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A Systematic Review Comparing Intraoperative Wound Irrigation with Aqueous Povidone Iodine Solution to Normal Saline in Reducing Surgical Site Infections

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ABSTRACT

Introduction: Surgical site infections (SSIs) remain a significant challenge in patients undergoing various operations. It is one of the most common healthcare associated infections that lead to increased morbidity, mortality, and longer hospital stays. Surgical wound irrigation is one of the common measures used intraoperatively to prevent surgical site infections. Adopting the right method of irrigation provides maximum benefit without damaging the healthy body tissue. The differences observed in surgical wound irrigation practice in various health settings indicate the absence of the standard protocol or guideline in irrigation practice.

Objective: To conduct a systematic review and meta-analyses to identify, evaluate and synthesize the results of individual study comparing povidone-iodine and normal saline surgical wound irrigation practices in reducing surgical site infections.

Method: A systematic search was conducted in PubMed, Embase, Cochrane library and Google scholar. Studies comparing the effect of normal saline and povidone-iodine surgical irrigation in reducing surgical site infections were included. Cochrane risk-of bias tool and Newcastle-Ottawa Scale were used for the quality assessment. A forest plot was used to summarise the results from the meta-analysis. Heterogeneity among studies was measured by the $I2$ statistic.

Results: Total of nine studies were included in the systematic review. Forest plot analysis identified reduced infection rate in the povidone-iodine irrigation compared to normal saline wash. But the differences identified in the infection rate was not significant enough to confirm the effectiveness of one irrigation method. The clinical and methodological heterogeneity of the studies downgraded the level of evidence that resulted in inconsistent findings in the meta-analysis.

Conclusion: More randomised studies comparing the two methods of normal saline and povidone-iodine surgical irrigation are recommended for better quality evidence and conclusive findings. Systematic reviews including high quality studies are required to identify the safe and efficient practice in surgical irrigation.

Introduction

Surgical site infections are considered a complex health problem due to its impact on patients and hospitals. SSIs accounts for 31% of all healthcare-associated infections among hospitalised patients and specifically up to 16% of all nosocomial infections (Palumbo, et al. [1,2]). According to a World Health Organisation (WHO) report, the rate of SSI is 11.8 per 100 surgical patients and 5.6 per 100 surgical procedures (World Health Organisation, et al. [2,3]). Despite the significant advances in infection prevention practices, hospital associated infection is ranked as the fifth leading cause of death resulting in huge economic burden on the health care system. Identifying the risk factors and developing practice guidelines and recommendations are important to tackle the issue and prevent the complications. Studies focusing on surgical irrigation practices are encouraged to develop standardised guidance and recommendations on surgical wound irrigation. The impact of SSIs on patients includes incisional pain, delayed healing, longer hospitalisation, potential development of incisional hernia, adverse long-term complications including a decrease in patient quality of life (Papadakis, et al. [4,5]).

The highest rate of SSI is reported in colorectal surgeries with the potential contaminated nature of the surgery. Different factors that are patient-related, environmental and surgical contribute to the development of surgical site infections (Gillespie, et al. [5,6]). Lower rate of SSIs was reported in laparoscopic surgeries when compared to open surgical procedures (Papadakis, et al. [4,5]). SSIs result in serious complications in patients undergoing oncological surgeries causing increased mortality and morbidity rates (Ambe, et al. [4,7,8]). The infections adversely affect the surgical outcomes and long-term survival rates of oncology patients undergoing surgeries (Abboud, et al. [4,9]). Patients with diabetes are at significantly higher risk of developing SSIs (Ling, et al. [9,10]).

Wound irrigation is a simple measure to remove microbes from the surgical site by washing out the debris, waste, and tissue exudate before wound closure. Different types of irrigants are used for the process as per surgical preferences (Gillespie, et al. [6,11]).

The most commonly used irrigation solution is normal saline. (Ling, et al. [4,9]). Iodine is the traditional method used in the prevention and treatment of wound infection (Ambe, et al. [4,7]). Chlorhexidine gluconate is another antiseptic solution used in surgical wound irrigation. Hydrogen peroxide and antibiotics are also used in different combinations with normal saline or povidone-iodine for the surgical wound irrigation (Ambe, et al., [4,7,8]). Despite the popularity of surgical wound irrigation as a preventive intraoperative measure, no standard protocol has been followed in implementation of the practice (Gillespie, et al. [4,6]). Wound irrigation is still considered as an optional measure and practice varies in different specialities. Lack of research and convincing results about the relevance of wound irrigation hinder the utilisation of this practice as a standard preventive measure (Gillespie, et al. [2,6,10]). This study aims to understand the importance of intraoperative wound irrigation in reducing the incidence of surgical site infections by comparing the two most commonly used methods of normal saline and povidone-iodine wound irrigation.

