Impact of wound irrigation during laparoscopic appendectomy on surgical site infection in acute appendicitis: a multicenter retrospective analysis

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Abstract

Background

Surgical site infection (SSI) is one of the major complications after appendectomy. Among the many efforts to reduce variable risk factors, subcutaneous wound irrigation has been reported in some abdominal surgeries. However, there are no relevant literatures regarding patients who underwent laparoscopic appendectomy. This study aimed to determine the effect of wound irrigation before skin closure when performing laparoscopic appendectomy.

Methods

We included patients who had undergone laparoscopic appendectomy due to acute appendicitis from March 2017 to October 2019 from three hospitals. Clinical data of 333 patients were retrospectively collected, and we divided 333 patients into three groups according to the method of wound irrigation: no irrigation (n = 93), saline irrigation (n = 144), and povidone-iodine (PI) (n = 96) groups.

Results

A total of 15 patients (4.5%) were diagnosed with SSI within postoperative 30 days. There was no difference in the SSI rates (4.3% vs. 5.1% vs. 4.5%, $p = 0.953$). None of the factors were associated with SSI among the variables (sex, age, ASA, perforated appendicitis, preoperative WBC and hemoglobin levels, operation time, wound irrigation, type of wound closure material, and preoperative and postoperative fever).

Conclusions

Wound irrigation did not affect the SSI rate in patients who underwent laparoscopic appendectomy.

Introduction

Acute appendicitis is a very common inflammatory disease. According to the severity of inflammation or whether it is a perforated appendix or not, the surgical wound can be classified as clean-contaminated, contaminated or dirty wound by surgical wound classification [1]. Surgical site infection (SSI) is one of the major complications after appendectomy.

The incidence of SSI after appendectomy is reported as 7.0–8.7% [2, 3]. As the laparoscopic approach has been introduced, laparoscopic appendectomy reduced the SSI rate as well as minimized the time of operation and produced better cosmetic outcome [4]. Thus, the SSI rate after laparoscopic appendectomy has been reported as 4.2% [5], which is lower than that of open appendectomy. Although some of the

known risk factors for SSI cannot be corrected, many efforts to reduce variable risk factors have been performed. The use of a specimen retrieval bag in laparoscopic appendectomy significantly decreased SSI [5]. The use of an antibiotic powder before skin closure reduced SSI [6]. To decrease the SSI rate, wound irrigation utilizing various materials are performed. Povidone-iodine (PI) irrigation during spinal surgery significantly reduced the SSI rate compared to saline irrigation [7]. In abdominal surgery, subcutaneous wound irrigation with 0.04% polyhexanide solution significantly reduced SSI [8]. Moreover, 0.05% chlorhexidine gluconate irrigation reduced SSI after loop ileostomy closure [9]. However, there is lack of studies about the relationship between wound irrigation and SSI in acute appendicitis.

This study focused on the effect of wound irrigation before skin closure in the multicenter setting. We aimed to study the kind of irrigation solution that can influence the occurrence of SSI during laparoscopic appendectomy in acute appendicitis. In addition, we attempted to determine the risk factors related to SSI after laparoscopic appendectomy.

Methods

Patients

We included patients who had undergone laparoscopic appendectomy due to acute appendicitis from March 2017 to October 2019 from three hospitals. All patients were diagnosed with acute appendicitis by abdominopelvic computed tomography (APCT) scan. We excluded patients who needed open appendectomy or open conversion after laparoscopic approach owing to severe inflammation or adhesion during the operation. Patients under 18 years old were also excluded. To minimize the confounding effect derived from different types of skin preparation solution, only patients who underwent skin preparation with PI were included. Laparoscopic appendectomies were performed by four experienced colorectal surgeons. Finally, a total of 333 patients were included in the analysis.

We divided 333 patients into three groups according to the method of wound irrigation during laparoscopic appendectomy: no irrigation (n = 93), saline irrigation (n = 144), and PI (n = 96) groups (Fig. 1). The suturing technique was adopted according to the surgeon's discretion, i.e., stapler, vertical matrix suture with nylon, or subcuticular suture with absorbable materials. Absorbable sutures were used for approximation of the fascia, and the subcutaneous space was irrigated with saline or PI.

