Journal of Hospital Infection 100 (2018) 393–399

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Timing, diagnosis, and treatment of surgical site infections after colonic surgery: prospective surveillance of 1263 patients

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ARTICLE INFO

Article history:
Received 9 August 2018
Accepted 19 September 2018
Available online 25 September 2018

Keywords:
Colorectal surgery
Surgical site infection
Timing
Treatment
Diagnosis

SUMMARY

Background: Surgical site infections (SSIs) are the most frequent complication after colorectal surgery and have a major impact on length of stay and costs.
Aim: To analyse the incidence, timing, and treatment of SSIs within 30 days after colonic surgery.
Methods: This was a quality improvement project through retrospective analysis of consecutive colonic surgeries between February 2012 and October 2017 at Lausanne University Hospital (CHUV). SSIs were prospectively assessed by an independent national surveillance programme (www.swissnoso.ch) up to 30 postoperative days. Treatment strategies including drainage of infection (direct wound opening or percutaneous) and surgical management were reviewed.
Findings: The study cohort included 1263 patients with 532 procedures (42%) performed as emergencies. SSIs were observed in 271 patients (21%), occurring at median postoperative day (POD) 9 (interquartile range (IQR): 4–16). Specifically, 53 (4%) were superficial incisional, 65 (5%) deep incisional, and 153 (12%) organ space infections (anastomotic insufficiency included). Superficial incisional SSI occurred at a median of POD 10.5 (IQR: 7–15), deep incisional at a median of POD 10 (8–15) and organ space at a median of POD 8 (5–11). Diagnosis was performed post discharge in 64 cases (24%). Whereas 47% of organ space infections were detected by POD 7, this rate was only 26% for superficial and deep incisional infections ($P = 0.003$). Surgical management was necessary in 133 cases (49%), and the remaining cases were managed by drainage without general anaesthesia (138 cases, 51%).
Conclusion: Organ space infections occurred early in the postoperative course, whereas incisional infections were mostly detected post discharge over the entire 30-day observation period, emphasizing the importance of proper follow-up using a systematic, complete and independent surveillance programme.

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https://doi.org/10.1016/j.jhin.2018.09.011
0195-6701/

Introduction

Surgical site infections (SSIs) are the most frequent complication after colorectal surgery and have a major impact on length of stay and costs [1,2]. Reported SSI rates vary widely and depend, besides on quality of care, on patient- and surgery-related factors and on quality and integrity of postoperative surveillance, including accuracy of chart review and data collection [3]. In the light of shorter hospital stays within the enhanced recovery era, the proper follow-up for the timespan between patient discharge and outpatient control visits after index hospitalization is especially important. Whereas risk factors for SSI have been widely described, SSI diagnostic criteria are less well established, and little is known about the specific role of different caregivers within SSI surveillance systems [4,5].

The present study aimed to assess incidence and precise timing of SSI up to 30 days after colonic surgery, and to provide comprehensive diagnostic criteria and management strategies.

Methods

Patients

All consecutive patients undergoing colonic resections between February 1st, 2012 and October 31st, 2017 at Lausanne University Hospital (CHUV), a tertiary academic centre, were prospectively monitored and registered by the independent Swiss national infection surveillance committee (Swissnoso, www.swissnoso.ch). Patients were treated within a standardized enhanced recovery pathway (ERAS) over the entire study period [6,7]. Open and laparoscopic procedures performed in elective and emergency settings were all included. All types of colectomies were included (left, right, segmental, total, subtotal). Stoma-related procedures (Hartmann reversal, ostomy closure) or rectal resections were excluded due to their clinical heterogeneity. Patients undergoing elective left-sided colectomy were treated by rectal enemas the day before and the morning of the day of surgery; patients undergoing right-sided colectomy received no bowel preparation.

Demographic items comprised age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, and presence of malignancy. Surgical items included setting (elective versus emergency, defined as surgery within 72 h after unplanned admission), approach (minimally invasive versus open), additional procedures (defined as further intestinal resections or >1 h adhesiolysis), and procedure duration. Wound class (stratified between II (clean contaminated), III (contaminated), and IV (infectious)) and National Nosocomial Infection Surveillance (NNIS) score (0–3, a composite of ASA score extracted from anaesthesia sheets, wound contamination and duration of surgery), were both independently assessed by Swissnoso [8].

For comparison purposes, the previously published median hospital stay of seven days after colonic surgery was used to analyse the occurrence of different types of SSI [6].

Ethical considerations

This study was conducted as part of an institutional quality improvement project and data extraction was approved by the Institutional Review Board (CER-VD # 2016-00991).

