Original Article

Pattern of anaesthetic equipment contamination and infection prevention in anaesthesia practice at university hospitals

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ABSTRACT

Background and Aims: Infection control is essential in anaesthetic practice for both personnel and equipment used. This study aims to evaluate knowledge of anaesthesiologists about infection control practices and to detect the pattern of anaesthetic devices contamination. **Methods:** Cross-sectional observational study at two university hospitals was done. Self-administered questionnaires were distributed to 80 anaesthesiologists and 90 nursing staff. Forty-four samples were taken from rigid laryngoscopes (22 pairs from handle and blade) for detection of bacterial or fungal contamination. Same laryngoscopes were tested for occult blood. **Results:** The response rate among the physicians was 72% while for nurses 94.4%. The responses were variable reflecting lack of adequate knowledge and unsatisfactory compliance to infection control practices. Tested samples showed no fungal growth. Fourteen (31.8%) samples were negative for bacteriological contamination and 5/44 (11.4%) showed gram-positive bacilli; gram-positive cocci were isolated from 12 samples (27.3%) where *Staphylococcus epidermidis* and *Staphylococcus aureus*, respectively, shared 18.2% and 9.1% of the total samples. Gram-negative bacilli were isolated from 13 samples (29.5%), of which *Klebsiella* spp. were most frequent (11.4%). Both *Pseudomonas aeruginosa* and *Acinetobacter baumannii* were isolated from 6.8% each. *Citerobacter* spp. was isolated from 4.5%. Occult blood was found in 45.5% of samples. **Conclusion:** The current study showed contamination of ready-to-use laryngoscopes in operative theatres and ICUs.

Key words: Anaesthesia, equipment, infection control

INTRODUCTION

The risk of causing nosocomial infections during anaesthesia care has been largely overlooked. Studies have shown that anaesthesia providers can contribute to the risk of health-care-acquired infections. In addition, the potential for cross-contamination from airway equipment to patient has been frequently reported.[1] On the other hand, the anaesthesiologist can play a major role in perioperative infection control by practising good personal hygiene and by properly disinfecting anaesthetic equipment.[2] The laryngoscope is used routinely in hospitals and health care for tracheal intubation. The laryngoscope handle has a knurled finish that improves grip. However, this surface favours dirt accumulation. The blade is complex, consisting of removable parts, joints, grooves and recesses that facilitate the accumulation of organic material during use.[3] Current practices of decontamination and disinfection between patients are frequently ineffective leaving residual contamination that is implicated as a source of

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cross-infection and represents a risk to the patients and the health-care worker. Anaesthesiologist should show great care when handling laryngoscopes; wear gloves during intubation and place used instruments in a designated receptacle to prevent contamination of surfaces and drapes.[4] According to the Spaulding device classification, disinfection is indicated for semicritical articles that "make direct contact with mucous membrane"; however, sterilisation of reusable laryngoscope blades has significant advantages over high level disinfection (HLD). Sterilisation has larger margin of safety, and coupled with reliability, significantly removes the human element from the process of decontamination. It is cost-effective, and improves efficiency due to improved theatre turnover rates, decreased risk of nosocomial infection, and decreased exposure to high-level disinfectants and their residue. Not only that, sterilisation reduces the anaesthesia staff workload. It removes occupational health and safety hazards associated with high-level disinfectants. The challenge with sterilisation is the progressive decrease in the light intensity of the laryngoscope blades.[5]

This study aims to evaluate knowledge of anaesthesiologists about infection control practices and to study the pattern of contamination by bacteria, fungi, and occult blood of reusable laryngoscope at two university hospitals.

METHODS

This cross-sectional study was carried out after approval from the appropriate Institutional Review Boards. The following settings were included: operative suites and intensive care units (ICUs) at both universities' hospitals. Bacteriological work was done at laboratory of Medical Microbiology and Immunology Departments, Faculty of Medicine, UH1, and UH2. Validated self-administered questionnaires [Appendix 1] were distributed to 80 anaesthesiologists and 90 nursing staff.

First section of the questionnaire covered the demographic data. The second section covered general infection control practices while the last section addressed the laryngoscope reprocessing procedures.

Bacteriological sampling was done as described by Williams *et al*.[6] New sterile gloves were used for each sample with adoption of "no touch" technique. Sterile paper templates with a circular hole of 2 cm diameter were used to define a consistent area from which sampling occurred. The area within the template on the handle was swabbed by sterile saline moistened swab. The swab was immersed in a bottle containing 3 mL of brain–heart infusion (BHI) broth to be transported to laboratory for culture and identification. On reaching the laboratory, the BHI broths were shaken vigorously in order to remove as much microbial material as possible from the swab. A sterile 1-mL Pasteur pipette was used to remove about 0.25 mL from the broth to be inoculated to the surface of the prepared culture media.

Sampling was carried out from "ready-to-use" laryngoscopes on the resuscitation trolleys at ICUs, paediatric ICUs, and neonatal ICUs. From operative theatres, laryngoscopes from the tracheal intubation set ready for the next operative procedure were sampled with complete aseptic technique.[6]

Occult blood testing was performed as described by Ballin *et al*. The separated laryngoscope blade and handle were sprayed with 10 mL of normal saline; 0.7 cm^3 pyramidon and H_2O_2 were mixed with three drops of rinses. The mixture was observed for 5 min. Any change of colour (purple) within 1 min represented a "positive" test.[7]

RESULTS

The response rate among the physicians was 72% (60/80) while for nurses it was 94.4% (85/90). The demographic data of respondents are shown in Table 1. The respondents' response to the questions addressing hand hygiene and personal protective equipment (PPE) infection control practices are summarised in Tables 2 and 3.

