Improvement in Emergency Airway Equipment Transport

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BACKGROUND: Airway management out of the operating room in many major institutions is often performed by teams, requiring airway providers to carry their own materials at all times. The bag containing airway equipment must be light enough to be carried easily, while containing sufficient equipment to manage airways in various settings. Additionally, transport of the bag throughout the hospital raises concern about transmission of infection. We hypothesized that a new system of multiple, smaller bags would decrease weight, facilitate prompt location of equipment, and reduce the risk of bags acting as fomites. METHODS: The service purchased small, nylon laryngoscope bags with dividers to keep equipment organized. The contents of the original bag and a new replacement bag were cataloged and both bags were weighed. Fourteen clinicians working on emergency airway consults at the time of the study were timed as they searched the bags for predetermined equipment with 2 scenarios and intubated a mannequin. The surfaces of the bags were swabbed for culture. RESULTS: Clinicians were significantly faster to locate equipment with the new compared to the original bag, with a difference of 39 s ($P < .001$, 95% CI 19–58 s) in the first scenario, and 22 s ($P < .001$, 95% CI 13–32 s) in the second. The cultures from the original bag demonstrated coagulase-negative *Staphylococcus*, enterococcus, *Bacillus* species, alpha-hemolytic *Streptococcus*, non-hemolytic *Streptococcus*, and a *Staphylococcus* species of a second type. The culture of the new bag after clinical use but before cleaning grew rare *Aspergillosis* species. The culture of the new bag after undergoing proper cleaning demonstrated no growth. CONCLUSIONS: Exchanging a large canvas bag for several smaller nylon bags has improved the transport of emergency airway equipment, with benefits in carrying the bag, locating equipment, and reducing the transport of pathogens throughout the hospital. *Key words: airway equipment; transport; laryngoscope bag; nosocomial infection; fomite; infection control.* [Respir Care 2010;55(7):852–857. © 2010 Daedalus Enterprises]

Introduction

Airway management out of the operating room in many major institutions is often performed by centralized teams, many responding to over 1,000 consults for airway management annually. Consults for emergency airway management occur at different locations throughout the hospital, including intensive care units (ICUs), general care units, and non-patient-care areas.[1] At many institutions, including ours, airway teams carry their own equipmentand medications at all times. The need to carry airway equipment raises logistical problems. First, the airway equipment bag must be light enough to be carried by every provider, while containing sufficient equipment to perform airway management in various settings. Additionally, because the airway bag must be immediately available for an urgent consult, having one sole bag means that it cannot be

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readily cleaned. Transport of the bag throughout the hospital raises concern about the spread of infection, with hospital and physician instruments increasingly recognized as agents for transmitting pathogens.[2-7]

Because the old system raised concerns about weight, inability to locate equipment, and potential concerns for transmission of infectious material, a new system of transporting airway equipment was recently introduced.

In this study we evaluated the introduction of a new system of transporting airway equipment. We hypothesized that the new bag would facilitate the prompt location of critical equipment, reduce the weight carried by the residents, and reduce the likelihood of the bags acting as fomites for nosocomial infections.

Methods

Setting

Massachusetts General Hospital, a level I trauma center, is a > 900-bed tertiary-care center with multiple connected buildings. Consults for airway management of adult as well as pediatric patients outside of the operating room are performed by residents and fellows from the surgical ICU.[1] In adapting to the size of the hospital and the complex nature of airway management, in which specific equipment and medications are used, a system of bringing all necessary materials has evolved. Airway providers carry a bag containing equipment and medications for airway management at all times.

Development and Selection of the Bag

A multidisciplinary group of staff physicians, residents, infection-control nurses, and anesthesia technicians developed a new system. The following guidelines were set:

- The bag should be light.
- Because airway consults may occur in rapid succession without time to restock in between, the bags must contain sufficient equipment to perform 2 emergency adult airway consults and basic supplementary pediatric materials.
- The bags will contain individually wrapped, sterile equipment, including pre-styleted endotracheal tubes (ETT), whenever possible.
- To minimize transmission of infection, the hospital infection-control department mandated that the bags be made of a non-porous substance that could be wiped with antiseptic cloths.
- A price limit was set at $65 per bag.

