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Original Article

Skin Preparation with Chlorhexidine Versus Povidone-Iodine for the Prevention of Surgical Site Infection

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ABSTRACT

Background: Surgical site infections are common preventable postoperative complications that increase morbidity, hospital stay, readmission, and healthcare cost. Preoperative skin antisepsis is a key component of SSI prevention, but comparative evidence regarding chlorhexidine and povidone-iodine remains variable across clinical settings. Objective: To compare the effectiveness of chlorhexidine and povidone-iodine skin preparation in reducing surgical site infections among patients undergoing elective clean and clean-contaminated surgery. Methods: This prospective comparative observational study was conducted at Services Hospital Lahore among 200 adult elective surgical patients, with 100 patients prepared using chlorhexidine and 100 using povidone-iodine. Demographic, clinical, operative, and postoperative outcome data were collected using standardized forms. SSI occurrence was assessed according to CDC criteria. Group comparisons were performed using chi-square and independent-sample tests, while binary logistic regression for age, gender, BMI, diabetes mellitus, operative duration, and ASA class. Results: SSI occurred in 5% of patients in the chlorhexidine group and 12% in the povidone-iodine group, yielding an absolute risk reduction of 7%. Chlorhexidine was independently associated with lower SSI odds after adjustment for confounders (AOR 0.44, 95% CI 0.25–0.78; p=0.005). Diabetes mellitus, higher BMI, longer operative duration, and ASA class III–IV significantly increased SSI risk. Hospital stay was shorter with chlorhexidine than povidone-iodine (4.2 ± 1.1 vs 5.6 ± 1.8 days; p=0.001). Conclusion: Chlorhexidine skin preparation was associated with reduced SSI risk and shorter hospitalization compared with povidone-iodine and should be considered within comprehensive perioperative infection-prevention protocols. Keywords: Surgical site infection, Chlorhexidine, Povidone-iodine, Skin antisepsis, Elective surgery, Infection prevention

INTRODUCTION

Surgical site infections remain a major cause of preventable postoperative morbidity, prolonged hospitalization, delayed wound healing, readmission, and increased healthcare expenditure. Despite improvements in operative technique, sterilization practices, perioperative antibiotic prophylaxis, and infection-control protocols, SSIs continue to represent a substantial proportion of healthcare-associated infections, particularly in low- and middle-income settings where resource limitations may affect surveillance, aseptic compliance, and postoperative follow-up (1–4). Because microbial contamination of the incision site frequently originates from endogenous skin flora, preoperative skin antisepsis is a critical component of SSI prevention bundles. Effective antisepsis reduces the microbial burden at the surgical field before incision and may lower the probability of intraoperative wound contamination, especially in clean and clean-contaminated procedures (5–7).

Chlorhexidine gluconate and povidone-iodine are among the most widely used antiseptic agents for surgical skin preparation. Chlorhexidine has rapid broad-spectrum antimicrobial activity and a

prolonged residual effect because of its binding affinity to the stratum corneum, whereas povidone-iodine acts through iodine release, microbial cell-wall penetration, and disruption of protein and cellular metabolism (8). Although both agents are clinically accepted, their pharmacodynamic characteristics differ in ways that may influence SSI risk. Chlorhexidine's persistent activity and relative resistance to inactivation by organic material may provide longer intraoperative protection, while the efficacy of povidone-iodine may be reduced after drying or in the presence of blood and serum. These mechanistic differences provide a biologically plausible basis for comparative evaluation in surgical patients.

Previous randomized trials, observational studies, and meta-analyses have reported mixed findings regarding the superiority of chlorhexidine over povidone-iodine. Several studies have suggested lower SSI rates with chlorhexidine-based preparations, particularly when alcohol-based formulations are used and when procedures involve clean-contaminated wounds (9–17). However, other studies have reported non-significant differences between antiseptic agents, and heterogeneity in antiseptic formulation, application technique, surgical specialty, wound classification, follow-up duration, and outcome definitions limits the generalizability of existing evidence (18–23). This inconsistency is clinically important because antiseptic selection is a simple, low-cost, and modifiable perioperative decision that may influence postoperative outcomes.

