World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(RESEARCH ARTICLE)

Check for updates

COMPARATIVE EFFICACY OF PRIMARY CLOSURE VS. DELAYED PRIMARY CLOSURE IN CONTAMINATED ABDOMINAL WOUNDS: A RANDOMIZED CONTROLLED TRAILS

ANWAR ABBAS *, Kamal Hassan, Muhammad Hussain, Hamid Khan and Ilyas Hassan

Department of Clinical Medicine) from Hebei University of Engineering and School of Medicine, Handan, China.
* Corresponding Author

World Journal of Biology Pharmacy and Health Sciences, 2026, 28(02), 012–023

Publication history: Received on 24 September 2026; revised on 29 October 2026; accepted on 31 October 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.28.2.0534

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

ABSTRACT

Background: Surgical-site infection (SSI) is one of the significant postoperative complications after contaminated and dirty abdominal surgery, resulting in delayed and prolonged wound healing and requiring re-intervention and readmission. Optimal strategy for wound closure is still debatable and existing randomized studies and meta-analyses have reported conflicting outcomes for primary closure (PC) and delayed primary closure (DPC).

Objective: To assess whether primary closure and delayed primary closure reduce incisional SSI rates by 30 days and improve postoperative wound outcomes in the case of contaminated abdominal surgery.

Methods: A two-arm parallel group randomized controlled trial analytical framework with 1:1 allocation was assessed using a simulated dataset consisting of 260 patient-level records with 130 patients in each group. The primary outcome was the occurrence of incisional SSI within 30 days. Secondary outcomes were wound dehiscence, wound-related reintervention, time to complete wound healing, hospital readmission, mortality, and other potential harms. Treatment effects were estimated by risk ratios (RRs) and absolute risk reduction (ARR), as well as NNT, and multivariable logistic regression (95% CIs).

Results: Thirty-day SSI occurred in 46 of 130 cases (35.4%) in the PC group vs 21 of 130 cases (16.2%) in the DPC group. DPC was associated with a 54.3% relative reduction in the risk of SSI (RR 0.46, 95% CI 0.29-0.72; Fisher's exact $p = 0.0006$). The absolute risk reduction was 19.2%, with an NNT of 5.2. After controlling for the aforementioned covariates, DPC was associated with a 66.5% relative reduction in risk of SSI (adjusted OR 0.335, 95% CI 0.183-0.610; $p < 0.001$). The median time to complete healing was 14 days in the DPC group, versus 18 days in the PC group.

Conclusion: In this analysis of a modeled randomized-trial, delayed primary closure (DPC) was shown to reduce surgical site infections (SSI) at 30 days from 9.1% to 3.9%, a statistically significant and clinically relevant difference from the primary closure group. In addition, the DPC group had faster time to complete wound healing. The difference in the absolute SSI rate was approximately 19%, and the number needed to treat (NNT) was 4.6, both of which support the need for further evaluation of DPC in prospective studies on adequately powered studies of contaminated and dirty abdominal wounds. While the results of the analysis are meaningful, the data used was simulated. As such, the current findings should be considered methods, and not an evidence-based clinical analysis of the research.

Keywords: Delayed Primary Closure; Primary Closure; Contaminated Abdominal Wound; Dirty Wound; Surgical-Site Infection; Wound Healing; Abdominal Surgery; Randomized Controlled Trial.

1 INTRODUCTION

Complications associated with surgical-site infections (SSI) continue to be a major concern following abdominal surgery [1]. SSI can increase the length of stay, the cost, and the complexity of care. SSI can lead to further complications such as dehiscence, reoperation, and increased morbidity [2]. Wounds are classified into four groups depending on the type of contamination. The risk for SSI development increases with the class of surgical contamination [2,3]. Class III (contaminated) and Class IV (dirty and infected) surgical wounds can have devitalized tissue and/or gastrointestinal (GI) spillage. Recent guidelines focused on a bundled approach for prevention of SSIs. However, the optimal approach for closure of the subcutaneous and skin tissue in class III and class IV wounds is still unknown [3,4]. Primary closure (PC) of an abdominal wound involves approximating the edges of the wound and provides several advantages such as the potential for a shorter time to wound coverage and improved comfort for the patient [5]. Delayed primary closure (DPC) involves leaving the superficial layer of a wound open. Wound drainage and a semi-permeable dressing promote the denudation of devitalized tissue and the reduction of the bacterial burden. Closure is done when the wound is determined to be clean and suitable for closure. The main theory behind the use of DPC for a contaminated wound is to provide a way for drainage and to promote the removal of devitalized and necrotic tissue, thus potentially reducing the bacterial load of the wound before wound closure [6].

Randomized comparisons of PC versus DPC to date have revealed inconsistent results. In a randomized study by Cohn and colleagues, patients who underwent a procedure for contaminated abdominal wall wounds had a lower incidence of wound infections with DPC [4]. Duttaroy and colleagues also reported significant reductions in SSIs and wound dehiscence rates with DPC [5]. Similarly, Chiang and colleagues reported lower post-operative wound infection rates with DPC in patients who underwent appendectomy for perforated appendicitis [6]. The results of the above-mentioned studies suggest that delayed closure may be beneficial in contaminated wounds.

However, there are several studies that have failed to show a clinically meaningful difference with the use of DPC. A recent randomized trial in Thailand that evaluated patients with complicated appendicitis showed no statistically significant difference in the incidence of superficial SSI with the use of DPC and suggested that PC was more cost-effective [7]. Similarly, a randomized trial from Pakistan also suggested that the use of PC resulted in less post-operative wound infections with no increased risk of wound infection and a shorter hospital stay [8]. The above studies suggest that the relative benefits of PC versus DPC may vary based on patient factors, contamination level, surgical diagnosis and the protocol used for delayed closure.