Aim and Research Question

The aim of this review is to understand the significance of surgical wound irrigation practices in reducing surgical site infections and to identify the best practice in surgical wound irrigation by comparing the two commonly used methods of povidone-iodine and normal saline wound irrigation, addressing the following research question. In intraoperative patients, is povidone-iodine wound irrigation more effective than normal saline irrigation in reducing surgical site infections?

Methods

Design

A systematic review and meta-analysis were undertaken adheres to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) protocols. The systematic review was registered in the PROSPERO database (CRD42023404930).

Inclusion Criteria

The systematic review included original research studies comparing the effect of aqueous povidone iodine and normal saline wound irrigation in reducing the incidence of SSIs in patients undergoing surgery. Studies published in English or other languages with English translation were considered with no restrictions on study design, sample size or surgical procedures.

Exclusion Criteria

Studies included multiple irrigation methods using different irrigant solutions are excluded from the review because of the inability to determine the comparative effect of normal saline and povidone-iodine irrigation.

Primary Outcome

The studies included in the systematic review assessed outcomes in diverse ways. Differences in outcome reporting identified in eligible studies resulted in exclusion of some studies from meta-analysis. Surgical site infection was the main outcome of the review. Many eligible studies had more than one outcome parameters. The only parameter that was considered in the systematic review was the infection rate.

Search Strategy

Different databases such as PubMed, Embase, Cochrane library and Google scholar were used to identify the studies. Manual search of additional studies was conducted by using the similar article option and by cross checking the references of included studies. A combination of key words and correlated words using terms surgical site infection, wound irrigation, saline irrigation, betadine, or aqueous povidone-iodine irrigation were used in the search strategy. Boolean operators were used as mentioned below 'wound irrigation' or 'surgical site infection' and 'saline irrigation' or 'normal saline irrigation' and betadine or 'aqueous povidone-iodine irrigation' or compare*.

Data Extraction

Data was extracted objectively and accurately with studies summarised in a format that facilitated data synthesis. The format followed was discussed and agreed with the reviewer. Following the same standardised format by the reviewers in data collection enhanced reliability of the process. Any discrepancies were communicated and resolved through discussion. A clear and comprehensive data extraction process was followed using the research question, inclusion and exclusion criteria. The standard information recorded from the studies include full article citation, study design, participant numbers, intervention, comparison and the results.

Quality Assessment

Risk of bias was evaluated for all included individual studies using the Cochrane's risk of bias appraisal tool. Various sources of bias included in the Cochrane's appraisal tool are biases during selection, performance, detection, attrition and reporting. Risk of bias of the two included retrospective studies was appraised using the Newcastle-Ottawa quality assessment scale. Selection, comparability and outcome were the three different domains assessed under the scale. Two reviewers individually assessed the risk of bias for all included studies of the systematic review. The selected studies were categorised into different levels of evidence based on the relevant checklists. Cochrane's tool categorised the studies as high, low and unclear risk of bias. Whereas the Newcastle Ottawa scale assessed the studies into good, fair or poor quality based on the scoring. Conflicting or unclear information was discussed with the reviewer and clarified.

Data Synthesis

The results from the relevant studies were extracted in relation to the review question using the PICO format. The descriptive details of the selected studies including the study design, participants, interventions, comparison and the outcome were considered in data extraction and synthesis. Eligible data was pooled for meta-analysis. The results were summarised into a meta-analysis of pooled odds ratios with 95% confidence intervals (95% Cis). A random effect model for pair-wise comparison were used due to clinical heterogeneity. The degree of statistical heterogeneity was investigated using a combination of methods which involved visual inspection of the $X2$and $I2$ statistics to examine the total variance across studies due to heterogeneity rather than chance. The percentage of total variations across studies caused by heterogeneity was examined and categorised as low (0%-40%), moderate (30%-60%), high (50%-90%), or very high (75%-100%). In cases of high heterogeneity, a random effect model was used and if otherwise, a fixed model was applied. All statistical analyses were performed using Review Manager (RevMan, version 5.3) which is the software used for preparing and maintaining systematic reviews.