Fig. 1. New bag and equipment.

Additional senior residents, fellows, and attendings were surveyed regarding the proposed contents and organization of the bag, leading to a consensus with the multidisciplinary group for the required contents.

To assess common practice for airway equipment transport outside of the operating room, the group searched the Internet with the search terms "emergency," "airway," "laryngoscope," "equipment," "instruments," "bag," and "transport," on a standard search engine. The group preferentially viewed sites with equipment for emergency-medical-services providers, as these providers face the same challenges as the airway consult group, only in more extreme conditions in the out-of-hospital setting.

The New System

The service purchased a 36 × 25 × 4 cm laryngoscope bag with a 3-sided zipper from an emergency-medical-services supply company, for $56.50 apiece. The water-resistant and wipeable bag is made of a proprietary universal-precautions material, a nylon polymer coated in vinyl, with handles and trim made of polypropylene webbing, also dipped in vinyl. The bag opens flat, with small nylon dividers and pockets inside to keep equipment organized for ease of location (Fig. 1).

The new bag contains the items listed in Table 1. All of the materials within the bags are individually wrapped and are to be replaced if opened. After use the bags would be returned, cleaned, and restocked in a central location. Anesthesia technicians have been trained by the infection-control nurse to clean the inside and outside of these bags with antiseptic wipes. The technicians restock the bags following a schematic designed by the multidisciplinary group.

The residents are responsible for obtaining medications used for airway management and often carry them within the bag, but they are obtained and monitored independently of the airway instruments and the bag.

Table 1. Contents of the New Bag

Category	Type, Size, and Number
Handles	One long
	One short
	One pediatric
Blades	One Wis-Hippel 1.5
	One Miller 2
	One Miller 3
	Two Macintosh 3
	One Macintosh 4
Pre-styleted ETTs	One cuffed 4.0 mm
	One 6.0 mm
	One 7.0 mm
	One 7.5 mm
	One 8.0 mm
Airways	One #3 oral airway
	One #5 oral airway
	One #28 nasal trumpet
Bougies	One
Laryngeal mask airways	One #4

Development of the Cleaning and Restocking Protocol

A preliminary step in the study protocol was the development by the group of a process for cleaning and restocking the bags. Residents are instructed that the airway bag may never enter the room of a patient on contact or droplet precautions, but rather should be left outside the room at all times. The resident should take all equipment he or she anticipates needing into the room and ask an assistant who has not been contaminated to obtain additional equipment if required. For a patient not on precautions, the bag may enter the room, but should be opened at a location remote from the patient. Once the resident managing the airway comes into contact with the patient, an assistant must provide any additional equipment from the bag. After completion of the consult, any piece of prepackaged equipment that was opened, or any that was handled if not individually wrapped, is considered contaminated and is discarded appropriately.

Following each consult, the resident returns the bag with all unopened and unused equipment to the anesthesia work room. Trained anesthesia technicians evaluate the equipment, ensuring that all sterile packaging remains unopened. The technicians then clean the outside and inside of the bag, and the exposed plastic surfaces of individually wrapped items, with Germicidal Disposable Wipes (Super Sani-Wipes, PDI [Professional Disposables International], Orangeburg, New York) a quaternary ammonium chloride antiseptic cloth that is effective against common bacterial, viral, and fungal pathogens, including extended-spectrum β-lactamase *Escherichia coli*, methicillin resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, *Pseudomonas aeruginosa*, *Acinetobacter,* mycobacteria, *Candida albicans*, respiratory syncytial virus, influenza viruses (including H1N1), hepatitis B and C, and human immunodeficiency virus.

