

## EFFECTIVENESS OF DOUBLE-GLOVING METHOD ON PREVENTION OF SURGICAL GLOVE PERFORATIONS AND BLOOD CONTAMINATION: A PROSPECTIVE STUDY

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### ABSTRACT

**Objectives:** The objectives of the study are to evaluate the efficacy of double gloving to provide a mechanical barrier against communicable diseases and also to evaluate different parameters affecting glove perforation rate.

**Methods:** This prospective study was performed in the Department of General Surgery at Tertiary Care Teaching Hospital of Gujarat. This study involved a group of surgeons and operation theater nursing staff. Randomization of the participants was done with the closed envelope method in two groups: Single gloving and double gloving. Glove perforation rate and hand contamination rate were calculated and compared between both groups. Participants of double-gloving groups were also asked for discomfort using double gloves and compromised tactile sensations.

**Results:** There was no statistically significant difference in the glove perforation rate between single gloves and double outer gloves ( $p=0.55$ ). However, the glove perforation rate was significantly lower in double inner gloves than in single gloves ( $p=0.004$ ). The hand contamination rate was significantly lower among perforated double gloves than perforated single gloves ( $p=0.00001$ ). Awareness of glove perforation was absent in the majority of the participants in both groups. All the participants in the double-gloving group were comfortable with using double gloves and their tactile sensations were not compromised.

**Conclusion:** This study concluded that double gloving efficiently prevented hand contaminations during surgery. There was no significant difference noted in glove perforation rates in both single and double-gloving groups. Double gloving is recommended for the surgeons and nursing staff to protect them from blood-borne infections and eliminate the chances of surgical site infections in the patients.

**Keywords:** Hand contamination, Glove perforation, Single gloving, Double gloving.

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### INTRODUCTION

Gloves are the most integral part of a surgeon's life. Gloves are the mechanical barrier which can prevent the transmission of micro-organisms in both directions – from the surgeon's hands to the patient and vice versa [1].

Nowadays, the awareness of the risk of contamination with body fluids during surgery is increasing, and pooled data indicate that the average probability of transmission after needle stick exposure is 0.2–0.5% for HIV-1, 30% for hepatitis B, between 5% and 10% for hepatitis C [1]. This has led to the wearing of double gloves during surgical procedures among surgeons, particularly in low-resource countries.

However, there are quite a number of surgeons who still prefer to wear single gloves during operations because of the loss of tactile sensation and comfort if the double set is worn [2]. The physical integrity of gloves is very important. The integrity of the gloves depends on the make or manufacturer duration of wearing, duration and type of surgery performed, role of staff within the surgical team, and the experience of the surgeon [3].

The present study was conducted to evaluate the efficacy of double gloving to provide a mechanical barrier against communicable diseases and also to evaluate different parameters affecting glove perforation rate.

### METHODS

This prospective single-center cohort study was performed in the Department of General Surgery at Tertiary Care Teaching Hospital

of Gujarat during a period from January 2022 to March 2022. Ethical approval for the study was obtained from the Institutional Ethical Committee. All the surgeries were included except for the surgeries performed on the patients who were seropositive for HIV and HBsAg. This study involved a group of consultant surgeons, resident surgeons of general surgery, and operation theater nursing staff.

### Procedure

After prior explanation and obtainment of consent from the participants, randomization of the participants was done with the closed envelope method in two groups: Single gloving and double gloving. Each member of the operating team wore gloves of the size of their personal choice and comfort during the surgical procedure. If any member of the surgical team noticed glove perforation at any point of time during the surgery, the member notified the event observer and all the gloves that the member was wearing were changed and the member's hands were inspected for contamination with blood/body fluid or injury at that point of time only. All the gloves, along with the perforated glove, underwent perforation tests later on. Moreover, after the event that particular member did not further participate in the study for that particular surgery.

For all other members of the surgical team, at the end of the surgical procedure, inspection of the participant's hands was carried out and the presence of blood/body fluid or injury on their hands was recorded. Both inner and outer pairs of used gloves (for double glove pattern) and pairs of single gloves were tested for perforations immediately after the surgical procedure using the water leak method.

## WATER LEAK METHOD

Each and every used glove were separately filled with approximately 500–700 cc of tap water and were suspended in the air and were compressed from different sites. On careful inspection, a thin stream of water was seen from the site of the perforation, as shown in Fig. 1. The number and site of the perforation along with the side of the hand were documented in the proforma.