Clinical data were retrospectively collected, such as sex, age, American Society of Anesthesiologists (ASA) physical status classification [10], and body mass index (BMI). Preoperative laboratory findings were reviewed, including white blood cell (WBC) count ($\cdot 10^3/\mu L$) and hemoglobin (g/dL), albumin (g/dL), C-reactive protein (CRP) (mg/dL), and erythrocyte sedimentation rate (ESR) (mm/hr) levels. The presence of fever was defined as body temperature higher than 37.8°C. Both preoperative fever and postoperative fever were recorded. Operative data including operation time, presence of perforated appendicitis, the method of wound irrigation, wound closure, and umbilical skin incision were also collected.

SSIs were defined according to the criteria of the National Nosocomial Infection Surveillance System (NNIS) by the Centers for Disease Control and Prevention(CDC) [11, 12], which can be superficial, deep, and organ/space SSI. Superficial incisional SSI involves only the skin and subcutaneous tissue. Deep incisional SSI involves deep tissues, such as fascial and muscle layers, and organ/space SSI involves any part of the organs' anatomy and spaces that are incised, which were opened or manipulated during operation [13].

Waiver of informed consent was approved by the Institutional Review Boards (AJIRB-MED-MDB-20-030, NHIMC 2020-04-031, UC20RASI0043).

Statistical analysis

Categorical variables were analyzed using chi-square or Fisher's exact test. Continuous variables were analyzed using Student's t-test. Data were presented as number (%) or mean ± standard deviation. Univariate logistic regression analysis was done to identify risk factors associated with SSI. $P < 0.05$ was considered statistically significant. Statistical analysis was done using IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA).

Results

Patient characteristics and data related to the operation

The demographics of total 333 patients are listed in Table 1. There is no significant difference in sex, age, BMI, and the status of preoperative fever (> 37.8℃) between the groups when comparing according to the method of wound irrigation. However, the ASA score differed significantly and the ratio of ASA I was higher in the no irrigation group ($p < 0.001$). In the preoperative laboratory test, hemoglobin and total bilirubin levels were higher in the saline group than that in the other groups ($p < 0.001$, $p = 0.011$), and albumin level was significantly lower in the PI group ($p < 0.005$). Although the ratio of perforated appendicitis was higher in the PI group ($p < 0.001$), there was no significant difference in the preoperative fever (> 37.8℃) ($p = 0.539$), preoperative WBC count ($p = 0.921$), and CRP levels ($p = 0.488$) among the groups. In the method of wound closure, most patients in the no irrigation and PI groups underwent skin closure using a stapler or nylon, while patients in the saline group underwent subcuticular suture ($p < 0.001$). The umbilical skin incision was performed differently, and supraumbilical incision was a substantial portion of the methods in the no irrigation and PI groups ($p < 0.001$) (Table 2).

Table 1
Demographics of all laparoscopic appendectomy patients

	n = 333
Sex	
Male	172 (51.7%)
Female	161 (48.3%)
Age (years)	44.58 ± 17.38
ASA	
1	192 (57.7%)
2	118 (35.4%)
3	22 (6.6%)
4	1 (0.3%)
BMI (kg/m^2) (n = 328)	23.57 ± 3.47
WBC(x10^3/μl)	12.61 ± 4.21
Hemoglobin (g/dl)	13.90 ± 1.92
Albumin (g/dl) (n = 321)	4.44 ± 0.46
Total bilirubin (mg/dl)	0.91 ± 0.50
CRP (mg/dl) (n = 326)	3.84 ± 8.05
ESR (mm/hr) (n = 176)	24.52 ± 24.99
Operation time (minute)	39.69 ± 18.64
Perforated appendicitis, yes	93 (27.9%)
Wound irrigation	
None	93 (27.9%)
Saline	144 (43.2%)
Povidone-iodine (PI)	96 (28.8%)
Wound closure method	
Nylon or stapler	219 (65.8%)
Subcuticular suture	114 (34.2%)
Umbilical skin incision	

	n = 333
Supraumbilical incision	178 (53.5%)
Transumbilical incision	71 (21.3%)
Infraumbilicial incision	24 (7.2%)
Lateral incision	60 (18.0%)