Comparison of the 2 Bags

After clinical use, the contents of the original bag and the new replacement bag were each cataloged and both bags were weighed. To evaluate the functionality of the new bag, 14 residents and fellows working in the surgical ICU and performing emergency airway consults at the time of the study participated in a timed demonstration. Twelve of the clinicians were familiar with both bags, but 2 residents were new to the service and had never used either bag. In random order, we presented the clinicians with 2 scenarios. Each clinician performed each scenario with both bags. The clinicians were timed as they searched the 2 bags for predetermined equipment and intubated a mannequin.

The equipment list for scenario 1 included: a functional Macintosh 3 blade and handle, a 7.5-mm ETT with a stylet, a 10-mL syringe, a bougie, and an oral airway. The equipment list for scenario 2 consisted of a functional Miller 2 blade and handle, a 6.5-mm ETT, a 10-mL syringe, a #4 laryngeal mask airway, and a nasal trumpet. The clinicians were then timed from receiving the list until they placed the blade of the correct laryngoscope into the mouth of the airway mannequin as a means to capture the time directly affected by locating items in the bag. The study was approved by the Human Research Committee of the Massachusetts General Hospital.

Statistics

After assessing for normality of the data, paired *t* tests were used for comparison of individual performance times with each of the 2 airway bags. Statistical calculations and data analysis were performed using Stata 10 (StataCorp, College Station, Texas). $P < .05$ was considered statistically significant. All P values are the result of 2-sided tests.

Infection-Control Measures

To evaluate for potential bacterial colonization, cultures were obtained from each of the airway bags. The cultures were obtained from the bottom of the bag, the top of the bag, and the areas around the side pockets, using sterile swabs moistened with sterile water. The sole original bag was cultured after removal from clinical use. After 2 months of clinical use the surfaces of representative new bags were cultured for comparison. A new bag was cultured twice: once after undergoing the cleaning and restocking

Fig. 2. Original bag and equipment.

procedures as per the new protocol, and an additional time after the bag had been used clinically but before being cleaned and restocked, to demonstrate the value of a thorough cleaning protocol.

The swabs were processed in the Massachusetts General Hospital microbiology laboratory, using standard bacterial culture protocol with brucella agar, MacConkey agar, and thioglycollate broth, and were incubated at 35–37°C for 48 h. The bacteria were identified with standard protocols and reported in a semi-quantitative manner.

Results

Comparison of the 2 Bags

Given the large size, numerous pockets, and superfluous materials, locating a required piece of equipment in an emergency can be difficult (Fig. 2) and redundant equipment is routinely placed in the bag (Table 2). While the original bag and included equipment weighed 4.3 kg, the new bag and its contents weighed 1.4 kg.

Clinicians were significantly faster to locate equipment with the new compared to the original bag (Fig. 3). In the first scenario the time to locate equipment in the original bag was 39 s longer than with the new bag ($P < .001$, 95% CI 19–58 s). In the second scenario the time with the prior bag was 22 s longer ($P < .001$, 95% CI 13–32). Only one provider was faster with the original bag in the first scenario, and another provider was faster with the original bag in the second scenario.

The group reviewed the documentation for the over 400 emergency airway consults that occurred since the institution of the new bag, and did not find a single report of a provider requiring an instrument for non-surgical airway management that was not located in the new bag.

Table 2. Contents of the Original Bag

Category	Type, Size, and Number
Handles	One long
	One short
	One pediatric
Blades	One Wisconsin 1
	One Wis-Hippel 1.5
	One Miller 0
	One Miller 1
	One Miller 2
	One Miller 3
	Three Macintosh 3
	Three Macintosh 4
ETTs	One 3.5 mm
	One 4.0 mm
	One 4.5 mm
	One 5.0 mm
	Two 5.5 mm
	Three 6.0 mm
	Two 6.5 mm
	One 8.0 mm
Pre-styleted ETTs	One 6.5 mm
	Four 7.0 mm
	Three 7.5 mm
	Two 8.0 mm
Airways	One #3 oral airway
	One #4 oral airway
	One #30 nasal trumpet
	One #32 nasal trumpet
	One #34 nasal trumpet
Bougies	One
Laryngeal mask airways	One #3
	One #4
	One #5
Miscellaneous	Benzocaine spray
	Two 20-mL bottles of lidocaine
	Three 10 mL syringes
	Four 5 mL syringes
	One roll cloth tape
	One intravenous start pack
	Six 16-gauge needles
Intubating laryngeal mask airway	One #4

