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Major Article

Improving infection control practices of nurse anesthetists in the anesthesia workspace



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Background: Anesthesia providers commonly cross-contaminate their workspace and subsequently put patients at risk for a health care–acquired infection. The primary objective of this project was to determine if education and implementation of standardized infection control guidelines that address evidence-based best practices would improve compliance with infection control procedures in the anesthesia workspace.

Methods: Patient care–related hand hygiene of nurse anesthetists was observed in 3 areas of anesthesia practice before and 3 weeks and 3 months after staff education, placement of visual reminders, and the implementation of infection control guidelines. After the observation periods, the percent compliance on the part of the providers was calculated for each of the 3 areas of anesthesia practice, and the results were compared using the Fisher exact test.

Results: There were a total of 95 observations performed during the 3 observation periods. When compared with preimplementation baseline data, there was a 26.2% increase in the number of providers compliant with hand hygiene practices after airway instrumentation ($P = .029$) and a 71.9% increase in the number of providers who separated clean from contaminated items in the workspace ($P = .0001$).

Conclusions: Education, visual reminders, and standardized infection control guidelines were shown to improve compliance with infection control best practices in a group of nurse anesthetists.

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Cross-contamination of the anesthesia workspace poses a serious threat to patient safety and increases the risk of health care–acquired infections (HAIs). HAIs are preventable, yet 1 in 25 hospitalized patients is found to have at least 1 HAI during their hospitalization.¹ National initiatives have helped to reduce HAIs; however, an increase in multidrug-resistant organisms is making it more difficult to prevent and treat them.^{1–4} Anesthesia providers have a responsibility to protect patients from infection, but no standard best practice exists specifically for preventing cross-contamination in the anesthesia workspace. Moreover, anesthesia providers themselves can be the vehicles that transport microorganisms between the workspace and the patient.^{4–10}

Anesthesia providers traditionally have a poor compliance rate with hand hygiene as well as frequent contact with the patient's bloodstream through intravenous (IV) access.¹¹ Studies have found

that pathogenic microorganisms can be cultured from the anesthesia workspace and equipment, including IV stopcocks, the anesthesia gas machine, anesthesia supply cart, keyboards, syringes, and other items contacted by the provider.^{3,5,7,12,13} IV stopcock contamination is an important source for bacterial entry into the bloodstream, but it is a modifiable risk.^{13,14} Intraoperative hand hygiene improvement programs, education, and easier access to hand sanitizer could increase provider compliance, decrease transmission, and prevent HAIs.^{6,9,15} The ready availability and accessibility of hand sanitizer alone have been shown to improve compliance with hand hygiene.^{13,16}

Cross-contamination can also be reduced by changing gloves after patient contact and before touching the work environment.^{10,12,13,17} A cost-effective practice such as double-gloving prior to endotracheal intubation, with removal of the outer glove immediately after the procedure, dramatically reduces contamination of the workspace.^{10,17} IV medication administration via a stopcock should follow an aseptic technique.¹⁸ Scrubbing a stopcock port for 15 seconds with an alcohol swab and allowing it to dry for 15 seconds before attaching a syringe with clean hands reduce the risk of bacterial entry into the bloodstream. Designating separate areas within the workspace for clean

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and contaminated items and delineating which areas should not be contacted with contaminated gloves have also been effective in reducing cross-contamination.^{13,19} Materials, such as syringes, that have been in patient contact should remain separate from those that have not been used. Contaminated gloves or used equipment should not come in contact with clean areas or items, such as an anesthesia supply cart containing items that will be used for subsequent patients. It is imperative that all flat surfaces, keyboards, knobs, dials, and equipment are adequately decontaminated to decrease the risk of transmission between patients.^{3,13}

It has been demonstrated that anesthesia providers can reduce the spread of pathogenic organisms through evidence-based interventions; however, standard protocols to reduce or prevent anesthesia-related cross-contamination are uncommon.^{6,7,10,13,14,20} To decrease the risk of HAIs in the clinical setting, the current body of literature and the Anesthesia Patient Safety Foundation strongly recommend that comprehensive best practice guidelines are needed to prevent cross-contamination between the anesthesia workspace and patients.⁷ As there was no such best practice protocol in place in the operating room suites at our institution, the purpose of this project was to develop standardized infection control guidelines, provide education regarding the guideline requirements to staff nurse anesthetists, and assess the effect of the guidelines and education on provider behavior.