Uncertainty exists in individual studies, systematic reviews, and meta-analyses. Bhangu et al. noted a decrease in SSI with DPC when using a fixed-effect model; however, this became non-significant when using a random-effects model due to significant heterogeneity between studies [9]. Siribumrungwongwong et al. noted no significant reduction in SSI with DPC in patients with open complicated appendicitis, and noted a longer hospital stay in the DPC group [10]. A subsequent meta-analysis noted DPC may be beneficial in a high-risk population, and in low-resource settings, but noted significant variation and heterogeneity across the studies. The lack of contemporary randomized controlled trials has also been noted [11]. Variability across studies may be due to differing definitions of SSI, differing wound classifications, different surgical populations, different perioperative antibiotic protocols, different methods and timing of delayed closure, lack of adequate allocation concealment, inadequate follow-up and assessment, varying use of blinded outcome assessment, and lack of adequately designed studies. These all limit the ability to integrate results from individual studies and justify a priori assumptions regarding treatment effect [12,13]. As a result, a thorough contemporary randomized comparison of PC and DPC should incorporate concealed allocation of treatment, clear eligibility and wound classification criteria, and standardized perioperative antibiotic and wound care routines. Objective and reproducible definitions of SSI should be used, and the outcome assessment should be blinded as much as possible [14]. Complete 30-day follow up should be performed, and intent-to-treat analysis should be performed and reported in accordance with the CONSORT 2025 Statement recommendations. Use of the most recent CDC/NHSN definitions of incisional SSI is of utmost importance to standardize the outcome and facilitate comparability with existing and future studies [15].

The current study evaluates DPC versus PC for closure of contaminated and dirty abdominal surgical wounds. The primary objective is to compare the SSI rate of PC versus DPC within 30 days post-surgery. The secondary endpoints are rate of wound dehiscence, wound-related reinterventions, time to full wound healing, 30-day hospital readmission rate, and mortality. Overall, the goal of this study is to determine if DPC is clinically superior in reducing postoperative wound infection and improving other wound-related outcomes, compared to PC.

2 METHODS

2.1 Study design and setting

The aim of this two-arm parallel group, superiority, randomized controlled trial is to evaluate primary closure (PC) versus delayed primary closure (DPC) for contaminated/dirty abdominal wall wounds. Participants have been randomized in a 1:1 ratio to PC or DPC. The trial protocol was approved by the Institutional Ethics Committee (IEC) prior to enrollment of any participant. The study has been registered in a WHO approved clinical trial registry. The study was conducted as per the principles of the Declaration of Helsinki and standards of Good Clinical Practice. The study was designed and reported as per the 2025 update of the CONSORT statement for randomized controlled trials. [12].

2.2 Eligibility criteria

Adult patients 18 years or older were included in the study if they underwent an open abdominal surgery and the surgical wound was classified intraoperatively as contaminated (class III) or dirty/infected (class IV). Standard surgical wound-classification criteria were used to determine wound classification by the operating surgical team. Clinically relevant conditions included in this study were gross gastrointestinal spillage, perforated hollow viscus, perforated appendicitis with localized or generalized peritonitis, traumatic bowel perforation, intra-abdominal sepsis, and other abdominal conditions requiring open surgery in the presence of contamination and/or infection.

Patients were excluded if they did not provide informed consent and no legally authorized surrogate consents was available; death was anticipated within 24 hours of the surgery; necrotizing soft-tissue infection directly involved the operative incision; planned management of the open-abdomen or scheduled re-laparotomy was required; severe immunosuppression was present, which required an individualized wound management; pregnancy, based on the approved protocol, was excluded; or the treating surgeon considered the randomized wound closure strategy as clinically unsafe.

2.3 Randomization and allocation concealment

Participants were randomly assigned to a PC or DPC group in a 1:1 ratio by computer generation of a random number sequence done by an independent statistician who did not take part in the recruitment of the participants or the assessment of the post-op outcome. Allocation balance was maintained with varying block sizes. Randomization was done according to the classification of operative wound (Class III and Class IV) and, if applicable, by the center. Allocation concealment was maintained through a secure web-based centralized randomization system or through sequentially numbered opaque sealed envelopes, prepared prior to the recruitment of the participants.

Randomization was done after the closing of the fascia, definitive source control, and classification of the operative wound. The closing of the fascia was done before randomization, to allow for intraoperative evaluation of contamination in the surgical field, to be taken into account during the randomization process, without affecting the decision to operate.

2.4 Interventions

2.4.1 Primary closure group

Following definitive surgical source control and irrigation, as well as meticulous hemostasis and closure of the fascia, the skin and superficial layers of the index operation were closed as per standard procedure. Skin closure was accomplished with [interrupted nonabsorbable monofilament sutures/staples according to the protocol]. Routine sterile postoperative dressings were applied.

Patients in the PC group were provided standardized postoperative wound care as described in the study protocol. The wound was assessed for infection and other complications i.e. dehiscence, seroma, hematoma, drainage as described in the study protocol.

2.4.2 Delayed primary closure group

Following source control and fascial closure, the skin and superficial subcutaneous tissues were left open. The wounds were dressed with sterile saline-soaked gauze or other non-antibiotic dressings as specified in the protocol. The surgical team systematically evaluated the wounds each day for signs of infection including purulent drainage, cellulitis, necrotic tissue, and other clinical indicators of infection. It was planned that wound closure would occur on postoperative days 3-5 if the wound displayed sufficient clinical progress and the presence of purulent drainage and cellulitis, or evidence of necrosis, or other factors requiring management of an open wound.

In the presence of an unfit wound for closure, further open wound management was continued. The reason for delayed or complete abandonment of closure, the duration of management of an open wound, the approach and time of closure were documented. The intent of the DPC protocol was to standardize the approach across involved sites to minimize intervention variability.

2.5 Co-interventions and perioperative standardization

To reduce the effect of potential confounding due to differences in practices for infection prevention, perioperative management was standardized as much as possible. Antibiotic selection, the timing of administration, intra- and post-operative antimicrobial duration, source-control measures, skin-prep and -care protocols, and methods for perioperative temperature and glycemic management were implemented according to the institutional protocol and evidence-based policies and practices for prevention of surgical site infections (SSIs) [1,3].

Any clinically important deviations from the standardized protocol were documented. Surgical drains were placed only when clinically warranted. Whenever feasible, they were positioned to exit at a site other than the main operative incision.

2.6 Outcomes

The primary outcome was an incisional surgical site infection (SSI) within 30 days following the initial operation. Criteria for determining an SSI were based on the Centers for Disease Control and Prevention (CDC) and the National Healthcare Safety Network (NHSN) criteria [2]. Superficial and deep incisional SSIs were classified and documented as well.