Diagnostic criteria of SSI and treatment options

Surgical site infections were prospectively documented during the index hospitalization. Post discharge, SSI were tracked through systematic phone calls at postoperative day (POD) 30. Responsible for this assessment was a Swissnoso independent local committee, applying a previously published methodology [1]. Each suspected or diagnosed SSI was validated by a board-certified infectious disease specialist on the basis of full chart review without interaction with any surgeon. SSIs were subdivided according to the Centers for Disease Control and Prevention (CDC) National Nosocomial Infection Surveillance (NNIS) criteria into superficial incisional, deep incisional, and organ space infections [8]. Diagnostic CDC criteria were coded as: B1, purulent discharge; B2, positive culture; B3, presence of at least one of the following signs: pain, swelling, redness, warmth and deliberate wound-opening by surgeon (for superficial incisional SSI) or surgical or interventional abscess drainage (for deep incisional SSI and organ space SSI); and C, diagnosis by primary caregiver or general practitioner. Wound swabs of superficial infections were taken according to the surgeons' or general practitioners' discretion when clinically indicated. Microbiological evaluation was performed systematically when organ space infections were suspected, either through surgical or percutaneous access.

According to institutional guidelines for colonic resections, intravenous cefuroxime 1.5 g and metronidazole 500 mg were applied within 60 min before incision. The alternatives in case of non-tolerance were clindamycin 600 mg and ciprofloxacin 400 mg. Besides antibiotic prophylaxis, infection-preventing measures were adopted according to the National Institute for Health and Care Excellence (NICE) recommendations [9].

Infection treatment approaches were either drainage without general anaesthesia (bedside wound opening, punctures, percutaneous drainage) or surgical re-intervention under general anaesthesia. All organ space infections were first treated empirically with co-amoxicillin or piperacillin–tazobactam, then subsequently adapted according to cultures and antibiograms. Antibiotic treatment was introduced for incisional infections according to the surgeon's or treating physician's discretion. Treatment analysis focused on the invasive aspect (drainage without general anaesthesia versus surgery).

Statistical analysis

Quantitative variables were presented as mean (standard deviation: SD) or median (interquartile range: IQR) and compared with Student's *t*-test or Mann–Whitney *U*-test, according to their normality. Qualitative variables were presented as frequencies (percentage) and compared with Pearson's χ^2-test or Fisher's exact test as appropriate. All statistical tests were two-sided, and $P \leq 0.05$ was considered statistically significant. Data analysis was performed with the Statistical Software for Social Sciences SPSS Advanced Statistics 22 (IBM Software Group, Chicago, IL, USA).

Results

The study cohort included 1236 patients, and SSI was observed in 271 patients (21%). Among them, 53 (4%) were superficial incisional, 65 (5%) deep incisional and 153 (12%) organ

Table I
Demographic and surgical details

Variable	All patients ($N = 1263$)	SSI ($N = 271$)	No SSI ($N = 992$)	P
Age (years) (mean ± SD)	64 ± 17	64 ± 17	64 ± 17	0.552
Gender (M:F)	672:591	153:118	519:473	0.243
Body mass index (kg/m^2) (mean ± SD)	25.2 ± 5.5	26.0 ± 6.0	25.0 ± 5.4	0.208
ASA group (1/2:3/4)	705:558	121:150	584:408	<0.001
Malignancy	626 (50%)	130 (48%)	496 (50%)	0.351
Emergency indication	532 (42%)	157 (58%)	375 (38%)	<0.001
Minimally invasive approach	734 (58%)	95 (35%)	639 (64%)	<0.001
1 additional procedure	392 (31%)	102 (38%)	290 (29%)	0.009
2 additional procedures	66 (5%)	22 (8%)	44 (4%)	0.020
Operation duration (mean ± SD)	190 ± 100	210 ± 110	180 ± 100	0.002
Duration >180 min	569 (45%)	142 (52%)	427 (43%)	0.007
Antibiotic administration				
Before 1 h of incision	352 (28%)	96 (35%)	256 (26%)	0.002
Within 1 h of incision	832 (66%)	151 (56%)	681 (69%)	<0.001
Post incision	79 (6%)	24 (9%)	55 (6%)	0.046
Wound class ≥ II	696 (55%)	180 (66%)	516 (52%)	<0.001
NNIS score ≥ II	618 (49%)	173 (64%)	445 (45%)	<0.001

SSI, surgical site infection; ASA, American Society of Anesthesiologists; NNIS, National Nosocomial Infection Surveillance system.
Demographic and surgical items in patients with SSI ($N = 271$) and patients without SSI ($N = 992$).

space infections, with inclusion of anastomotic insufficiencies (Table I). SSI was diagnosed at median postoperative day (POD) 9 (IQR 4–16). Superficial incisional SSI occurred at a median POD 10.5 (7–15), deep incisional at a median POD 10 (8–15), and organ space at a median POD 8 (5–11). Diagnosis was made in-hospital in 207 cases (76%), while general practitioners reported SSI in 64 patients (24%). Diagnostic criteria for SSI are summarized in Table II. Of note, 66% of patients received antibiotic prophylaxis within 60 min of incision.

