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Major article

Quantifying the rambunctious journey of the anesthesia provider's hands during simulated, routine care

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Background: The role of anesthesia providers in dispersing potentially pathogenic material from one patient to another during intraoperative care needs further study. In this study we aimed (1) to quantify the dispersion of a surrogate pathogen from a simulated patient's mouth to the anesthesia workstation during routine anesthetic induction, (2) to test the hypothesis that there would be fewer contamination sites by providers who used a double-gloving technique, and (3) to examine the effectiveness of between-case anesthesia apparatus disinfection.

Methods: Twenty subjects were randomized to a single pair of gloves group (group 1) or a double-gloved group (group 2) and completed a simulated general anesthesia induction, completing a standardized set of interventions. Dispersion of a surrogate pathogen dye placed in the oral cavity of the simulated patient was tracked by a blinded observer and photography. Standard cleaning of the workstation was performed, and residual dye was quantified. Group performance was plotted using regression analysis and rate of contamination compared using parametric statistics.

Results: Group 1 contaminated an average of 16.0 (SEM = 0.89) sites compared with group 2, who contaminated an average of 7.6 (SEM = 0.85). The cart drawers, gas flow dials, medication vials, and ventilator controls were significantly contaminated by group 1, but not by group 2 ($P < .05$ in all cases). There were similar rates of contamination in both groups for the airway equipment, breathing system, intravenous access ports, and the roll of tape used to secure the endotracheal tube. Once the airway management phase of the induction ended, new site contamination continued at a high rate in group 1 but not group 2.

Conclusions: A double-gloving technique was associated with less spread of an oral inoculum to the workstation but was not uniformly protective. Between-case cleaning was ineffective in removing the contaminant, indicating that biologic material from one patient may be present when subsequent patients are cared for. This suggests risks for the current patient (eg, skin or oral site transfer to an intravenous site) and also may place future patients at risk. Importantly, using models that simulate actual clinical events can inform clinical practice and decipher challenging areas of ergonomics.

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During the course of even routine care, anesthesia providers may serve as vectors, contributing to the genesis of nosocomial infection.[1-8] Poor technique, inconsistent use of gloving, high task density, production pressure, poor ergonomic design, forgetfulness, and difficulty in readily accessing hand hygiene products all are contributory.

Munoz-Price et al demonstrated a unique and novel method to study potential vectors of transit of biologic material in the operating room.[9] This work was extended on by Birnbach et al who applied these techniques, using a fluorescent marker, to the anesthesia care domain.[8] It was this body of work that inspired the present study and served as a foundation from which to extend our understanding of the potential role that anesthesia providers play in pathogen dispersion during routine operative care.

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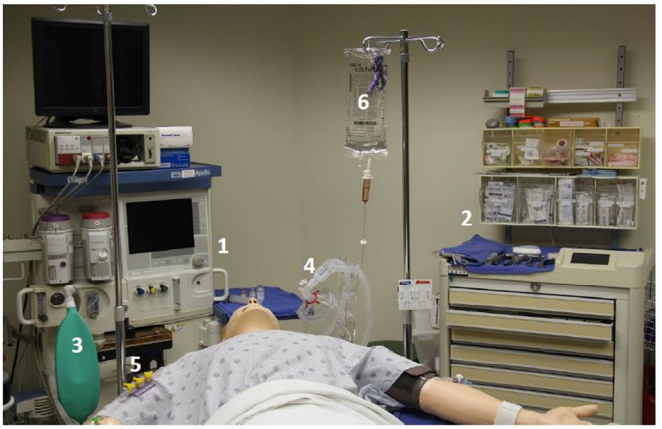

Fig 1. Anesthesia workstation and patient simulator. *IV*, intravenous.

We aimed (1) to quantify the dispersion of a surrogate pathogen from a simulated patient's mouth throughout the anesthesia workstation during routine general anesthetic induction, (2) to test the hypothesis that there would be fewer contamination sites caused by providers who used a double-gloving technique, and (3) to examine the effectiveness of the between-case anesthesia apparatus disinfection protocol.

METHODS

This study was approved by the Institutional Review Board at Virginia Commonwealth University and performed at Virginia Commonwealth University's Center for Research in Human Simulation. The patient was simulated by a SimMan 3G (Laerdal Medical, Wappingers Falls, NY), shown in Figure 1. The source of surrogate biologic contamination was a nonpathogenic inoculum in the form of DAZO (Ecolab, St Paul, MN), a clear and odorless fluorescent marking gel used as an analog for biologic material from the patient's mouth. One ampule of gel was mixed with 5 g of a water-soluble lubricant to create a saliva-like consistency. A standard Wood's lamp, emitting long-wave ultraviolet light, was used to fluoresce the dye, quantifying the dispersion of the surrogate biologic material. Dispersion of the dye from the oral cavity to other sites was considered to be caused by the actions of the anesthesia provider and served as the outcome variable.