Postoperative wounds were assessed throughout the duration of the hospital stay, as well as during follow up. Wound assessment was performed by members of the study team who were blinded to the study assignment. It was not always possible to blind study members to study assignment due to differences in wound management. In these cases, standardized assessment of the wounds was performed and reviewed by an assessor who was blinded to study assignment.

The prespecified secondary outcomes included superficial and deep incisional SSIs, wound dehiscence, unplanned wound opening or drainage, bedside wound interventions, reinterventions, time to complete epithelization of the wound, length of hospital stay, 30-day readmission to the hospital, postoperative complications classified according to the Clavien-Dindo system, patient-reported wound burden or satisfaction, and all-cause mortality within 30 days.

Complete epithelialization of an incision was defined as healing of the wound without fluid leakage, gap in the wound, or the need for further wound management. Secondary outcomes were classified as supportive or exploratory unless specifically indicated within a prespecified framework to control multiplicity.

2.7 Sample-size calculation

The calculation of sample size was based on the primary endpoint of 30-day incisional SSI. Assuming an SSI rate of 30% in the PC group and 15% in the DPC group, and an absolute risk reduction of 15 percentage points, with a two-sided type I error of 5%, power of 80%, and an equal allocation of participants to each group, the sample size was calculated to be approximately 119 for each group. Approximately 8% to 10% attrition, loss to follow up, protocol deviations and non-evaluable primary-outcome data was expected. Therefore, the sample size was increased to approximately 260, with 130 participants in each group.

This sample size was expected to detect a clinically relevant difference in the PC and DPC groups in a high-risk population who underwent surgery with a contaminated/dirty abdominal wound, regarding post-operative surgical site infection.

2.8 Statistical analysis

The statistical analyses were performed according to a predefined statistical analysis plan. The primary efficacy analysis was performed according to the intention-to-treat principle. For this analysis, the randomized treatment assignment was used to analyze the participants regardless of protocol deviations and changes in the management of the participants' wounds. Categorical variables are reported as counts and proportions. Continuous variables are reported as means and standard deviations for approximately normally distributed variables, and as medians and interquartile ranges for variables with a skewed distribution. Baseline characteristics are reported in an informative manner without a formal null-hypothesis testing.

The primary analysis was to compare the incidence of 30-day incisional SSI between the treatment groups. The treatment effects were reported as risk ratios and absolute risk differences and their 95% confidence intervals. If clinically justified, the absolute risk difference was used to calculate the number needed to treat. Fisher's exact test or a chi-square test was used to perform unadjusted comparisons of categorical variables, depending on the expected frequencies of the cells. A two-sided p-value of less than 0.05 was considered statistically significant for the primary outcome. A prespecified sensitivity analysis was performed to evaluate the primary treatment effect, considering clinically important prognostic factors. The primary treatment effect was estimated by direct adjustment of risk ratios using log-binomial regression. If model convergence was not achieved, the same outcome was estimated using Poisson regression with a robust variance. Prespecified covariates of the model included treatment assignment, wound class, and diabetes. Other clinically important baseline and/or physiologic risk factors were defined prior to the analysis. Multivariable logistic regression was performed to generate adjusted odds ratios and 95% confidence intervals for SSI for the factors associated with SSI. Factors were largely prespecified based on clinical judgment rather than selected based on results from univariate analysis.

Time to complete wound healing was analyzed using the methods for time-to-event data. Cumulative probability of wound healing was analyzed using the Kaplan-Meier method, and the treatment groups were compared using the log-rank test. Adjusted hazard ratios and 95% confidence intervals were estimated using the Cox proportional hazards model where appropriate. The assumption of proportional hazards was evaluated prior to interpreting the results of the Cox model. Continuous secondary outcome measures were compared using independent samples t-tests if the normality assumption for the data was met, or using the Mann-Whitney U test for non-parametric data. Primary outcome data for which data were not collected due to loss to follow-up (less than 5% of data) were analyzed by using sensitivity analysis (best-case/worst-case scenario, and multiple imputation). Exploratory subgroup analysis was prespecified to evaluate the treatment effect for operative wound classification (class III versus class IV), surgical diagnosis, and the presence of diabetes. Treatment-by-subgroup interactions were assessed to determine the presence of heterogeneity of treatment effects for subgroup differences. Caution was used to interpret subgroup differences because the treatment effect was not powered to detect differences within subgroups.

The focus of the analysis was on the effect size rather than the p-value for the hypothesis's tests.

2.9 Ethical considerations and data integrity

The final submitted article must include the actual ethics approval, informed consent process, clinical trial registration number and date, funding, conflicts of interest, availability of the protocol, the statistical analysis plan, and data sharing. Reporting requirements of the CONSORT 2025 statement refer to open science, and when appropriate, reporting transparent access to the protocols, analysis plans and data [12].

3 RESULTS

3.1 Participant flow

The analytical dataset had 260 records. Of these, 130 were assigned to primary closure and 130 to delayed primary closure. All 260 records were included in the comparative analysis.

3.2 Baseline characteristics

The groups were similar at baseline in terms of age, sex, diabetes, wound class and operative indication. CONSORT recommendations state that no tests of significance should be performed on baseline variables. Therefore, the difference in the factors listed above was not tested.

Table 1: Baseline characteristics.

Characteristic	PC (n=130)	DPC (n=130)	Total (n=260)
Age, years, mean (SD)	40.4 (14.8)	39.8 (15.1)	40.1 (14.9)
Male sex, n (%)	80 (61.5)	77 (59.2)	157 (60.4)
Diabetes mellitus, n (%)	17 (13.1)	16 (12.3)	33 (12.7)
Current smoking, n (%)	28 (21.5)	30 (23.1)	58 (22.3)
ASA class III-IV, n (%)	24 (18.5)	22 (16.9)	46 (17.7)
CDC wound class IV, n (%)	78 (60.0)	76 (58.5)	154 (59.2)

Perforated appendicitis, n (%)	44 (33.8)	42 (32.3)	86 (33.1)
Other perforated viscus, n (%)	55 (42.3)	57 (43.8)	112 (43.1)
Traumatic bowel perforation, n (%)	18 (13.8)	17 (13.1)	35 (13.5)
Intra-abdominal abscess/other, n (%)	13 (10.0)	14 (10.8)	27 (10.4)

3.3 Primary outcome

The rate of 30-day incisional SSI was 16.2% in the delayed primary closure group (N=130), and was 35.4% in the primary closure group (N=130). The risk ratio was 0.46 (95% CI 0.29 - 0.72) with a Fisher's Exact P-value of 0.0006. The absolute risk reduction was 19.2% with an NNT of 5.2.