Timing of occurrence of superficial incisional, deep incisional, and organ space SSI are displayed in Figure 1a and b showing the cumulative incidence for each type. Whereas 47% of organ space infections were detected by median hospital stay at POD 7, this rate was only 26% for superficial and deep incisional infections ($P = 0.003$).

Distribution of superficial, deep incisional, and organ space infections differed considerably between elective and emergency procedures (Table III).

Treatment

Treatment modalities for SSI on each postoperative day are displayed in Figure 2. Surgical management was performed in 133 cases (49%); the remaining cases were managed by drainage without general anaesthesia (138 cases, 51%). Rehospitalization to treat SSI, either due to detection post discharge, or failure to treat during the index hospitalization, was necessary in 48 patients (18%).

Discussion

This study shows that the majority of organ space infections are diagnosed early during index hospitalisation, whereas superficial SSI appear later and after discharge from hospital. Their treatment is clearly different. In addition, organ space infections occurred significantly more frequently after emergency operations.

Prospective assessment of SSI in this cohort of elective (58%) and emergent (42%) colonic resections by the Swissnoso programme over a five-year period revealed an overall SSI rate of 21%. Half of SSIs needed surgical re-intervention, predominantly within the first 10 postoperative days.

Surveillance on a national scale is a way to ascertain best possible detection of SSI, even if they occur post discharge [10]. Rates of SSI are also viewed as a measure of hospital performance [11]. However, accurate detection of SSI post

Table II
Diagnostic CDC criteria

Criteria	Superficial incisional ($N = 53$)	Deep incisional ($N = 65$)	Organ space ($N = 153$)
B1: purulent discharge from respective compartment	38 (72%)	45 (69%)	51 (33%)
B2: positive culture retrieved from respective compartment	28 (53%)	55 (85%)	122 (80%)
B3: abscess formation visualized during wound opening, drainage or re-intervention	42 (79%)	59 (91%)	147 (96%)
C: diagnosed post discharge/by GP	18 (34%)	24 (37%)	22 (14%)

CDC, Centers for Disease Control and Prevention; GP, general practitioner.

