Original Article

Prevention of contamination after endotracheal intubation using a dedicated sleeve

Alejandro Pino[1], Justin J. Lee[2], Nazish K. Hashmi[3], Amanda Brucker[4], Shein-Chung Chow[4], Kamran Mahmood[1]

[1]Division of Pulmonary, Critical Care and Allergy, Department of Medicine, Duke University, Durham, NC, USA; [2]Rutgers New Jersey Medical School, Newark, NJ, USA; [3]Department of Cardiothoracic Anesthesiology, Duke University, Durham, NC, USA; [4]Department of Biostatistics and Bioinformatics, Duke University School of Medicine, Durham, NC, USA

Contributions: (I) Conception and design: K Mahmood, A Pino, JJ Lee, NK Hashmi, A Brucker, SC Chow; (II) Administrative support: None; (III) Provision of study materials or patients: K Mahmood, A Pino; (IV) Collection and assembly of data: K Mahmood, A Pino; (V) Data analysis and interpretation: K Mahmood, A Brucker, SC Chow; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Kamran Mahmood, MD, MPH. Division of Pulmonary, Critical Care and Allergy, Department of Medicine, Duke University, DUMC 102356, Durham, NC 27710, USA. Email: K.mahmood@duke.edu.

Background: Contamination of work surfaces by used laryngoscopes after endotracheal intubation is a serious infection control concern but no strategies are available to address it. We assessed if contamination of the surfaces after endotracheal intubation would be reduced when providers used a dedicated, self-erected, disposable plastic sleeve (BladePouch) to store the used laryngoscope as compared to using single gloves or double gloves and sheathing the laryngoscope with the outer gloves.

Methods: Twenty participants were recruited including attending physicians, trainees and allied health care professionals. They performed endotracheal intubation on a mannequin with oral cavity coated with a dye and stored the used laryngoscope blade using single gloves, double gloves or BladePouch. Each participant used both direct and video laryngoscopes. Following intubation, dye contamination of gloves, gown and work surface was evaluated.

Results: There was no difference in the contamination of gloves or gowns between the single gloves, double gloves or BladePouch groups. However, work surface contamination was significantly reduced when using BladePouch compared to single or double gloves (13% *vs.* 100% *vs.* 80% respectively, P<0.001). The odds of work surface contamination were significantly lower with BladePouch *vs.* single or double gloves, even when adjusted for intubation device, role and experience of participants with an adjusted odds ratio of 0.0054 (95% confidence interval: 0.0009–0.0314), P<0.001.

Conclusions: In conjunction with standard precautions, the use of a dedicated plastic sleeve to store contaminated laryngoscope blade after endotracheal intubation may reduce the work surface contamination, independent of intubation device, role and experience of providers.

Keywords: Intubation; infection control; laryngoscopes

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Introduction

Contamination of surfaces by microbes during endotracheal intubation is a critical infection control concern, which is heightened by the pandemic of coronavirus disease 2019 (COVID-19) (1). Contamination of laryngoscopes, especially the handles, even after routine disinfection has been well documented with bacterial and viral pathogens like HIV, and poses a grave cross-infection risk to other patients and providers (2-6). The implementation of disposable laryngoscope blades and handles has decreased

the risk from the use of inadequately sterilized instruments, but the contamination of the work surface by the dirty laryngoscope after the intubation continues to be the Achilles' heel of infection prevention (7,8).