Table 2
Clinical features of patients according to method of irrigation

	No irrigation (n = 93)	Saline irrigation (n = 144)	PI irrigation (n = 96)	*P* value
Sex				0.108
Male	50 (53.8%)	81 (56.2%)	41 (42.7%)	
Female	43 (46.2%)	63 (43.8%)	55 (57.3%)	
Age (years)	42.1 ± 15.0	45.8 ± 18.8	45.1 ± 17.2	0.248
ASA				< 0.001
1	75 (80.6%)	82 (56.9%)	35 (36.5%)	
2	16 (17.2%)	59 (41.0%)	43 (44.8%)	
3	2 (2.2%)	3 (2.1%)	17 (17.7%)	
4	0 (0.0%)	0 (0.0%)	1 (1.0%)	
BMI (kg/m^2) (n = 328)	23.37 ± 3.27	23.89 ± 3.73	23.26 ± 3.23	0.322
WBC($x10^3/\mu l$)	12.70 ± 3.47	12.50 ± 4.47	12.68 ± 4.48	0.921
Hemoglobin (g/dl)	13.42 ± 2.34	14.35 ± 1.62	13.68 ± 1.76	< 0.001
Albumin (g/dl) (n = 321)	4.55 ± 0.39	4.42 ± 0.40	4.33 ± 0.60	0.005
Total bilirubin (mg/dl)	0.81 ± 0.47	1.00 ± 0.52	0.88 ± 0.46	0.011
CRP (mg/dl) (n = 326)	3.21 ± 5.19	4.18 ± 6.11	3.92 ± 6.70	0.488
Operation time (minute)	40.90 ± 16.31	43.27 ± 17.90	33.15 ± 20.24	< 0.001
Perforated appendicitis, yes	21 (22.6%)	29 (20.1%)	43 (44.8%)	< 0.001
Wound closure method				< 0.001
Nylon or stapler	90 (96.8%)	34 (23.6%)	95 (99.0%)	
Subcuticular suture	3 (3.2%)	110 (76.4%)	1 (1.0%)	
Umbilical skin incision				< 0.001
Supraumbilical incision	68 (73.1%)	15 (10.4%)	95 (99.0%)	
Transumbilical incision	1 (1.1%)	69 (47.9%)	1 (1.0%)	
Infraumbilicial incision	24 (25.8%)	0 (0.0%)	0 (0.0%)	
Lateral incision	0 (0.0%)	60 (41.7%)	0 (0.0%)	

	No irrigation (n = 93)	Saline irrigation (n = 144)	PI irrigation (n = 96)	*P* value
Preoperative fever (> 37.8°C), yes	10 (10.8%)	13 (9.0%)	6 (6.2%)	0.539
Postoperative fever (> 37.8°C), yes	2 (2.2%)	41 (28.5%)	36 (37.5%)	< 0.001
Surgical site infection	4 (4.3%)	10 (5.1%)	4 (4.5%)	0.953

Surgical site infection

A total of 15 patients (4.5%) were diagnosed with SSI within postoperative 30 days. In the no irrigation group, few patients showed postoperative fever (≥ 37.8°C) than that in the other groups ($p < 0.001$) (Table 2). However, there was no difference in the SSI ratio (4.3% vs. 5.1% vs. 4.5%, $p = 0.953$). No significant difference was observed in the status of preoperative fever ($p = 0.618$), operation time ($p = 0.951$), whether perforated appendicitis or not ($p = 0.215$), the method of wound closure ($p = 0.940$), umbilical skin incision ($p = 0.482$), and the method of wound irrigation ($p = 0.533$), as well as the ratio of postoperative fever ($p = 0.494$) (Table 3). In the univariate analysis, none of the factors was associated with SSI (Table 4).

