pISSN 2586-3290 · eISSN 2586-3533
Arch Hand Microsurg 2022;27(2):119-124
<https://doi.org/10.12790/ahm.21.0151>

Received: December 8, 2021
Revised: January 4, 2022
Accepted: January 6, 2022

Corresponding author:

Dong Min Lee
Department of Orthopaedic Surgery,
Nowon Eulji Medical Center, Eulji
University, 68 Hangeulbiseok-ro,
Nowon-gu, Seoul 01830, Korea
Tel: +82-2-970-8036
Fax: +82-2-973-3024
E-mail: drdmlee@gmail.com
ORCID:
<https://orcid.org/0000-0002-5541-3836>

The role of skin antisepsis in upper extremity surgery to reduce surgical site infection: a comparison between single and triple regimens

Ji Sup Hwang¹, Dong Min Lee², Yo Han Lee³

¹Department of Orthopaedic Surgery, Seoul National University Hospital, Seoul, Korea

²Department of Orthopaedic Surgery, Nowon Eulji Medical Center, Eulji University, Seoul, Korea

³Department of Orthopaedic Surgery, Seoul National University Boramae Hospital, Seoul, Korea

Purpose: No consensus exists regarding preoperative skin antisepsis for upper extremity surgery. We aimed to determine whether the use of povidone-iodine only (single regimen) instead of povidone-iodine and alcohol-chlorhexidine (triple regimen) resulted in an increased rate of surgical site infection (SSI), and to detect any associated factors that increased the infection risk.

Methods: A cross-sectional, retrospective review of medical records was conducted for patients who underwent upper extremity surgery from March 2020 to February 2021. Either the single or triple regimen was used for preoperative skin antisepsis. The rate of SSI was compared based on a marked elevation of C-reactive protein (CRP) at 2 weeks after surgery, superficial SSI, and deep SSI. Logistic regression analysis was performed to identify factors associated with SSI among the evaluated parameters.

Results: Among 175 patients (male, 81 and female, 94), the single regimen was used in 78 patients (44.6%) and the triple regimen in 97 patients (55.4%). The single regimen (odds ratio [OR], 2.425; 95% confidence interval [CI], 1.040–5.655) and a surgical procedure using a metal implant (OR, 3.602; 95% CI, 1.184–10.953) were significantly associated with a marked CRP elevation at 2 weeks. However, there was no difference in SSI rates between the single and triple regimens. Diabetes mellitus (OR, 6.636; 95% CI, 1.259–34.969) was the only factor significantly associated with superficial SSI through logistic regression analysis.

Conclusion: Our study suggests that the single regimen resulted in a longer CRP elevation than the triple regimen, but was similarly effective in preventing SSI for upper extremity surgery.

Keywords: Skin antisepsis, Povidone-iodine, Surgical wound infection

Introduction

The prevalence of surgical site infection (SSI) ranges up to 23% in orthopedic surgery [1,2]. The occurrence of the infection prolongs hospital stays [3], and is associated with morbidity [4] and excess medical costs [5]. The main source of infection is suggested the normal skin flora of the skin [6]. Therefore, appropriate presurgical skin antisepsis of the surgical site is essential.

A guideline has been suggested for the presurgical skin antisepsis regimen in general orthopedic surgery. Both mechanical cleansing and painting with multiple antisepsis agents are recommended as in traditional [7]. However, it is time- and cost-consuming, and excessive scrubbing the skin risks release of the bacteria harbored in the pores of the dermis [8]. Various alternatives to the traditional methods of presurgical antisepsis have recently been used, such as chlorhexi-

dine-gluconate spray, iodophor-in-alcohol paint, and market soap scrub with alcohol paint [9,10].

To our knowledge, there have been no studies of the association between antisepsis regimens and SSI in upper extremity surgery. In our institute, using povidone-iodine only and using povidone-iodine and alcohol-chlorhexidine painting with skin scrubbing have both been attempted as skin antisepsis before upper extremity surgery. The purposes of this study were to determine if the use of povidone-iodine only during skin preparation resulted in increased rate of SSI after upper extremity surgery, and to detect any associated factors that increase the infection risk.

Methods

Ethics statement: Institutional approval for this study was obtained from the Institutional Review Board of Institutional Review Board of Seoul National University Boramae Medical Center (No. 20-2020-321). This study was a cross-sectional, retrospective review of medical records. As the study did not involve any further intervention on patients, we were given an exemption for written consent.

