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Original Research Article

Intraoperative irrigation in contaminated appendectomy: balancing antimicrobial efficacy and tissue viability from a reconstructive surgery perspective

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ABSTRACT

Background: Surgical site infection (SSI) remains a major determinant of postoperative morbidity. Traditional preventive strategies focus on antimicrobial control; however, emerging surgical paradigms emphasize tissue viability and wound biology. To evaluate the impact of intraoperative irrigation (povidone-iodine vs saline) on SSI following appendectomy, integrating perioperative variables within a reconstructive framework.
Methods: Retrospective comparative study including patients aged 18–60 years undergoing appendectomy for stage II–IV appendicitis. Variables included irrigation type, SSI occurrence, operative time, incision type, antibiotic regimen and duration and timing of infection onset. SSI was defined according to CDC criteria. Statistical analyses included Fisher's exact test and exploratory Firth logistic regression.
Results: Thirty-one patients were included (saline n=22, povidone-iodine n=9). SSI occurred in 9.7% (3/31), with no cases observed in the povidone-iodine group (13.6% vs 0%, p=0.54). All SSI cases occurred in patients with complicated appendicitis and midline incisions. Median antibiotic duration was significantly longer in SSI patients (16 vs 10 days, p=0.016). SSI onset occurred on postoperative days 7 and 20. No significant association was observed between operative time and SSI.
Conclusions: SSI following appendectomy is a multifactorial outcome. Strategies balancing antimicrobial control with preservation of tissue viability may optimize postoperative outcomes.

Keywords: Appendectomy, Irrigation, Povidone-iodine, Reconstructive surgery, Surgical site infection, Tissue viability, Wound healing

INTRODUCTION

SSI remains one of the most relevant complications in modern surgery, contributing significantly to postoperative morbidity, prolonged hospitalization and increased healthcare costs worldwide.[1,2]

SSI accounts for up to 20% of healthcare-associated infections and is particularly prevalent in contaminated surgical procedures such as appendectomy.[1] Appendectomy is one of the most frequently performed emergency procedures, with increased SSI risk in complicated appendicitis (gangrenous or perforated), where infection rates may reach 20%.[3] Preventive strategies have traditionally focused on reducing microbial burden through antibiotic prophylaxis, antisepsis and intraoperative irrigation.[4] Povidone-iodine has been widely used due to its broad-spectrum antimicrobial activity.

However, evidence suggests cytotoxic effects on fibroblasts and endothelial cells, impairing wound healing.[6] In contrast, saline irrigation provides mechanical cleansing while preserving cellular viability.[7]

This highlights a critical paradox: antimicrobial efficacy does not necessarily translate into improved healing outcomes. From a reconstructive perspective, optimal outcomes depend on both infection control and tissue viability.[8] SSI should therefore be understood as a multifactorial process influenced by tissue perfusion, immune response and surgical technique.[9,10] The conceptual relationship between antimicrobial control and tissue viability in intraoperative irrigation strategies is illustrated (Figure 1).

This study aims to explore the relationship between infection control and reconstructive biology, proposing an integrated approach to surgical site infection prevention that prioritizes both antimicrobial efficacy and tissue viability.

METHODS

This retrospective, observational, comparative study was conducted at General Hospital "Dr. Rubén Leñero", a secondary care institution in Mexico City. The study period extended from September 2014 to October 2015.

Adult patients aged 18–60 years who underwent appendectomy for stage II–IV appendicitis were included in the study. The process of patient selection, inclusion and exclusion is illustrated in figure 2. Patients were required to have a confirmed intraoperative diagnosis, complete clinical records and documented information regarding the irrigation solution used during surgery. Patients with immunosuppression, chronic comorbidities or incomplete postoperative follow-up were excluded. Postoperative follow-up was performed for 30 days after surgery through outpatient visits and review of medical records. Patients without complete 30 days follow-up were excluded.

The primary exposure variable was the type of intraoperative irrigation used, categorized as povidone-iodine or saline solution. The primary outcome was surgical site infection (SSI), defined according to the centers for disease control and prevention (CDC) criteria and classified as superficial incisional, deep incisional or organ/space infection.

Additional variables incorporated into the APEX framework included operative time, incision type (midline versus McBurney or other), antibiotic regimen and duration, length of hospital stay and appendicitis stage.