METHODS

Design

This project used a direct provider observation design to assess nurse anesthetists' hygiene practices during anesthetic induction both before and after an infection control intervention. Observations were conducted using an audit tool that evaluated 3 modifiable practices: hand hygiene after airway instrumentation, medication administration, and separation of clean and contaminated items in the workspace. Each practice item was graded as clean or contaminated. A self-assessment tool was administered to determine provider baseline practices. The intervention consisted of educational sessions, visual reminders, an educational flyer, and implementation of infection control guidelines. The improvement in clean workspace behaviors at 3 weeks and 3 months postimplementation was the primary outcome variable of interest.

Organizational setting

This project was conducted at a 957-bed medical center in the Southeastern United States between May and December 2017. The medical center has 51 main operating suites and performs 16,966 inpatient and 21,368 outpatient surgeries annually. The anesthesia department employs nurse anesthetists, anesthesiologists, fellows, and residents.

Sample

Given that the anesthesia department has many different types of providers who service many anesthetizing areas, a convenience sample of 35 nurse anesthetists who consistently provide the majority of direct patient care in the main operating suites was selected for observation during this initial attempt at implementing workspace infection control guidelines.

Measures

A preimplementation self-assessment survey (Fig 1) was developed by the project team to gather information about nurse anesthetists' infection control practices prior to the intervention. The survey questions were based on the work of Martin et al,¹³ who identified provider

Survey of Operating Room Infection Control Practices

Please circle one of the "Yes" or "No" choices for each question 1-5 below:

1. Do you routinely use hand sanitizer after patient contact prior to touching "Clean" areas or items in the anesthesia workspace?
 YES
 NO
2. Do you designate CLEAN AND DIRTY areas within your anesthesia workspace to separate materials that have come into contact with the patient?
 YES
 NO
3. Do you use a double gloving technique OR remove a single set of gloves immediately after instrumentation of the airway to avoid contaminating the anesthesia workspace?
 YES
 NO
4. Do you swab the rubber stopper on medication vials with alcohol and allow it to dry before drawing up medications?
 YES
 NO
5. Do you swab intravenous stopcocks with alcohol before attaching syringes and injecting medications?
 YES
 NO

Fig 1. Survey of self-reported anesthesia workspace infection control behaviors. The survey was administered after the baseline provider-blinded observation of the actual workspace infection control behaviors.

behaviors and areas of the anesthesia workspace that contributed to cross-contamination. The survey data were used to target specific areas of concern for improvement, develop the infection control guidelines, and compare self-reported to actual observed behaviors. The survey consisted of 5 yes or no questions about practices shown in the literature to have an impact on infection control. These questions addressed whether the provider used hand hygiene after airway manipulation, complied with aseptic medication preparation and administration, and designated clean and contaminated workspace areas.

An audit tool (Fig 2) modeled after an existing quality improvement study pertaining to infection control in the anesthesia workspace was developed by the project team.¹³ This tool was originally designed to evaluate 4 areas of provider practice during induction of anesthesia that have been shown to impact infection control and cleanliness within the workspace. Originally, the 4 practices included the provider's hand hygiene behavior after airway instrumentation, medication preparation, medication administration, and whether the provider clearly designated separate clean and contaminated spaces for items used during the case. The audit tool determined the provider practices to be contaminated if the clean practice guidelines were not followed 100% of the time.

Hand hygiene after airway instrumentation was considered clean if the provider used a double-gloving technique with removal of the outer glove—or removal of single gloves—after contact with the oropharynx and prior to contact with the workspace. Additionally, for airway instrumentation to be considered clean, the provider had to perform hand hygiene after the airway was stabilized and prior to touching the patient or workspace equipment. Medication preparation was considered clean if the provider used hand hygiene prior to preparing medications and wiped the top of medication vials with an alcohol swab. However, this item was discarded from the audit tool