In local tertiary-care surgical settings, where patients may present with variable baseline risk profiles such as obesity, diabetes mellitus, prolonged operative duration, and higher anesthetic risk classification, comparative evidence on antiseptic effectiveness remains limited. A context-specific evaluation is therefore needed to determine whether chlorhexidine provides clinically meaningful benefit over povidone-iodine after adjustment for relevant patient- and procedure-related confounders. Based on the PICO framework, the population comprised adult patients undergoing clean or clean-contaminated elective surgery; the intervention was chlorhexidine skin preparation; the comparator was povidone-iodine skin preparation; and the primary outcome was postoperative surgical site infection. This study therefore aimed to compare the effectiveness of chlorhexidine and povidone-iodine preoperative skin preparation in reducing SSI occurrence among elective surgical patients, with the hypothesis that chlorhexidine would be associated with a lower risk of postoperative SSI and shorter hospital stay than povidone-iodine.

MATERIALS AND METHODS

This study was conducted as a prospective comparative observational study at Services Hospital Lahore, a tertiary-care teaching hospital providing elective surgical services in general surgery, orthopedics, obstetrics, and gynecology. The study evaluated the comparative effectiveness of two routinely used preoperative skin antiseptic agents, chlorhexidine and povidone-iodine, for preventing postoperative surgical site infection among adult patients undergoing clean or clean-contaminated elective procedures. A prospective design was used because exposure to the antiseptic agent was documented at the time of surgery and patients were subsequently monitored for postoperative infection outcomes.

The study included 200 adult patients aged 18 years or above who underwent elective clean or clean-contaminated surgical procedures under standard sterile operating conditions. Participants were allocated according to the antiseptic preparation used in routine clinical practice, with 100 patients in the chlorhexidine group and 100 patients in the povidone-iodine group. Eligible patients included those undergoing obstetric, gynecologic, orthopedic, or general surgical procedures. Patients were excluded if they had known hypersensitivity to chlorhexidine or povidone-iodine, pre-existing infection at or near the operative site, immunocompromised status, minor procedures performed without standard sterile technique, incomplete postoperative infection data, loss to follow-up, or exposure to combined or non-standard antiseptic regimens.

The sample size was calculated using OpenEpi software, assuming a 95% confidence level, 5% margin of error, and anticipated SSI occurrence of 9.5%, yielding a final sample of 200 participants. A non-

probability convenience sampling technique was used to recruit eligible patients during the four-month study period. Written informed consent was obtained before enrollment after explaining the study objective, data collection process, potential risks, and voluntary nature of participation.

The exposure variable was the type of preoperative antiseptic skin preparation, categorized as chlorhexidine or povidone-iodine. The primary outcome was occurrence of surgical site infection during postoperative follow-up, assessed according to CDC diagnostic criteria. Secondary outcomes included type of SSI, timing of infection onset, readmission due to SSI, wound dehiscence, progression to severe infection, final recovery status, mortality, and length of hospital stay. Covariates included age, gender, body mass index, diabetes mellitus, hypertension, smoking status, surgical specialty, surgical classification, type of anesthesia, duration of surgery, prophylactic antibiotic administration, and ASA class.

Data were collected using a standardized data collection form. Baseline demographic and clinical characteristics were recorded before surgery, including age, gender, BMI, comorbidities, smoking status, surgical specialty, and wound classification. Intraoperative data included antiseptic type, mode of application, drying time, type of anesthesia, prophylactic antibiotic administration, duration of surgery, and intraoperative complications. Patients were monitored postoperatively through inpatient ward assessment, outpatient review, and telephone follow-up where required. Suspected SSI cases were classified as superficial incisional, deep incisional, or organ/space infection, and clinical indicators such as redness, swelling, pain, warmth, purulent discharge, fever, delayed wound healing, and microbiological culture results were documented.