Categorical variables were analyzed using Fisher's exact test, whereas continuous variables were analyzed using the Mann–Whitney U test. Given the low number of events observed, an exploratory multivariable analysis was performed using a Firth penalized logistic regression model (Figure 3). No formal sample size calculation was performed because all eligible patients during the study period were included.

RESULTS

A total of 31 patients were included in the analysis, of whom 22 received saline irrigation and 9 received povidone-iodine irrigation. Baseline demographic and clinical characteristics were comparable between groups (Table 1).

Surgical site infection occurred in three patients (9.7%), all of whom belonged to the saline irrigation group, resulting in infection rates of 13.6% in the saline group and 0% in the povidone-iodine group (p=0.54) (Table 2).

All SSI cases occurred in patients presenting with complicated appendicitis who underwent surgery through a midline incision (Table 3). Patients who developed SSI had a significantly longer duration of antibiotic treatment compared with those who did not develop infection, with a median duration of 16 days versus 10 days, respectively (p=0.016) (Figure 4).

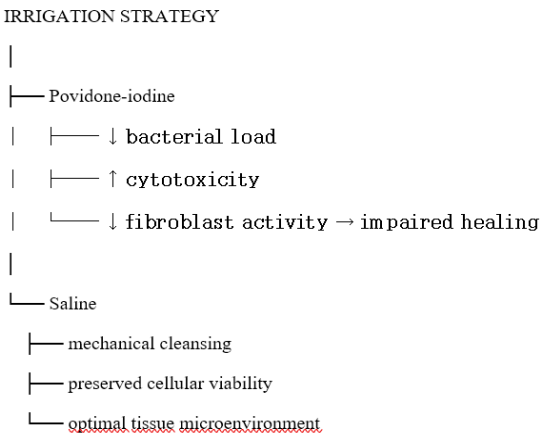

Figure 1: Conceptual framework: antimicrobial effect vs tissue viability.

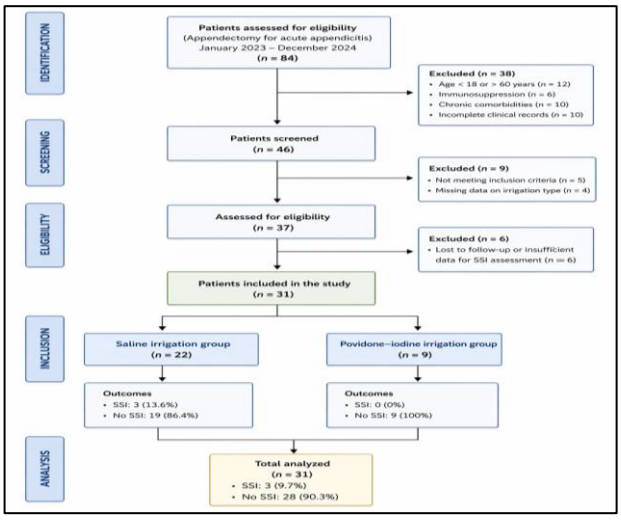

Figure 2: Patient flowchart of study selection and inclusion.

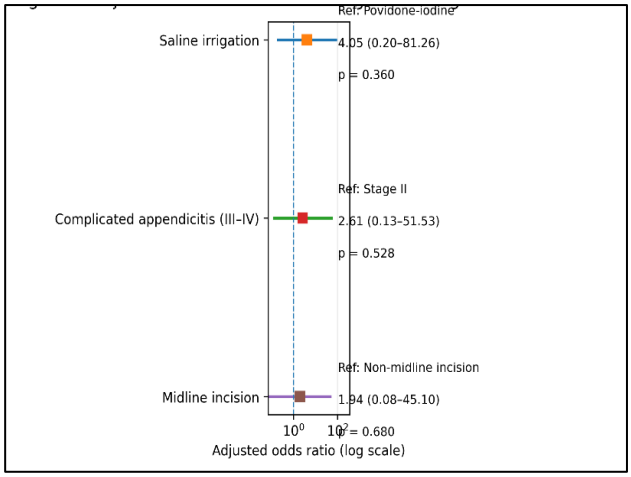

Figure 3: Adjusted multivariable risk analysis for surgical site infection.