Results

Multiple databases were used to identify studies comparing the effect of normal saline and povidone-iodine surgical irrigation in reducing surgical site infections. CINAHL, Pubmed central, Cochrane and Google scholar were the databases used for the literature search. Search key words included ("surgical site infection" OR "surgical wound infection") AND ("saline" OR "normal saline") AND ("betadine" OR "povidone" OR "povidone-iodine") AND (compare*) AND ("surgical irrigation" OR "irrigation" OR "lavage"). The systematic searches retrieved a total of 250 studies that were discussing the effect of surgical irrigation in reducing surgical site infection. A total of 37 studies were identified from the CINAHL database. Highest number of 196 studies were retrieved from PubMed central. Cochrane identified 14 studies of the related type. In addition, another 3 studies discussing surgical irrigation were identified from the google scholar. The screening conducted at title and abstract level identified 157 eligible studies. The removal of duplicates excluded another 124 studies. The remaining 33 articles were assessed for eligibility using the full text content. Another 24 studies were excluded as they did not meet the inclusion criteria. After the screening and eligibility process, nine studies were identified comparing normal saline and povidone iodine irrigation in reducing surgical site infection. Differences in outcome measurement excluded two studies from meta-analysis. The lack of outcome data and variations in methods used in those two studies made it impossible to utilise the data for the meta-analysis. Finally, a total of seven eligible studies were included in the meta-analysis. The screening and the selection process were performed independently by the two reviewers (CPW, JF).

Study Characteristics

Nine studies that compared the effect of normal saline and povidone-iodine wound irrigation in reducing the surgical site infection during intra-operative period were included in the systematic review. Table 1 describes the characteristics of all included studies (Figure 1).

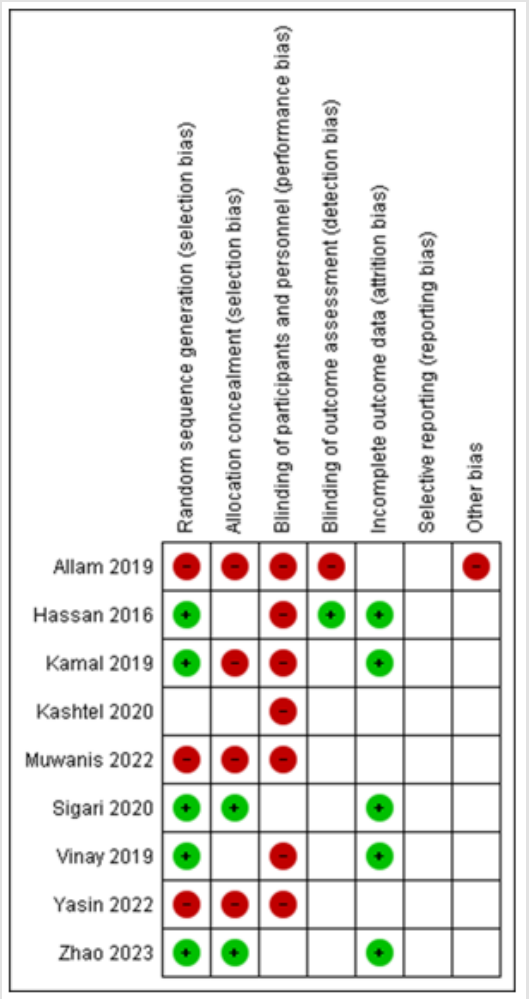

Figure 1: Risk of bias graph as a percentage of overall research articles.

Table 1: Characteristics of included studies.

Author, year, and country.	Setting	Sample size	Control	Intervention	Infection rate [n (%)]
(Allam, et al. [12]). Egypt	Patients underwent lumbar spine fusion surgeries	Control, n=90 Intervention, n=106	NS	PVI	Control-4 (4.4%) Intervention- 0(0%)
(Hassan, et al. [18]). Iraq	Patients undergoing appendicectomy	Control, n=50 Intervention, n=50	NS	PVI	Mean of the number of bacterial colonies before and after the wash. Control, before- 100.36, after-16.32 Intervention, before- 134.22, after-169.62
(Kamal et al, [15]). India	Patients undergoing laparotomy & laparoscopic procedures	Control, n=118 Intervention , n=118	NS	PVI	Control- 11(9.3%) Intervention- 14(11.8%)
(Kashtel et al, [17]). Iraq.	Patients undergoing appendicectomy	Control, n=58 Intervention , n=58	NS	PVI	Control-9 (15.5%) Intervention- 20 (34.4%)
Control-9 (15.5%) Intervention- 20 (34.4%)	Patients underwent total hip arthroplasty or total knee arthroplasty	Control, n=1511 Intervention , n=1207	NS	PVI	Control- 30(2%) Intervention- 10 (0.8%)