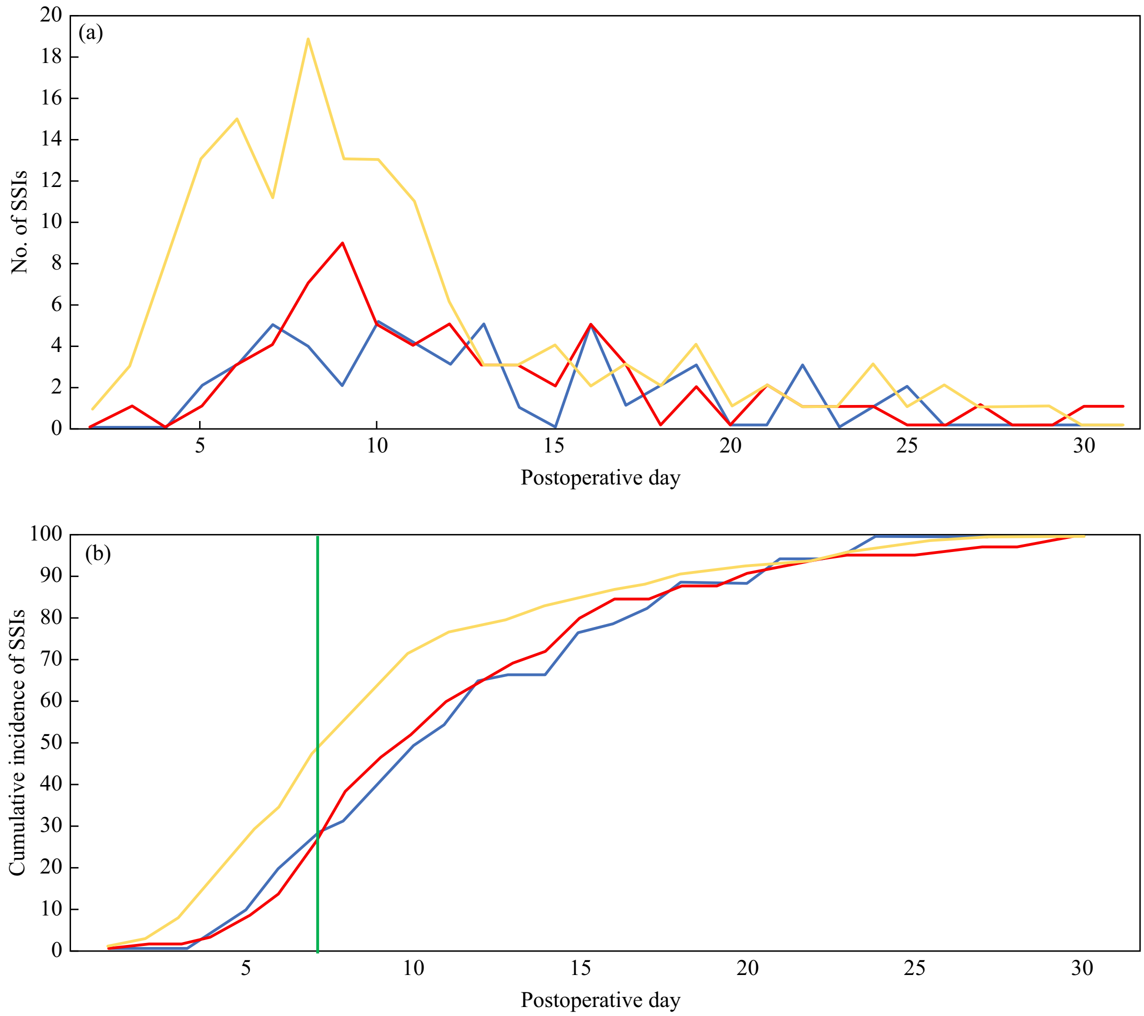

Figure 1. Timing and cumulative incidence of different types of surgical site infection (SSI). Frequency (a) and cumulative incidence (b) of SSI until postoperative day 30 comparing superficial incisional (blue line), deep incisional (red line) and organ space (yellow line) infections. The green line indicates median hospital stay of seven days [6].

hospital discharge is not easy, and existing research has not identified a valid and reliable method [11]. Patient self-assessment strategies overestimate institutional SSI rates [12]. Undoubtedly, standardized definitions with precise criteria are of utmost importance especially for post-discharge SSI, and were part of methodology of surveillance of the present cohort. Enhanced recovery programmes enabled reduction of length of hospital stay after surgery [13]. In this context, SSI will preferentially be detected post discharge, emphasizing the important role of primary healthcare providers [11,14,15].

Table III
Distribution of infections between elective and emergency procedures

Surgical site infection	Elective ($N = 731$)	Emergency ($N = 532$)	P
Overall	113 (15%)	158 (30%)	<0.001
Superficial incisional	16 (2%)	37 (7%)	<0.001
Deep incisional	36 (5%)	29 (5%)	0.609
Organ space	61 (8%)	92 (17%)	<0.001

This point was recognized by the present study, in which general practitioners detected about a quarter of all infections.

The 21% overall SSI rate of the present study is comparable to a former report including 3701 patients within a national surveillance system (18.1% SSI), as well as in retrospective studies (20–25% SSI) [1,16–18]. The National Healthcare Safety Network reported an SSI rate after colorectal surgery of as low as 5.6% [19]. Reported rates vary widely and different definitions for SSI have been used: some include anastomotic leakage, whereas others do not. In addition, other factors might explain these differences. First, a thorough, systematic, unbiased, and methodological surveillance strategy allowed for exhaustive detection of SSI [3]. Second, 42% of cases were performed in emergency. Emergency surgery has been identified as an important risk factor for postoperative SSI, similar to this present study: overall SSI, and most notably superficial incisional and organ space SSI, were predominant in patients undergoing emergency procedures [5,20,21]. Deep incisional SSIs on the other hand were comparable, supposedly due to frequent use of negative wound pressure therapy with secondary wound closure when confronted with contaminated deep incisional wound spaces