Bias and confounding were addressed through standardized eligibility criteria, use of uniform SSI diagnostic criteria, documentation of antiseptic application and drying time, and multivariable regression adjustment for clinically relevant confounders. Potential confounders included BMI, diabetes mellitus, duration of surgery, ASA class, age, and gender. Observer bias was minimized by verifying suspected SSI cases through qualified infection-control personnel where available. Data integrity was maintained through coded participant records, cross-checking of entered data, screening for missing or inconsistent values, and secure storage of electronic files.

Data were entered into Microsoft Excel and analyzed using SPSS version 26 and R Studio. Categorical variables were summarized as frequencies and percentages, while continuous variables were reported as means with standard deviations or medians with interquartile ranges depending on distribution. Between-group comparisons were performed using chi-square tests for categorical variables and independent-sample t-tests or Mann–Whitney U tests for continuous variables, as appropriate. Binary logistic regression was used to estimate the association between antiseptic type and SSI occurrence while controlling for confounders. Results were reported as odds ratios with 95% confidence intervals, and a p-value below 0.05 was considered statistically significant. Ethical approval was obtained from the relevant Institutional Review Board, and the study was conducted in accordance with the Declaration of Helsinki.

RESULTS

Baseline demographic and clinical characteristics were broadly comparable between groups, supporting the validity of between-group outcome comparisons. The mean age was 41 ± 12 years in the chlorhexidine group and 42 ± 11 years in the povidone-iodine group. BMI distribution, comorbidities, surgical specialty, surgical classification, anesthesia type, drying time, and prophylactic antibiotic use were also similar between groups. Postoperative SSI occurred in 5 patients in the chlorhexidine group and 12 patients in the povidone-iodine group. This corresponded to an absolute risk reduction of 7.0 percentage points, a relative risk of 0.42, and an estimated number needed to treat of approximately 15 patients to prevent one SSI. The un comparison did not reach conventional statistical significance when

recalculated from the available counts (Pearson χ^2 p=0.076), but the regression model demonstrated a statistically significant protective association for chlorhexidine.

Table 1. Baseline Demographic and Clinical Characteristics of Patients

Variable	Chlorhexidine (n=100)	Povidone-Iodine (n=100)	Effect / Test	p-value
Age, mean ± SD	41 ± 12	42 ± 11	Mean difference -1.0 years	0.540
Male sex	45	47	χ^2	0.776
Female sex	53	51	χ^2	0.777
BMI, mean ± SD	27.5 ± 4.2	27.8 ± 4.6	Mean difference -0.3 kg/m²	0.631
Diabetes mellitus	18	20	χ^2	0.718
Hypertension	25	28	χ^2	0.629
Obesity	32	30	χ^2	0.760
Smoking	15	17	χ^2	0.699
Clean surgery	60	58	χ^2	0.775
Clean-contaminated surgery	40	42	χ^2	0.775
Prophylactic antibiotic administered	90	91	χ^2	0.817
Proper drying time allowed	92	88	χ^2	0.347

Table 2. Comparative Postoperative Outcomes by Antiseptic Group

Outcome	Chlorhexidine (n=100)	Povidone-Iodine (n=100)	Effect Size / 95% CI	p-value
SSI occurrence	5	12	RR 0.42, 95% CI 0.15–1.14	0.076
Absolute risk reduction	—	—	7.0%, 95% CI -0.7 to 14.7	—
Number needed to treat	—	—	NNT ≈ 15	—
Superficial SSI	4	9	OR 0.42	0.149
Deep incisional SSI	1	2	OR 0.49	0.561
Organ/space SSI	0	1	—	0.316
Readmission due to SSI	1	3	OR 0.33	0.312
Wound dehiscence	0	2	—	0.155
Progression to sepsis	0	1	—	0.316
Complete recovery	98	94	OR 3.13	0.279
Recovery with complications	2	5	OR 0.39	0.248
Mortality	0	1	—	0.316
Length of hospital stay, mean ± SD	4.2 ± 1.1	5.6 ± 1.8	Mean difference -1.4 days	0.001