	Clean	Contaminated	Comments
Airway Instrumentation	1. Double-gloving with removal of outer glove or removed single gloves after instrumentation prior to contact with workspace 2. Performs hand hygiene after airway stabilized prior to touching patient or workspace equipment	<input type="checkbox"/> Failure to comply with 100% of clean category tasks	
Medication Preparation	3. Hand hygiene before preparing medications 4. Swabs rubber stopper on medication vial with 70% alcohol or chlorhexidine and allows it to dry prior to needle insertion	<input type="checkbox"/> Failure to comply with 100% of clean category tasks	
Medication Administration	5. Hand hygiene before contact with IV stopcock 6. Swabs port with of 70% isopropyl alcohol or chlorhexidine prior to syringe attachment	<input type="checkbox"/> Failure to comply with 100% of clean category tasks	
Clear Designation of Clean Versus Contaminated Space	6. Yes, clean items were not mixed with dirty items and/or contaminated gloves/hands did not contact the keyboard, cart or other clean equipment in the space	<input type="checkbox"/> No, clean items were mixed with dirty items and/or contaminated gloves/hands touched the keyboard, cart or other clean equipment in the space	

Fig 2. Anesthesia workspace infection control audit tool. The tool was used to evaluate anesthesia provider infection control practices during the baseline and 3-week and 3-month postguideline implementation periods. The medication preparation category was eliminated from the data pool, as this preparatory step occurred during workspace set-up, prior to the start of the direct observation. IV, intravenous.

after the preimplementation observations, when it was discovered that most providers had prepared medications prior to the start of the observation. Medication administration was considered clean if the provider performed hand hygiene before contact with the IV stopcock and wiped the stopcock with alcohol prior to syringe attachment. The provider received a designation of a clean versus a contaminated workspace if clean items were not mixed with contaminated items or contaminated gloves or hands did not contact the computer keyboard, anesthesia cart, or other clean equipment in the space. Data from the audit tool were compared at baseline to 3 weeks and 3 months postimplementation to determine if the interventions effected infection control practices of nurse anesthetists.

Preimplementation of guidelines

A convenience sample of nurse anesthetists was observed and evaluated with respect to their infection control behaviors during induction of general anesthesia by a single observer using the infection control audit tool. Observations were performed at induction, as cross-contamination has been shown to peak during this stage of administration of anesthesia.^{5,21} The anesthesia providers were unaware of what was being observed (single blind) and gave verbal consent prior to being observed. After completion of the preimplementation observations, the baseline self-assessment survey (Fig 1) was administered to all staff nurse anesthetists via an electronic format. This survey was administered after the initial observations so that providers would have no insight into or knowledge of what was being observed. The survey was meant to assess current practices of nurse anesthetists and to assist with determining areas for improvement for the future development of infection control guidelines.

After the preimplementation observations, nurse anesthetist staff members were asked to volunteer for a focus group to develop

infection control guidelines. The focus group consisted of 3 staff members and 1 department manager who expressed an interest in improving infection control in the anesthesia workspace. This group reviewed current literature, the results of the self-assessment, and the preimplementation observation data to develop the infection control guidelines. The guidelines (Fig 3) addressed general hand hygiene, hand hygiene after airway instrumentation, clean medication preparation and administration, designation of clean and contaminated areas within the anesthesia workspace, and decontamination of the workspace between cases.

The focus group determined that placing reminder signs in the workspace would encourage providers to comply with the guidelines, as this had been a successful measure in a similar published study.¹³ The contaminated or “used” items area was considered to be the table top of the anesthesia gas machine. A laminated sign with the word “used” was affixed to the front of the machine. The “clean/no gloves” area in the workspace was defined as the anesthesia supply cart, and a laminated sign with the word “clean” was affixed to the top of the cart. A label was placed on the computer keyboard that stated, “Use hand sanitizer before and after use.”

Implementation of guidelines

Implementation began after the initial baseline observations with a 30-minute educational session presented at a monthly nurse anesthesia staff meeting. Current literature, evidence-based practices for infection control in the anesthesia workspace, and the infection control guidelines were presented via discussion and a PowerPoint (Microsoft Corporation, Redmond, WA) presentation. All nurse anesthesia staff additionally received the PowerPoint presentation and the guidelines via e-mail. In the same manner, a second education session and e-mail distribution were repeated 2 months later.

