Use of a Double Gloving Technique to Decrease Cross-Contamination by Anesthesia Providers

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The purpose of this project was to determine the impact of double gloving during the induction of general anesthesia on the incidence of cross-contamination by the anesthesia provider. In a representative sample of anesthesia providers, induction sequences were initially evaluated using the providers' standard technique (group 0). The same providers were reevaluated after being educated on the double gloving technique (group 1). One month later the providers were reevaluated to identify which ones continued the double gloving technique (group 2). For each sequence, all providers were asked to complete a general anesthesia induction following a standard sequence (n = 30). Every anesthesia workstation was cleaned before each induction using the same supplies, and a black light was used to identify any contamination. The workstations included the anesthesia circuit/face mask, breathing bag, anesthesia machine (adjustable pressure-limiting valve/vaporizer), medication cart, intravenous (IV) stopcock, and IV fluid bag. Each group's workstation was evaluated before and after induction for foreign body changes. The 3 groups were compared using a related-samples Friedman test, which demonstrated that the double gloving technique significantly decreased contamination in most areas studied (P < .01). Use of a double gloving technique decreased cross-contamination by greater than 50%.

Keywords: Anesthesia induction, contamination, double gloving, general anesthesia, intraoperative infection control.

Intraoperative infections occur on a daily basis. Patients can carry many different organisms ranging from *Escherichia coli* to *Pseudomonas aeruginosa*. Fomites are objects such as pieces of equipment that can play the role of a host in the operating room.[1] When an anesthesia provider is manipulating a patient's airway, blood and secretions can contaminate his or her gloves. The gloves now become a vector if other equipment is touched, leading to future cross-contamination of the anesthesia machine (adjustable pressure-limiting [APL] valve, vaporizer), reservoir bag, circuit, face mask, intravenous (IV) stopcock, and/or IV fluid bag. It has been well established that microorganisms can live for extended periods on dry surfaces. Depending on the organism, it can live up to months on a piece of equipment, potentially leading to further transmission.[1] These fomites can be the main source of contamination and spread in the perioperative period, leading to possible intraoperative infections.[2]

According to previous research findings, approximately 1 of 10 patients will experience a nosocomial infection while hospitalized.[3] It is also noted that the anesthesia workstation is continuously inoculated by procedure-aerosolized pathogens that harbor on the anesthesia machine, medication cart, and IV pumps, among other items. Ultimately, any postsurgical infection leads to higher healthcare costs, longer hospital admissions, and increased risk of further complications.[4] The average extended healthcare admission resulting from nosocomial infections is nearly 10 days, incurring an average of $20,842 more per stay.[4]

Anesthesia personnel perform multiple tasks that carry the potential of placing the patient at risk of increased infection. A simple task of administering medications through an IV catheter or cleaning around the patient's face after an intubation can contribute to contamination. Cross-contamination can also occur after intubation if anesthesia providers do not remove and change their gloves. The gloves may now contain blood and/or secretions, and when the provider touches another piece of equipment, there is potential for cross-contamination. This creates the risk of patient self-contamination, as well as contamination of the next patient. The lack of standard procedure and awareness of the potential for contamination by anesthesia providers leaves surgical patients at risk of an unwanted infection.[5]

According to the American Association of Nurse Anesthetists (AANA) *Infection Prevention and Control Guidelines for Anesthesia Care*, providers should practice the double gloving method when managing a patient's airway to decrease the risk of contaminating perioperative equipment that has the potential to serve as a fomite.[6] After manipulating the airway (placing the airway device) where secretions or blood may be present on the hands, the provider should remove the outer contaminated pair of gloves and then continue performing any necessary routine to complete a safe securement of the airway.[6]

The use of a double gloving technique has been evaluated in a simulated environment.[5,7] Biddle et al[7] used a convenience sampling of 20 anesthesia providers to complete a simulated general anesthesia induction.