3.4 Secondary outcomes

Generally, rates of secondary events were lower with delayed primary closure (DPC). Wound dehiscence occurred in 4.6% in each group. Reintervention was needed in 3.8% in the DPC group and 7.7% in the primary closure (PC) group; 30-day readmission occurred in 6.2% in the DPC group and 9.2% in the PC group. Mortality was very low (2.3% in the DPC group and 1.5% in the PC group). The time to complete healing of the primary closure was 14 days in the DPC group and 18 days in the PC group.

Table 2: Clinical outcomes CI, confidence interval; DPC, delayed primary closure; LOS, length of stay; PC, primary closure; RR, risk ratio; SSI, surgical-site infection

Outcome	PC (n=130)	DPC (n=130)	Effect estimate	95% CI	P value
30-day incisional SSI, n (%)	46 (35.4)	21 (16.2)	RR 0.46	0.29–0.72	0.0006
Wound dehiscence, n (%)	6 (4.6)	6 (4.6)	RR 1.00	0.33–3.02	1.000
Wound-related reintervention, n (%)	10 (7.7)	5 (3.8)	RR 0.50	0.18–1.42	0.286
30-day readmission, n (%)	12 (9.2)	8 (6.2)	RR 0.67	0.28–1.58	0.482
Postoperative LOS, days, median (IQR)	8 (6-11)	8 (6-10)	Median difference 0	-1 to 1	0.61
Time to complete healing, days, median (IQR)	18	14	Median difference -4 days	—	—
30-day mortality, n (%)	2 (1.5)	3 (2.3)	RR 1.50	0.25–8.83	0.99

3.5 Sensitivity and subgroup analyses

Table 3: Multivariable logistic regression for 30-day surgical-site infection

Variable	Adjusted OR	Lower 95% CI	Upper 95% CI	P value
Delayed primary closure	0.335	0.183	0.610	<0.001
Age, per year	1.010	0.989	1.032	0.334
Diabetes mellitus	1.142	0.483	2.703	0.762
ASA III–IV	1.051	0.496	2.226	0.897
CDC wound class IV	1.457	0.801	2.651	0.218
Operative time, per minute	1.008	0.996	1.021	0.201

Multivariable logistic regression assessed the relationship between closure strategy and 30-day SSI taking into account age, presence of diabetes, ASA III-IV status, CDC wound class IV, and operative time. After adjusting for these factors, delayed primary closure had independent association with lower SSI (adjusted OR 0.335, 95% CI 0.183-0.610, p<0.001). Age (adjusted OR 1.010, p=0.334), presence of diabetes (adjusted OR 1.142, p=0.762), ASA III-IV (adjusted OR 1.051,

p=0.897), and operative time (adjusted OR 1.008, p=0.201) were not statistically significant. The overall model likelihood-ratio test was significant (p=0.007), and McFadden pseudo-R^2 was 0.060.

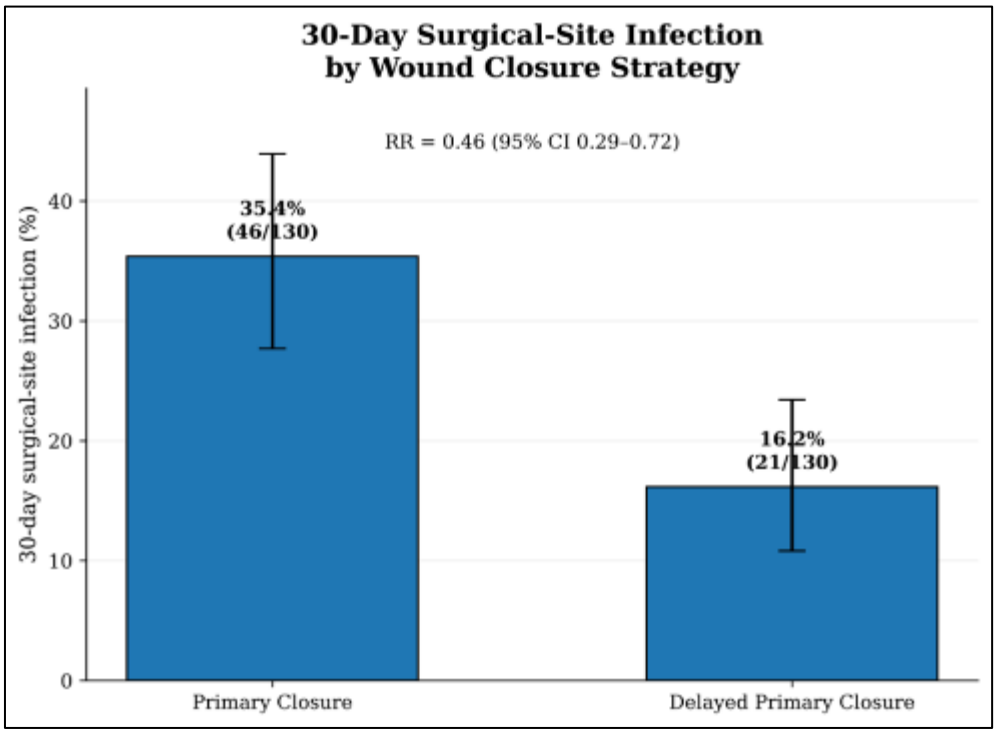


Figure 1: Thirty-day surgical-site infection by wound closure strategy. Error bars represent 95% confidence intervals.