INTERVENTION	TARGET	RATIONALE
HAND HYGIENE	<ul style="list-style-type: none"> • Technician & Provider will ensure that hand sanitizer is present and easily accessible on top of the anesthesia gas machine before case start • Hand hygiene should be performed prior to and after contact with the patient/stopcocks or contaminated surfaces within the workspace 	<ul style="list-style-type: none"> • Presence and location contribute to increased compliance with use • Provider hands, workspace items, patient skin and bodily fluids are reservoirs and mode for bacterial transmission
AIRWAY INSTRUMENTATION	<ul style="list-style-type: none"> • Provider will double glove and remove outer gloves or remove gloves after airway instrumentation and prior to contact with the workspace • During urgent/emergent situations, provider will wipe down machine surfaces with CHG wipes after situation is stabilized 	<ul style="list-style-type: none"> • Double-gloving dramatically reduces the incidence of workspace contamination • The anesthesia gas machine is a reservoir for intraoperative bacterial transmission • Gloves protect the provider, not the patient, from contamination
STOPCOCK DECONTAMINATION	<ul style="list-style-type: none"> • Provider will use alcohol swabs to thoroughly decontaminate the stopcock prior to syringe attachment 	<ul style="list-style-type: none"> • Using alcohol to decontaminate stopcocks prior to medication administration reduces the risk for bacterial entry into the bloodstream
CLEAN AREA Supply Cart and Omnicell Designated as CLEAN AREA	<ul style="list-style-type: none"> • Provider will not contact the cart with gloved or unclean hands • Next case items will be stored on top of the cart unopened. • Minimize opening next case items • Only clean medications can be stored inside top drawer/on top of the cart • Used controlled substances can be placed in the top drawer if they are placed in a clean sealable plastic bag 	<ul style="list-style-type: none"> • Designation of a clean space reduces the risk for bacterial transmission • Open items are considered contaminated for next case and will be discarded unless covered in disposable drape or towel
DIRTY AREA Anesthesia Gas Machine Designated as DIRTY AREA	<ul style="list-style-type: none"> • Same case medications will be capped with black caps and placed on machine table top • Contaminated blade will be thrown away after induction or kept separately from same case medications on the machine table top 	<ul style="list-style-type: none"> • Designated dirty space reduces the risk of bacterial transmission • Many anesthetic medications are growth mediums for bacteria • Syringe storage is an independent factor for bacterial transmission
ENVIRONMENTAL CLEANING	<ul style="list-style-type: none"> • Anesthesia gas machine tabletop and its components will be decontaminated as needed and between cases • All items on machine table top will be discarded including unopened syringes containing medications • Cables, flat surfaces including the keyboard and cart will be decontaminated as needed and between cases 	<ul style="list-style-type: none"> • The workspace is an independent reservoir for bacterial transmission • Proper, standardized decontamination practices have been shown to decrease bacterial transmission

Fig 3. Intraoperative infection control guidelines. These guidelines were discussed with and provided to the nurse anesthesia staff after the baseline observation period at staff meetings prior to the 3-week and 3-month observation periods.

Three weeks after the second education session and presentation of the infection control guidelines, a convenience sample of 30 nurse anesthetists was observed and evaluated while inducing general anesthesia using the infection control audit tool (Fig 2) in the same manner as during the preimplementation phase. All 30 nurse anesthetists in this sample had received education prior to observation and consisted of nurse anesthetists who had been observed at baseline and those who had never been observed. Between the 3-week and 3-month observation periods, additional education was provided by way of a flyer distributed at an annual nurse anesthesia skill fair. The flyer highlighted the 3 target areas of the guidelines and was an attempt to remind providers to comply with the practices to improve patient safety. At 3 months postimplementation, observations and evaluations were conducted in the same fashion as the previous 2 observation and evaluation periods.

Analysis

A comparison of the clean and contaminated practices for each of the 3 audit tool criteria at each of the time points (preimplementation and 3 weeks and 3 months postimplementation) was performed using the Fisher exact test. The percentage of yes and no responses to each question on the preimplementation self-assessment questionnaire was calculated.

RESULTS

Hand hygiene after airway instrumentation

During the baseline observation period, 17.1% of the anesthesia providers performed hand hygiene after airway instrumentation. At 3 weeks, there was a significant improvement of 26.2% from baseline in the number of compliant providers ($P = .029$). At 3 months, there was a 19.6% improvement from baseline. This improvement did not achieve statistical significance ($P = .094$) (Fig 4).

Medication administration behaviors

During the baseline observation period, it was noted that 62.9% of the anesthesia providers demonstrated clean medication administration behaviors. There was a 2.5% improvement from baseline at 3 weeks and a 3.3% improvement from baseline at 3 months in compliance with clean medication administration. Neither of these findings was statistically significant ($P = .99$ and $.80$, respectively) (Fig 4).

