

Randomized Controlled Trial Evaluating the Efficacy and Cost Effectiveness of a Ready-to-Use Applicator Containing Iodine Povacrylex and Isopropyl Alcohol Compared with Conventional Skin Scrubbing and Painting in Patients Undergoing Colorectal Surgery

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ABSTRACT

Objective: The aim of this study was to evaluate the efficacy and cost-effectiveness of a ready-to-use applicator containing iodine povacrylex and isopropyl alcohol (IPIA) for the prevention of surgical site infection (SSI) following colorectal surgery.

Materials and Methods: The IPIA was randomly used in patients who underwent colorectal surgical procedures. The control group for comparison was a group of patients who underwent colorectal surgical procedures using conventional skin scrubbing and painting with antiseptic solutions without IPIA. In total, 100 patients were included in the study, randomized into 2 groups: IPIA was applied in study group and convention skin preparation was applied in control group. The outcome measurements included ease-of-use as assessed by a questionnaire, preparation time comparison, estimated skin preparation expense, adverse reactions, and rate of SSI. All the patients were visited daily up to 7 days postoperation or until discharge, and then 14 and 30 days postoperatively for monitoring the occurrence of SSI.

Results: Of the 100 patients undergoing elective colorectal surgery enrolled in the study, 51 were males and 49 females, with the mean age of 63.5 ± 11.3 years. The majority of the patients had colorectal cancer undergone colectomies or rectal resections. There was no mortality. Seven patients (7%) had postoperative SSI (4 patients in the control group and 3 patients in the IPIA group, 8% vs. 6%, $p = 0.45$). The bacterial cultures revealed Gram negative-bacilli in all of the patients with SSI. The preparation time for the skin preparation was 5.48 ± 2.49 min in the control group and 2.65 ± 1.55 min in the IPIA group ($p = 0.002$), without statistical significance of expenses.

Conclusion: IPIA was demonstrated to be as safe and effective as conventional antiseptic solutions as a skin preparation to prevent SSI following colorectal surgery. With good ease of use, IPIA proved more convenient than a scrubbing preparation as well as offered better cost effectiveness by significantly reducing the time and cost of the skin preparation.

Keywords: Surgical site infection; Skin preparation; Colorectal surgery; A ready-to-use applicator containing iodine povacrylex and isopropyl alcohol (IPIA) (Siriraj Med J 2021; 73: 570-575)

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INTRODUCTION

Surgical site infection (SSI) is an infection of the tissues, organs, or spaces exposed to contaminated environment, surgical equipment or personnel, or even to a patient's own flora during performing of invasive clinical procedures or operations. SSI occurs when endogenous flora are translocated to a sterile site. Up to 5% of patients undergoing clean extra-abdominal operations and up to 20% of patients undergoing intra-abdominal operations develop SSI.¹ SSI is associated with considerable morbidity and mortality as well as substantial health-care costs and patient dissatisfaction.² In addition to a good surgical technique, the use of appropriate antiseptics at the surgical site with antibiotic prophylaxis can reduce the incidence of SSI rates during certain types of procedures. The antimicrobial activity of such antiseptics should be effective against the types of bacteria that are likely to be encountered during the particular types of operation performed in clinic and should certainly be safe for patients. For this reason, in May 2004, the US National Surgical Infection Prevention Project announced a consensus on antimicrobial prophylaxis for surgery. They concluded that infusion of the first antimicrobial dose should be administered within 60 min before surgical incision. In addition, prophylactic antimicrobials should be discontinued within 24 h after the end of surgery.³ The appropriate antiseptics and antibiotics should contain antibacterial activity against the intestinal flora and common pathogens. Nowadays, various antiseptic solutions have been used with a prophylactic intention for SSI. Concerning mixed aerobic and anaerobic bacterial domination, broad-spectrum antiseptics, such as povidone-iodine, have been commonly used as the first-line agent. The application of antiseptics in conventional theaters involves preparing sterile containers, applicators (i.e., sponge holder forceps), and packs of sterile gauzes. The antiseptics have to be poured out of the container, during which, most of the time, the excess solution has to be discarded. However, if the complexity of administration is an issue of concern, or due to a busy workload or lack of nursing staff, the use of ready-to-use antiseptics is certainly favorable. One of the most widely used antiseptics preparation for SSI prophylaxis is a ready-to-use applicator containing iodine povacrylex and isopropyl alcohol (IPIA). Excellent efficacy and safety of IPIA for SSI prophylaxis have been reported in the literature. Also, IPIA solution has been shown to require significantly less time to apply than a traditional scrub and paint preparation.⁴ Alcohol-based solutions are quick, can be sustained, and are durable, with a broader spectrum of antimicrobial activity. These

