American Society of Anesthesiologists (ASA) score, and male gender [4, 6, 7]. The use of prophylactic antibiotics reduced the incidence of postoperative SSI after laparoscopic cholecystectomy only in part; however, additional factors impact on the incidence of SSI [8, 9]. Laparoscopic cholecystectomy is frequently performed as an additional procedure during laparoscopic upper GI, bariatric, and colorectal surgeries, and we hypothesized that additional procedures impact on the incidence of postoperative SSI [10].

The aims of this multicenter registry-based study were to evaluate the incidence of postoperative SSI after laparoscopic cholecystectomy and to elucidate risk factors and in particular the role of additional surgical procedures for the development of SSI during a short-term postoperative follow-up.

Materials and methods

The prospective database of the Swiss Association of Laparoscopic and Thoracoscopic Surgery (SALTC), with voluntary participation of over 70 Swiss surgical divisions, consisting of all consecutive patients undergoing laparoscopic cholecystectomies in Switzerland between 1995 and 2008 was explored. All data were collected prospectively and entered in a centralized database (Qualicare®, Qualidoc, Liebefeld, Bern, Switzerland) by an independent data manager and were analyzed in a retrospective manner.

Demographic and clinical outcome parameters regarding age, gender, body mass index (BMI), previous biliary pancreatitis or endoscopic retrograde cholangiopancreatography, elective or emergency procedure, primary or additional surgical procedure, indication for laparoscopic cholecystectomy, use of intraoperative cholangiography, duration of operation, conversion to open procedure, surgeon's experience measured by quantity of laparoscopic cholecystectomies, ASA score, need of surgical revision, postoperative hematoma (abdominal wall or abdominal cavity), perforation of gallbladder, cystic stump insufficiency, postoperative need of ICU therapy, length of hospital stay, in-hospital mortality, and occurrence of SSI were analyzed. Incidence of SSI was assessed in an adapted manner to previously published criteria [11] and included superficial incisional SSI, deep incisional SSI, and organ/space SSI. The study population was then divided into a group with and without documented SSI, and each recorded parameter was then analyzed for possible risk factor for SSI after laparoscopic cholecystectomy.

Statistics

Continuous variables are expressed as median with range and compared using unpaired *t* test. Preoperative characteristics and surgery-related data were compared using Pearson's chi-square or Fisher's exact test as appropriate for categorical variables.

Multivariate binary logistic regression analysis was used for the analysis of risk factors for SSI. Parameters with $p<0.2$ were included into multivariate logistic regression analysis. Data with $p<0.05$ were considered as statistically significant, and adjusted odds ratio with 95 % confidence intervals was derived from logistic regression analysis. Statistical analysis of the data was performed with SPSS 20.0 software package (SPSS, Chicago, IL, USA).

Results

Between 1995 and 2008, 35,432 patients undergoing laparoscopic cholecystectomy were included into the database. The incidence of SSI after laparoscopic cholecystectomy was 0.8 % (291/35,432). In the majority of patients superficial incisional SSI (type I) occurred, and organ/space SSI (type III) occurred only in a minority of patients (Table 1). Patients' demographic characteristics and surgical details are given in Table 2 according to the presence of the outcome variable SSI. Laparoscopic cholecystectomy was performed as primary surgical procedure in 98.8 % and an additional procedure in 1.2 % of the patients. The postoperative mortality was significantly increased after SSI than without SSI (2.1 vs 0.2 %, $p<0.001$). Length of hospital stay was significantly prolonged in patients with SSI than those without SSI (11 vs 3 days, $p<0.001$, Table 2).

Use of intraoperative cholangiography, BMI, symptomatic cholelithiasis, incidence of gallbladder cancer, previous biliary pancreatitis, surgeon's experience, and antibiotic prophylaxis had no significant impact in univariate analysis on the incidence of SSI.

Postoperative course and complications are given in Table 3. The incidence of postoperative complications was

Table 1 Total incidence of SSI and distribution of subtypes

SSI	Total	291 (100)
	Type 1	273 (93.8)
	Type 2	17 (5.9)
	Type 3	1 (0.3)

Values are numbers (%)