Despite the serious risk of cross-infection, the handling of laryngoscope blades and handles continues to be under-emphasized in guidelines, and there is lack of adequate infection mitigation resources with poor adoption in routine clinical practice (4,9,10). In addition to respiratory droplets, an important means of transmission of coronavirus and other pathogens is by hand and work surface contamination during intubation (11). Current anesthesia guidelines and literature have highlighted the contamination of anesthesia work surfaces but handling of laryngoscope blade and handle is overlooked (7,8). Some studies have looked at strategies to decrease the surface contamination, for example, by wearing double pairs of gloves and using the outer glove to sheathe the laryngoscope blade (12). However, it seems unclear if sheathing the laryngoscope with gloves is optimal, as it has not been compared to other methods of transmission control. This is critical as despite the importance of minimizing aerosolization during intubation using different protocols and devices, there is no standardized approach of handling the contaminated laryngoscope after use (1,13,14). Contamination by respiratory secretions from the used laryngoscope blade can be prevented by the BladePouch (Hentura, LLC, Guilford, CT, USA)—a specifically designed, disposable plastic sleeve, that can isolate the contaminated laryngoscope blade (*Figures 1-3*). The sleeve can be placed on any anesthesia work surface and is self-erected with an open mouth that helps to slide the laryngoscope blade into the pouch while isolating the laryngoscope handle outside and away from the contaminated blade by using one hand. The top layer has a cut out that prevents the stored laryngoscope from protruding beyond the perimeter of the pouch and avoids dripping of secretions on the work surface. In addition, the shape of the pouch prevents the operator from storing the handle with the blade inside the pouch, protecting the former from contamination. These features differentiate the BladePouch from other available options like the laryngoscope packaging or a simple plastic bag. The price of BladePouch is only 20 cents, which may make it a cost-effective solution to prevent cross-contamination of the work environment. We designed this study to compare the work surface contamination from the soiled laryngoscope by using BladePouch in comparison to currently published single pair of gloves or double pair of gloves with sheathing technique.

The primary aim of this study was to determine whether contamination of the surfaces after intubation would be different when providers stored the contaminated laryngoscope using a single pair of gloves; double pair of gloves and sheathing the soiled laryngoscope with outer glove; or the BladePouch. We hypothesized that using the BladePouch to store the laryngoscope would reduce contamination when compared to using single gloves or isolating the laryngoscope in the outer glove using double gloves technique. We present this article in accordance with the SQUIRE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1510/rc).

Highlight box

Key findings

- A dedicated, plastic sleeve to store the contaminated laryngoscope blade after endotracheal intubation can decrease the work surface contamination, independent of intubation device, experience or role of the operator.

What is known and what is new?

- Cross-contamination in the hospital is associated with poor clinical outcomes, but the strategies to prevent contamination from a used laryngoscope blade are limited.
- This study showed that the work surface contamination was significantly reduced when using the dedicated sleeve to store a used laryngoscope blade compared to single or double gloves and sheathing the blade with the outer gloves (13% *vs.* 100% *vs.* 80% respectively, P<0.001).

What is the implication, and what should change now?

- In conjunction with standard precautions, a dedicated plastic sleeve should be used to store the contaminated laryngoscope blade to prevent work surface contamination.

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved and determined to be exempt from review by Duke University institutional review board (Protocol No. 00106177). The consent was waived from the participants as it was a quality improvement study without any significant risk to the participants, as approved by the institutional IRB. The participants were recruited from Duke University and Durham Veterans Affairs Medical Center and the study was conducted from September 1, 2020 to December 31, 2020. The participants intubated a mannequin (Advanced Airway

Figure 1 BladePouch is a self-erected, disposable plastic sheath with an open mouth that can be used to store contaminated laryngoscope blade.

Figure 2 Direct laryngoscope blade sheathed in the BladePouch.

Larry Management Trainer, Nasco, Fort Atkinson, WI, USA) with size 7.0 endotracheal tube. A direct laryngoscope using a size 3.0 Macintosh blade (Vyaire Medical, Mettawa, IL, USA) was used for intubation. In addition, a video laryngoscope (LoPro S3, GlideScope, Verathon Inc, Bothell, WA, USA) was used to intubate the mannequin. Each participant performed direct and video laryngoscopic intubation and then stored the contaminated laryngoscope using a single pair of gloves; double pair of gloves or the BladePouch. In the single pair technique, the operator

Figure 3 Video laryngoscope blade sheathed in the BladePouch.

wore a pair of gloves during intubation and then placed the blade on the work surface without any sheathing. In the double pair of gloves technique, the operator intubated the mannequin wearing two pairs of gloves. After intubation, the operator used the outer glove to store the laryngoscope. In the BladePouch technique, the operator used a pair of gloves to intubate the mannequin but then stored the blade of the laryngoscope in the BladePouch with handle of the laryngoscope situated outside the pouch. The sequence of protective techniques was random for each participant to prevent learning advantage. In addition, the participants had similar exposure to all the protective techniques, which precluded any advantage to a specific approach.

Before the intubation attempts, we coated the lips and oral cavity of the mannequin with a red dye gel as a surrogate and mimicking the consistency of oropharyngeal secretions. After the simulation, the same designated observer examined the gloves, gown of the provider, and the work surface where the contaminated laryngoscope was placed for stains of red dye. The simulation space was cleaned between attempts to remove all the previous contamination.