(Sigari, et al. [20]). Iran	Patients undergoing thoracic/lumbar spinal fusion surgery	Control, n=468 Intervention , n=468	NS	PVI	Control- 21(4.48%) Intervention- 5(1.1%)
(Vinay, et al, [16]). India	Patients undergoing laparotomy	Control, n=90 Intervention , n=90	NS	PVI	Control-7 (7.8%) Intervention- 9 (10%)
(Yasin, et al, [19]). Lahore, Pakistan.	Patients undergoing caesarean section	Control, n=100 Intervention , n=100	NS	PVI	Percentage mean after 30 days Control-3.10 Intervention- 2.10
(Zhao, et al, [14]). China	Patients undergoing gastrectomy	Control, n=167 Intervention , n=166	NS	PVI	PVI Control- 9(5.42%) Intervention- 11(6.59%)

Quality Assessment

Cochrane risk-of bias tool was used to assess the risk of bias in individual studies. The risk of bias summary of all included studies were shown in Figure 2. A low risk of attrition bias and a high risk of performance bias were the common identified trend in all the selected studies. As shown in Table 2 the Newcastle-Ottawa Scale was used to identify the quality of two retrospective studies of (Allam, et al. [12,13]).

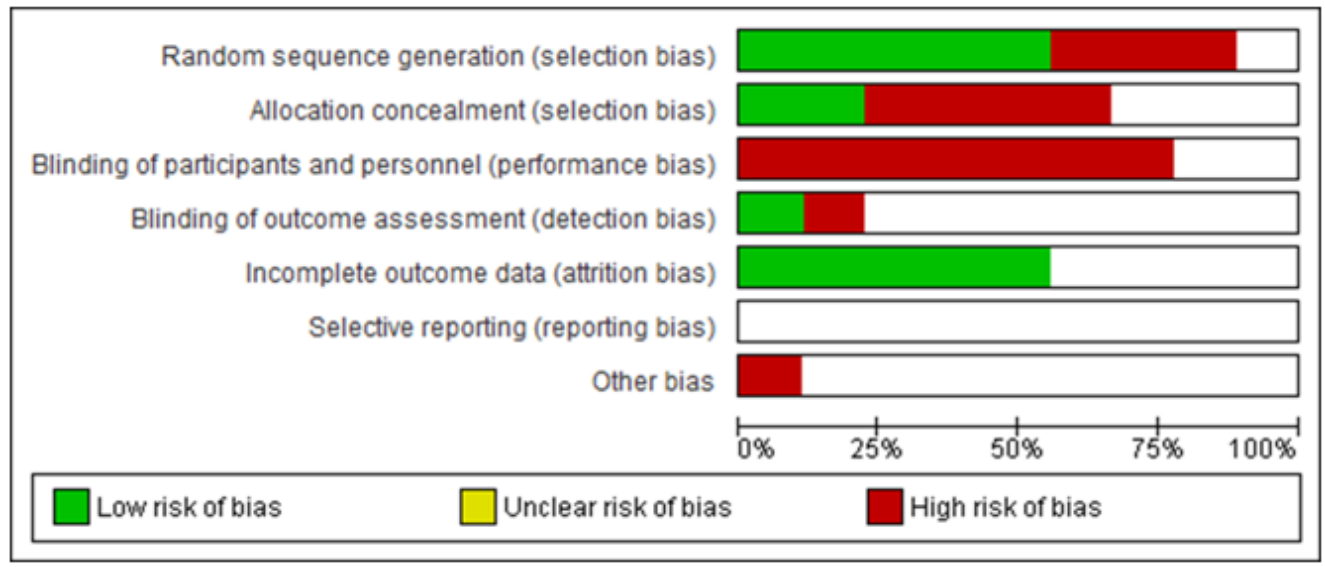

Figure 2: Risk of bias summary for each research article.

Table 2: Risk of bias summary for each research article.