A convenience sample of 20 experienced anesthesia providers performed a simulated, routine, uncomplicated induction of general endotracheal anesthesia. One member of the research team monitored their performance and gave verbal cues, if necessary, to ensure performance of a set of standardized interventions, as listed in Table 1. The 20 subjects were randomly divided into 2 groups. Group 1 (n = 10) was told to wear a single pair of gloves throughout the induction period and immediately after successful tracheal intubation but before attaching the breathing system to the endotracheal tube. The laryngoscope was managed at the provider's discretion. Laryngoscope management ranged from placing it on the surgical bed, on the drug-supply cart, on the mannequin's chest, or in a basin attached to the cart. All are common behaviors in routine clinical practice. No provider in group 1 put on (or was asked to do so) a second pair of clean gloves. Group 2 (n = 10) was told to double-glove, and immediately after successful intubation of the trachea, but before attaching the breathing system to the endotracheal tube, the outer gloves were removed and placed, along with the laryngoscope, into a collecting basin attached to the side of the drug-supply cart. If the outer gloves were not removed at this point the participant was prompted to do so. Each simulation was conducted in a high-fidelity, realistic manner except participants were told that there was no need to chart what was done.

Table 1
List of routine interventions performed by all providers

Scenario steps
Preoxygenation
Administering IV midazolam, fentanyl, lidocaine, propofol, succinylcholine
Adjusting the flow control of the intravenous fluids
Controlling ventilation by mask with an oral airway in situ
Performing laryngoscopy and placing an endotracheal tube
Connecting the circle system to the endotracheal tube and inflating pilot balloon
Auscultating breath sounds
Securing the endotracheal tube with tape
Adjusting the mechanical ventilator settings to achieve normocarbia
Administering a volatile anesthetic agent via the anesthetic vaporizer
Readjusting the flow control of the intravenous fluids
Placing an orogastric tube and an esophageal temperature probe
Administering an intravenous antibiotic
Administering an intravenous antiemetic

NOTE. All of the interventions were performed by each provider. These represent routinely performed clinical actions occurring with the induction of general anesthesia. *IV*, intravenous.

Participants were unaware of the nature of the gel and lubricant used in the mannequin's mouth or to the true reason for their performing the induction sequence. Participants were informed that their induction sequences were being videotaped for use in future didactic training of anesthesia providers just starting their education and training. After a 10-minute familiarization process with the simulation setup, the participants were taken to another room to obtain gloves and surgical masks. With the participants absent from the simulator, the mannequin's tongue and incisors were inoculated with 1.5 mL of the dye mixture. Prior to each scenario, the entire workstation and mannequin were scanned with the Wood's light by 2 members of the research team to ensure the absence of the dye from any surface.

On completion of the scenario, participants exited the simulator. At that time the mannequin, intravenous lines, cables, anesthesia circuit, supply cart, and machine were swept with the Wood's light by a technician blind to the participant's group assignment. A standardized data collection tool was used to inventory areas of contamination. The data collection tool consisted of photographs of the mannequin and anesthesia workspace where dye dispersion was observed and recorded by the scanning technician using a pen. In a prestudy assessment, 4 anesthesia providers who were nonparticipants in the study examined the collection tool as having high face validity. A checklist of specific target areas was included to ensure consistency and comprehensiveness in the Wood's light sweep. Additional clarifying notes could also be added as necessary. Each data sheet was coded, for follow-up analysis, to indicate if the participant was in group 1 (single pair of gloves) or group 2 (double pairs of gloves) with no other identifiers. After each scenario, the entire workstation and mannequin was photographed during Wood's lamp exposure using a Canon EOS Rebel T5i digital camera (Canon, Tokyo, Japan). Photos were archived and quantified to ensure reliable capture of all contaminated domains by the initial technician sweep (100% capture was validated). Participants received a $10.00 gift card at a local eatery.

After the data were collected, all surfaces were cleaned with soap and water per the DAZO manufacturer's recommendation. The dye is readily removed with a light wiping of soap and water. Masks, circuits, reservoir bags, laryngoscope handles, laryngoscope blades,

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