agents seem ideal for longer open surgeries with the potential for irrigation or surgical spillage.⁵ However, most studies in the literature have been conducted with Western populations, whose responses to antiseptics and adverse reactions may be different from Thai patients. Consequently, the aim of the present study was to evaluate the efficacy and safety of IPIA for the prevention of SSI following abdominal surgery in a Thai population.

MATERIALS AND METHODS

After obtaining ethical approval from our institute's ethical committee, an open prospective controlled randomized comparative trial was conducted in the Department of Surgery, Faculty of Medicine Siriraj Hospital, Bangkok, Thailand between December 1, 2011, and November 30, 2012.

In total, 100 patients were included and were randomized into 2 groups. Each group of patients was applied either a ready-to-use applicator containing iodine povacrylex and isopropyl alcohol (IPIA) or a conventional skin preparation (skin scrub and paint) with antiseptic solutions without IPIA. DuraPrep™ (3M Corporate Headquarters, Minnesota, US) is a ready-to-use cylinder containing 26 ml of an alcohol-based surgical skin preparation solution with an applicator at one end. Its active ingredients are iodine povacrylex (0.7% available iodine) and isopropyl alcohol 74% (w/w). Patients were enrolled with the following inclusion criteria: aged between 18 and 80 years old; ASA class I–III; and undergoing an intra-abdominal operation for elective endorectal surgery.

Patients were excluded by one of the following criteria: previous history of hypersensitivity or allergy to seafood, iodine or its derivatives; women with pregnancy or lactation; renal insufficiency; hepatic impairment; APACHE II score more than 15; and consent refusal.

All the patients underwent colorectal operations under balanced general anesthesia. The details of the operative procedures depended on diagnosis and the intra-operative findings. The appropriate intravenous prophylactic antibiotics were given to all patients by anesthesiologists at the time of anesthetic induction (approximately 30 minutes before skin incision). Subsequently, the skin antiseptics were applied after a randomized label was attached (open code in the theater). The subjects were randomized into two groups given either the conventional technique as a skin preparation or a ready-to-use applicator containing iodine povacrylex and isopropyl alcohol solution.

The conventional technique was based on a

skin preparation with water-based or alcohol-based antiseptics. Basically, chlorhexidine (alcohol-based) or povidone-iodine (water-based) were used as the active antiseptic ingredient. We followed the standard regulations established by US-CDC and WHO. The steps were the following: 1) the affected skin was scrubbed with soap-based chlorhexidine for 5 minutes; 2) the skin was then dried with sterile clothes; 3) the water-based or alcohol-based antiseptic was applied thoroughly to the skin twice using the antiseptic refilled in a stainless cup and soaked onto a prepared sponge-stick (typically, 3 pieces of 4 x 4 gauze were used for each case); 4) the skin was then ready for sterile draping.

IPIA was applied as per the manufacturer's instructions. Briefly, the following steps were carried out: 1) the sponge was held parallel to the floor to touch the affected skin; 2) a lever was snapped to allow all the fluid to flow into the sponge; 3) the cap end of the applicator was pressed to the skin; 4) a single uniform coat of solution was painted onto the skin; 5) the solution was allowed to dry thoroughly on the skin for 3 minutes.