Item	Authors		
		Allam et al, 2019	Muwanis et al, 2022
A	Selection		
	Representativeness of the exposed cohort	*	*
	Selection of the non- exposed cohort	*	*
	Ascertainment of exposure	*	*
	Demonstration that outcome of interest was not present at start of the study	*	*
B	Comparability		
	Comparability of cohorts on the basis of the design or analysis	*	*

C	Outcome		
	Assessment of outcome	*	*
	Was follow-up long enough for outcomes to occur	*	-
	Adequacy of follow up of cohorts	*	-
	Score	8	6
	Quality	Good	Fair

Outcome

A forest plot is used to summarise the results from the meta-analysis. As displayed in Figure 3 no significant difference was observed in the infection rate on comparing povidone- iodine and normal saline irrigation. Forest plot also displayed information about the heterogeneity among studies. All the data from the seven studies were used to create a single estimate which was represented by the diamond in the forest plot. The forest plot displayed a P value of 0.07 which concluded that there was no convincing evidence supporting any intervention. For the studies included in the meta-analysis, the infection rate ranged from 0%- 34.4% in the povidone-iodine irrigation group and 4.4%-15.5% in the normal saline group. There was considerable variation in the sample size of the individual studies. Participants of the included studies were undergoing different surgical procedures, including all genders within different age groups. The method of surgical irrigation, timing and the duration were also different across the studies. All the included studies used both normal saline and povidone-iodine surgical irrigation in the patients to estimate and compare its effect on the surgical site infection. The methods followed in estimating the infection rate also varied across the studies. All these factors contributed to the heterogeneity of the meta-analysis. The overall analysis concluded that there was no statistically significant difference in the infection rate in using povidone-iodine and normal saline irrigation.

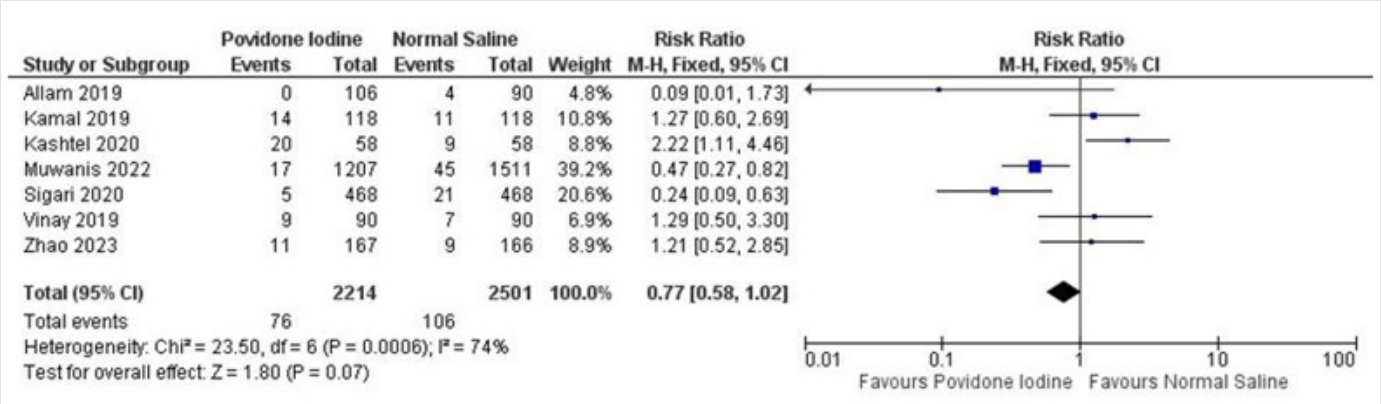

Figure 3: Forest plot for comparison of povidone-iodine versus normal saline irrigation for surgical site infection.

Discussion

This systematic review and meta-analysis were conducted to compare the effect of normal saline and povidone-iodine irrigation in reducing surgical site infections in patients undergoing various surgical procedures. No similar systematic reviews comparing normal saline and povidone-iodine surgical irrigation were identified. Normal saline and povidone- iodine are the two commonly used irrigation solutions during intra-operative period (Papadakis, et al. [4,14]). The review aimed to identify the most effective method among the two in reducing infections. In the study of (Zhao, et al. [14]) povidone-iodine and normal saline was used in incisional wound irrigation in patients undergoing gastrectomy. Study concluded that normal saline and povidone-iodine were equally effective surgical irrigation solutions in preventing SSI after gastric surgeries. Similar findings were reported in the studies of (Kamal, et al. [15,16]) conducted studies on patients undergoing elective laparotomy procedures that involved clean contaminated wounds of gastrointestinal tract. The study concluded that using 0.9% normal saline or 5% povidone-iodine in surgical wound irrigation made no difference in the SSI rate for patients undergoing laparotomy or laparoscopic procedures (Kamal, et al. [15]).

