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The effects of two surgical gowning and gloving methods on the extent of contamination of surgical team members' gowns and gloves: A single-blind controlled trial

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Abstract

Background: The method used to wear the surgical gown and gloves has a critical role in the extent of surgical site contamination.

Objectives: The purpose of this study was to compare the effect of gown and gloves wearing in the integrated and closed methods on the extent of contamination of surgical team members' gowns and gloves.

Methods: A single-blind controlled trial was conducted with 70 eligible surgical staff who were randomly assigned to two groups of 35. The intervention group wore sterile, integrated gown-glove units, whereas the control group wore separate gowns and gloves using the closed technique. Glitterbug fluorescent powder was used to measure contamination. An ultraviolet flashlight was used to make the Glitterbug powder visible. Participants in both groups wore their gowns and gloves after dipping their hands in fluorescent powder. After one hour of the surgery, the gowns and gloves were removed from the body, a mobile phone was used to take photos of the areas containing powder, and ImageJ software was used to measure the area of contamination. The independent samples t-tests and chi-square test were used to analyze the data.

Results: The contaminated area of gloves was 0.06±0.24 mm2 for the integrated gown-glove unit method and 2.26± 5.87 mm2 for the closed gown and gloves wearing method (P= 0.03). The contaminated area of the gown was zero for the integrated method and 3.06±7.57 mm2 for the closed method (P= 0.02).

Conclusion: The extent of contamination was less when using the integrated gown-glove unit than the closed method. The surgical staff are recommended to use integrated gown-glove units to reduce the risk of contamination of gowns and gloves used for surgery.

Keywords: Contamination, Operating room, Surgical glove, Surgical gown.

Introduction

Surgical site infection (SSI) is an infection occurring at or near the surgical incision within 30 days of surgery or one year after implant placement. SSI can result in failure to achieve the purpose of the surgery and causes irreparable damages to the patient.[1] It is the main cause of postoperative emotional distress, increased costs, antibiotic resistance, and disability and also accounts for one-third of postoperative deaths.[2,3] SSIs are the most common healthcare-related infections in low- and middle-income countries, occurring in 11% of patients undergoing surgery.[4]

Various measures are taken to reduce the rate of postoperative infections, including the wearing of gowns and gloves during surgery.[5] It is necessary for surgical team members to wear sterile gowns and gloves. However, the technique of wearing gowns and gloves also affects the extent of contamination. There are different techniques for wearing gloves, such as the open method, the closed method, and donning with the help of a scrub nurse.[6] The

surgical gown and gloves are separate from each other in these techniques. When wearing gloves, pulling the glove cuff over the sleeve of the gown transfers potential contamination from the inside of the glove to the outside of the gown. Since standard hand washing is not sufficient to eliminate pathogens, we can suppose that touching the inside of the glove (when the glove is pulled up over the sleeve) will transfer pathogens from the surface of the hand to the sleeve of the gown. It has also been observed that gloves' cuffs are spontaneously lowered during surgery, exposing the contaminated surface to the surgical site.[7]

Studies have shown that none of the gloving and gowning methods are free of contamination.[6-8] A study found that both closed and open techniques were associated with degrees contamination.[7] Another study compared the degree of contamination in three surgical gloving techniques (i.e. open, closed, and open nurse-assisted). The closed technique was found to be associated with less contamination than the other two methods. The average glove contamination in the open nurse-assisted technique was also lower than in the open method. Totally, the average contamination was significantly greater in the open technique than in the other methods.[8] A study also reported that wearing gloves before the surgical gown prevented gown sleeve contamination.[7] The aforementioned studies show that gowning and gloving methods do not guarantee the continuity of gloves and gown sterility. Therefore, researchers are always trying to find ways to reduce gown and gloves contamination. We hypothesized that the combination of gown and gloves would prevent the transfer of contamination from the hands to the gloves and gown. Therefore, in the current study, we investigated the effect of integrated gown and gloves on the degree of contamination of gloves and gown. For this purpose, cotton-polyester gloves (sizes 7, 7.5 and 8) were sewn onto the sleeves of disposable polypropylene gowns. The gown-glove units were sterilized by ethylelne oxide gas and used.

Objectives

The purpose of this study was to compare the effect of gown and gloves wearing in the integrated and closed methods on the extent of contamination of surgical team members' gowns and gloves.

Methods

Study design and participants

A single-blind controlled trial was conducted from August 2021 to September 2021 with 70 eligible surgical staff working in Al-Zahra and Kashani hospitals in Isfahan, Iran. Participants were conveniently recruited and randomly assigned to two groups of 35. The intervention group wore sterile, integrated gown-glove units, whereas the control group wore separate gowns and gloves using the closed technique [Figure 1].