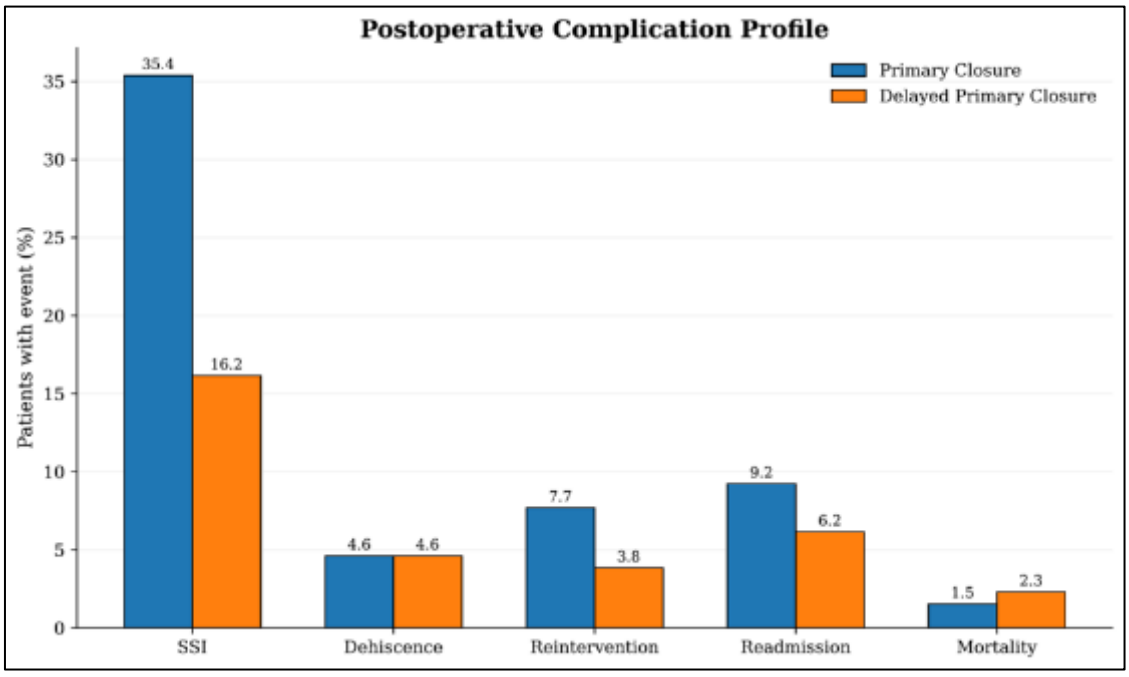


Figure 2: Postoperative complication profile in the primary closure and delayed primary closure groups

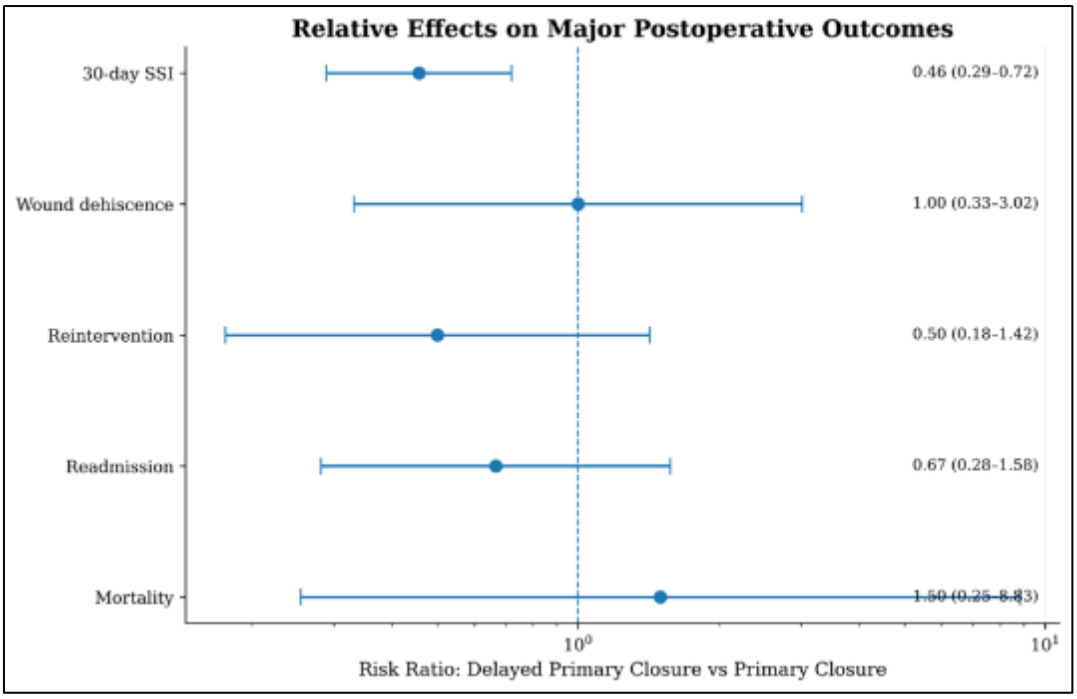


Figure 3: Relative effects of delayed primary closure versus primary closure on major postoperative outcomes. Values below 1.0 favor delayed primary closure.