SSI surgical site infection

Table 2 Demographic and technical operation data

	SSI group n=291	Non-SSI group n=35,141	p value[b,c]
Age (years)[a,c]	67.1 (18–92)	55.4 (3–100)	<0.001
Gender			
Male	123 (42.3)	11,446 (32.6)	<0.001
BMI (kg/m^2)[a,c]	27.98	27.56	0.266
ASA score[a,c]	2 (1–5)	2 (1–4)	<0.001
Exitus	6 (2.1)	61 (0.2)	<0.001
Hospital stay (days)[a,c]	11 (1–87)	3 (0–374)	<0.001
Additional surgical procedure	14 (4.8)	403 (1.1)	<0.001
Cholecystolithiasis	281 (96.6)	34,294 (97.6)	0.247
Acute cholecystitis	105 (36.1)	7,698 (21.9)	<0.001
Gallbladder empyema	25 (8.6)	935 (2.7)	<0.001
Previous ERCP	55 (18.9)	4,775 (13.6)	0.011
Previous biliary pancreatitis	30 (10.3)	2,576 (7.3)	0.051
Intraoperative cholangiography	104 (35.7)	12,538 (35.7)	1.000
Emergency procedure	70 (24.1)	5,637 (16.0)	<0.001
Conversion to open procedure	69 (23.7)	2,078 (5,0)	<0.001
Gallbladder perforation	11 (3.8)	22 (0.1)	<0.001
Surgeon's experience			
>50 operations	215 (73.9)	26,899 (76.5)	0.298
Duration of operation (min)			
>60 min	181 (62.2)	11,746 (33.4)	<0.001

[a] Values are median (range)

[b] Fisher's exact test unless indicated otherwise

[c] Unpaired *t* test

SSI surgical site infection, *ASA* American Society of Anesthesiologists, *BMI* body mass index, *ERCP* endoscopic retrograde cholangiopancreatography

Table 3 Univariate analysis of postoperative complications

	SSI group n=291	Non-SSI group n=35,141	p value[a]
Surgical revision	70 (24.1)	260 (0.7)	<0.001
Postoperative ICU	26 (8.9)	154 (0.4)	<0.001
Postoperative hematoma	33 (11.3)	418 (1.2)	<0.001
Cystic stump insufficiency	7 (2.4)	18 (0.1)	<0.001

Values are numbers (%)

[a] Fisher's exact test

SSI surgical site infection, *ICU* intensive care unit

significantly increased in the SSI group compared to the group without SSI (46.7 vs 2.4 %, $p<0.001$). Patients with SSI had significantly higher incidence for hematoma in the abdominal wall (5.8 vs 0.6 %, $p<0.001$) and abdominal cavity (5.5 vs 0.6 %, $p<0.001$).

An additional surgical procedure together with laparoscopic cholecystectomy was associated with an increased risk for SSI ($p<0.001$). Further, additional surgical procedures to the initial cholecystectomy were associated with a significantly increased risk for cystic stump insufficiency ($p=0.035$, Table 4).

The multivariate logistic regression analysis of the independent risk factors revealed additional surgical procedure as a significant risk factor for SSI among others (Table 5). The association of operation time and incidence of SSI are shown in Fig. 1 with a distinct increase of the frequency of infections in operations with a prolonged duration of more than 60 min.

Discussion

The incidence of SSI after laparoscopic cholecystectomy is infrequent. This study identified several risk factors for SSI. In particular, additional surgical procedure is a risk factor that can be addressed in the clinical routine.

Importantly, laparoscopic cholecystectomy as an additional surgical procedure during, e.g., fundoplication, bariatric surgery, or gastric surgery, was a risk factor for SSI. A potential reason for that finding is a prolonged duration of operation as two operations are performed during one surgical procedure, which is associated with an increase of SSI. In addition of that, cholecystectomy as additional surgical procedure was associated with a significantly higher rate for cystic stump insufficiency and a higher incidence for intra-abdominal bleeding. Both factors for themselves were identified as risk factors for SSI in this analysis. On the other hand, the incidence of SSI is probably not only determined by the cholecystectomy itself but to the second operation. However, it was impossible to elucidate this problem in detail on the basis of the present database, as well as the impact whether laparoscopic cholecystectomy was the primary or the secondary operation. Nevertheless, the indication to perform a cholecystectomy during a second operation should be carefully selected.

Table 4 Univariate analysis of postoperative complications after laparoscopic cholecystectomy as primary or additional surgical procedure

	Primary procedure n=35,015	Additional procedure n=417	p value[a]
SSI	277 (0.8)	14 (3.4)	<0.001
Hematoma abdominal wall	235 (0.7)	2 (0.5)	1.000
Hematoma abdominal 1cavity	221 (0.6)	6 (1.4)	0.053
Cystic stump insufficiency	23 (0.1)	2 (0.5)	0.035

Values are numbers (%)

[a] Fisher's exact test

SSI surgical site infection

Table 5 Multivariate binary logistic regression analysis of independent risk factors for SSI

	Odds ratio (95 % CI)	p value
Additional surgical procedure	4.011 (2.149–7.486)	<0.001
Age >55 years	2.398(1.777–3.235)	<0.001
Conversion to open procedure	2.647 (1.935–3.621)	<0.001
Postoperative hematoma	1.910 (1.192–3.060)	0.007
Duration of operation >60 min	2.493 (1.710–3.635)	<0.001
Cystic stump insufficiency	12.451 (4.169–37.189)	<0.001
Gallbladder perforation	6.161 (2.365–16.047)	<0.001
Gallbladder empyema	1.704 (1.080–2.689)	0.022
Surgical revision	15.725 (10.439–23.686)	<0.001