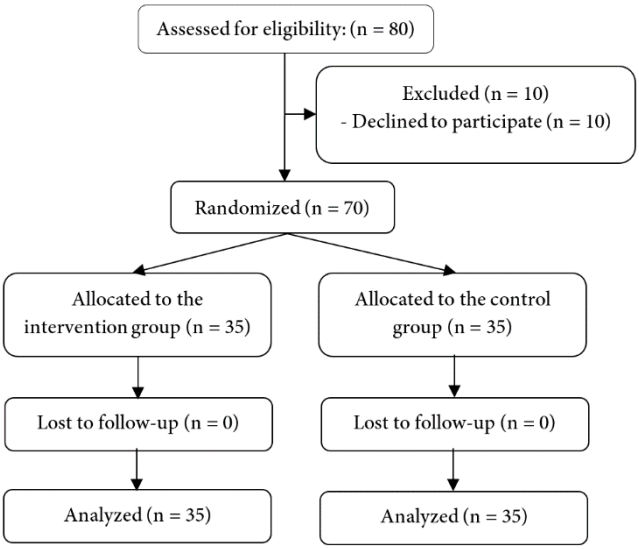

Figure 1. The study flow diagram

The sample size was calculated using G Power version 3.1., and based on the results of a previous study.[6] Based on the difference between two independent groups, alpha = 0.05, power = 0.90, a standard deviation of 0.7, a median effect size, and given a 10% dropout [Formula 1], 35 participants were needed in each group.

$$n = \frac{\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2 2s^2}{d^2}$$

Formula 1. Sample size calculation formula

Inclusion criteria were surgical staff with at least 6 months of work experience, no allergy to fluorescent powder, participation in surgery for at least one hour, and willingness to participate in the study. Exclusion criteria included holes or tears in gloves during surgery, failure to properly perform the procedures taught, and the participant's decision to withdraw from the study.

Data collection instruments

Data collection instruments included a researcher-made checklist, a camera, an ultraviolet flashlight, and ImageJ software.

The checklists included two sections. The first section includes demographic information such as age, gender, work experience, and education level. The second section contains two tables. The first table has two separate columns. The first column is used to record the contaminated surface area of the fingers, palm, back of the hand, and cuff of the right glove, and the second column is used to record the contaminated surface of the same areas of the left glove [Figure 2]. The second table is also divided into three columns. The first and second columns have three boxes for recording the surface area of contamination on the right and left hands of the gown (ie, the area of the cuff, the area between the sleeve and the elbow, and the area between the elbow and the shoulder). In the third column, the contaminated area of the upper body of the gown is recorded (i.e. from the umbilical area to the neck) [Figure 3].

Glitterbug fluorescent powder manufactured by DayGlo Color Corp was used to measure contamination.[6-8] Fluorescent powder is a substance widely used in the investigation of surface contamination.[9,10] This powder becomes visible in the presence of ultraviolet (UV) light. The same brand of UV flashlight (315 to 400 nm wavelength) was used to make the *Glitterbug* powder visible. The day before the intervention, some powder was applied to the inner part of the participants' forearm, and its range was marked with a marker. After 24 hours, the place of the powder was checked. No one showed allergy symptoms.

A HUAWEI Y9s mobile phone was used to take photos of the areas containing powder. This phone consists of a 48-megapixel main sensor with a wide-angle lens and f/1.8 aperture, an 8-megapixel sensor with an f/2.4 aperture lens, and a 2-megapixel depth-of-field sensor.

ImageJ software was used to measure the area of the surface impregnated with fluorescent powder. ImageJ is a Java-based image processing program developed at the National Institutes of Healthand the Laboratory for Optical and Computational Instrumentation. This software provides the possibility to estimate the area of irregular shapes and also to display, edit, analyze, process, store, and print 8-bit, 16-bit, and 32-bit images.

To estimate the reliability of the UV flashlight, the fluorescent powder was applied to the specified area, the flashlight was shone on it, and the contaminated areas were measured. After 15 minutes, the flashlight was turned on again and each contaminated area was measured.