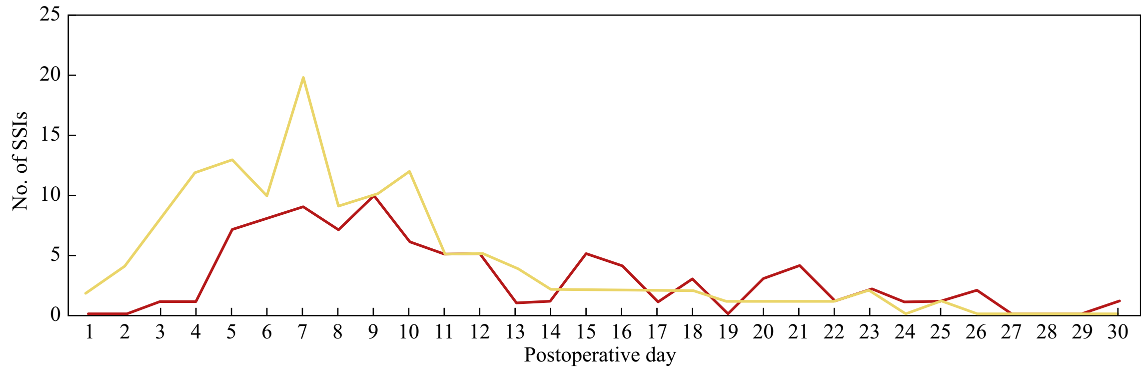

Figure 2. Timing of treatment modalities for surgical site infection (SSI). Treatment strategies for SSI until postoperative day (POD) 30 comparing drainage of infection (including bedside wound opening, punctures and percutaneous drainage, red line) and surgical management (yellow line).

during emergency surgery. As a tertiary referral centre within an urban environment with several smaller hospitals, the present institution fulfils a back-up role for high-risk patients and procedures, which might contribute to higher infection rates. Regarding this subset of patients, a two-stage strategy (damage control, second look at 48 h) has been adopted within the present institution for septic and severely contaminated emergency operations [22]. Nevertheless, there is probably room for improvement in infection prevention. For example, the present study observed a low compliance with up-to-date antibiotic prophylaxis recommendations [23]. NICE guidelines were adhered to, however, without auditing effective compliance [9]. Due to the results of the present surveillance study, new infection-preventing measures were launched, embedded within a prospective SSI reduction bundle. Actual guidelines were thoroughly reviewed to define strategy with several infection-preventing measures according to NICE guidelines, including a tailored closure strategy. SSI reduction bundles have been successfully implemented in other institutions [24—26]. A multidisciplinary approach, standardized perioperative care including checklists, and prospective audit of compliance have been identified as indispensable tools [27,28].

The respective roles of hospitals and surgeons have not been evaluated in this study but other reports mention their influence on SSI [29,30]. Surgeons themselves can be considered risk factors or protective factors for SSI, independent of other factors linked to the patient, the procedure, or the hospital where the intervention takes place [29,31]. A Dutch multicentre cohort study based on surveillance data found that patients operated by surgeons with low operation rate had an increased risk of developing SSI. This was not true for overall hospital activity, which was not associated with SSI risk [32]. Implementation of measures to prevent SSI varies greatly among surgeons, and adherence to the current NICE guidelines is low for many procedures, irrespective of the surgeon's experience [9,33].

Surgical site infections were subdivided according to the CDC criteria into superficial incisional, deep incisional, and organ space infections [8]. In the CDC classification, the attending physician is the final arbiter for diagnosis [34]. Therefore, some authors suggest that there may be a discrepancy in clinical interpretation, which oftentimes is subjective and difficult to discern from the medical record [35]. These findings could explain the wide variability reported in the literature with regard to SSI following colorectal surgery. CDC criteria represent a suitable standard definition for monitoring and identifying SSI, even if some cases of less clinically significant superficial SSI are included [36].

Several limitations of the present study need to be discussed. Even though assessment of SSI was prospective and independent, data analysis was performed retrospectively with inherent limitations. Data on compliance with infection prevention care items beyond antibiotic administration were not documented in this observational study, but will be a major focus of the future quality improvement project. However, data were derived from the official national infection surveillance registry, thus eliminating observer or selection bias. Exhaustive surgical details were not assessed within this surveillance, impeding analysis of subgroups or further conclusions. Specifics on type of anastomotic leaks as surrogate parameter for organ space infections were not available either. Furthermore, the median length of stay was not available for this cohort. Finally, the type of wound closure (staples, nonresorbable or absorbable intra-dermal threads) as well as postoperative wound care were not specified and could be cofactors in the occurrence of incisional infections. This also applies to the antibiotic treatment possibly associated with the invasive treatment, which has not been analysed but was supposed to follow institutional guidelines. On the other hand, the strengths of this study are the substantial number of observed patients within a single-centre experience, the independent nature of the assessment, and the unselected patient cohort.

In conclusion, organ space infections occurred early in the postoperative course, whereas incisional infections were more likely to be detected post discharge over the entire 30-day observation period, emphasizing the importance of proper follow-up using a systematic, complete and independent surveillance programme with precise diagnosis criteria.

Conflict of interest statement

None declared.

Funding sources

None.

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