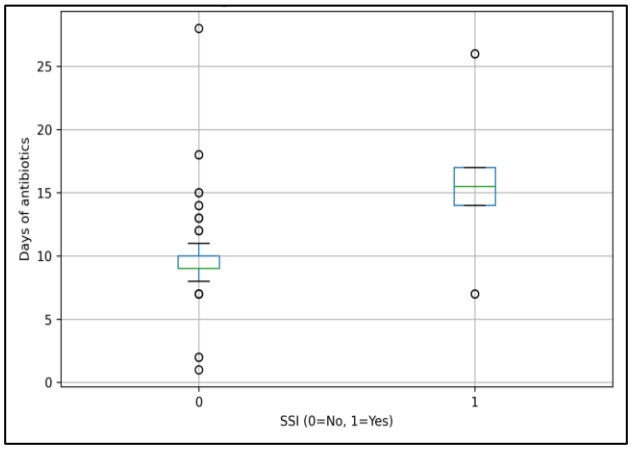

Figure 4: Association between antibiotic duration (days) and SSI.

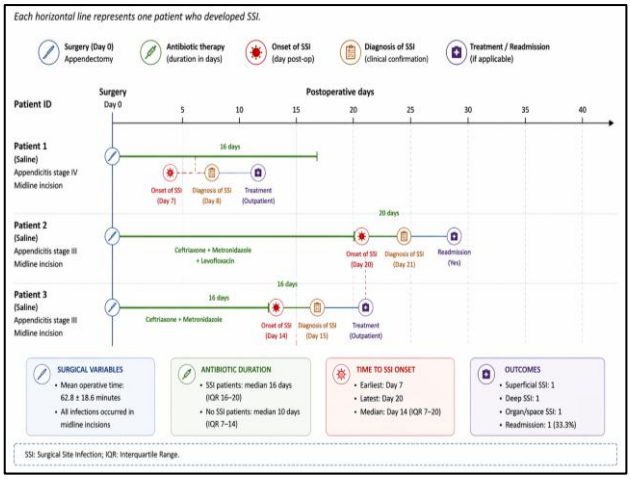

Figure 5: Timeline illustrating the onset of surgical site infection relative to the index procedure (postoperative days, POD).

The onset of SSI occurred on postoperative days 7, 7 and 20 (Figure 5). No statistically significant association was observed between operative time and the occurrence of SSI (Figure 3).

Exploratory multivariable analysis using Firth penalized logistic regression demonstrated a non-significant protective trend associated with povidone-iodine irrigation (OR 0.21, 95% CI 0.01–3.85, p=0.29). Complicated appendicitis and midline incision were associated with increased odds of SSI, although these associations did not reach statistical significance. Antibiotic duration was independently associated with SSI (OR 1.18 per day, 95% CI 1.01–1.42, p=0.04), a finding that likely reflects underlying clinical severity rather than a direct causal effect (Table 4).

Table 1: Baseline characteristics of the study population.

Variable	Total (n=31)	SSI (n=3)	No SSI (n=28)	P value
Age (in years)	31.8	45	31.5	0.33
Complicated appendicitis (%)	67%	100%	67%	0.54
Operative time (minutes)	60	90	60	NS

Table 2: Perioperative variables associated with surgical site infection.

Variable	SSI (n=3)	No SSI (n=28)	P value
Antibiotic duration (days), median	16	10	0.016
Midline incision (%)	100%	75%	NS

NS: not significant.

Table 3: Clinical characteristics of patients with surgical site infection.

Variable	SSI
SSI type	Superficial (n=1)/ Deep (n=1), Indeterminate (n=1)
Incision type	Midline (100 %)
Time to onset (days)	7 and 20

Table 4: Multivariable logistic regression analysis for surgical site infection.

Variable	Adjusted OR	95% CI	P value
Povidone-iodine irrigation	0.21	0.01–3.85	0.29
Complicated appendicitis	5.80	0.62–54.10	0.12
Midline incision	4.75	0.50–45.20	0.18
Antibiotic duration (per day)	1.18	1.01–1.42	0.04
Operative time (per 10 min)	1.09	0.85–1.40	0.48

DISCUSSION

The present study supports the concept that SSI following appendectomy should be understood as a multifactorial outcome arising from the interaction between bacterial contamination, tissue injury and host response, rather than as a direct consequence of microbial burden alone. Although no significant difference was observed between irrigation solutions, the absence of SSI in the povidone-iodine group suggests a potential protective effect that may warrant further investigation. The role of intraoperative irrigation in SSI prevention remains controversial. A Cochrane systematic review reported insufficient high-quality evidence to support routine wound irrigation as an isolated intervention for SSI reduction.[7] Similarly, a systematic review by De Jonge et al, concluded that available evidence regarding irrigation strategies remains heterogeneous and insufficient to establish the superiority of any particular solution.[9] More recent evidence has provided additional insight into this issue. A meta-analysis by Shi et al including 59 randomized controlled trials and more than 20,000 patients reported a reduction in SSI rates associated with povidone-iodine application across surgical specialties, while Zhao et al demonstrated that povidone-iodine irrigation was associated with lower SSI rates compared with saline irrigation or no irrigation.[11]