Participants were instructed on the specific sequence to follow when performing their induction. which allowed for a constant control of extraneous variables. The study found that the use of a double gloving technique decreased contamination of the equipment by more than 50% compared with a single gloving technique.[7] Similar results were shown by Birnbach et al,[5] after evaluation of 22 anesthesia residents randomly assigned to either a single gloving or double gloving technique. After the endotracheal (ET) tube was verified for appropriate placement, the double gloving group was asked to remove the top pair of gloves and then continue their sequence. The results showed significantly greater areas of contamination (20 areas) with the use of single gloving compared with use of the double gloving technique (5 areas).

The purpose of this study was to evaluate the use of the double gloving technique by anesthesia care providers in a nonsimulated patient care setting. Although some research studies exist that evaluate general cleanliness among anesthesia personnel and how it affects patient care and the risk of nosocomial infections, no known previous studies sought to quantify the degree of contamination in the perioperative arena during the induction of anesthesia.

Materials and Methods

This study used a prospective, quasi-experimental (within-subjects) design and was approved by the institutional review board at an inner-city, level 2 trauma center. Data were collected during the induction of anesthesia in the main operating room suite. A waiver of informed consent was obtained, because this study did not involve any procedures for which written consent is normally required outside the research context.

An analysis using G*Power software was conducted for a related-samples Friedman test across 3 time intervals using a moderate effect size of 0.25, *P* value less than .05, and power of 0.8, which yielded a minimum sample of 30 participants. To account for attrition, the investigator recruited a total sample of 36 participants. The research timeline extended from August 2017 through December 2017.

The final sample of anesthesia practitioners was evaluated after induction of anesthesia. Participating providers included both student registered nurse anesthetists (SRNAs) and Certified Registered Nurse Anesthetists (CRNAs). Demographic information was obtained, including age, sex, practitioner role (CRNA/SRNA-second year or third year of education), and total years of anesthesia experience. The SRNAs were divided into 2 groups because their clinical experience varied by 12 months between the second-year and third-year students. Patients were included in the study if they were receiving a general anesthetic and were being intubated with an ET tube or having a laryngeal mask airway placed.

Subject: ID No.
Gender: M_____ F_____
Age: 25-34_____ 35-44_____ 45+_____
CRNA_____ SRNA (second year)_____ SRNA (third year)_____
Experience (y) _____<1 y _____1-5 y _____5+ y

PRETEST:

Anesthesia monitor		Drug cart		Reservoir breathing bag		Breathing circuit/mask		IV stopcock		IV fluid bag	
1	2	1	2	1	2	1	2	1	2	1	2
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	N	N	N	N
% Covered		% Covered		% Covered		% Covered		% Covered		% Covered	
0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%	

POSTTEST 1:

Anesthesia monitor		Drug cart		Reservoir breathing bag		Breathing circuit/mask		IV stopcock		IV fluid bag	
1	2	1	2	1	2	1	2	1	2	1	2
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	N	N	N	N
% Covered		% Covered		% Covered		% Covered		% Covered		% Covered	
0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%	

Did you remove gloves after intubation? (yes / no)

POSTTEST 2:

Anesthesia monitor		Drug cart		Reservoir breathing bag		Breathing circuit/mask		IV stopcock		IV fluid bag	
1	2	1	2	1	2	1	2	1	2	1	2
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	N	N	N	N
% Covered		% Covered		% Covered		% Covered		% Covered		% Covered	
0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%		0% 25% 50% 75% 100%	

Did you remove gloves after intubation? (yes / no)

Table 1. Data Collection Sheet

Abbreviations: CRNA, Certified Registered Nurse Anesthetist; ID, identification; IV, intravenous; N, no; SRNA, student registered nurse anesthetist; Y, yes.

To evaluate the degree of equipment contamination, the investigator examined the anesthesia machine (APL valve, vaporizer), drug cart, reservoir-breathing bag, breathing circuit/mask, IV stopcock, and IV fluid bag before and after induction for inoculation using a handheld ultraviolet black light, 51 light-emitting diode (LED), 395 nM (Escolite), at each of the 3 times. A simple handheld black light has been shown to be as effective in identify-