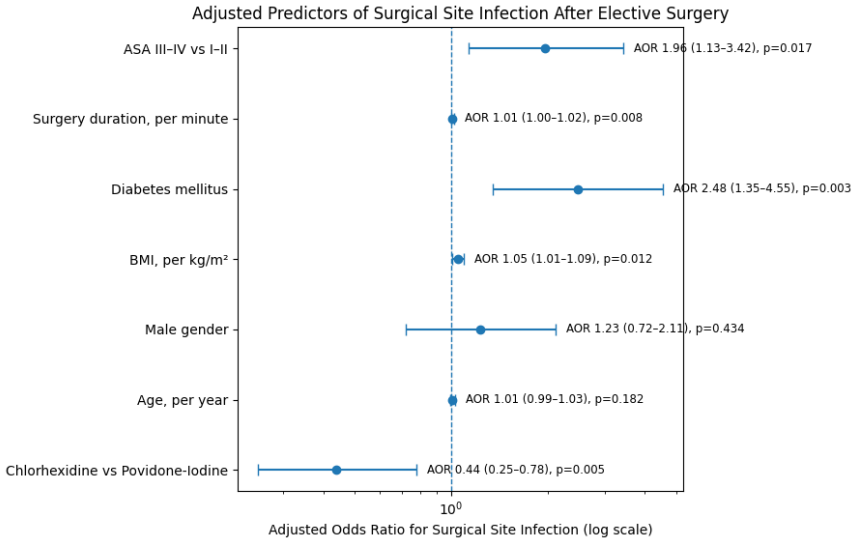

Figure 1. Predictors of Surgical Site Infection After Elective Surgery

The predictor profile showed that chlorhexidine was independently associated with lower SSI odds than povidone-iodine, with an OR of 0.44 (95% CI 0.25–0.78; p=0.005). In contrast, diabetes mellitus showed the strongest positive association with SSI risk (AOR 2.48, 95% CI 1.35–4.55; p=0.003), followed by ASA class III–IV (AOR 1.96, 95% CI 1.13–3.42; p=0.017), higher BMI (AOR 1.05 per kg/m²; p=0.012), and longer operative duration (AOR 1.01 per minute; p=0.008).

Multivariable logistic regression showed that chlorhexidine remained independently associated with lower SSI odds after adjustment for age, gender, BMI, diabetes mellitus, duration of surgery, and ASA class. Chlorhexidine reduced the odds of SSI by 56% compared with povidone-iodine. Diabetes mellitus, higher BMI, longer operative duration, and ASA class III–IV were significant independent predictors of SSI.

Table 3. Multivariable Logistic Regression for Predictors of Surgical Site Infection

Predictor	β	SE	Wald χ^2	OR	95% CI	p-value
Chlorhexidine vs povidone-iodine	-0.82	0.29	8.01	0.44	0.25–0.78	0.005
Age, per year	0.012	0.009	1.78	1.01	0.99–1.03	0.182
Male gender	0.21	0.27	0.61	1.23	0.72–2.11	0.434
BMI, per kg/m²	0.045	0.018	6.25	1.05	1.01–1.09	0.012
Diabetes mellitus	0.91	0.31	8.61	2.48	1.35–4.55	0.003
Surgery duration, per minute	0.008	0.003	7.12	1.01	1.00–1.02	0.008
ASA III–IV vs I–II	0.67	0.28	5.70	1.96	1.13–3.42	0.017