Members of the surgical team were also asked for awareness of the occurrence of any glove perforation and associated skin puncture during the operative procedure in which glove perforation was detected. Participants of double-gloving groups were asked for discomfort using double gloves and compromised tactile sensations.

Records were made of the site of perforation, dominant/non-dominant hand, index finger/middle finger/ring finger/little finger/thumb/palm/other, duration of the surgery, type of surgery (sub-specialty), operating surgeon/assistant surgeon/scrub nurse, level of operating surgeon, discomfort (only for double-gloving groups), and impairment of tactile sensations (only for double-gloving groups). Glove perforation rate and hand contamination rate were calculated and compared between both groups.

## Statistical analysis

Data were expressed as a number or percentage. The data of the two groups were analyzed using the Chi-square test. A  $p < 0.05$  was considered significant.

## RESULTS AND DISCUSSION

A total of 90 surgeries were randomly selected for this study. Out of them, six surgeries were excluded from the study. Full details of the rest of the 84 operations were recorded in a pro forma. A total of 380 pairs of gloves were studied which were collected from 75 surgeries. Out of 380 pairs, 128 pairs were used under a single-gloving pattern and 252 pairs (126 inner and 126 outer) were used under a double-gloving pattern.

Out of 254 participants, 170 were surgeons and 84 scrubbed nurses. There was equal distribution of various subspecialties in both groups (Table 1).

There was no statistically significant difference in the glove perforation rate between single gloves and double outer gloves. ( $p = 0.55$ ). However, the glove perforation rate was significantly lower in double inner gloves than in single gloves ( $p = 0.004$ ) (Table 2).

The hand contamination rate was significantly lower among perforated double gloves than perforated single gloves ( $p = 0.00001$ ) (Table 3).

Overall glove perforation noted among general surgeries was 4.93%. It was 9.72% in uro-surgeries. No glove perforation was noted



**Fig. 1: Thin stream of water was seen from the site of the perforation**

during pediatric and plastic surgeries in the present study. The glove perforation rate was significantly higher in major surgeries. There was no statistically significant difference in the glove perforation rate between emergency and elective surgeries. The glove perforation rate was significantly lower in surgeries lasting up to 2 h when compared to the surgeries lasting more than 2 h.

The glove perforation rate was significantly lower in nurses than in surgeons. There was also a significant difference in the glove perforation rate between consultant and resident surgeons. There was no significant difference in the glove perforation rate between morning–noon and evening–night surgeries (Table 4).

The most common site of perforation was the non-dominant index finger (47.82%) followed by the dominant index finger (23.07%) and dominant thumb (23.07%) (Table 5).

Awareness of glove perforation was absent in the majority of the participants in both groups. All the participants in the double-gloving group were comfortable with using double gloves and their tactile sensations were not compromised (Table 6).

During surgery, intact gloves act as a protective barrier against blood-borne pathogens such as human immunodeficiency virus (HIV), hepatitis B virus, and hepatitis C virus [4]. Nowadays, double gloving during surgery is a common practice to decrease the risk of hand contamination. In developing countries such as India, it becomes necessary to prioritize the use of single gloving for those surgeries in which glove perforations are less likely. Hence, this study was planned to compare glove perforation and hand contamination rates in single-gloving and double-gloving groups and also to relate glove perforation rate with surgery.

Overall glove perforation rate in the present study was noted lower compared to other studies [5-7]. Almost 65% of the surgeries lasted for 2 h or less. Makama *et al.* study has noted that there is a sharp rise in glove perforation rate once the duration of the surgery exceeds 2 h [1]. Laine and Aarnio's study had 50% of surgeries which lasted <2 h [6]. Similarly, De Oliveira *et al.* study had 65% of surgeries which lasted for <2 h [5]. Bekele *et al.* study had a higher glove perforation rate (38.34%) compared to the present study [7]. This may be because it included orthopedic and cardiothoracic surgeries also, which involves dealing with bone fragments leading to a higher risk of glove perforation and maybe other studies had used more stringent perforation detection methods than the present study.