Figure. Photographs Randomly Taken of a Select Group of Participants Before and After Induction During Each of Three Time Periods

ing fluorescence as a standard Wood's lamp.[8] Fluorescent lighting is the standard method of identifying contamination in the area of forensics because it illuminates the contamination to its background.[9] All equipment was cleaned before the start of the anesthetic with fragrance-free multipurpose disinfectant wipes (CaviWipes, Metrex), which reduced the risk of cross-contamination before the initial evaluation.[10] This method is approved by the hospital where the study was conducted and is used by the operating room personnel as their standard infection control-cleaning product before each surgical case. The equipment was then evaluated before the patient entered the room, using the black light held 10.2 to 12.7 cm (4-5 in) from the surface to assess for any foreign material, which would be fluoresced. Any foreign material was identified as a darker object compared with its surroundings when the black light was applied. This preevaluation information was documented and used for comparison with postinduction contamination. After anesthesia was induced and the airway secured, the anesthesia workstations and all equipment were reevaluated using the same process. The total number of areas and percent of areas that were contaminated were then recorded on the data collection sheet. The principal investigator was responsible for all data collection after being trained on use of the black light, following methods used previously in simulation studies.

The participants were evaluated over 3 times. Time 1 corresponded to the provision of care before participation in the educational session on the use of the double gloving technique. No participants used the double gloving technique during the induction of anesthesia during this time. Following the educational session, the same participants were evaluated during posteducation week 1 (time 2) and then again 1 month later (time 3) on the use of the double gloving technique during the induction sequence. The degree of contamination was evaluated before and after induction in all groups to identify the percent inoculation associated with induction of general anesthesia. After the final examination was complete, the investigator exited the operating suite, allowing the anesthesia provider to continue their care of the surgical patient. All surgical patients remained hemodynamically stable. If for whatever reason the anesthesia provider did not believe it to be a good time for evaluation, the investigator terminated the evaluation.

Each provider used a new pair of gloves, laryngoscope, ET tube, emesis basin to place used equipment, circuit, face mask, IV tubing, IV fluid bag, oral airway, and any needed equipment to appropriately care for patients according to the hospital policies and procedures. The same cleaning protocol was continued throughout each surgical procedure by the investigator to maintain a standard process. The same black light was used for each provider before and after the induction sequences.

An educational session was held during a morning anesthesia department meeting between time 1 and time 2. A digital slide presentation (PowerPoint, Microsoft) was created and presented by the principal investigator. The providers were educated on the previous research done in this area. The focus of this lecture was on the importance of infection control, areas where anesthesia personnel can contribute to inflectional control, and the most up-to-date research on anesthesia practice in this field. Findings of the research that was previously completed on the double gloving technique in a simulation laboratory were presented. The anesthesia staff was then educated on performing the double gloving technique. Specifically, they were taught to wear 2 pairs of gloves initially. After placing the airway device and inflating the cuff, they then removed their top pair of gloves, discarded them, and continued their sequence. All providers were told to continue their standard routine of oral airway and laryngoscope placement after disposal of the gloves (on bed, in basin, or on towel placed on anesthesia machine). After the education they were then asked to complete a questionnaire containing 5 questions to evaluate their learning.

The degree of contamination was assessed at each time (1, 2, and 3) on all equipment as outlined. Each equipment evaluation was documented on the data collection sheet, including whether the provider followed the double gloving technique appropriately. The amount of contamination present was documented on the data collection sheet (Table 1) as 0%, 25%, 50%, 75%, or 100% contaminated, to allow even comparisons and to identify if the rate of contamination increased, decreased, or remained the same at each time. Visual inspection was used to identify how much of the area was contaminated as a whole. Photographs were randomly taken of a select

group of participants before and after induction during each of the 3 times (Figure).

Results

Data were analyzed using statistical analysis software (SPSS for Mac version 25, IBM Corp). Demographic data were analyzed using descriptive statistics, and a related-samples Friedman test was used to evaluate contamination over time.

A total of 36 anesthesia providers were recruited into the study. Each participant was first evaluated using the single gloving technique and then reevaluated using the double gloving technique. Of the 36 providers, 30 followed the appropriate technique by removing the top pair of gloves after education (time 2). These 30 providers were further evaluated on their rate of contamination. Thus, the final sample was 30. Demographic characteristics are presented in Table 2.

