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Implementing a surgical site infection prevention bundle for emergency appendectomy: Worth the effort or waste of time?

Jonas Jurt, MD[a], Laura Floquet, MD[a], Martin Hübner, MD[a], Estelle Moulin, MD[b], Laurence Senn, MD[b], Nicolas Demartines, MD[a,*], Fabian Grass, MD[a]

[a] Department of Visceral Surgery, Lausanne University Hospital CHUV, Switzerland
[b] Department of Hospital Preventive Medicine, Lausanne University Hospital CHUV, Switzerland

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ABSTRACT

Background: The aim of this study was to evaluate feasibility and impact of an intraoperative surgical site infection prevention bundle for emergency appendectomy.

Methods: Consecutive adult patients undergoing emergency appendectomy were prospectively included during a 10-year study period (2011–2020). The care bundle was implemented as of November 1, 2018, and focused on 4 intraoperative items (disinfection, antibiotic prophylaxis, induction temperature control >36.5°C, and intracavity lavage). The primary outcome was the compliance to bundle items. Thirty-day surgical site infections were assessed by the independent Swiss National SSI Surveillance Program (2011 to October 2018) and by an institutional audit (November 2018–2020). Independent risk factors for surgical site infection were identified through multinominal logistic regression analysis.

Results: Of 1,901 patients, 449 (23.6%) were included after bundle implementation. Overall surgical site infection rate was 111 (5.8%). In 42 patients with surgical site infection (37.8%), antibiotic treatment alone was done, and additional surgical management was necessary in 31 patients (27.9%), computed tomography-guided drainage in 30 patients (27%), and bedside wound opening in 9 cases (8.1%). Overall compliance to the bundle was 79.9%. Overall surgical site infection rates were decreased after bundle implementation (17/449 [3.8%] vs 94/1,452 [6.5%], $P = .038$), mainly due to a decrease in superficial incisional infections ($P = .014$). Independent risk factors for surgical site infection were surgical duration ≥60 minutes (odds ratio: 1.66, $P = .018$), contamination class IV (odds ratio: 2.64, $P < .001$), and open or converted approach (odds ratio: 4.0, $P < .001$), and the bundle was an independent protective factor (odds ratio: 0.58, $P = .048$).

Conclusion: Implementation of an intraoperative surgical site infection prevention bundle was feasible and might have a beneficial impact on surgical site infection rates after emergency appendectomy.

Introduction

Acute appendicitis is frequent, with an estimated lifetime risk between 6.7% to 8.6%.[1] Laparoscopic appendectomy is the standard of care, although it has recently been challenged by nonoperative treatment strategy.[2,3] Surgical site infections (SSIs) after appendectomy are frequent with rates of up to 10%[4,5] with important implications concerning sick leave and costs.[6] Several constitutional and surgical risk factors for SSI include complicated, gangrenous, or perforated disease presentation.[7] Tailored SSI reduction care bundles have proven their efficacy in elective colorectal surgery.[8] However, data regarding feasibility and compliance in the emergency setting are scarce.[9] The aim of this study was to assess the feasibility of an intraoperative SSI prevention bundle for emergency appendectomy and its impact on SSI rate.

Methods

This is a retrospective study of consecutive adult patients undergoing emergency (surgery within 12 hours of unplanned admission) appendectomy who were prospectively included between July 1, 2011, and October 31, 2020. All procedures were performed by board-certified surgeons from the general surgery department at Lausanne University Hospital. Appendectomies

J. Jurt and L. Floquet contributed equally to this article.

* Reprint requests: Nicolas Demartines, MD, Department of Visceral Surgery, Lausanne University Hospital CHUV, Bugnon 46, 1011 Lausanne, Switzerland.
E-mail address: demartines@chuv.ch (N. Demartines);
Twitter: @ProfDemartines

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were performed using a linear stapling device (first choice) or a synthetic absorbable (vicryl) suture loop (alternative if non-inflamed base of appendix). According to international guidelines, patients presenting at admission with an accessible abscess >4 cm were initially treated with computed tomography (CT)–guided percutaneous drainage and antibiotics.[1] Elective appendectomy was performed after successful conservative treatment, and these patients were excluded from this analysis. Patient data were deidentified for analysis and the study was approved by the institutional review board (CER-VD # 2020–238 and CER-VD # 2016–991).