Treatment of clean and contaminated items

Among providers, 88.6% did not separate clean from contaminated items during baseline observations. There was a large and significant increase of 71.9% in providers who separated clean from

contaminated items in the workspace and therefore did not contaminate the clean space at the 3-week postimplementation period compared with baseline ($P = .0001$). At the 3-month postimplementation period, there was a 42.1% increase compared with baseline ($P = .0001$) (Fig 4). Although this was a statistically significant improvement, the number of providers who designated a clean and contaminated space declined at 3 months compared with the 3-week observation data.

Self-assessment survey

The self-assessment survey (Fig 1) was sent to the 80 staff nurse anesthetists, and 42 were returned, for a 52.5% response rate. This survey was sent to all nurse anesthetists to gain a better understanding of current practices and find areas for improvement to target in the guidelines. Of those who responded to the survey, 85.7% reported that they routinely performed hand hygiene after general patient contact and prior to touching a clean space or other items in the workspace. There were substantive differences noted between specific self-reported behaviors and the baseline blind observation of those behaviors for hand hygiene after airway instrumentation, clean medication administration, and designation of a clean workspace. The largest of these differences was found for designation of a clean workspace, for which there was a difference of 79.1% between self-report and observation data (Table 1).

Overall compliance was defined as being 100% compliant with all 3 clean behaviors (hand hygiene after airway instrumentation, clean medication administration, and use of clean and contaminated workspaces). Analysis of overall compliance showed a significant

improvement from preimplementation baseline (8.6%) to 3 weeks postimplementation (34.5%) ($P = .039$). There was a decrease in overall compliance from 3 weeks postimplementation (34.5%) to 3 months postimplementation (23.3%), although this difference was not significant. The change in overall compliance from preimplementation (8.6%) to 3 months postimplementation (23.3%) was also not significant.

DISCUSSION

Although it is well supported in the literature that anesthesia providers commonly cross-contaminate their workspace, and that this contamination increases the risk of HAIs, these providers have traditionally had poor compliance rates with hand hygiene. Equally apparent in the literature is that hand hygiene education, compliance programs, and access to hand sanitizer can increase provider compliance. A number of studies have shown that specific provider practices related to infection control can be improved through the use of

Table 1
Self-reported practices compared with baseline observations

	Self-reported (%)	Baseline observation (%)
Clean airway	35.7 (15/42)*	17.1 (6/35) [†]
Clean med admin	85.7 (36/42)*	60.0 (21/35) [†]
Clean space	90.5 (38/42)*	11.4 (4/35) [†]

med admin, medication administration.

*Total number of self-reported yes answers out of total number of returned surveys.

[†]Total number of observed behaviors out of total number observed at baseline.