A similar study conducted by (Vinay, et al. [16]) on patients undergoing elective laparotomies over a period of three years reported no significant difference in the infection rate on comparing 5% povidone-iodine to 0.9% normal saline irrigation solution. The study by (Kashtel, et al. [17]) assessed the role of surgical irrigation in patients with perforated appendix undergoing appendicectomy surgery. The

study favoured normal saline irrigation as more effective than povidone-iodine with statistically significant results (Kashtel, et al. [17]). The study by Hassan et al. (2016) was also conducted among acute appendicitis patients for a period of one year. The study concluded significant reduction in the wound contamination when high pressure irrigation using normal saline was used compared to povidone-iodine soaking of the wound (Hassan, et al. [18]). The study by (Yasin, et al. [19]) conducted among caesarean section patients also favoured normal saline as the safe irrigation method due to minimal chances of skin irritation and toxicity (Yasin, et al. [19]).

A retrospective study by (Muwanis, et al. [13]) compared the effect of surgical irrigation methods in reducing peri-prosthetic infections. The statistically significant findings concluded betadine lavage as the effective method in reducing periprosthetic joint infections compared to normal saline irrigation (Muwanis et al., 2022). Another retrospective study by (Allam, et al. [12]) recommended povidone-iodine as the safe and effective choice of surgical irrigation method in lumbar fusion surgeries (Allam, et al. [12]). A similar study of (Sigari, et al. [20]) conducted among spinal fusion surgery patients reported povidone- iodine irrigation as an effective and safe method in preventing surgical site infections. The differences in the outcome measurement excluded a few studies from the meta- analysis. On analysing data from the different studies, povidone-iodine irrigation was identified as more effective than the normal saline irrigation. But the difference identified in the infection rate in comparing the two methods was not significant enough to completely favour povidone-iodine irrigation [21].

Povidone-iodine irrigation was found effective in preventing infections in orthopaedic surgeries and caesarean sections. A substantial amount of heterogeneity was identified in the included studies during meta- analysis. Variations were identified in both the methodological and clinical aspects of the studies. In the forest plot analysis, povidone-iodine irrigation was identified as more effective than normal saline irrigation in reducing infections. But the difference in infection rate was not significant enough to confirm povidone-iodine irrigation as best practice. The current literature on surgical irrigation comparing povidone-iodine and normal saline was not enough to demonstrate the ideal practice. More randomised control trails comparing different irrigation solutions are required to identify the safe and efficient practice to prevent surgical site infections.

Limitations

Studies included in the review were conducted during different surgical procedures. The method, administration and timing of surgical irrigation varied across the studies that had resulted in the heterogeneity. Differences in outcome measurement resulted in exclusion of some eligible studies from meta-analysis. Variations identified in the primary outcome of the included studies resulted in conflicting conclusions. The limited number of studies included in the meta-analysis and variations in the clinical and methodological approach resulted in inconsistency which affected the outcome analysis. The inconsistent findings of the systematic review and meta-analysis could not confirm any practice recommendations. Further studies are recommended to identify clinically meaningful recommendations regarding surgical irrigation practice.

Conclusion

To conclude, the impact of surgical site infection on patients and health care environment is discussed along with the importance of wound irrigation practice in reducing the infection rate. A systematic review and meta-analysis were conducted to evaluate the effect of surgical wound irrigation practice in reducing surgical site infections by comparing normal saline and povidone-iodine irrigation. Forest plot analysis identified reduced infection rate in the povidone-iodine irrigation compared to normal saline wash. But the differences identified in the infection rate was not significant enough to confirm the effectiveness of one irrigation method. The clinical and methodological heterogeneity of the studies downgraded the level of evidence that resulted in inconsistent findings in the meta-analysis. Systematic reviews including high quality studies are required to identify the safe and efficient practice in surgical irrigation. More consistent findings are required to confirm the significance of surgical irrigation in reducing post operative infections.

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