Additional antibiotics were prescribed as appropriate if the patients bore certain risks or later developed symptoms and signs of SSI. SSI was diagnosed following the US Centers for Disease Control and Prevention (CDC) criteria 1992.⁶

Health economic data were collected, including the ease-of-use questionnaire results, preparation time comparison, estimated skin preparation expense, adverse reactions, and rate of SSI. All the patients were visited daily up to 7 days postoperation or until discharge, and then 14 and 30 days postoperatively for monitoring the occurrence of SSI.

The patients were discharged from the hospital if they had no fever, had normal bowel function, good ambulation, and no sign of infection. All the patients were scheduled for follow-up at 14 and 30 days postoperatively.

Outcome measures

The primary outcome would be that IPIA is as safe and effective as conventional antiseptic solutions as a skin preparation to prevent SSI following colorectal surgery. The secondary outcome would be that, with good ease of use, IPIA proved more convenient than a scrubbing preparation as well as offered better cost effectiveness by significantly reducing the time and cost of the skin preparation.

Statistical analysis

The sample size was calculated for a two-sided test of 5%. Descriptive statistics, such as the number and

percentage, of the categorical data were described in terms of the mean and standard deviation. For continuous variables with the normal distribution, student t-tests were conducted. If nonparametric tests were required, Mann-Whitney U tests were used. Inferential statistics, including the chi-square test or Fisher's exact test, were used to compare the diseases, results of surgical site infection and mortality between patients within the two groups. Here, p-values less than 0.05 were considered as indicating a statistically significant difference.

RESULTS

In total, 100 patients who underwent elective colorectal surgery were enrolled in the study. A summary of the results is given in Table 1. The 100 study population comprised 51 males and 49 females, with the mean age of 63.5 ± 11.3 years old. Of these, 48 patients received a conventional skin preparation (control group), while 52 patients received a ready-to-use applicator containing IPIA as a skin preparation (study group). There were 26 males and 22 females with the mean age of 63.4 ± 13.0 years old in the control group, compared with 25 males and 27 females with the mean age of 63.6 ± 11.9 years old in the study group. The majority of patients with colorectal cancer underwent colectomies (30 patients in the control group vs. 32 patients in the study group, $p = 0.921$) or rectal resections (16 patients in the control group vs. 19 patients in the study group, $p = 0.737$). Three patients with benign diseases underwent colorectal resections (a colovesical fistula and a colovaginal fistula in the control group vs. a rectosigmoid polyp in the study group, $p = 0.606$). There was no mortality. Seven patients (7%) had postoperative SSI (4 patients (8%) in the control group vs. 3 patients (6%) in the study group, $p = 0.45$). The bacterial cultures revealed Gram negative-bacilli in all of the patients with SSI. The preparation times were 5.48 ± 2.49 minutes in the control group and 2.65 ± 1.55 minutes in the study group ($p = 0.002$). The expenses for the skin preparations were US\$10.96 \pm 1.20 in the control group compared to US\$10.82 \pm 5.02 in the study group ($p = 0.844$). The satisfaction scores in terms of ease of use for the control group and study group were 8.39 ± 1.10 and 8.47 ± 1.26 out of 10, respectively ($p = 0.754$).

DISCUSSION

Surgical site infection (SSI) is one of the risk burdens following major operations, such as intra-abdominal surgery, especially in patients with colorectal cancer.⁷⁻⁸ Patients with SSI are more likely to stay longer in the hospital, pay more expenses (i.e., for expensive antibiotics), and subsequently have an increased mortality rate.⁹⁻¹¹

TABLE 1. Results of the control group using a standard skin preparation vs. the study group using a ready-to-use applicator containing iodine povacrylex and isopropyl alcohol (IPIA).