In the present study, the double-gloving group had a significantly lower hand contamination rate compared to single-gloving group. Similar results were found in other studies also [8,9]. This can be explained by the fact that for double-gloving group, inner glove perforation is the only way of getting hands contaminated during surgery. Although there is no significant difference between the perforation rates of outer gloves and single gloves; in double-gloving group, the inner glove perforation rate was much lower than the outer gloves. Thus lower rate of perforation of inner gloves is the main reason for less hand contamination in double-gloving group and it prevented hand contamination in almost 85% of the cases where the outer glove was perforated in the present study.

Naver and Gottrup's study concluded that the use of indicator double gloves led to increased awareness of perforation during the intraoperative period [8]. Hence, frequent changes of outer gloves during surgery protected the inner glove. Furthermore, they noticed less number of matching perforations in both inner and outer gloves simultaneously. Therefore, they detected a lower rate of hand contamination in double-gloving group. Compared to other studies [8,9], hand contamination rate was much higher in single-gloving group in the present study, which may be due to inter-observer bias or variable awareness rates regarding perforation.

Table 1: Demographic distribution of participants

Demographic	Single-gloving pattern (n=128)	Double-gloving pattern (n=126)	p-value
Type of surgery			
Major	47	56	0.21
Minor	81	70	
Mode of surgery			
Elective	90	75	0.07
Emergency	38	51	
Time of surgery			
Morning-noon (8 am–4 pm)	83	75	0.3
Evening-night (4 pm–8 am)	45	51	
Participants			
Surgeons	82	88	0.3
Scrubbed nurses	46	38	
Duration of surgery			
Up to 2 h	88	81	0.45
More than 2 h	40	45	
Surgery sub-specialty			
General surgery	102	96	0.38
Uro-surgery	8	14	
Plastic surgery	8	10	
Pediatric surgery	10	6	

Table 2: Glove perforation rate according to gloving patterns

Gloving pattern	Total no. of gloves studied	No. of gloves perforated	Percentage
Single	256	15	5.85
Double	504	21	4.16
Double (outer)	252	18	7.14
Double (inner)	252	3	1.19
Total	760	36	4.73
Unused gloves	332	3	0.90

Table 3: Hand contamination rate among perforated gloves

Gloving pattern	Total No. of gloves perforated	No. of hands contaminated	Percentage
Single	15	14	93.33
Double	21	3	14.28

No glove perforation was noted in pediatric and plastic surgeries included in the present study. The possible reason for that may be an extremely small sample size in pediatric and plastic surgeries. In addition to this, all the included plastic surgeries were split-thickness skin grafting, which involved minimal use of sutures or vigorous tissue handling; hence, less chances of glove perforation. Bekele *et al.* study noted a higher rate of perforations in both the sub-specialties [7]. They noted that in their study period, there was a lack of variety of size of gloves, so inappropriate size of glove can cause discomfort to the surgeon and may lead to increased chances of perforation. They also opined that the use of imported cheap quality gloves had more chances of manufacturing related perforations. The rate of glove perforation in the present study among different subspecialties is somewhat similar to the result of a study by Laine and Aarnio [6].

In the present study, although there was a lower rate of perforations in minor surgeries, it was statistically significant. It was supported by similar findings in the study conducted by Naver and Gottrup [8]. Minor surgeries are relatively of shorter duration, and mostly, they do not involve dissection in deeper tissues.

A lower rate of perforations was noted in elective surgeries compared to emergency surgeries; however, it was not statistically significant. In other studies, most of the emergency procedures were performed at antisocial hours by surgical residents with relatively limited surgical

experience [1,6,7]. This could have led to a higher rate of perforation in those studies.

Alike previous studies, the present study had lower rates of glove perforation for surgeries lasting for <2 h than those lasting more than 2 h, which was statistically significant [1,6]. Duration of operation has been noted to influence the increase in the rate of glove perforation during different studies. If the operation is longer, it becomes more demanding resulting in fatigue and a decrease of attentiveness of the surgeon [10].

In the present study, the glove perforation rate was relatively lower in the morning and noon hours compared to evening and night hours, which was contradicting other studies [1]. At this tertiary center, it is a routine protocol to conduct elective minor surgeries which can be performed under local anesthesia in the evening hours. Such surgeries had much lower perforation rates leading to lower perforation rates during 4 pm–8 am and the majority of surgeries with a duration of more than 2 h were performed in the morning hours.

The perforation rate in scrubbed nurses was <1% which was much less than in other studies [1,7,8]. In our setup, as it is a teaching hospital, the role of scrubbed nurses is very limited during the surgery. They are not actively involved in assisting positions as resident doctors are usually the first assistants. In addition to that, following basic operating room etiquettes such as passing sharps in a kidney tray and no touch technique to mount the needle on a holder makes them less prone to perforations.