Figure 2. Glove zoning

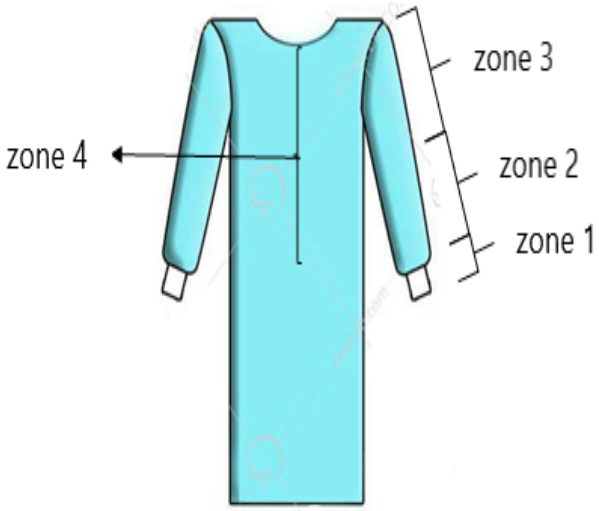

Figure 3. Gown zoning

Intervention

Surgical staff participating in the study were instructed on how to wear gowns and gloves, according to their groups. All participants were also taught how to powder their hands.

After washing their hands in the standard way, the participants first took 3 grams of sterile fluorescent powder from a third person wearing sterile gloves, and dipped their hands (palms, backs of hands, and between fingers) in the powder from fingertips to wristsand then put on theirgowns. Participants in the control group donned their latex gloves with a closed technique after wearing the gown. Participants in the intervention group donned an integrated gown-glove unit after dipping their hands in the powder and then also wore a latex glove over

each cotton-polyester glove (i.e. the glove attached to the gown) [Figure 4].

After one hour of the surgery, the gloves and gown of the scrub persons were removed by a third person wearing disposable gloves, and this was the same for all participants (all gloves were removed first from the right hand and then from the left hand). The edge of the glove and the shoulder of the gown were taken and carefully and slowly removed from the hands of the participants. Immediately, and in a relatively dark place, the researcher turned on the ultraviolet flashlight and placed it in front of the gloves and gown to measure the extent of contamination (fluorescent powder) of the gloves and different areas of the gowns [Figure 5].

The contaminated areas of the gowns and gloves were photographed by phone, loaded into the ImageJ software, and the surface area of each contaminated zone was recorded in the checklist in square millimetres (mm^2).

Statistical analysis

The continuous variables were expressed as the mean±SD, and the categorical variables were presented as a percentage and frequency. The Kolmogorov–Smirnov test was used to examine the normal distribution of the quantitative variables. The independent samples t-test was used to compare the mean area of contamination between the two groups. The chi-square test was used to compare the two groups in terms of nominal variables. All statistical analyses were performed with SPSS (version 16.0, SPSS Inc, Chicago, IL, USA). A "P-value" less than 0.05 was considered significant.

Ethical consideration

The Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran approved the study (approval code: IR.MUI.NUREMA.REC.1400.071). The study protocol was also registered in the Iranian Registry of Clinical Trials (code: IRCT20150715023216N8). The subjects were informed of the research objectives and procedures. Written informed consent was obtained from all of them. They were assured of the confidentiality of their data and informed of their right to either participate in or withdraw from the study at any time. The guidelines of the Committee on Publication Ethics were followed, and the research was conducted in compliance with Helsinki Declaration on the ethical standards of medical research on human subjects.[11] The statistical consultant was blind to the nature of the intervention and the group of participants.

Figure 4. Integrated gown and glove

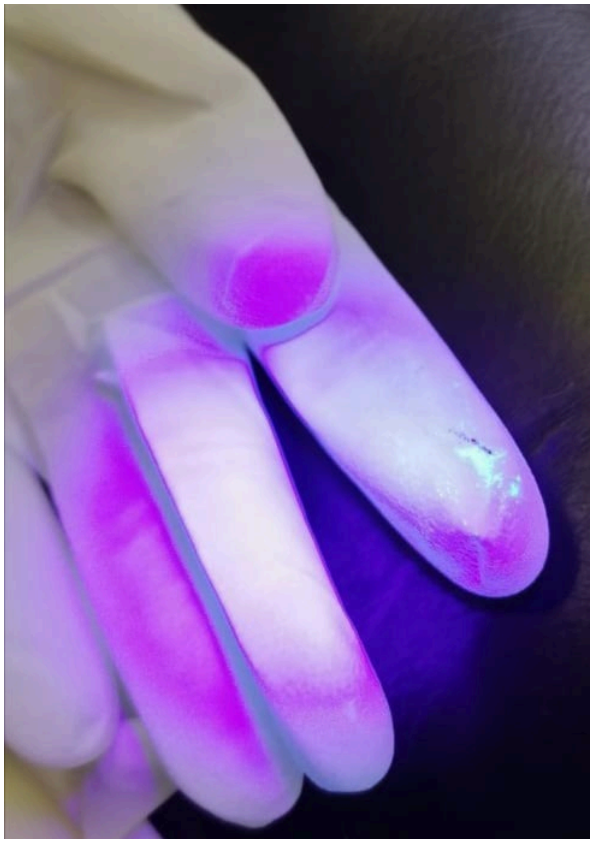

Figure 5. Contamination reagent in closed method

Results

The mean work experience of the participants in the intervention and control groups was 7.91±5.53 and 7.37±4.52 years, respectively (P= 0.655). The two groups were also homogeneous in other demographic characteristics [Table 1].