Table 3
Clinical features of patients according to presence of surgical site infection

	No SSI (n = 318)	SSI (n = 15)	*P* value
Operation time (minute)	39.70 ± 18.74	39.40 ± 16.80	0.951
Perforated appendicitis, yes	87 (27.4%)	6 (40.0%)	0.215
Wound closure method			0.940
Nylon or stapler	209 (65.7%)	10 (66.7%)	
Subcuticular suture	109 (34.3%)	5 (33.3%)	
Umbilical skin incision			0.482
Supraumbilical incision	171 (53.8%)	7 (46.7%)	
Transumbilical incision	66 (20.8%)	5 (33.3%)	
Infraumbilicial incision	24 (7.5%)	0 (0.0%)	
Lateral incision	57 (17.9%)	3 (20.0%)	
Method of irrigation			0.533
None	89 (28.0%)	4 (36.7%)	
Saline	136 (42.8%)	8 (53.3%)	
Povidone-iodine (PI)	93 (29.2%)	3 (20.0%)	
Preoperative fever (> 37.8℃), yes	28 (8.8%)	1 (6.7%)	0.618
Postoperative fever (> 37.8℃), yes	75 (23.6%)	4 (26.7%)	0.494

Table 4
Univariate analysis for risk factor of surgical site infection after laparoscopic appendectomy

	OR (95% CI)	*P* value
Sex, female	1.56 (0.60–4.32)	0.365
Age (years)	1.01 (0.98–1.03)	0.618
ASA	0.96 (0.43–1.96)	0.917
WBC(x10^3/μl)	1.06 (0.95–1.18)	0.289
Hemoglobin (g/dl)	1.11 (0.85–1.48)	0.464
Operation time (minute)	1.00 (0.97–1.02)	0.993
Perforated appendicitis, yes	1.62 (0.58–4.21)	0.333
Wound closure method, subcuticular suture	1.07 (0.39–2.77)	0.895
Preoperative fever (> 37.8℃), yes	0.56 (0.03–2.82)	0.572
Postoperative fever (> 37.8℃), yes	1.58 (0.54–4.17)	0.375

Discussion

In this study, SSI occurred in 15 of 333 patients (4.5%). No deep SSI was observed among these patients. There was no difference in the SSI rate between groups according to the wound irrigation method. Previous researches on wound irrigation have been conducted to reduce SSI in surgery, not only appendectomy but also other surgeries. Various materials can be used for wound irrigation such as saline, PI, chlorhexidine gluconate, and topical antibiotics. Antiseptic irrigation at the surgical wound can decrease microbial burden and the need for systemic antibiotics [14]. One meta-analysis revealed that irrigation with any solution significantly decrease SSI than no irrigation [15]; however, no sufficient evidence is available for its acceptance as a standard procedure. Chlorhexidine irrigation in caesarean section did not significantly decrease SSI [16]. During spinal surgery, deep SSI was significantly reduced after surgery when irrigation was performed with PI at regular intervals during surgery [7]. Topical antibiotics are also applied to the surgical wound to reduce SSI. Topical antibiotics can kill bacteria that cause SSI more effectively than systemic antibiotics because the concentration of antibiotics at the wound is higher than systemic antibiotics [17]. Although there is no sufficient evidence that the application of topical antibiotics is beneficial, it is said to be beneficial in abdominal surgery in obese patients [18]. During pancreaticoduodenectomy, intraperitoneal irrigation with antibiotic solution did not significantly decrease infectious complications [19]. However, if it has been reported to be meaningful only in some studies, it is not generally accepted as a way to reduce SSI [20].

We attempted to find the risk factors for SSI by logistic regression analysis using previously known risk factors as variables for analysis. However, there was no significant risk factor. Diabetes mellitus and uncontrolled blood glucose are well-known risk factors of SSI [21]. Although the detailed underlying disease could not be known in this study, SSI incidence did not show a significant relationship with the ASA score in reflecting the patient's underlying disease and severity. Advanced age is also a known risk factor of SSI [22]. However, advanced age did not affect SSI in this study. Prolonged operation time can increase SSI, but not in this study.