Demographics included age, sex, body mass index, and American Society of Anesthesiologists (ASA) score. Surgical specifics included approach (laparoscopic versus open/converted to open), wound contamination class defined according to the Center for Disease Control and Prevention (CDC) classification,[10] and duration of surgery. Data regarding SSI was assessed according to CDC criteria by trained abstractors with clinical follow-up until 30 postoperative days and stored in a prospectively maintained database of the independent Swiss National SSI Surveillance program (www.swissnoso.ch) for the comparative preimplementation cohort.[11] Swissnoso is a nationwide surveillance and prevention program of nosocomial infections. During the postimplementation study period (starting November 1, 2018), SSIs were assessed through institutional audit using the same criteria and methodology. Interobserver agreement of both surveillance methods has been previously assessed for colonic resections and was rated high.[12] National Nosocomial Infections Surveillance scores (0–3) were calculated for each patient based on wound contamination class, ASA score, and the duration of surgery.

Intervention

The institutional SSI prevention bundle was systematically implemented as standard of care for appendectomy on November 1, 2018. Items of the prevention bundle were identified based on validated international guidelines.[13,14] Furthermore, the bundle needed to be pragmatic and simple to apply in an emergency setting. Dedicated checklists were completed by the main surgeon and the anesthetist immediately on completion of the procedure to assess compliance to 4 composite key items (Supplementary Appendix S1). These were (1) antisepsis (skin disinfection (alcoholic Chlorhexidin 2%, B. Braun, Melsungen, Germany, according to predefined technique); (2) single shot antibiotic prophylaxis (type [intravenous co-amoxicilline 2.2 g if treatment initiated at the emergency department or cefuroxime 1.5 g + metronidazole 500 mg at induction of anesthesia] and timing of administration within 60 minutes of incision); (3) perioperative core temperature control >36.5°C (selective use of heated saline perfusion, pre- and perioperative use of preheated blankets to cover exposed skin areas); and (4) intracavity lavage (not recommended for uncomplicated appendicitis; lavage or suction for complicated appendicitis only in contaminated areas). Technique of skin disinfection was standardized as follows: a square was drawn to delimit the desired disinfected zone. The belly button then was used as a starting point for circular disinfection to the outside, without crossing the previously drawn borders of the square. This procedure was repeated 3 times. A teaching video was created to educate young residents in charge of disinfection.

The appendiceal stump was ligated with Vicryl Suture (Endoloop, Ethicon Endo-Surgery Inc., New Brunswick, NJ) or stapled with a linear stapler (Multifire Endo GIA 30mm, Covidien, Dublin, Ireland). The resected appendix was extracted from the abdomen in a dedicated plastic bag (Inzii, Applied Medical, Rancho Santa Margarita, CA). Wounds were closed with intradermal continuous monocryl sutures and covered by surgical glue (Histoacryl, B.Braun, Melsungen, Germany). Postoperative broad spectrum antibiotic treatment (co-amoxicilline 2.2 g 3 times in a day or ciprofloxacin 500 mg 2 times and metronidazole 500 mg 3 times in a day) was only continued in the case of complicated appendicitis for 3 to 5 days, as recommended by international guidelines.[1] Surgical drains were not routinely used but could be used after peritoneal lavage, at surgeon's discretion.

Outcomes/study end points

Compliance to the bundle was calculated based on the number of fulfilled items out of the total number of items. A threshold of 70% was used according to a previously observed critical threshold to achieve clinical relevance.[9] Thirty-day SSI were categorized as superficial incisional, deep incisional, and organ space infection according to the CDC classification.[10] Independent risk factors for SSI were identified through multiple logistic regression analysis. SSI rates were further analyzed year by year during the study period.

Statistical analysis

Continuous variables were summarized as median (interquartile range) or mean ± standard deviation (SD) and categorical variables as frequencies and percentages. The differences between groups were compared using χ^2 test for categorical variables and Mann-Whitney or independent sample t-test as appropriate for continuous variables.