Infection-Control Measures

The culture results from the original bag returned rare coagulase-negative *Staphylococcus*, *Enterococcus*, *Bacillus* species, alpha-hemolytic S*treptococcus*, non-hemolytic *Streptococcus*, and a *Staphylococcus* species of a second type. Antibiotic sensitivities were not performed. The culture of the new bag after 2 months of clinical use but before cleaning grew rare *Aspergillosis* species from the outside surface of the bag. The culture of the new bag after clinical use and proper cleaning demonstrated no growth (Table 3).

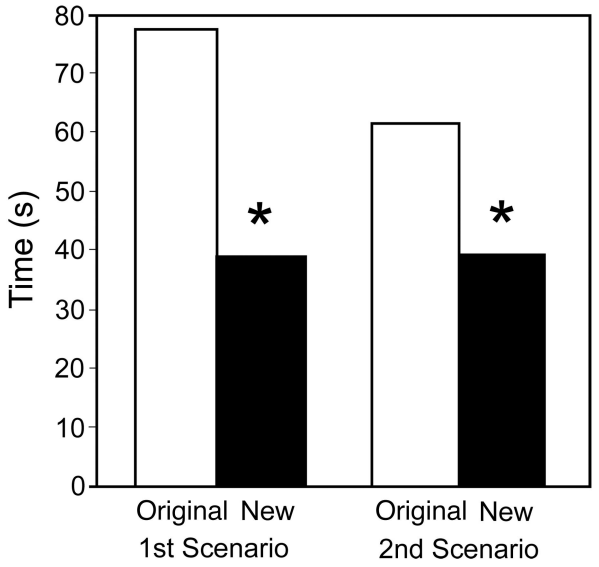

Fig. 3. Time to locate predetermined equipment in the 2 bags. In scenario 1 the original bag mean time was 77 ± 35 s, and the new bag mean time was 36 ± 16 s. In scenario 2 the original bag mean time was 62 ± 16 s and the new bag mean time was 39 ± 8 s. * $P < .001$.

Table 3. Microbiology Results From Bags

Original Bag
Rare coagulase-negative *Staphylococcus*
Enterococcus
Bacillus species
Alpha-hemolytic *Streptococcus*
Non-hemolytic *Streptococcus*
Staphylococcus of second type
New Bag Before Cleaning
Rare *Aspergillosis*
New Bag After Cleaning
No growth

Discussion

The principal findings of our study are that the new airway bag is lighter than the original bag, and equipment is easier to locate. In addition, no bacteria were detected after implementation of a new cleaning protocol.

At our institution, clinicians on the airway consult service carry a bag containing equipment and medications for airway management at all times. This is based on the size of our institution and the requirement that clinicians respond to locations throughout the hospital, including ICUs, general care units, and non-patient-care areas. While other institutions use airway carts or code carts that are cleaned and restocked after each use, these carts often contain only the simplest of airway equipment, and at our hospital, carts are not stocked with intubation medications. The airway team is often called to intubate in non-code situations, as codes represent the minority of intubations at our facility. Additionally, many airway consults occur in non-clinical areas, making a code cart unavailable.

The new system of transporting the emergency airway equipment provides numerous advantages over using one large canvas bag with numerous large pockets and dividers. Not only is the new bag smaller and lighter, but equipment in the nylon bag is instantly exposed upon opening the bag.