Characteristics	Control Group (n = 48)	IPIA Group (n = 52)	p-value
Age	63.4 ± 13.0	63.6 ± 11.9	0.214
Sex : Male	26 (54%)	25 (48%)	0.543
Female	22 (46%)	27 (52%)	
Colon Cancer	30 (63%)	32 (62%)	0.921
Rectal Cancer	16 (33%)	19 (36%)	0.737
Benign Diseases	2 (4%)	1 (2%)	0.606
Mortality	0 (0%)	0 (0%)	-
Surgical Site Infection	4 (8%)	3 (6%)	0.450
Preparation Time (min)	5.48 ± 2.49	2.65 ± 1.55	0.002
Expense of Skin Preparation (US Dollars, US\$)	10.96 ± 1.20	10.82 ± 5.02	0.844
Satisfaction Score in Terms of Ease of Use (1–10)	8.39±1.10	8.47±1.26	0.754

According to the practice guidelines for SSI prevention, an appropriate skin preparation with an effective antiseptic solution, and wound-edge protection, as well as an intravenous antibiotic prophylaxis could be an important combination to avoid SSI.¹² The incidence of SSI in both tested groups in the present study was in an acceptable and similar range to previous reports of elective colorectal surgery.^{7,13-14} When we looked at the results of the bacterial cultures and sensitivity tests, *E. coli* was found in all seven specimens. This finding suggested that the contamination did not originate from the skin incision, but rather the contamination arose from intestinal flora during the operation. *Streptococcus epidermis* and *Staphylococcus aureus* are the pathologic organisms mostly involved in the majority of patients with SSI. This occurs if skin is not properly disinfected with applicable antiseptics. Basically, surgeries with colorectal resection are categorized as clean-contaminated procedures that can carry a risk of SSI developing, with an incidence rate of between 4.7 - 27.3 % according to the published literature.¹³⁻¹⁶ Undoubtedly, one of the most important factors is the surgical technique, especially intraoperative soiling and insufficient wound-edge protection. In this study, most of the cases in both groups were reported to have wound-edge protectors, such as Alexis wound protectors and abdominal swabs. The rates of SSI in both groups were rather low compared to the rates of SSI reported in previous studies.¹⁴⁻¹⁵ In addition, our better

short-term postoperative outcomes including lower SSI rate have been achieved after the establishment of specific Colorectal Surgery and Minimally Invasive Surgery Units within the Division of General Surgery.¹⁷⁻¹⁸

The skin preparation time in the IPIA group was on average half that of the control group, with a saving of over 2.5 minutes. The authors did not put this time reduction in to the unit cost calculation. In addition, the reusable items included bowls and sterile towels as well as their depreciation costs and re-sterilization cost were not taken into consideration. Otherwise, a couple of dollars could have been credited to each case in the IPIA group. Nevertheless, the expenses for skin preparation in the IPIA group was only 14 cents cheaper when compared to the skin preparation costs in the control group. Definitely, this fractional saving money showed no statistically significant difference in costs. Regarding the satisfactory score in the ease of use, the staff who used the IPIA seemed to express fractional higher scores, but these were not statistically significant different. At least, from the economic evaluation perspective, it may be assumed that users might be able to switch from the conventional method to this new method without much difficulty.

In conclusion, we demonstrated that a ready-to-use applicator containing IPIA was as safe and effective as conventional antiseptic solutions as skin preparations to prevent SSI following colorectal surgery. With good

ease of use, IPIA provided more convenience for the scrubbing personnel as well as better cost effectiveness by significantly reducing the time and cost of skin preparation.

Limitation of the study

As this study was conducted in a single university hospital, it may be inapplicable for other institutes. Although the fractional saving cost could not demonstrate the statistically significant difference, this randomized study may indicate the cost-saving tendency depending on the economy of scale. From the hospital perspective, an individual cost-minimizing analysis should be conducted to compare the economic efficiency between an IPIA and conventional skin scrubbing and painting.

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Ethics approval and consent to participate:

Before its commencement, this research is eligible for exemption review by the Institutional Review Board of Siriraj Hospital, Siriraj Institutional Review Board (SIRB). This study conducted in established educational settings, involving normal educational practice such as research on regular and special education instructional strategies, research on the effectiveness of the comparison among instructional techniques, curricula, or classroom management methods. The need for consent for participation is deemed unnecessary according to the research nature without identifiable patient information. The requirement for informed consent was waived.

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