Univariate risk factors for SSI with $P > .05$ were entered in a multiple logistic regression model to identify independent risk factors for SSI and to assess the impact of the prevention bundle. Furthermore, subgroup analysis was performed in patients with complicated (contamination class IV) and uncomplicated (contamination class II-III) appendicitis to assess the independent impact of the bundle in each group. All tests were two-sided. The analysis was conducted using the Statistical Package for Social Sciences (SPSS, version 27; SPSS, Inc., Armonk, NY).

Results

The study cohort included 1,901 patients, of which 111 (5.8%) developed SSI, with 30 (1.6%) superficial incisional, 13 (0.7%) deep incisional, and 68 (3.6%) organ or space infections. Demographic and surgical characteristics of both groups are displayed in Table I. Univariate risk factors for any SSI were age ≥40 years, ASA class ≥3, open or converted approach, surgical duration ≥60 minutes, perioperative contamination grade 4, and National Nosocomial Infections Surveillance score 2 and 3. Surgical site infections occurred at a median of 8 (interquartile range 5–12) days after surgery. In 42 of 111 patients (37.8%), antibiotic treatment alone was done. Additional surgical management was necessary in 31 patients (27.9%), CT-guided drainage in 30 patients (27%), and bedside wound opening in 9 patients (8.1%).

Care bundle

In total, 449 patients (23.6% of the study cohort) were included after implementation of the multimodal care bundle. Bundle compliance to individual items in these patients is displayed in Figure 1. The overall compliance was 79.9%.

The care bundle had a beneficial impact on overall SSI rates (17/449 [3.8%] vs 94/1452 [6.5%], $P = .038$), as illustrated in Figure 2, *A*. This difference was mainly due to a decrease in superficial incisional infections ($P = .014$), while no significant impact of the bundle on deep incisional and organ space infections was observed

Table I
Demographics and surgical details

	Total N= 1,901	SSI n= 111	No SSI n= 1790	P value
Age (y, mean ± SD)	36 ± 16	40 ± 19	35 ± 16	.011
≥40 (%)	625 (33)	49 (44)	576 (32)	.012
Female (%)	856 (45)	47 (42)	809 (45)	.623
ASA class ≥3 (%)	106 (6)	12 (11)	94 (5)	.029
BMI (kg/m^2, mean ± SD)	24.7 ± 5.4	24.9 ± 4.7	24.7 ± 5.0	.765
Laparoscopy (%)	1856 (98)	99 (89)	1757 (98)	<.001
Conversion (%)	18 (0.9)	8 (7)	10 (0.6)	<.001
Surgical duration (min, mean ± SD)	60 ± 40	73 ± 41	59 ± 40	.001
≥60	746 (39)	64 (58)	682 (38)	<.001
Contamination class (%)				< .001
II	303 (16)	7 (6)	296 (17)	
III	1,136 (60)	48 (43)	1,088 (61)	
IV	462 (24)	56 (50)	406 (23)	
NNIS score (%)				<.001
0	229 (12)	3 (3)	226 (13)	
1	1,217 (64)	55 (50)	1,162 (65)	
2	408 (21)	46 (41)	362 (20)	
3	47 (2)	7 (6)	40 (2)	

Baseline demographic parameters of patients with and without Surgical Site Infection (SSI) within 30 postoperative days. Age, BMI, and surgical duration are presented as mean ± standard deviation (SD). All others are frequency with percentage.
ASA, American Society of Anesthesiologists; *BMI*, body mass index; *NNIS*, National Nosocomial Infection Surveillance (including ASA score, wound contamination class and surgical duration); *SD*, standard deviation.

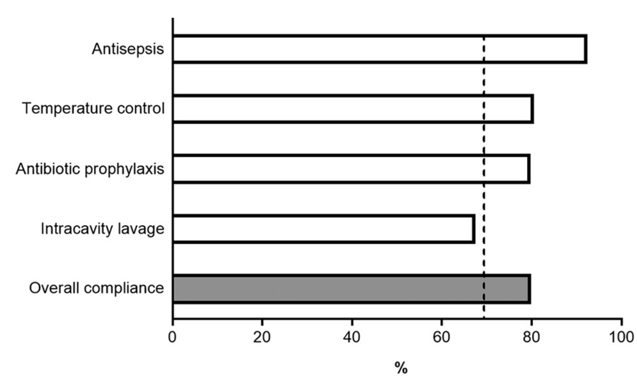

Figure 1. Compliance to prevention bundle. Individual and total compliance in percentage to items of the prevention bundle. The dotted line indicates 70% compliance.