The time required to locate the airway equipment most commonly used in emergency situations was significantly reduced with the new bag. The difference in the first scenario, using the most common equipment for airway consults, including a Macintosh 3 laryngoscope and a 7.5-mm ETT, was 39 s, and in the second scenario, with a Miller 2 blade and 6.5-mm ETT (common back-up materials for a difficult airway), was 22 s. This difference is of clinical importance, as the majority of the emergency airway consults are for patients in extremis, who are difficult or impossible to pre-oxygenate, leading to rapid desaturation.[8]

Upon implementation of the new bag, senior residents familiar with the original bag voiced concerns that they would need equipment not contained in the smaller, more limited bag. Review of the data has not found this to be the case. Additionally, our data indicate that the larger, overflowing bag made it take longer to find needed equipment.

Infection-Control Measures

The new system reduces the risk of pathogen transmission. Culture of the new bag before undergoing cleaning with bactericidal wipes grew *Aspergillosis,* a common fungal contaminant in the environment that can be a pathogen in immunocompromised patients. As the emergency airway service provides airway management for all patients, including immunocompromised patients such as lung-transplant patients, any equipment that may contact these patients' airways should be held to the highest standards of cleanliness. After proper cleansing the new bag had no growth. And having multiple small bags in reserve ensures the possibility of proper cleaning of used bags.

Over the past 2 decades, several studies have demonstrated that pathogenic bacteria can be spread to the environment surrounding the patient, which may be then picked up by the healthcare worker and transmitted to other patients.[2,3,9-11] Recent reports on contamination of anesthesia work-spaces in the operating room, physicians' neckties, stethoscopes, patients' textiles, and pens have focused attention on the cleanliness of the hospital environment as a means to reduce nosocomial infections.[5-7,12] Equipment used with multiple patients can cause outbreaks of resistant organisms in ICUs.[13]

As staphylococcus and enterococcus species can survive for weeks to months on fabric in the hospital environment, using a bag amenable to bactericidal wipes is imperative.[14,15] Our bag cultures found several clinically important bacteria, including enterococcus, group A hemolytic *Streptococcus*, and coagulase-negative *Staphylococcus*, one of the most common nosocomial pathogens.[16] Our anesthesia technicians have been trained by the infection-control nurse to clean the inside and outside of the bags with antiseptic wipes. Having the bags cleaned by anesthesia technicians, as compared to physicians, may reduce the risk of infection, as it has been demonstrated in the case of hand-washing that adherence to protocol is inversely related to medical training.[15] In addition, the technicians restock the bags following a schematic designed by the multidisciplinary group, thus preventing unnecessary equipment from finding its way into the bag. By limiting the number of blades and ETTs in the bag, we decreased the risk of contaminating the equipment remaining in a bag for weeks or months while traveling throughout the hospital without being cleaned.

This study has several limitations. First, reducing the time to locate equipment in the airway bag does not necessarily translate to improved intubation outcomes, given the numerous factors involved in any emergency airway situation. However, shorter equipment-finding time should reduce time to intubation.

Whether the original bag contributed to the development of clinically important nosocomial infections is not known. Numerous studies over the last decade have shown inanimate objects to be covered with pathogenic bacteria, but very few of these studies have shown that these objects were responsible for transmission of nosocomial infections. Nonetheless, based on the available data, removal of this bag from clinical practice was necessary.

The bags were not evaluated for *Clostridium difficile*, which is presently one of the most concerning infections in hospitalized patients. At our institution, testing for *C. difficile* is performed via toxin assay from stool specimens and is not amenable to detection by sterile swabs. Additionally, environmental infection-control cultures are only performed for aerobic, not anaerobic, bacteria. Although *C. difficile* is an important nosocomial pathogen, it is not detected with routine environmental culture, and has not been tested in other studies of fomites.[5-7,11,12]

Conclusions

In summary, simply replacing a large canvas bag with several smaller nylon bags improved the transport of emergency airway equipment, with benefits in carrying the bag, locating equipment, and reducing the transport of pathogens throughout the hospital.

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