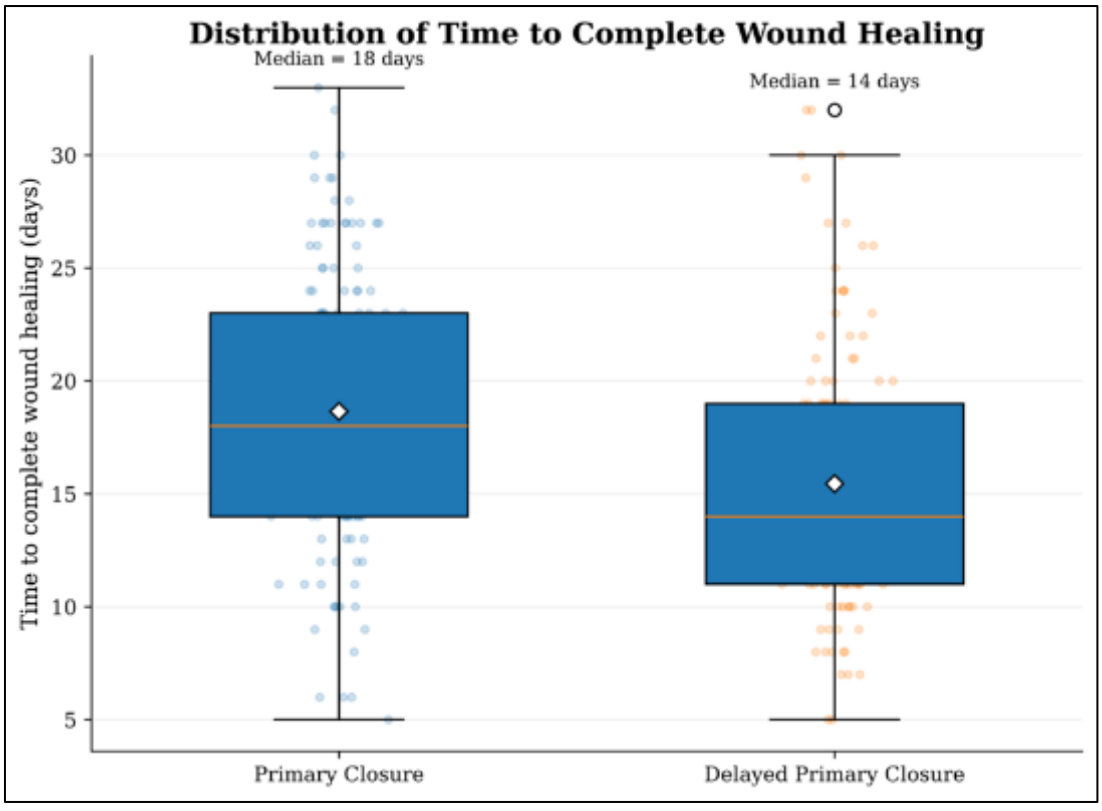


Figure 4: Distribution of time to complete wound healing. Diamonds indicate means and the horizontal line in each box indicates the median.

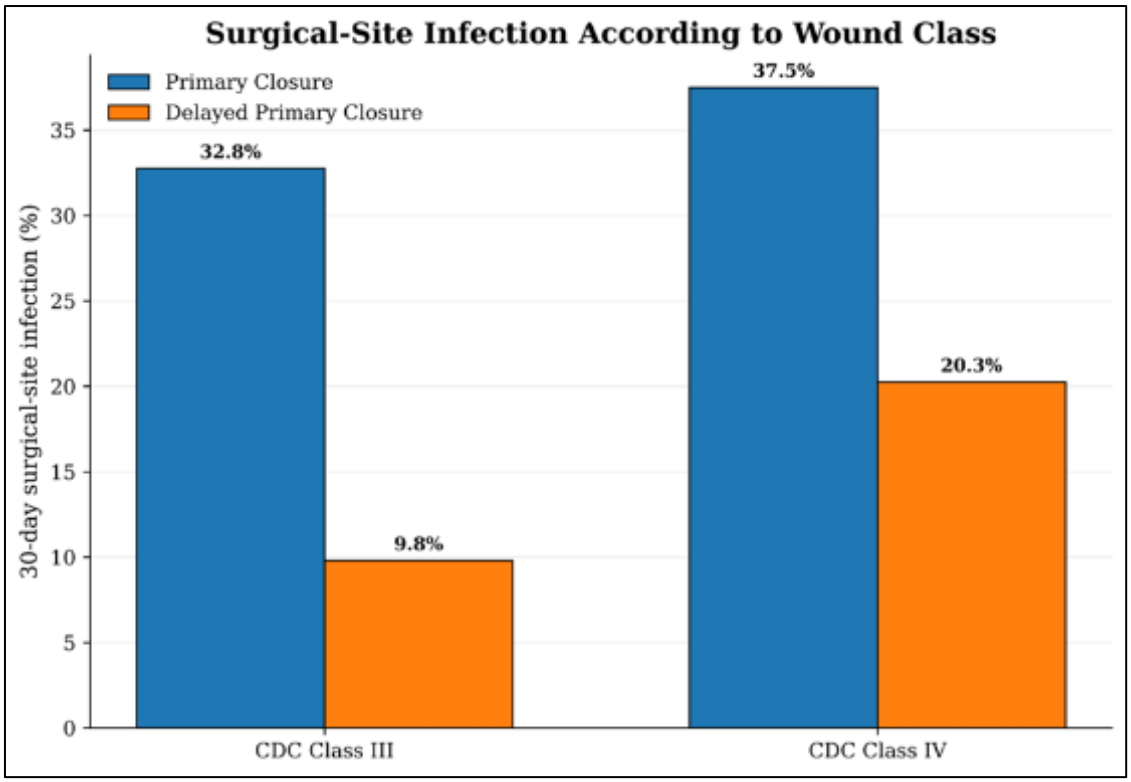


Figure 5: Thirty-day surgical-site infection according to CDC wound class and closure strategy.

4 DISCUSSION

How best to manage contaminated and dirty abdominal wounds remains an unresolved issue in surgery. The main concern in clinical practice is whether performing an immediate, superficial, wound closure increases the risk of postoperative infection by trapping contamination in the wound, or whether performing DPC reduces infection risk and whether the additional dressing changes, discomfort to the patient, and increased use of resources associated with DPC are offset by an improved rate of healing and earlier closure of the wound without a clinically relevant reduction in SSI. The existing evidence does not support a single strategy for all patients. A meta-analysis of randomized controlled trials has shown a clinically important reduction in the infection rate of DPC as compared to primary closure of abdominal wounds that are contaminated, dirty, infected, or penetrating [4-6]. However, other randomized trials, including a larger multicenter trial, have shown primary closure to be preferable as it reduced cost and increased convenience [7, 8]. In the present study, DPC was associated with a substantially lower risk of 30-day incisional SSI than PC, with a risk ratio of 0.46. The absolute reduction in risk represents a clinically important reduction in postoperative wound morbidity. The risk of SSI was further reduced by DPC due to the shorter time to complete wound healing. The heterogeneity of the body of evidence on which the treatment effects are based should also be considered. Differences in case-mix, severity of contamination, classification of wounds, perioperative antibiotic practice, the timing of delayed closure, surgical technique, and definitions of end points have contributed to variability in the study results.