(both $P > .05$). The annual incidence of SSI over time is displayed in Figure 2, *B*.

Multivariable analysis

Independent risk factors for SSI were surgical duration ≥60 minutes ($P = .018$), contamination class IV ($P < .001$) and open or converted approach ($P < .001$), while the SSI prevention bundle constituted and independent protective factor ($P = .048$, Figure 3). Subgroup analysis of patients with complicated appendicitis (n = 462) revealed a non-significantly stronger protective effect of the bundle (odds ratio: 0.5; 95% confidence interval, 0.22–1.16; $P = .1$) than in patients with uncomplicated appendicitis (n = 1,439; odds ratio: 0.65; 95% confidence interval, 0.32–1.32; $P = .23$).

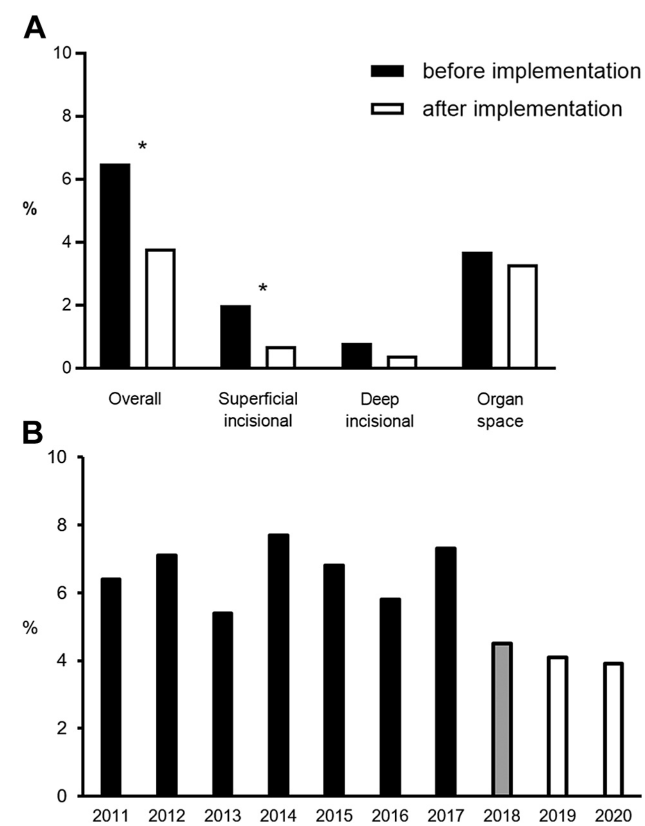

Figure 2. SSI rates. Pre- and postbundle implementation (A) and over time (B). SSI rates (a) before (black bars, n = 1452) and after (white bars, n = 449) implementation of the institutional SSI prevention bundle and (B) per year during the study period. The gray bar displays the year of implementation.

Discussion

The present study demonstrated feasibility of standard implementation of a multimodal SSI prevention bundle in the emergency setting of appendectomy. Furthermore, bundle application was an independent protective factor leading to the intended decrease of superficial SSI.

Surgical site infection preventing bundles are increasingly used for colorectal surgery, resulting in up to 50% SSI reduction according

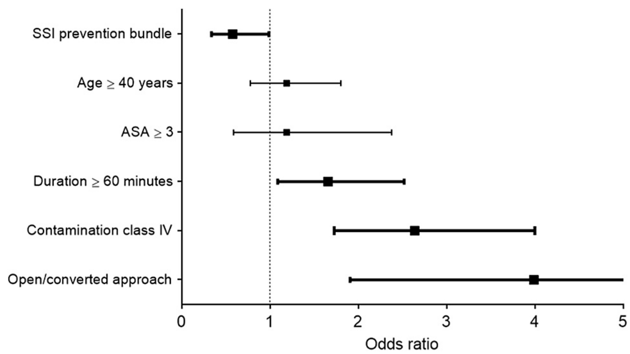

Figure 3. Multivariable analysis of risk factors for SSI. Multiple logistic regression of items associated with SSI after emergency appendectomy.

to two recent meta-analyses.[8,9] However, emergency operations are frequently excluded from such bundled interventions given that even in the elective setting their application is challenging with compliance rates of around 70%.[9] However, high compliance appears to be clearly associated with better outcomes in a dose-response pattern.[9] The present series revealed a high overall compliance of 79.9%, which may be explained by the focus on 4 simple and easily applicable core measures.