In our study, wound irrigation was performed according to surgeon's preference, not for specific reasons. In other words, wound irrigation was done not because SSI is expected, but rather as a routine procedure. In this study, selection bias did not occur, which may happen if irrigation was performed considering that SSI was likely to arise. However, in this study, there was a small number of SSI because the SSI rate was low. Larger studies may show different results if the number of SSI cases increases. Due to the small sample size and the retrospective design, there may be some uncontrolled confounding factors. Laparoscopic appendectomy has already reduced the SSI rate by nearly twice that of open appendectomy. Since our study included only laparoscopic appendectomy, it is unclear if wound irrigation reduces SSI in this study.

To reduce SSI, various efforts can be made before, during, and after surgery. Various methods before and after surgery have been studied for reducing the SSI rate. Wound irrigation during surgery was considered to be one of the methods used to reduce SSI, and many studies were conducted in various surgeries. To reduce SSI in laparoscopic appendectomy, we tried wound irrigation in previous studies. However, in this study, it was not concluded that wound irrigation using PI and saline reduces SSI.

Conclusions

We tried to figure out the relation between wound irrigation and SSI according to previous known factors for SSI. We could not show any risk factor associated with SSI, and it was not related to wound irrigation. A large-scale retrospective study or a randomized controlled study is required to determine relevant factors and reduce SSI in the future.

Abbreviations

SSI
surgical site infection
PI
povidone-iodine

Declarations

Ethics approval and consent to participate

Waiver of informed consent was approved by the Institutional Review Boards (AJIRB-MED-MDB-20-030, NHIMC 2020-04-031, UC20RASI0043).

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to privacy but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Study conception and design, Soomin Nam, Youn Young Park, and Chinock Cheong; acquisition of data, Soomin Nam, Youn Young Park, Yun Tae Jung, and Chinock Cheong; analysis and interpretation of data, Soomin Nam, Youn Young Park, and Chinock Cheong; drafting the manuscript, Soomin Nam, Youn Young Park, and Chinock Cheong; and critical revision, Soomin Nam, Youn Young Park, and Chinock Cheong. The authors read and approved the final manuscript.

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Figures

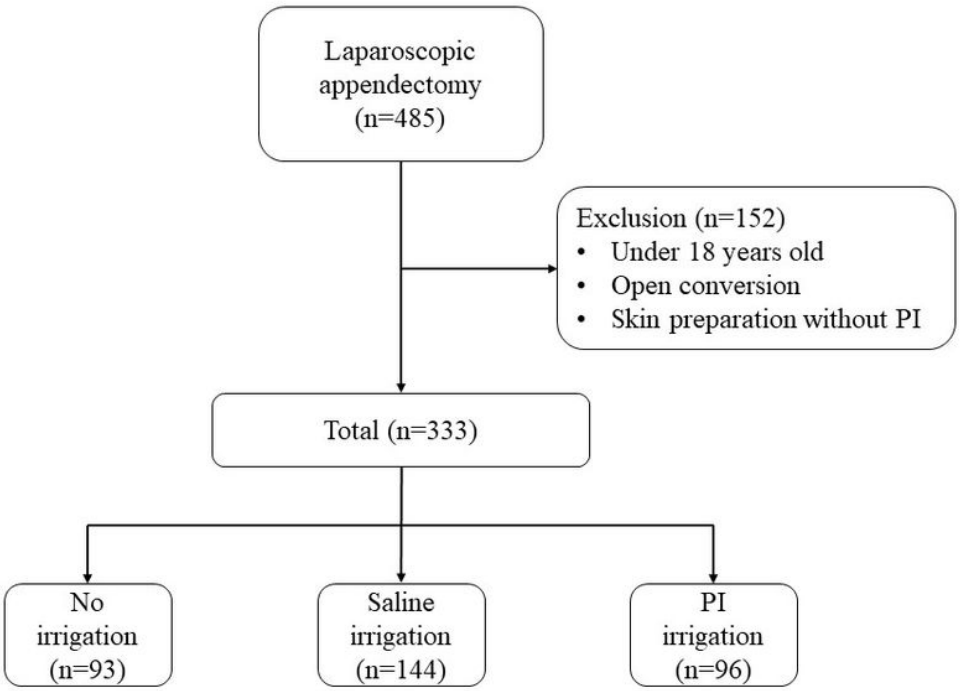

Figure 1

The flowchart of study subjects