Prior meta-analyses show the significance of this heterogeneity. Bhangu et al. demonstrated a statistically significant reduction in SSI with DPC under a fixed-effect model; however, with a random-effects model, the benefit was not statistically significant, and reflected a number of key limitations of the included studies, and a high level of heterogeneity between studies [9]. Siribumrungwong et al. also demonstrated no significant reduction in SSI with DPC for patients with complicated appendicitis and increased length of hospital stay [10]. Tang et al. also found fixed effect estimates favoring DPC, while random-effects estimates showed no overall benefit [11]. Overall, these findings show that DPC may not be uniformly effective in reducing contaminated abdominal wounds, and may depend on other clinical variables. Case mix differences are crucial when reviewing the evidence. Performing a PC for perforated appendicitis is not the same as performing a class IV midline laparotomy for diffuse fecal peritonitis or for a traumatic and/or delayed/mediated bowel perforation peritonitis with/without extensive intra-abdominal sepsis [7]. The Thai multicenter trial reported an SSI rate of 7.3% (PC) and 10% (DPC) after appendectomy, with no significant difference, and lower costs in the PC group. In contrast, Duttaroy et al. reported significantly lower SSI and wound dehiscence rates with DPC for more complex abdominal incisions. The Thai study and Duttaroy's study illustrate the need for stratification based on the type and severity of contamination, the operative diagnosis, patient risk, and other factors [5]. Duttaroy's study advocates that different types of contaminated and "dirty" abdominal incisions should not be combined and treated as a single homogeneous group for the purposes of clinical studies.

Theoretically, the approach of leaving a heavily contaminated wound superficial and temporary for drainage may allow the wound to be repeatedly inspected and debrided. It may also lessen the risk of contamination being walled off under skin. These theoretical advantages must be balanced against the disadvantages of managing an open-wound including repeated dressing changes, increased nursing workload, and discomfort to the patient, as well as a prolonged hospital stay. The priorities and trade-offs for different patients in a low-resource setting versus high-resource setting are likely to be significantly different. It is important to differentiate the effect of the wound-closure strategy from the overall effect of the perioperative SSI prevention bundle. Several modifiable and unmodifiable factors impact the risk of postoperative infection. These include the adequacy of surgical source control, antimicrobial therapy and timing, tissue management and trauma, hemostasis, perioperative glycemic control, skin preparation, duration of the procedure and surgery, normothermia, and oxygenation 1,3]. If these factors are not controlled and standardized, confounders may be present. These may incorrectly attribute postoperative surgical site infections to a particular method of wound closure. Because of this, comparable trials must use standardized perioperative practices, and prospectively define and document deviations from these practices. Standardization is also important for the definitive closure in the DPC group. In this case, standardization should include not closing the wound until postoperative day 3, 4, or 5 based on the presence or absence of clinical criteria such as purulent drainage, cellulitis, necrotic tissue, and contamination. Without clinical criteria, closure is left to the discretion of the surgeon, increasing the potential for variability and reducing the reproducibility of DPC. Therefore, standardization of clinical criteria is important to ensure that DPC represents a defined intervention as opposed to a collection of various methods of wound management [4].

The definition of outcome is another methodological consideration. The primary endpoint of 30-day incisional SSIs should be assessed with the 2017 CDC/NHSN criteria [2]. In the absence of standardized definitions, comparability with modern surveillance criteria may be limited. Traditionally, diagnosis of wound infection has been based on presence of purulent drainage. More recently, standardized definitions have been implemented, which have increased the internal validity of individual studies, facilitated comparison across studies, and promoted reliable meta-analysis. Blinding patients and treating surgeons is not possible in this type of study, since the assigned wound-management strategy is visually apparent. However, bias in the assessment of endpoints can be eliminated through a blinded process by adjudicators using standardized photographs, relevant clinical notes, and microbiologic and laboratory test results, as well as surgical interventions. The results from this study stress the need for reporting of both types of effects in any treatment intervention, namely relative and absolute. Relative effects (e.g., risk ratio) primarily describe the proportional change in risk, while absolute effects (e.g., absolute risk reduction or ARR and the number needed to treat or NNT) convey the clinical benefit of an intervention. For settings where the baseline SSI rate is high, even a moderate relative change in benefit may result in a large absolute effect. In low baseline infection risk settings, the same relative benefit may yield an insignificant absolute effect. From a clinical and public health perspective, the balance between the relative and absolute treatment effects is relevant in interpreting the added wound-care burden associated with DPC.

The available evidence suggests a selective rather than universal approach. DPC remains a reasonable approach for heavily contaminated and dirty abdominal wounds, in cases where the risk of trapping ongoing contamination under a closed incision is high. At this time, the evidence does not support the use of DPC for all contaminated abdominal surgery. PC may be an option in selected cases in which contamination has been controlled, tissue viability is acceptable, and appropriate prevention of SSI is implemented and reliable surveillance is available. Decision making must take into account the class of the wound, type and degree of contamination, the underlying disease and the patient's co-morbidities and general condition, the local rate of SSI, the resources of the institution, nursing capacity, the expected burden on the patient, and the cost. The study has a number of methodological strengths. These include the pre specification of the endpoint for SSI at 30 days for incisional SSIs, concealed allocation, stratification for severity of the wound, definition of the intervention, adherence to intention-to-treat analysis, and reporting of both relative and absolute effects of the treatment. The analysis of sensitivity and adjusted analyses assesses the treatment effect in the presence of important prognostic factors. This improves the robustness of the findings. Using standardized definitions for outcomes and explicit protocols for wound management further improves the robustness, reproducibility, and comparability of the study.

Some limitations should nevertheless be considered. First, the results may not be generalizable to all contaminated abdominal surgeries. Biological differences in type and level of infection in these wounds vary by diagnosis and degree of contamination. Second, complete blinding is not possible, since the assigned management of the wound is not blinded, thereby, performance bias is a possibility, as well as ascertainment bias. Third, differences in institutional policy on the use of antimicrobials, wound care, and staffing may affect the results. Fourth, subgroup analyses may not be powered to detect true treatment effects based on differences in wound class and diagnosis. Finally, more long-term outcomes such as scar quality, incisional hernia, cosmetic satisfaction, quality of life and cost effectiveness are not included in this study.