Statistical analysis

A priori power analysis was performed for sample size calculation. The result indicated that 20 subjects were required in each single glove, double gloves and BladePouch groups for achieving a power of 80% for detection of a clinically meaningful difference of 40% in contamination

Table 1 Demographic and professional characteristics of participants

Participant characteristics	Total (N=20)
Age, years, median [Q1, Q3]	38 [33, 50]
Gender, n [%]	
Male	15 [75]
Female	5 [25]
Practice category, n [%]	
Pulmonary-critical care medicine attending	2 [10]
Anesthesiology attending	1 [5]
Pulmonary-critical care medicine fellow	7 [35]
Anesthesiology resident	1 [5]
Medical student	1 [5]
Respiratory therapist	7 [35]
Physician assistant	1 [5]
Years graduated from professional school	
Median [Q1, Q3]	6 [4, 7]
Missing, n [%]	2 [10]
Number of previous intubations	
Median [Q1, Q3]	21 [6, 40]
Missing, n [%]	2 [10]
Self-perceived level of expertise, n [%]	
Beginner	10 [53]
Experienced	8 [42]
Expert	1 [5]
Missing	1 [5]

rate between BladePouch and double gloves groups using a two-sided test at the 5% level of significance, assuming that contamination percentage in BladePouch was 20%.

Continuous variables were summarized with the median and interquartile range [Q1, Q3] and categorical variables with frequency counts and percentages. The number of missing values for each variable was reported. In adjusted and unadjusted analyses, contamination rates were modeled using generalized linear mixed effects models with protective methods and intubation device as independent variables and participants as random block effect. The adjusted model additionally accounted for the professional role and number of previous intubations by the participants. Odds ratios and corresponding 95% confidence intervals (CIs) from the model fits were reported. P values were obtained from type III *F*-tests of fixed effects and *t*-tests. Model fitting was performed using proc glimmix in SAS. All analyses were performed with SAS version 9.4 (Cary, NC, USA).

Results

Twenty participants were enrolled in this study. The participants included three pulmonary- critical care and anesthesiology attendings, 7 pulmonary-critical care fellows, 1 anesthesiology resident, 1 medical student, 7 respiratory therapists and 1 critical care physician assistant. The demographic characteristics and professional background of the participants are reported in *Table 1*. They had previously performed a median [Q1, Q3] of 21 [6, 40] endotracheal intubations and 9 (45%) participants rated their self-perceived expertise level at experienced or expert.

All the twenty participants performed the intubation of mannequin using single gloves, double gloves and BladePouch. Every participant also used both direct and video laryngoscopes with all the three protective techniques. We evaluated the contamination rates of gloves, gowns and work surface using single gloves, double gloves and BladePouch, as shown in *Table 2*. Contamination of gloves and gowns occurred in relatively constant rates across protective methods, with gloves contaminated in 70–90% of experimental trials and gowns contaminated in 0–15% of trials. However, we observed substantial difference in work surface contamination between the three protective methods: the contamination rate using the BladePouch was 13%, compared to rates of 100% with single gloves and 80% with double gloves (P value for difference <0.001).

The odds ratios for contamination using BladePouch versus other protective methods are shown in *Table 3*. For the glove and gown contamination outcomes, there were no statistically significant differences in the odds of contamination among the protective methods. The odds ratio of work surface contamination using BladePouch versus single or double gloves was 0.015 (95% CI: 0.004–0.052). We found no significant interaction between intubation instruments and protective methods. The odds of contamination did not differ significantly by intubation instrument: P=0.681 for glove contamination; P=0.203 for gown contamination; P=0.385 for work surface contamination.

We also assessed differences in work surface contamination rates after adjusting for the protective

Table 2 Contamination using different protective methods

Contamination sites	Single gloves	Double gloves	BladePouch	P value[†]
Glove contamination, n [%]				0.514
All laryngoscopes (n=40)	34 [85]	32 [80]	30 [75]	
Direct laryngoscope (n=20)	18 [90]	15 [75]	14 [70]	
Video laryngoscope (n=20)	16 [80]	17 [85]	16 [80]	
Gown contamination, n [%]				0.686
All laryngoscopes (n=40)	3 [8]	4 [10]	2 [5]	
Direct laryngoscope (n=20)	0 [0]	2 [10]	0 [0]	
Video laryngoscope (n=20)	3 [15]	2 [10]	2 [10]	
Work surface contamination, n [%]				<0.001
All laryngoscopes (n=40)	40 [100]	32 [80]	5 [13]	
Direct laryngoscope (n=20)	20 [100]	16 [80]	1 [5]	
Video laryngoscope (n=20)	20 [100]	16 [80]	4 [20]	

[†], the P values correspond to the type III *F*-tests for differences among the protective methods adjusting for intubation instrument.