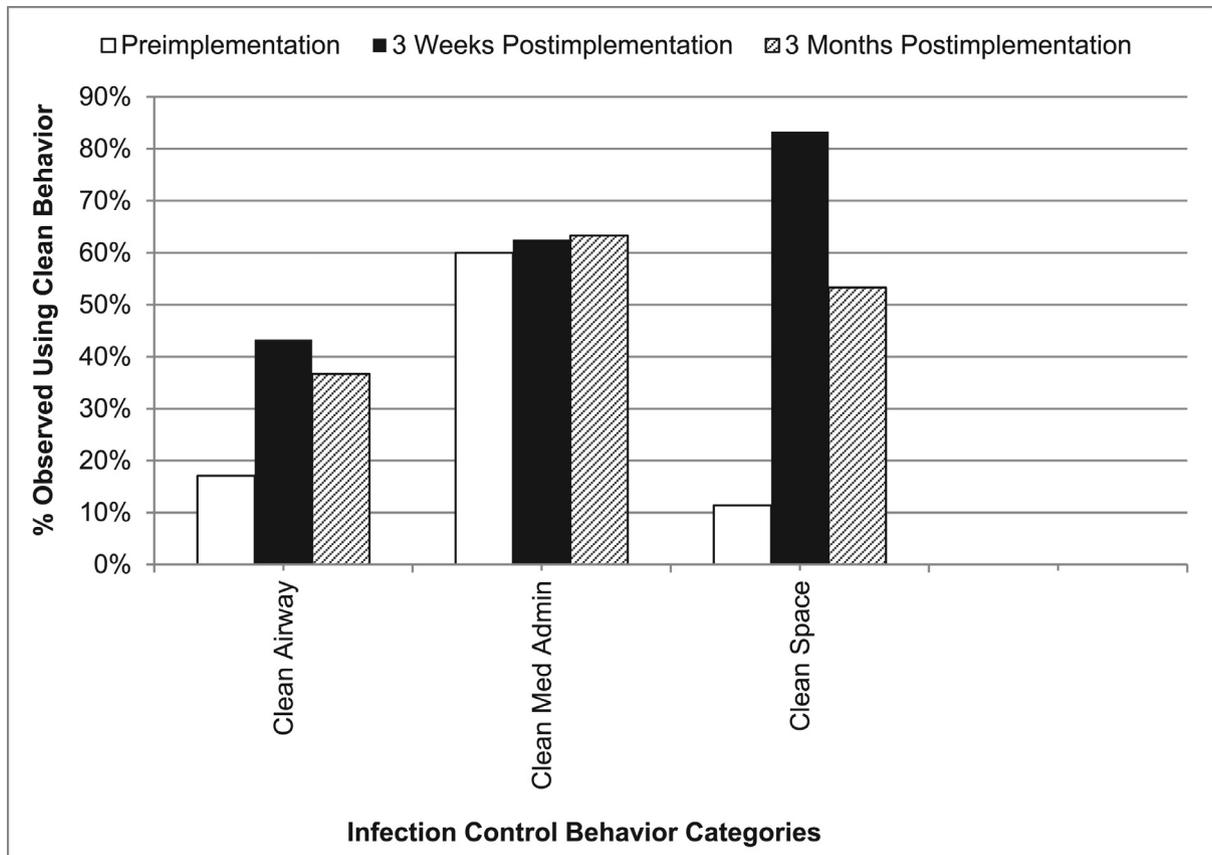


Fig 4. Comparison of percentage of observed clean behaviors by providers at the 3 observation periods, as defined by the audit tool by category. The categories included hand hygiene after airway instrumentation (clean airway), clean medication administration (clean med admin), and designating clean and contaminated workspace (clean space). A behavior was considered clean if 100% of the audit criteria were met during the observation.

multimodal approaches, unique devices, and educational offerings, with a resultant reduction in workspace contamination.^{3,6,10,13} This suggests that the factors associated with anesthesia provider cross-contamination of the workspace are modifiable and can therefore be reduced. After the evaluation of the baseline state of potential provider cross-contamination of the anesthesia workspaces at our institution, we educated nurse anesthetists about the mechanisms of contamination and introduced a set of infection control guidelines. These interventions produced an overall increased awareness of potential avenues of cross-contamination in the anesthesia workspace as well as an improvement in specific patient care–related clean behaviors on the part of the nurse anesthetists at our institution.

The most substantial improvement demonstrated during the project was in establishing and using clean and dirty areas within the anesthesia workspace. This improvement was apparent at the 3-week assessment period after implementing the guidelines, and although the percentage improvement was lower at 3 months compared with 3 weeks, it remained much improved over baseline. This is an important behavioral change, as contamination of the general workspace will likely lead to more opportunities for provider hand contamination and patient cross-contamination. There was also clear improvement in performing hand hygiene after instrumentation of the airway at 3 weeks and 3 months over baseline. However, again, the percent of improvement at 3 months was less than at 3 weeks.

The decline in clean behaviors observed at 3 months to below the improvement demonstrated at 3 weeks is in keeping with literature that has shown a decline in skill retention as a factor of time from exposure to lectures, workshops, or courses designed to reinforce a skill and suggests that different or multiple educational modalities or education provided at more frequent intervals could improve guideline adherence. The impact of time on compliance with the desired behaviors in this project may have also been summative with the inadvertent removal of posted workspace visual reminders of the infection control guidelines. Permanent reminder signage would be a valuable component for compliance; however, this was not feasible at our institution within the time frame of this project. There was a stringent and lengthy approval process for posting permanent signage or other equipment within the anesthesia workspace. The highest baseline preimplementation adherence to the guidelines was recorded for cleaning the IV stopcock prior to medication injection. Unfortunately, guideline adherence was only somewhat greater than 50%, and there was only marginal improvement in this behavior at both the 3-week and 3-month assessment periods.