1. Study sample

We enrolled patients who underwent upper extremity surgery at a single institute from March 2020 and February 2021 and who were followed up postoperatively for at least 3 months. During the period, the method of presurgical antisepsis was decided by the preference of the chief resident between using povidone-iodine only ("single regimen") and using iodine-alcohol-chlorhexidine with skin scrubbing ("triple regimen"). Because the surgeons did not participate in this decision, they were not aware of how the skin had been prepared when they started the surgery. We excluded surgeries performed for infection or abscess of the soft tissue or bone.

Before the presurgical skin preparation, a razor was used to remove hair from the operative site. Patients in the triple regimen group underwent a vigorous 5-minute scrub using urethane sponges saturated with povidone-iodine detergent (available iodine, 0.75%). Detergent was then washed away with alcoholic chlorhexidine, before painting the operative site with aqueous povidone-iodine solution (available iodine, 1.0%), which was allowed to air-dry. Patients in the single regimen group underwent painting of the operative site with aqueous povidone-iodine solution (available iodine, 1.0%) only. Single application of aqueous povidone-iodine solution was also allowed to air-dry.

Cefazolin was given as intravenous antibiotics to all patients for prophylactic purposes. The dose differed according to the bodyweight of the patients; –1 g for those under 70 kg and 2 g for those over 70 kg. We administered the appropriate dose one hour before the skin incision, and additionally if the surgery lasted more than three hours. Because of the insurance policy, no oral antibiotics were prescribed after the discharge that was made 1 day after the surgery, and the patients were educated not to check the wounds at home unless seemed contaminated. At the follow-up visits, the routine evaluation included laboratory check-ups and inspection of the wound.

2. Clinical assessment for surgical site infection

The patients were evaluated as either marked elevation of C-reactive proteins (CRP) at 2 weeks after surgery, superficial and deep SSI. The level of CRP was regarded as markedly elevated if the level exceeded 1.5 mg/dL [11]. An elevation of CRP was considered high inflammatory status. Assessment of SSI was made following National Healthcare Safety Network [12]. If the surgical wound had at least one sign among redness, warmth, or focal tenderness, it was diagnosed as superficial SSI and oral antibiotics was prescribed. If the elevated CRP level and presence of the infection signs persisted for more than 1 month after the surgery, it was diagnosed as deep SSI, and re-admission was made for more aggressive management such as intravenous antibiotics therapy or surgical debridement.

3. Data collection

We collected demographic factors, such as age, sex, and body mass index (BMI). To evaluate risk factors associated with SSI, presence of diabetes mellitus and smoking status were identified. For surgical factors, we checked surgical time, whether an open incision was made for the procedure or an arthroscopic or closed reduction procedure was performed, and whether the surgery was emergency or elective procedure. Whether metal implants were inserted and kept inside the body was confirmed. We also documented whether the surgical procedure involved bony tissue or not.

4. Statistical analysis

All statistical analyses were performed using the IBM SPSS Statistics ver. 26.0 (IBM Corp., Armonk, NY, 2006), and a p-value of <0.05 was considered statistically significant. We generated descriptive statistics for all variables and assessed distributions of continuous variables. The mean, standard deviation, and percentage were calculated. The occurrence of SSI was compared between the single regimen group and the triple

regimen group using the chi-square tests. To determine which factors are associated with the occurrence of SSI, univariate logistic regression analyses were performed for age, sex, BMI, diabetes mellitus, smoking, presurgical antiseptic regimen, and surgical factors including use of open incision, insertion of metal implant(s), and bone surgery. For variables with p-values of <0.1 , we further performed multivariate logistic regression analysis.

Results

1. Patient characteristics

Among 190 patients who were surgically treated at our hospital, 175 patients (male, 81 and female, 94) met the criteria and were included in the study. Their average age was 52.0 ± 22.0 years, and the average BMI was 24.5 ± 3.9 kg/m². Twenty-five (14.3%) had diabetes mellitus and 30 (17.1%) were current smoker. Surgery was performed most commonly for wrist (87 patients, 49.7%), elbow (39 patients, 22.3%), and hand (27 patients, 15.4%). Other upper extremities included forearm (13

patients, 7.4%), finger (six patients, 3.4%), and upper arm (three patients, 1.7%). The surgical time averaged 39.3 ± 10.7 minutes. Seventy-six among 175 procedures (43.4%) were elective surgeries. Triple regimen was used as presurgical antiseptic in 97 patients (55.4%) and single regimen in 78 patients (44.6%). Marked elevation of CRP at 2 weeks after surgery was found in 27 patients (15.4%). Use of single regimen was associated with the marked elevation with odds ratio (OR) of 2.425 (95% confidence interval [CI], 1.040–5.655) (Table 1).