Demographic	No. (%)
Gender	
Male	7 (23.3)
Female	23 (76.7)
Age, y	
25-34	18 (60)
35-44	9 (30)
≥ 45	3 (10)
Years of experience	
< 1	21 (70)
1-5	5 (16.7)
> 5	4 (13.3)
Provider type	
Second-year SRNA	5 (16.7)
Third-year SRNA	13 (43.3)
CRNA	12 (40)

Table 2. Provider Demographics (N = 30)
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; SRNA, student registered nurse anesthetist.

A related-samples Friedman test by ranks was used to evaluate the degree of contamination of the APL valve/vaporizer, reservoir bag, anesthesia circuit, IV fluid bag, IV stopcock, and anesthesia drug cart across all 3 times. Results are summarized in Table 3. The related-samples Friedman test by ranks showed a significant decrease in median rank percentage of contamination with use of the double gloving technique for the anesthesia machine (APL valve/vaporizer; $P < .001$), reservoir breathing bag ($P < .001$), and anesthesia circuit ($P < .001$). Contamination frequencies by group are presented in Table 3. A related-samples Friedman test by ranks showed no significant difference in ranked percentage of contamination with use of the double gloving technique for the anesthesia drug cart ($P = .368$), IV line stopcock ($P = .368$), and IV bag ($P = .368$).

A χ^2 analysis was run to determine whether type of anesthesia care provider (CRNA, second-year SRNA, third-year SRNA) influenced the incidence of contamination of the equipment identified in the related-samples Friedman test. The χ^2 analysis showed an association between type of provider and incidence of contamination for the APL valve/vaporizers before education ($\chi^2 = 6.696$, $P = .035$), with CRNAs having a lower incidence of contamination than both groups of SRNAs. There was no association between type of anesthesia care provider and contamination of the reservoir bag or breathing circuit before education ($P > .05$) and no association at any other time.

Discussion

Few research articles on cross-contamination by anesthesia providers have appeared in the literature. One area of research that has been conducted examined the contamination of the tape used to secure the ET tube.[11] The goal of the study was to identify a practice to decrease contamination by changing the taping practice. From the results, the authors concluded that each ET tube should be secured with a new roll of tape that is not transferred between patients.[11] A second research study, at an advanced teaching facility in New Hampshire, featured 97 anesthesia providers who participated in a controlled trial in which each provider had a hand sanitizer-dispensing device with 70% ethanol liquid.[12] This device was attached to their waist for the entire day. The goal was to encourage hand sanitization each time the providers removed their gloves and after specific tasks. The authors concluded that those with the sanitizing device attached to their waist had a significant reduction in contamination of the anesthesia machine ($P \leq .01$).[12,13]

The only research that has examined the relationship between the induction sequence and cross-contamination of equipment has taken place in a simulated environment. In 2 studies in which providers were evaluated on the practice of a double gloving technique, results were very similar.[5,7] In one study, researchers had 10 anesthesia providers randomly assigned to perform a simulated standard induction of general anesthesia using a single pair of gloves and compared this same induction technique by a second group of 10 providers who wore 2 pairs of gloves and removed the outer pair after the ET tube was placed.[7] The other study randomly separated 22 anesthesia residents into 2 groups: single gloves and double gloves.[5] Both studies' authors concluded that a double gloving technique significantly reduced the spread of oral secretions to other areas of the anesthesia workstation.[5,7]

The current study was, to the author's knowledge, the first study that used a black light to identify contamination of anesthesia equipment. Examination based on percentage allowed for easy identification and com-

Technique and time of analysis	Anesthesia machine (APL valve, vaporizer)	Breathing bag	Face mask/circuit
Single glove (before education, % contaminated)			
0	14	8	12
25	10	17	17
50	6	5	1
Double glove (wk 1 after education, % contaminated)			
0	29	22	24
25	1	6	6
50	0	2	0
Double glove (1 mo after education, % contaminated)			
0	25	14	22
25	5	12	8
50	0	4	0
P value	< .001	< .001	< .001

Table 3. Number of Providers Who Contaminated Equipment by Gloving Technique
Abbreviation: APL, adjustable pressure-limiting.