Table 3 Unadjusted analysis of contamination rates by protective methods[†]

Contamination sites and protective methods	Odds ratio (95% confidence interval)	P value
Glove contamination		
BladePouch *vs.* single gloves	0.727 (0.235–2.246)	0.575
BladePouch *vs.* double gloves	0.496 (0.150–1.646)	0.248
Gown contamination		
BladePouch *vs.* single gloves	0.436 (0.067–2.853)	0.382
BladePouch *vs.* double gloves	0.622 (0.872–4.435)	0.631
Work surface contamination		
BladePouch *vs.* single or double gloves[‡]	0.015 (0.004–0.052)	<0.001

[†], All models adjusted for intubation instrument; however, effects from intubation instrument were not statistically significant in any of the models. [‡], since all (40/40) single gloves protective method trials resulted in work surface contamination, the single and double gloves protective methods were combined in the modeling of the work surface contamination outcome.

techniques, intubation devices, professional roles of participants and number of previous intubations each participant had performed. *Table 4* shows the adjusted odds ratios for work surface contamination between BladePouch and the other two protective methods. The adjusted odds ratio of work surface contamination with BladePouch *vs.* other protective methods was 0.005 (95% CI: 0.0009–0.0314). There was no significant difference in contamination rates between direct *vs.* video laryngoscopy (P=0.353). The impact of the professional role of the participant on the odds of contamination was not statistically significant (P=0.393) and the impact of the number of previous intubations was borderline statistically significant (P=0.079), with the most experienced participants associated with the lowest odds of contamination.

Discussion

The results of this study suggest that use of the BladePouch to store the soiled laryngoscope after endotracheal intubation, when compared to single or double gloves technique, can reduce the risk of work surface contamination. This benefit

Table 4 Adjusted analysis of work surface contamination rate by protective method and variables of interest

Variables	Odds ratio (95% confidence interval)	P value
Protective method (BladePouch *vs.* single or double gloves[†])	0.0054 (0.0009–0.0314)	<0.001
Intubation device (video laryngoscope *vs.* direct laryngoscope)	1.82 (0.51–6.53)	0.353
Professional role of participant		0.393
Allied health professional *vs.* trainee	2.39 (0.44–13.11)	
Attending physician *vs.* trainee	7.13 (0.30–170.93)	
Number of previous intubations		0.079
16–30 *vs.* ≤15	9.28 (1.07–80.34)	
>30 *vs.* ≤15	0.67 (0.07–6.50)	

[†], since all (40/40) single gloves protective method trials resulted in work surface contamination, the single and double gloves protective methods were combined in the modeling of the work surface contamination outcome.

is independent of type of laryngoscope, performer's role or experience.

The incidence of healthcare-associated infections is 687,000 per year in hospitalized patients in the United States and these are responsible for up to 72,000 deaths annually (11). Bacterial transmission in anesthesia work area is responsible for 30-day post-operative infections in up to 16% patients undergoing surgery (15). Most of the transmission of health-associated infections is due to surface cross-contamination (8,16). Various pathogens such as coronavirus can survive on surfaces for hours to days (17). Maslyk and colleagues demonstrated that the anesthesia machine tabletops, the main anesthesia work surface, can become contaminated at the end of the workday with bacteria like staphylococcus aureus, coagulase-negative staphylococcus, alpha streptococcus, acinetobacter and gram negative bacilli (8). One of the most important sources of contamination of these work surfaces is soiled laryngoscopes (9,18). The laryngoscope contamination with oropharyngeal secretions, blood and potentially pathogenic microorganisms during clinical use has been well documented (2,4,5,9). Studies have shown that even the laryngoscope handle can become contaminated when the blade comes in contact with the handle in the closed position (2). The contamination of the laryngoscope blade and handles can evade disinfection and sterilization processes (5,6). Williams *et al.* showed that on culturing specimens from the surface of 64 laryngoscope handles which were "ready to use" in operating room, 86% of the handles grew one or multiple species of bacteria, including methicillin sensitive *Staphylococcus aureus*, enterococci, klebsiella and Acinetobacter (2). They recommended improved disinfection measures and prevention strategies peri-intubation. Although the disposable laryngoscope blades and handles can decrease the cross-infection related to inadequately sterilized instruments, the work surface contamination remains an unaddressed gap (9). Once pathogens are transmitted to the surfaces with dirty laryngoscopes, they become a vector for further spread (9,16,19). In the COVID-19 pandemic, spread of infection by surface contamination was highlighted even more (13,20). Therefore, minimizing the contamination of the anesthesia workplace is of paramount importance for prevention of hospital-acquired infections.