SSI surgical site infection

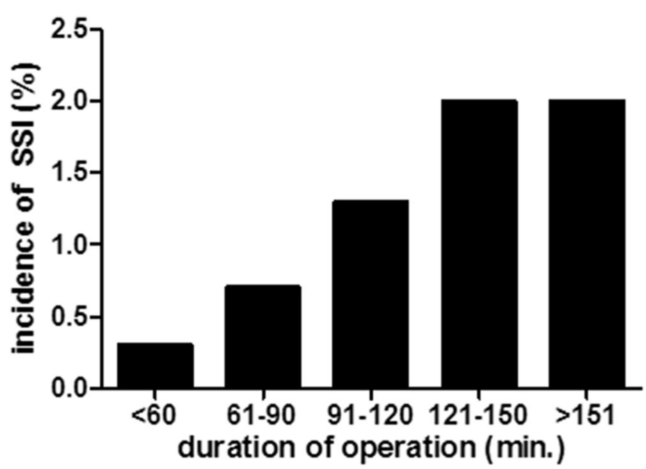

Fig. 1 Incidence of SSI after laparoscopic cholecystectomy in relationship to duration of operation

The incidence of 0.8 % of SSI after laparoscopic cholecystectomy in this study was low but is comparable to that of the previous reports with an incidence between 0.6 and 1.1 % [7, 8, 12, 13]. With the introduction of laparoscopic cholecystectomy, the incidence of postoperative infections decreased compared to that of the open cholecystectomy [4, 7, 14]. The routine use of preoperative prophylactic antibiotics has been shown not to reduce the incidence of postoperative infections mainly after elective laparoscopic cholecystectomy. There are some small prospective studies, in which there was no reduction of SSI despite of antibiotics, whereas the overall incidence of SSI was low which both correspond to our results [8, 9, 15].

Patients older than 55 years were more predisposed for SSI than younger patients in this investigation. One reason might be that patients with SSI had significantly higher ASA score reflecting the collective of older patients in this study. Higher ASA score was reported as risk factor for SSI after laparoscopic cholecystectomy and colorectal surgery [6, 7].

Increased duration of operation longer than 60 min was associated with an increase of SSI in this investigation. Several studies have shown that an increase of the duration of the surgical procedure is associated with an increase of SSI [6, 16–18]. Advanced disease or inflammation of the gallbladder might be one reason for prolonged duration of the operation and therefore associated with an increase of SSI.

The increased rate of SSI after loss of bile fluid into the abdominal cavity might be explained as bacteribilia in patients undergoing laparoscopic cholecystectomy that is common and was already shown as risk factor for SSI in open cholecystectomy, whereas others could not detect a relationship between infected bile and the incidence of SSI [8, 9, 19–21]. The fact that acute cholecystitis or gallbladder empyema was found as risk factors for SSI after laparoscopic cholecystectomy in this study, the infectious state of the bile seems to be a relevant cofactor for the development of SSI.

Open cholecystectomy has been shown to be associated with an increased rate of SSI than laparoscopic cholecystectomy [5, 13, 22]. Therefore, it is not surprising that conversion to an open procedure during laparoscopic cholecystectomy was associated with an increase of SSI in this investigation. On the other hand, conversion to laparotomy is mostly necessary due to technical problems or unclear anatomical situation with probable increase of intraoperative complications and consecutively higher risk for SSI.

The present study is limited by the biases that are typically associated with the analysis of outcome registries: Precision and completeness of data acquisition are very difficult to control and to evaluate specific questions that are sometimes impossible to address (e.g., exact localization of infection and use of harvesting bag). The quality and validity of such a large multicenter database are dependent on the collaboration of each participating surgical center. There is often not a centralized control institution to check the correctness and completeness of the data. This study is based on short-term in-hospital outcome and does not reflect a 30-day follow-up as required in accordance with the Centers for Disease Control and Prevention guidelines, so that a certain percentage of patients with SSI dropped out of the database [11]. Thus, the incidence of SSI might be underestimated in this database as, e.g., wound infections often occur later than the median hospital stay of 3 days in the non-SSI group. In order to omit such bias, prospective protocols are required with a longer follow-up.

Conclusion

In conclusion, this analysis of a nationwide multicenter database revealed independent risk factors for SSI after laparoscopic cholecystectomy such as age, acute cholecystitis, gallbladder empyema, conversion, duration of operation, and surgical complications. In particular, cholecystectomy as additional surgical procedure seems to be an important additional risk factor that can be addressed during the planning of an operation. On the basis of these results, the surgeon's technique, timing, and indication for the operation may influence the risk of SSI besides of patient-related factors.

Conflicts of interest All authors have no conflicts of interest or financial ties to disclose.

Authors' contributions: Study conception and design
R. Fahrner, T. Malinka, J. Klasen, D. Candinas, G. Beldi
Acquisition of data
R. Fahrner, T. Malinka, J. Klasen
Analysis and interpretation of data
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Drafting of manuscript
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