DISCUSSION

The present study found that chlorhexidine skin preparation was associated with a lower postoperative SSI burden than povidone-iodine among patients undergoing elective clean and clean-contaminated surgery. Although the un comparison showed a clinically meaningful reduction in SSI occurrence from 12% with povidone-iodine to 5% with chlorhexidine, the model provided stronger evidence by demonstrating that chlorhexidine independently reduced the odds of SSI after controlling for age, gender, BMI, diabetes mellitus, operative duration, and ASA class. This finding supports the biological plausibility that chlorhexidine may provide superior perioperative protection because of its rapid antimicrobial action, sustained residual activity, and comparatively better persistence in the presence of organic material. The observed absolute risk reduction of 7 percentage points and an estimated number needed to treat of approximately 15 patients suggest that the benefit is not only statistical in the model but also clinically relevant in routine surgical practice.

These findings are consistent with several previous trials and pooled analyses suggesting that chlorhexidine-based preparations, particularly alcohol-containing formulations, may reduce SSI risk more effectively than povidone-iodine in selected surgical populations (12–18). The predominance of superficial incisional infections in the current study also aligns with the expected mechanism of skin antisepsis, as preoperative preparation primarily reduces microbial contamination at the incision site rather than deeper organ-space infection, which is more strongly influenced by operative contamination, tissue handling, host immunity, and procedure complexity. The lack of statistically significant differences in deep incisional and organ-space infections should therefore be interpreted cautiously, as the low number of events limited the power to detect differences across SSI subtypes.

The regression model further demonstrated that SSI prevention is multifactorial. Diabetes mellitus showed the strongest positive association with SSI, indicating that impaired immunity, microvascular dysfunction, and delayed wound healing may substantially increase postoperative infection susceptibility. Higher BMI was also independently associated with SSI, likely reflecting technical difficulty, reduced tissue perfusion, larger dead space, and prolonged wound healing in patients with obesity. Longer operative duration and ASA class III–IV were additional predictors, suggesting that both procedural exposure time and baseline physiological risk contribute meaningfully to postoperative infection. These findings reinforce that antiseptic selection should be integrated within a broader perioperative infection-prevention bundle rather than viewed as an isolated intervention.

The shorter hospital stay observed in the chlorhexidine group further supports its potential clinical utility. Patients prepared with chlorhexidine had a mean hospital stay of 4.2 ± 1.1 days compared with 5.6 ± 1.8 days in the povidone-iodine group, representing a mean reduction of 1.4 days. This difference may reflect fewer postoperative wound complications, earlier clinical stabilization, and reduced need for

infection-related monitoring. In resource-constrained hospital settings, even modest reductions in SSI and length of stay may translate into improved bed availability, reduced treatment costs, and lower antibiotic burden.

The study has important limitations. First, the observational design and convenience sampling introduce the possibility of selection bias and residual confounding. Although regression adjustment was performed, unmeasured factors such as exact antiseptic concentration, alcohol-based versus aqueous formulation, surgeon-level variation, operating room traffic, nutritional status, glycemic control, and postoperative wound-care compliance may have influenced outcomes. Second, the follow-up period was limited to early postoperative surveillance, whereas standard SSI surveillance may extend to 30 days depending on procedure type. Third, multiple surgical specialties were included, which improves practical relevance but introduces heterogeneity in baseline infection risk. Fourth, the relatively small number of SSI events limits subgroup analysis by surgical specialty and wound classification. Future randomized controlled trials with standardized antiseptic formulations, longer follow-up, blinded outcome assessment, and specialty-specific stratification are needed to confirm these findings.

CONCLUSION

Chlorhexidine skin preparation was associated with a lower risk of surgical site infection and shorter hospital stay than povidone-iodine among patients undergoing elective clean and clean-contaminated surgery. After adjustment for relevant clinical and surgical confounders, chlorhexidine remained independently protective, while diabetes mellitus, higher BMI, longer operative duration, and higher ASA class were significant predictors of SSI. These findings support the routine use of chlorhexidine as part of a comprehensive perioperative infection-prevention strategy, particularly in patients with elevated baseline risk.

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