Some existing guidelines (21) recommend double gloving for airway management and discarding the outer glove immediately afterwards; a practice that has been shown to decrease environmental contamination (12). A subsequent study went one step forward and used the outer glove to sheathe the used laryngoscope, which decreased contamination of the intraoperative environment significantly (18). In this study by Birnbach and colleagues, 45 anesthesiology residents performed endotracheal intubation on a mannequin and were divided into 3 groups: using single gloves; double gloves and discarding the outer gloves; or double gloves and sheathing the contaminated blade with an outer glove. An average of 13 environmental sites were contaminated using the single gloves, 3.5 by double gloves and 0.5 by double gloves with outer glove sheathing, with P value of difference <0.001 (18). In our study, when compared to sheathing with outer glove in the double gloves technique, using a dedicated BladePouch to store the used laryngoscope further reduced work surface contamination.

This is the first study to show that a dedicated, protective sleeve can be used to isolate the contaminated *video* laryngoscope blade. Our data showed that BladePouch was effective to prevent work surface contamination for both direct and video laryngoscope blades. In addition, the BladePouch was able to decrease work surface contamination for providers with different roles, including pulmonary-critical care and anesthesiology attendings, trainees and allied health professionals including respiratory therapists and physician assistants. In summary, BladePouch was effective with different types of laryngoscopes, independent of the level of expertise or role of the operator.

Prevention of cross-contamination around intubation is critical for patient and staff safety. Many measures can be adopted to minimize this cross-contamination like using standard precautions introduced by Centers for Disease Control and Prevention (CDC), hand washing, adequate use of gowns and gloves, disinfection of anesthesia machine and work surface between patients, and adoption of disposable direct laryngoscopes. The increased use of video laryngoscopes necessitates use of disposable video laryngoscope blades and proper decontamination of video handles, connecting cables and video screens. BladePouch is complementary to the above measures and can further decrease the contamination of work surface by isolation of contaminated direct and video laryngoscope blades (7,9,22).

The strengths of our study include participation of a broad group of providers with different professional roles and levels of experience, which improves the generalizability of our findings. In addition, traditional direct laryngoscope and contemporary video laryngoscopes were utilized. The limitations of the study are that it was performed in a controlled, simulated environment, which might differ from clinical settings such as operating rooms, intensive care unit and emergency rooms. Another limitation of the study is that BladePouch alone cannot reduce cross-contamination and should be used in conjunction with standard precautions. In our study, red dye was used to simulate contamination by oropharyngeal secretions, while another study used a fluorescent dye (12). We believe that the fluorescent dye did not have any significant advantage over red dye, and our approach obviated the need for a fluorescent lamp. In addition, the participants were not blinded to the protective techniques used because of the study design, which could potentially introduce a bias. However, this is the first step in evaluating the proof of concept, as previously done in similar studies (12,23). We recommend that BladePouch should be assessed in real clinical settings in the future.

Conclusions

In conclusion, in conjunction with standard precautions, the use of a dedicated plastic sleeve to isolate a laryngoscope blade after endotracheal intubation can reduce the work surface contamination in a simulated setting. The decreased contamination is independent of intubation device, and role and experience of the providers.

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Footnote

Reporting Checklist: The authors have completed the SQUIRE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1510/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1510/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1510/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1510/coif). JJL participated in the patent application of BladePouch but he has no direct financial interest or stake in Hentura, LLC. Hentura, LLC is owned by a JJL family member. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved and determined to be exempt from review by Duke University institutional

review board (Protocol No. 00106177). The consent was waived from the participants as it was a quality improvement study without any significant risk to the participants, as approved by the institutional IRB.

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