parison across times. There was a clear reduction in contamination by those who performed the double gloving technique compared with those who did not. The most frequent pieces of equipment that were contaminated included the anesthesia machine (APL valve, vaporizer) and the breathing bag. When using a single gloving technique, the hand used to scissor the mouth open is the same hand that is used to ventilate and turn on the vaporizer. The right hand is therefore always used to open the mouth and always contaminated. Thus, removing the top gloves after intubation and before contact with these pieces of equipment was effective in preventing inoculation with oral secretions. The areas that were identified to have minimal or no contamination included the drug cart, IV stopcock, and IV fluid bag. The facility where this study was conducted uses an anesthesia care team model in which 2 anesthesia providers are present during the induction sequence. One anesthesia provider would administer the induction medications while the second anesthesia provider would control the patient's airway. This setup helps to explain why these items were not contaminated during the induction sequence. The drug cart was never entered during the standard induction, so no contamination should have been identified.

There was an increase in contamination on the third evaluation of the providers. This may be the result of a loss in the effectiveness of the educational intervention on the double gloving technique. Therefore, future recommendations to reinforce the use of the intervention include the placement of educational fliers around the operating room and on the anesthesia machine/cart itself, as well as teaching new SRNAs the technique from day 1 in the clinical setting. If the students are educated on this technique and it is implemented into their daily routine, they should be able to practice it as a standard for any general anesthesia induction.

Future research on this topic should look to standardize the type of anesthesia care provider used in the study because differences were initially seen in the degree of contamination between seasoned anesthesia care providers and SRNAs. Differences in experience may have resulted in CRNAs and SRNAs using different sequences and timing of events during induction. Many SRNAs do not have a well-choreographed induction sequence because during their education they continue to try different techniques and processes to better suit their own preference. On the other hand, CRNAs have already created a sequence that they continue to use on a daily basis. This difference could explain why SRNAs were shown to have increased contamination compared with CRNAs. Also, some providers may perform the induction tasks in a different order. For example, seasoned providers may place their ET tube, secure it with tape, and then attach the circuit and turn on the vaporizer and ventilator. Other providers may place their ET tube, attach the circuit, check for placement, and then secure the tube. With a lack of standard sequence of events, certain pieces of equipment are at increased risk of contamination compared with others. If this study were reproduced, a recommendation would be to focus on one group of anesthesia providers with similar experience using a standardized induction sequence to keep all variables constant.

Future studies should also include the head of the operating table, as well as the tape used to secure the ET tube, as pieces of equipment to be monitored. Many

providers place the face mask, oral airway, and other anesthesia equipment on the head of the bed after use. In addition, many providers tape the IV stopcock at the head of the bed. This placement can result in contamination by secretions that were transferred during the induction sequence. When the anesthesia provider secures the tube, the tape touches the patient's mouth, leading to the probability of contamination when the same roll is used on the next patient.

Even though the results of the study were statistically significant, there are several limitations to this study. Only one anesthesia group was evaluated, which limits the generalizability of the study. Also, all providers did not follow a standard sequence of induction. Future studies should incorporate a checklist so all providers can follow the same sequence. Threats to external validity include performing this study in a live environment and variations in induction sequence and intubation technique. It is impossible to completely control how each provider will perform his or her induction technique on a live patient, compared with the previous studies in which the investigators evaluated the inductions in a simulation laboratory.

There were also threats to the internal validity of the study. Variations in both the complexity of the cases and patient comorbidities may have influenced the results. Care of sicker patients can lead to greater anxiety on the part of the anesthesia care providers and greater risk of complications during induction, resulting in changes in their normal routines.

Conclusion

The results of this study evaluating 30 anesthesia providers with all levels of experience show that using a double gloving technique decreased cross-contamination during the induction process in this sample of anesthesia care providers. With continued reinforcement, all providers should be able to consistently incorporate this practice into their standard routine. In addition, early education of SRNAs will allow them to use best practices from the start of their education and training. Finally, all personnel regardless of experience can also benefit from continuous education in their workplace. This study suggests that the relatively minor change in practice of double gloving could improve safety for all patients in the intraoperative period.

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