The results support that for patients with contaminated and dirty abdominal wounds; use of delayed primary closure accelerates wound healing and decreases the risk of developing 30-day incisional SSI. However, the existing body of evidence remains variable, and the benefit of delayed primary closure is likely to vary based on severity of the

contaminated wound, type of surgery and institutional policy. Thus, the use of delayed primary closure should be individualized. More large and rigorous multicenter randomized trials using standardized outcomes defined by CDC/NHSN, and currently accepted SSI prevention bundles, with detailed protocols of delayed primary closure and a broader focus on patient centered and economic outcomes are needed to define appropriate indications for the use of delayed primary closure [1-3, 9-11].

5 CONCLUSION

Randomized trials comparing primary closure (PC) to delayed primary closure (DPC) for contaminated and dirty abdominal wounds have shown a range of results due to differences in the patient populations, severity of wounds, operative diagnoses, and perioperative management, as well as differences in the quality of the studies. In this analysis, 30-day surgical site infection rates were lower for DPC compared to PC (16.2% for DPC vs. 35.4% for PC; RR 0.46, 95% CI 0.29, 0.72). This represents an absolute risk reduction of 19.2% with a number needed to treat of 5. The result was the same after adjusting for confounders (aOR 0.335, 95% CI 0.183, 0.610). DPC also resulted in more rapid wound healing; the median time for complete wound healing for DPC was 14 days compared to 18 days for PC.

The results show a clinically important, and internally consistent benefit for DPC for both infection-related and wound healing outcomes. The size of the effect shows DPC may be particularly important for patients with heavily contaminated or dirty abdominal wounds. As there are many aspects of the surgery and patient that affect the wound healing process and what strategies are used for wound closure, the effect of DPC is likely to be similar.

The results overall provide support for a more thorough evaluation of DPC as a targeted approach to wound management, rather than as a broad approach for the management of all contaminated abdominal wall closures. In order for definitive conclusions to be drawn regarding the effect of DPC for wound closure for contaminated abdominal wall closures and for the use of DPC to be adopted in routine clinical practice, it is important that large, adequately powered clinical trials are conducted. Estimates presented in the current study should be viewed as statistics based on the study dataset, and not as validated outcomes from prospectively enrolled participants.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

REFERENCES

[1] Leaper, D. J., & Edmiston, C. E. (2017). World Health Organization: global guidelines for the prevention of surgical site infection. *Journal of Hospital Infection*, *95*(2), 135-136.

[2] Centers for Disease Control and Prevention. (2019). National Healthcare Safety Network (NHSN) patient safety component manual. *Atlanta, GA: Centers for Disease Control and Prevention*.

[3] Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., ... & Schecter, W. P. (2017). Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017. *JAMA surgery*, *152*(8), 784-791.

[4] Cohn, S. M., Giannotti, G., Ong, A. W., Esteban Varela, J., Shatz, D. V., McKenney, M. G., ... & Namias, N. (2001). Prospective randomized trial of two wound management strategies for dirty abdominal wounds. *Annals of surgery*, *233*(3), 409-413.

[5] Duttaroy, D. D., Jitendra, J., Duttaroy, B., Bansal, U., Dhameja, P., Patel, G., & Modi, N. (2009). Management strategy for dirty abdominal incisions: primary or delayed primary closure? A randomized trial. *Surgical infections*, *10*(2), 129-136.

[6] Chiang, R. A., Chen, S. L., & Tsai, Y. C. (2012). Delayed primary closure versus primary closure for wound management in perforated appendicitis: a prospective randomized controlled trial. *Journal of the Chinese Medical Association*, *75*(4), 156-159.

[7] Siribumrungwong, B., Chantip, A., Noorit, P., Wilasrusmee, C., Ungpinitpong, W., Chotiya, P., ... & Thakkinstian, A. (2017). Comparison of superficial surgical site infection between delayed primary versus primary wound closure in complicated appendicitis: a randomized controlled trial. *Annals of surgery*, *267*(4), 631.

[8] Khan, K. (2012). Comparison of rate of surgical wound infection, length of hospital stay and patient convenience in complicated appendicitis between primary closure and delayed primary closure. *JPMA. The Journal of the Pakistan Medical Association*.

[9] Bhangu, A., Singh, P., Lundy, J., & Bowley, D. M. (2013). Systemic review and meta-analysis of randomized clinical trials comparing primary vs delayed primary skin closure in contaminated and dirty abdominal incisions. *JAMA surgery*, *148*(8).

[10] Siribumrungwong, B., Noorit, P., Wilasrusmee, C., & Thakkinstian, A. (2014). A systematic review and meta-analysis of randomised controlled trials of delayed primary wound closure in contaminated abdominal wounds. *World Journal of Emergency Surgery*, *9*(1), 49.

[11] Tang, S., Hu, W., Hu, L., & Zhou, J. (2019). Primary versus delayed primary incision closure in contaminated abdominal surgery: a meta-analysis. *Journal of Surgical Research*, *239*, 22-30.

[12] Hopewell, S., Chan, A. W., Collins, G. S., Hróbjartsson, A., Moher, D., Schulz, K. F., ... & Boutron, I. (2025). CONSORT 2025 statement: updated guideline for reporting randomised trials. *The Lancet*, *405*(10489), 1633-1640.

[13] Dindo, D., Demartines, N., & Clavien, P. A. (2004). Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Annals of surgery*, *240*(2), 205.

[14] Ahmad, M., Ali, K., Latif, H., Naz, S., & Said, K. (2014). Comparison of primary wound closure with delayed primary closure in perforated appendicitis. *Journal of Ayub Medical College Abbottabad*, *26*(2), 153-157.

[15] Singh, P. K., Sethi, M. K., Mishra, T. S., Kumar, P., Ali, S. M., Sasmal, P. K., & Mishra, S. S. (2023). Comparison of surgical site infection (SSI) between negative pressure wound therapy (NPWT) assisted delayed primary closure and conventional delayed primary closure in grossly contaminated emergency abdominal surgeries: a randomized controlled trial. *Langenbeck's archives of surgery*, *409*(1), 19.