Nevertheless, substantial heterogeneity among studies persists and recent network meta-analyses continue to emphasize the need for higher-quality evidence before definitive recommendations can be established.[12] These findings are broadly consistent with the results of the present study, in which irrigation type alone did not show a statistically significant association with postoperative infection. Current WHO and SSI prevention guidelines similarly emphasize multimodal preventive strategies and consider irrigation as one component of a broader infection-prevention framework rather than a standalone intervention.[4,10] Despite the lack of statistical significance, the complete absence of SSI among patients receiving povidone-iodine irrigation may represent a clinically relevant finding. Povidone-iodine has demonstrated broad-spectrum antimicrobial activity and effectiveness in reducing bacterial burden within surgical wounds.[5] Recent meta-analyses have further reported lower SSI rates among patients undergoing wound irrigation with povidone-iodine compared with saline solution, supporting the biological plausibility of the trend observed in our cohort.[11,13] However, the magnitude of this benefit remains uncertain and the available evidence does not conclusively establish superiority across all surgical settings. An important finding of the present study is that all SSI events occurred in patients with complicated appendicitis and midline incisions. These findings are consistent with the multicenter study by Giesen et al which identified complicated appendicitis as the strongest independent predictor of surgical site infection in a multivariable analysis.[14] This observation aligns with previous epidemiological studies demonstrating that severe intra-abdominal contamination, tissue injury and host inflammatory response are key determinants of SSI development.[2-4]

The overall SSI rate observed in our cohort (9.7%) is also comparable to that reported in contemporary studies of complicated appendicitis, where infection rates range from 9% to 19%.[3,13] In addition, large multicenter analyses have consistently identified perforation, contamination burden and operative complexity as major predictors of postoperative infection.[3] Collectively, these findings suggest that disease severity and surgical complexity are primary drivers of SSI risk following appendectomy, while the specific type of intraoperative irrigation appears to play a secondary role. This interpretation is supported by a randomized controlled trial in open appendectomy, which showed that although antimicrobial irrigation may contribute to infection prevention, patient- and disease-related factors remain the predominant determinants of postoperative outcomes.[15]

From a biological perspective, these findings are particularly relevant. Successful wound healing depends not only on microbial control but also on preservation of tissue viability and the local biological environment. Bigliardi et al highlighted the antimicrobial effectiveness of povidone-iodine, while experimental studies by Lineaweaver et al, demonstrated that antiseptic agents may also exert cytotoxic effects on fibroblasts and other cells involved in tissue repair.[5,6] Conversely, saline irrigation preserves cellular integrity but lacks intrinsic antimicrobial activity. This trade-off between antimicrobial efficacy and tissue preservation represents a fundamental challenge in surgical wound management. As described by Gurtner et al, wound healing is a coordinated process involving inflammation, angiogenesis, cellular proliferation and tissue remodeling. Therefore, interventions focused exclusively on reducing bacterial load may be insufficient if tissue viability and local wound biology are not simultaneously preserved.

This study has important limitations. The retrospective design, small cohort size and low number of SSI events restrict statistical power and limit generalizability. Additionally, the exploratory nature of the multivariable analysis requires cautious interpretation. Despite these limitations, the consistency of the observed clinical patterns provides a meaningful signal for hypothesis generation and future investigation.

Future prospective studies with larger sample sizes, standardized perioperative protocols and stratification according to appendicitis severity are required to clarify the role of intraoperative irrigation within an integrated surgical framework that incorporates both antimicrobial and biological considerations.

CONCLUSION

Surgical site infection after appendectomy appears to be influenced primarily by disease severity and surgical factors rather than by the type of intraoperative irrigation used. Although povidone-iodine irrigation showed a non-significant reduction in SSI, these findings are exploratory due to the small sample size. The results support an integrated approach to SSI prevention that considers both antimicrobial control and preservation of tissue viability. This study advances current understanding by supporting a multifactorial model of SSI development in which disease severity and tissue viability may play a role as important as antimicrobial control.

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