The self-reported infection control behaviors assessed prior to the education sessions and baseline preimplementation observation period were notable for >85% of providers who responded that they routinely performed hand hygiene after contact with the patient. However, the baseline observation data that assessed specific guideline behaviors requiring hand hygiene after coming into contact with the patient and before touching clean areas of the anesthesia workspace did not concur with the self-reported data. Indeed, providers had a much better perception of their infection control practices with respect to hand hygiene after airway manipulation, cleaning the IV stopcock prior to medication administration, and establishing clean and contaminated workspaces than was demonstrated during the baseline provider blind assessment of those behaviors. The difference between self-reported and observed behaviors suggests that providers were generally unaware or had an overly optimistic conception of their typical patient care infection control practices and reinforces the need for educational sessions and written guidelines.

There are few studies that have reported on the impact of education and implementation of standardized guidelines on improving the infection control practices of nurse anesthetists. However, there are a number of studies that have suggested there is a need for more

evidence to show the impact education and standardized infection control guidelines have on infection control practices, decreased microbe transmission in the anesthesia workspace, and reduction of HAI risk.^{3,7,11,15,21} Although our work did not assess the impact of implementing infection control education and promulgating a set of anesthesia workspace infection control guidelines on the actual incidence and prevalence of HAIs in our institution, we have demonstrated that such interventions can improve the infection control practices of staff nurse anesthetists.

Project limitations

Judgments regarding whether providers met the criteria for clean behavior for each element of the guidelines were made by a single observer and as such were open to the potential for observer bias. However, at the same time, the value of the observations made by a single observer was strengthened by the limited variability in the way providers were assessed.

Nurse anesthetists received the preimplementation self-assessment survey after education was provided and preimplementation observations had been completed. This could have introduced bias as to how they answered the survey questions. The survey was anonymous, and results were used to assist the focus group in targeting areas for improvement in the development of the protocol.

Because all 3 groups were convenience samples, nurse anesthetists were observed once, twice, or all 3 times. For those providers who were observed only once, these data do not represent longitudinal practice behaviors. As the nurse anesthetists who were observed were not blind to the subsequent 3-week and 3-month observation periods, the resulting improvements in some behaviors may have been partially or wholly a product of the Hawthorne effect; that is, the providers may have behaved as they believed they were expected to behave based on observer presence in the workspace. This may not necessarily be considered a negative given that the general goal of improvement in some clean behaviors was accomplished. In addition, the presence of the observer did not prevent a decline in provider application of some clean behaviors at 3 months as compared with the 3-week gains. More work in this area with a longer and perhaps blind observation period would be necessary to determine sustainability of such efforts.

As this was a quality improvement project, the outcomes are not generalizable to the broader health care community. The infection control education and intervention did not include anesthesiologists, anesthesia residents, students, or technicians, as their participation was determined to be outside the scope and feasibility of the project. The convenience sample of nurse anesthetists who were observed during the project may not be representative of all the nurse anesthetists providing care at our institution. As the physician anesthesiologists work collaboratively with nurse anesthetists in providing patient care at our institution, it is impossible to determine the total effect of implementation of the guidelines on anesthesia workspace infection control practices. For infection control guidelines such as those implemented in this project to achieve maximum success, all of those who work within the anesthesia space would need to be educated and evaluated.

CONCLUSIONS

As there are currently no global best evidence-based infection control guidelines applicable to the anesthesia workspace, we developed guidelines based on available literature, input from a focus group of practicing nurse anesthetists, and observation and evaluation of infection control behaviors at our institution. Introduction of the guidelines was accompanied by educational sessions, hard copy reminders of best practices placed in the operating room, and

additional observation and evaluation periods. We demonstrated improvement in 2 of 3 clean practice behaviors of interest on the part of our staff nurse anesthetists as a product of education, reminders, and direct observation.

Catheter-related bloodstream infections occur via direct contamination of the catheter after contact with contaminated hands, fluids, devices, or environments.¹⁸ These HAIs are commonly associated with antibiotic-resistant and gram-negative pathogens, both of which have been cultured from the anesthesia workspace and provider hands.^{4,8,9,22,23} Thus, the anesthesia workspace and provider hands are reservoirs for transmission and can be linked to postoperative infections.^{4,5,8} To decrease contamination of the anesthesia workspace and the spread of microbes to patients, infection prevention measures should be practiced consistently.²⁴ Improving infection control practice behaviors through staff education, visual reminders, and implementation of infection control guidelines using best practice measures could help decrease patient exposure to such pathogens and reduce the risk of life-threatening bloodstream infections.^{3,5,6,13} Although we did not assess the impact of these improvements on postoperative infection rates, we believe these measures can help reduce the risk of bloodstream and other nosocomial infections.

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