2. Surgical site infection between presurgical antiseptic regimens

Superficial SSI was diagnosed in six patients (3.4%), and deep SSI in three patients (1.7%). The rate of superficial and deep SSI did not differ according to the regimen selection (Table 2).

3. Associated factors with C-reactive protein elevation and surgical site infection

The univariate logistic regression analysis showed that use of

Table 1. Demographic data of all subjects according to the presurgical antiseptic regimen

Variable	Total	Single regimen ^a	Triple regimen ^b	p-value
No. of patients	175	78	97	
Age (yr)	52.0 ± 22.0	54.6 ± 19.8	49.9 ± 23.5	0.162
Sex				0.521
Male	81 (46.3)	34 (43.6)	47 (48.5)	
Female	94 (53.7)	44 (56.4)	50 (51.5)	
Body mass index (kg/m ²)	24.5 ± 3.9	24.7 ± 4.1	24.4 ± 3.8	0.642
Diabetes mellitus				0.214
No	150 (85.7)	64 (82.1)	86 (88.7)	
Yes	25 (14.3)	14 (17.9)	11 (11.3)	
Smoking status				0.911
No	144 (82.3)	64 (82.1)	80 (82.5)	
Yes	30 (17.1)	13 (16.7)	17 (17.5)	
Preoperative CRP (mg/dL)	0.24 ± 0.40	0.22 ± 0.29	0.25 ± 0.47	0.581
Site				0.655
Finger	6 (3.4)	5 (6.4)	6 (6.2)	
Hand	27 (15.4)	13 (16.7)	9 (9.3)	
Wrist	87 (49.7)	47 (60.3)	42 (43.3)	
Forearm	13 (7.4)	1 (1.3)	8 (8.2)	
Elbow	39 (22.3)	11 (14.1)	28 (28.9)	
Upper arm	3 (1.7)	1 (1.3)	4 (4.1)	
Surgical time (min)	39.3 ± 10.7	39.6 ± 12.4	39.1 ± 9.1	0.809
CRP at 2 weeks, >1.5 mg/dL	27 (15.4)	17 (21.8)	10 (10.3)	0.037*

Values are presented as number only, mean $\pm$ standard deviation, or number (%).

CRP, C-reactive protein.

^aPovidone-iodine, ^bpovidone-iodine and alcohol-chlorhexidine.

* $p < 0.05$, statistical significance.

Table 2. Occurrence of surgical site infection according to the presurgical antisepsis regimen

	Single regimen ^a (n = 78)	Triple regimen ^b (n = 97)	OR (95% CI)	p-value
Superficial surgical site infection			2.568 (0.458–14.401)	0.268
No	74 (94.9)	95 (97.9)		
Yes	4 (5.1)	2 (2.1)		
Deep surgical site infection			2.526 (0.225–28.389)	0.437
No	76 (97.4)	96 (99.0)		
Yes	2 (2.6)	1 (1.0)		

Values are presented as number (%).

OR, odds ratio; CI, confidence interval.

^aPovidone-iodine, ^bpovidone-iodine and alcohol-chlorhexidine.

Table 3. Regression outcomes between surgical site infection and other study variables

Variable	CRP elevation at 2 weeks		Oral antibiotics restarted		Readmission	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age	1.012 (0.993–1.032)	0.227	1.033 (0.983–1.085)	0.201	1.054 (0.978–1.135)	0.166
Sex	0.916 (0.401–2.090)	0.835	0.577 (0.103–3.236)	0.532	2.385 (0.212–26.797)	0.481
Body mass index	1.011 (0.907–1.126)	0.843	1.015 (0.826–1.248)	0.887	0.976 (0.729–1.308)	0.872
Diabetes mellitus	2.528 (0.938–6.816)	0.067	6.636 (1.259–34.969)	0.026*	3.062 (0.267–35.099)	0.368
Smoking	0.585 (0.164–2.089)	0.409	0.993 (0.112–8.828)	0.995	2.536 (0.222–28.931)	0.454
Single regimen ^a	2.425 (1.040–5.655)	0.040*	2.541 (0.453–14.252)	0.289	2.500 (0.222–28.096)	0.458
Surgical factors						
Open incision	0.970 (0.262–3.585)	0.963	0.600 (0.066–5.426)	0.649	NA	
Metal implant	3.602 (1.184–10.953)	0.024*	NA		NA	
Bone surgery	2.130 (0.693–6.540)	0.187	NA		NA	

CRP, C-reactive protein; OR, odds ratio; CI, confidence interval; NA, not applicable.