Consultants had a lower rate of perforations than resident doctors in the present study and a similar observation was made by Makama *et al.* study also [1]. The possible reason for this may be the surgical experience of the consultants.

In the present study, the overall perforation rate was higher in the non-dominant hand may be because of its less dexterity compared to the dominant hand. Operating surgeons had the majority of perforations in their non-dominant hands. As the sharp instrument is held by dominant hand, the glove on that side is less likely to get perforations and the non-dominant hand is active in the operative field so it has more chances of perforations. In the present study, the second most common site was the dominant index finger and dominant thumb, unlike other studies [1,5] where it was found to be a non-dominant middle finger and non-dominant thumb, respectively.

Table 4: Glove perforation rate according to demographics

Demographic	No. of gloves studied	No. of gloves perforated	Percentage (%)	p-value
Surgery sub-specialty				
General surgery	588	29	4.93	-
Uro-surgery	72	7	9.72	
Plastic surgery	56	0	0	
Pediatric surgery	44	0	0	
Type of surgery				
Major	318	23	7.3	0.006*
Minor	442	13	2.9	
Mode of surgery				
Elective	480	21	4.37	0.53
Emergency	280	15	5.35	
Duration of surgery				
Up to 2 h	500	14	2.80	0.0005*
More than 2 h	260	23	8.84	
Participants				
Surgeon	516	34	6.58	0.0004*
Scrubbed nurse	244	2	0.81	
Time of surgery				
8 am-4 pm	466	25	5.36	0.304
4 pm-8 am	294	11	3.74	

\*Significant

Table 5: Site of glove perforation

Site	Index finger	Middle finger	Ring finger	Little finger	Thumb	Palm	Others	Total
Dominant	4	3	1	1	4	0	0	13 (36.11)
Non-dominant	11	4	1	1	5	1	0	23 (63.88)
Total	15	7	2	2	9	1	0	36

Table 6: Awareness of perforation

Gloving pattern	Total No. of gloves perforated	Awareness present	Percentage
Single gloving	15	4	26.66
Double gloving	21	2	9.52
Total	36	6	16.66

Alike the results of Thomas *et al.* [9] in the present study, only 16% of participants were aware of their glove perforation. Almost 90% of the perforations went unnoticed. In contrast to the present study, Naver and Gottrup study found almost 7-8 times more awareness of glove perforations [8]. In the present study, latex rubber gloves were used, whereas in a study done by Naver and Gottrup, indicator glove system was used [8]. This may be the reason for the high awareness of glove perforation among double-gloving group. Unlike the study done by Naver and Gottrup, the present study revealed only 18% glove perforation awareness in single-gloving patterns [8].

Unlike other studies [9,11], all the participants in the double-gloving group were comfortable with using double gloves and their tactile sensations were not compromised. In our tertiary care hospital, it is a common practice to wear double gloves. Hence, surgeons are habituated to double-gloving patterns since the time of their initiation to surgical practice. This may be the reason behind the high comfort level of participants.

#### Limitations

Although the present study was adequately powered, the following limitations were noticed. The present study did not include neurosurgery, orthopedic surgery, or obstetric surgery. Hence, glove perforation rate in these branches could not be assessed. The use of different brands of gloves may have led to the use of gloves of different manufacturing standards, which may have ultimately affected the perforation rate. In the present study, the effect of the use of electrocautery on glove perforation rate was not evaluated. The rate of surgical site infections

in the surgeries performed with perforated and non-perforated gloves was also not estimated as has been done in some other studies.

#### CONCLUSION

This study concluded that double gloving efficiently prevented hand contaminations during surgery. There was no significant difference noted in glove perforation rates in both single and double-gloving groups, but the incidence of inner glove perforation was much less than outer glove perforation in double-gloving group. Double gloving is recommended for the surgeons and nursing staff to protect them from blood-borne infections and eliminate the chances of surgical site infections in the patients. Periodical changing of gloves after 2 h is recommended for the protection of the surgeons from hand contamination due to undetected glove perforations.

#### AUTHORS' CONTRIBUTION

All the authors contributed to the preparation of the final manuscript.

#### CONFLICTS OF INTEREST

None.

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Nil.

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