Intracavity lavage adapted to the degree of perioperative contamination was applied with the lowest compliance. Our protocol advocated intracavity lavage only for gross 4-quadrant spillage associated with perforated or purulent peritonitis to decrease pathogen load. Systematic peritoneal lavage induces the infection to spill in uncontaminated areas and may be associated with higher rates of postoperative abscess.[15] Recent meta-analyses, however, revealed no difference in postoperative intra-abdominal abscess formation with or without peritoneal lavage, even for perforated appendicitis.[15,16] This topic is still matter of debate and the World Society of Emergency Surgery guidelines do not formally recommend peritoneal lavage over suction alone for perforated appendicitis.[1]

In the present series, high compliance to normothermia at induction was noted. The negative impact of hypothermia as a risk factor for SSI was clearly demonstrated by several studies.[17,18] Stringent temperature control is part of enhanced recovery after surgery guidelines and thus this bundle item may have been previously established in the setting of the longstanding systematic enhanced recovery after surgery application in our institution. However, due to short operating time, air warming devices were not used for appendectomy. A selective use of this easily available device for preinduction hypothermic patient may be considered as a further way of improvement.

The SSI rate of 5.8% in the present cohort with two-thirds representing organ or space infections is in line with the literature, describing overall rates between 3.3% to 10.3% with a significant amount of organ/space infections (1.5% up to 9.4%).[4,5] In the post-implementation cohort of the present series, the significant SSI reduction was mainly driven by a decrease of superficial incisional SSI. This finding suggests that postoperative abscess formation was not influenced by bundle measures but may strongly be dependent on initial disease presentation. Increased awareness of this complication when facing significant perioperative contamination calls for a low threshold to perform a scheduled second look laparoscopy for repeated intracavity lavage. In the present institution, damage control surgery with a planned second stage laparotomy within 48 hours is applied in patients with severe intra-abdominal sepsis through predefined criteria.[19] Although the setting of emergency appendectomy is not comparable to a real damage control setting, the principle of a planned second look laparoscopy for lavage is still applicable. However, to this end, no rigorous criteria for a second look laparoscopy are available and treatment decisions rely on judgment calls of senior staff.

Surgical duration of ≥60 minutes, wound class contamination IV, and an open or converted approach were the expected independent risk factors for SSI, in line with a large cohort of the American National Surgical Quality Improvement Program database.[7] A former study suggested delayed primary skin closure for dirty wounds over primary closure.[20] However, meta-analyses failed to prove the benefit of delayed skin closure over primary closure and delayed primary skin closure was not retained by the latest guidelines.[1,21,22]

The present study has limitations beyond the retrospective design and the fact that compliance data was not available for the preimplementation cohort. First, underreporting of superficial SSI cannot be excluded, given many of them are diagnosed post-discharge and treated by general practitioners.[23] Second, the list of available potential risk factors for SSI was not exhaustive. Moreover, a temporal bias due to both more awareness of SSI prevention after bundle implementation and staff education cannot be excluded. Third, SSI surveillance was performed by institutional audit in the postimplementation study period because the national surveillance program no longer included appendectomies after October 2018. Although this represents a limitation of the study, high inter-observer reliability of both surveillance methods has been previously demonstrated for colonic surgery in our institution.[12] Finally, the individual impact of each bundle measure could not be evaluated due to both the low event rate in the study group and the lack of systematic assessment of compliance data in the pre-implementation cohort. Most likely, the sum of measures rather than one specific item helped to achieve a clinical benefit.

In conclusion, systematic implementation of a pragmatic SSI prevention bundle in the emergency setting of appendectomy was feasible and might have a beneficial impact on the incidence of SSI. Systematic auditing and the focus on standardized key measures are of particular importance.

Conflict of interest/Disclosure

We hereby confirm that the authors have no related conflicts of interest to declare.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.surg.2022.01.027.

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