^aPovidone iodine.

*p < 0.05, statistical significance.

single regimen (OR, 2.425; 95% CI, 1.040–5.655) and surgical procedure using metal implant (OR, 3.602; 95% CI, 1.184–10.953) were significantly associated with the marked CRP elevation at 2 weeks. And diabetes mellitus (OR, 6.636; 95% CI, 1.259–34.969) was the only associating factor with superficial SSI (Table 3).

In the multivariate analysis model including diabetes mellitus, single regimen, and metal implant, the marked CRP elevation at 2 weeks was associated with single regimen (adjusted OR, 2.439; 95% CI, 1.022–5.822) and surgical procedure using metal implant (adjusted OR, 3.530; 95% CI, 1.139–10.944), only. In superficial and deep SSI, multivariate analysis was not performed because the number of factors with a p-value of < 0.1 was insufficient.

Discussion

Appropriate selection of presurgical skin antisepsis regimen in orthopedic surgery is important for prevention of SSI. Two different regimens were used for upper extremity surgeries at

our institute in a blinded fashion, for which comparison was made through this study. Regardless of other evaluated parameters, marked CRP elevation was associated with using single regimen as skin antisepsis. However, rate of superficial and deep SSI was not increased.

Use of multiple agents for antisepsis has been the standard of care as skin antisepsis before performing general orthopedic surgery [7]. Unlike the general standard, our study suggested that, after the upper extremity surgeries, SSI did not increase even when only povidone-iodine was used. This might be explained by notably low rate of SSI in upper extremity in comparison to other body parts. The high resistance to the occurrence of SSI in upper extremity can be a reason for choosing different antisepsis regimen. Blood supply to the upper extremity is more abundant than to the lower extremity, and hygiene control is easier [13,14]. This anatomical factor may reduce the risk of SSIs. Shorter operation time is another reason for the low rate of SSI. Duration of operation is an independent risk factor for SSI [15]. Besides, despite the broadest antimicrobial spectrum, povidone-iodine has shorter duration of activity

than chlorhexidine [16,17]. For upper extremity surgeries with short operation time, necessity for using long-acting antiseptics would have been diminished, which might have reduced the effect of alcoholic chlorhexidine in our cases.

Results of our study do not imply that the single regimen can substitute the triple regimen. Several studies support the use of multiple regimens for general orthopedic surgeries [7]. Its superior antimicrobial effect is evident, especially when alcohol-chlorhexidine is included [18]. Our study also showed that the level of CRP at 2 weeks after the surgery was higher in the single regimen group than in the triple regimen group. This means that postsurgical inflammation lasted longer and that close follow-up for the SSI is required. Small number of subjects was used for this study, and the increase in the rate of SSI may reach statistical significance in a large-population study.

Our study can serve as a reference for upper extremity surgeries performed under unfavorable conditions. Strict guidelines can sometimes limit the optimal treatment. Povidone-iodine is relatively common antiseptics that is also used for simple wound care. Therefore, it can be used in urgent situations where invasive procedure is, though, necessary. Moreover, surgical practices that adhere to strict antiseptics guideline might not be possible in developing countries because of cost and available antiseptics agents, for which regimen of using povidone-iodine only can be attempted according to results of our study.

There are several limitations in this study. First, this was not a prospective randomized study. Second, as surgical factors, we evaluated whether an open incision was used, whether metal implant was inserted, and whether the surgery involved the bony tissue. However, other factors such as length of the incision site may also affect the infection risk, which was not evaluated. Third, the local bacterial load was not calculated. Fourth, because of the insurance policy, the CRP measurement could not be made at other perioperative periods except 2 weeks after surgery, unless SSI was suspicious. This limited the evaluation of the postoperative CRP level to be made only once in most of the patients who did not experience the SSI.