The contaminated area of gloves was 0.06±0.24 mm^2 for the integrated gown-glove unit method and 2.26± 5.87 mm^2 for the closed gown and gloves wearing method (P= 0.03). The contaminated area of the gown was zero for the integrated method and 3.06±7.57 mm^2 for the closed method (P= 0.02) [Table 2].

Table 1. Demographic characteristics of the participants

Variable	Intervention (Integrated method)	Control (Closed method)	P value
Gender			0.595[a]
Male	16 (45.72)	16 (45.72)	
Female	19 (54.28)	19 (54.28)	
Education			0.74 [a]
Associate degree	11 (31.43)	10 (28.57)	
Bachelor	13 (37.14)	15 (42.86)	
Masters	11 (31.43)	10 (28.57)	
Age (years)	32.03 ± 4.98	31.34 ± 4.39	0.544[b]
Work experience (years)	7.91 ±5.53	7.37± 4.52	0.655 [b]

Data presented as n (%) or mean ± SD, [a] Chi-square test, [b] t-test

Table 2. Comparison of the mean contamination area of separate gowns and gloves and integrated gown-glove unit techniques

Variable	Intervention (Integrated method)	Control (Closed method)	P value [a]
Contaminated area of the gloves (mm^2)	0.06 ± 0.24	2.26 ± 5.87	0.03
Contaminated area of the gown (mm^2)	0 ± 0	3.06 ± 7.56	0.02
Total contaminated area	0.06 ± 0.24	5.31 ± 12.42	0.01

Data presented as mean ± SD, [a] t-test

Discussion

The results of the present study showed that the contamination of gowns and gloves was significantly lower in the integrated method of gown-glove wearing than in the closed method of donning the gown and gloves. An earlier study compared particle contamination at the gown-glove interface in several modern surgical gowning and gloving techniques. Participants in the latter study dipped both hands up to the wrist in fluorescent powder, donned gowns and gloves according to the standard method, and performed a 20-minute simulated arthroplasty protocol. Particle contamination occurred at the gown-glove interface in all common surgical gowning and gloving techniques.[12] The gown-glove interface seems to be a source of contamination. However, in the current study, we omitted the gown-glove interface by integrating the gown and gloves. This significantly reduced the risk of contamination.

Evidence showed the weak points of the standard gowning and gloving method.[7,13] Referring to the role of the method used to don the surgical gown and gloves on the degree of gown contamination, Byrd *et al.* compared the differences in gown contamination between three different ways of donning gowns and gloves. The results showed that while closed (having the gown cuff at or distal to the fingertips while donning gloves) and open (pulling the gown cuff to the level of the carpus so that the finger and distal hand protrude while donning gloves) methods resulted in some level of contamination, the gloves-first technique demonstrated zero contamination.[7] The extent of contamination when using the integrated gown-glove unit in our study was comparable to the results of the gloves-first technique in the latter study, demonstrating that simultaneous wearing of gown and gloves can significantly reduce the risk of contamination.

Jalali and Naji also compared the unassisted and nurse-assisted closed gowning and gloving methods. Their results showed that the assisted-closed method was superior in preventing gown and glove contamination.[13] Hosseini et al. also compared the effects of three open, closed, and open nurse-assisted gloving techniques on contamination rates. The results indicated that the mean contamination was lower in the closed technique than in the other two methods.[8] Nonetheless, in the current study, the use of the integrated gown-glove unit resulted in less contamination than the closed method.

This study had some limitations, including small sample size and lack of measurement of SSI. A similar study to measure SSI rate with a larger sample size is therefore recommended.

Conclusions

Since the amount of contamination in the use of the integrated gown-glove unit was less than the closed method, the use of such an integrated gown-glove unit can cause less contamination in surgery and may reduce the risk of SSI. Surgical staff are advised to use integrated gown-glove units to reduce the risk of contamination of gowns and gloves used for surgery.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Surgical site infection: SSI;
Ultraviolet: UV.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Role of the funding source

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran approved the study (approval code: IR.MUI.NUREMA.REC.1400.071). The study protocol was also registered in the Iranian Registry of Clinical Trials (code: IRCT20150715023216N8).

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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