Conclusion

Use of triple regimen has been the standard of care for preoperative skin antiseptics in the orthopedic field. Our study suggests that single regimen of using povidone-iodine alone could be similarly effective in preventing SSI after upper extremity surgeries.

ORCID

Ji Sup Hwang, <https://orcid.org/0000-0001-8671-0350>

Dong Min Lee, <https://orcid.org/0000-0002-5541-3836>

Yo Han Lee, <https://orcid.org/0000-0002-2078-3167>

Conflicts of interest

The authors have nothing to disclose.

Funding

None.

References

1. Lee J, Singletary R, Schmader K, Anderson DJ, Bolognesi M, Kaye KS. Surgical site infection in the elderly following orthopaedic surgery: risk factors and outcomes. *J Bone Joint Surg Am.* 2006;88:1705-12.
2. Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. *Clin Orthop Relat Res.* 2008;466:1710-5.
3. Haley RW, Schaberg DR, Crossley KB, Von Allmen SD, McGowan JE Jr. Extra charges and prolongation of stay attributable to nosocomial infections: a prospective interhospital comparison. *Am J Med.* 1981;70:51-8.
4. Coello R, Glenister H, Fereres J, et al. The cost of infection in surgical patients: a case-control study. *J Hosp Infect.* 1993;25:239-50.
5. Wenzel RP. The Lowbury lecture: the economics of nosocomial infections. *J Hosp Infect.* 1995;31:79-87.
6. Mastrocola M, Matziolis G, Böhle S, Lindemann C, Schlattmann P, Ejler H. Meta-analysis of the efficacy of preoperative skin preparation with alcoholic chlorhexidine compared to povidone iodine in orthopedic surgery. *Sci Rep.* 2021;11:18634.
7. Meakins JL, Masterson BJ. Epidemiology of surgical site infection. In: Souba WW, Fink MP, Jurkovich GJ, editors. *ACS surgery: principles and practice.* New York: WebMD Inc; 2004. p. 17-36.
8. Zdeblick TA, Lederman MM, Jacobs MR, Marcus RE. Preoperative use of povidone-iodine: a prospective, randomized study. *Clin Orthop Relat Res.* 1986;(213):211-5.
9. Letzelter J, Hill JB, Hacquebord J. An overview of skin antiseptics used in orthopaedic surgery procedures. *J Am Acad Orthop Surg.* 2019;27:599-606.

10. Ellenhorn JD, Smith DD, Schwarz RE, et al. Paint-only is equivalent to scrub-and-paint in preoperative preparation of abdominal surgery sites. *J Am Coll Surg*. 2005;201:737-41.
11. Welsch T, Müller SA, Ulrich A, et al. C-reactive protein as early predictor for infectious postoperative complications in rectal surgery. *Int J Colorectal Dis*. 2007;22:1499-507.
12. Centers for Disease Control and Prevention (CDC). National Healthcare Safety Network: surgical site infection event [Internet]. Atlanta, GA: CDC; 2022 [cited 2021 Dec 8]. Available from: <http://www.cdc.gov/nhsn/PDFs/pscManual/9pscSSI-current.pdf>.
13. Ryan DJ, Minhas SV, Konda S, Catalano LW. Surgical site infection after open upper extremity fracture and the effect of urgent operative intervention. *J Orthop Trauma*. 2020;34:258-62.
14. Greenblatt DY, Rajamanickam V, Mell MW. Predictors of surgical site infection after open lower extremity revascularization. *J Vasc Surg*. 2011;54:433-9.
15. Leong G, Wilson J, Charlett A. Duration of operation as a risk factor for surgical site infection: comparison of English and US data. *J Hosp Infect*. 2006;63:255-62.
16. Barreto R, Barrois B, Lambert J, Malhotra-Kumar S, Santos-Fernandes V, Monstrey S. Addressing the challenges in antisepsis: focus on povidone iodine. *Int J Antimicrob Agents*. 2020;56:106064.
17. Peterson AF, Rosenberg A, Alatary SD. Comparative evaluation of surgical scrub preparations. *Surg Gynecol Obstet*. 1978;146:63-5.
18. Privitera GP, Costa AL, Brusaferrero S, et al. Skin antisepsis with chlorhexidine versus iodine for the prevention of surgical site infection: a systematic review and meta-analysis. *Am J Infect Control*. 2017;45:180-9.