Table 1: The demographic data of the respondents

Demographics	Group 1 (physicians)	Group 2 (nurses)
Age	30-55 years (34±4.2)	19-43 years (26±4.6)
Gender	40 female 20 male	70 female 15 male
Total years of experience	Range 1-28	Range 1-24
Years of experience in anaesthesia field	Range 1-28	Range 5-12
Highest qualification (%)	Premaster: 18 Master: 30 MD: 12	Nursing school: 40 (47.1) Nursing high institute: 15 (17.6) Nursing college: 27 (31.8) Postgraduate: 3 (3.5)

Table 2: Participant's responses to questionnaire addressing their knowledge of infection prevention practices

Question	Right answers (%)		Wrong answers (%)		I don't know (%)	
	Physicians	Nurses	Physicians	Nurses	Physicians	Nurses
Hand hygiene is necessary before patients care and after touching environmental surfaces	100	100	0	0	0	0
Hand hygiene is only indicated after patient care	100	100	0	0	0	0
It is obligatory to wear surgical mask for insertion of CVCs	87	59	5	31	8	10
It is obligatory to wear surgical mask for all spinal injection procedures	5	98	80	0	15	2
It is obligatory to wear surgical mask for neuraxial blocks	100	85	0	11	0	4
It is obligatory to wear mask during suctioning procedures	43	58.8	32	41.2	25	0
It is obligatory for anaesthesiologist to wear mask during operative procedures	13.3	3.5	81.7	70.6	5	25.9
It is obligatory to wear N95 respirator when dealing with open TB case	100	100	0	0	0	0
It is obligatory to wear goggles during suctioning procedures	87.5	16.5	3.2	83.5	9.3	0
Disposable clean gloves are used for insertion of peripheral catheters	91.7	82.4	3.3	10	5	7.6
Sterile gloves are mandatory for central venous line insertion	100	96.5	0	0	0	3.5
Laryngoscope blades are semicritical equipment to be high level disinfected between patients	16.7	74.1	53.3	25.9	30	0
Laryngoscope blades are critical equipment to be sterilised between patients	88.4	34.1	8.3	63.5	3.3	2.4
Laryngoscope should be cleaned, disinfected, and stored packed between patients	21.1	10.6	60	84.7	19.1	4.7
Wiping of the laryngoscope handle by ethyl alcohol 70% is sufficient for in-between patients reprocessing	22.4	8.2	42.3	62.4	35.3	29.4
Laryngoscope should be cleaned and stored on crash trolley for next use	16.7	94.1	53.3	5.9	30	0

CVC – Central venous catheters; TB – tuberculosis

Table 3: Responses of physicians and nurses to (yes/no) questions

Questions	Physicians (%)		Nurses (%)	
	Yes	No	Yes	No
Did you receive 3 doses of HBV vaccine	68.3	31.7	97.6	2.4
Did you know your immune status after complete vaccination	8.3	91.7	2	98
Do you officially notify your incident of needle stick injury	13.3	86.7	11	89
Did you receive training on the infection control for anaesthesia practice	23.3	76.7	85.9	14.1
In your facility Do you have infection control policy	63.5	36.5	70.5	29.5

Regarding best method of rigid laryngoscope, decontamination wasn't that clear for the nurses; 62.4% of respondent nurses agreed to the sufficiency of alcohol wiping of laryngoscope; 63.5% chose the intermediate disinfection to be the method of laryngoscope disinfection. Only 10.6% identified the recommended way (clean-disinfect and store packed till use) as the required method. About 84.7% respondents considered the cleaning and storing uncovered on the crash trolley acceptable.

In the questionnaire covering the knowledge of participant physicians about laryngoscope disinfection, 18.7% of them chose the Spaulding classification as semicritical device and 30% agreed to washing and HLD as the acceptable method for reprocessing between patients; 53.3% could not identify which level of reprocessing was needed. 88.4% agreed that this equipment was a critical item, when asked.

Responses of both nurses and physicians regarding Hepatitis B Virus (HBV) vaccine coverage, immune status to hepatitis B, needle stick injury notification, and infection control training are shown in Table 3.

A total of 44 samples were taken from laryngoscopes, 12 paired (handle and blade) samples were taken from handle and blade of each device at ICUs. Ten

paired samples were taken from rigid laryngoscopes of operative theatres. Sample distribution is presented in Figure 1. Twenty out of 44 (45.5%) samples were positive for occult blood.

The tested samples showed no fungal growth. Fourteen (31.8%) samples were negative for bacteriological contamination and 5/44 (11.4%) showed gram-positive bacilli; gram-positive cocci were isolated from 12 samples (27.3%), where *Staphylococcus epidermidis* and *Staphylococcus aureus*, respectively, shared 18.2% and 9.1% of the total samples. Gram-negative bacilli isolated from 13 samples (29.5%) of which *Klebsiella* spp. got the largest share (11.4%). Both *Pseudomonas aeruginosa* and *Acinetobacter baumannii* were isolated from 6.8% for each. Citrobacter spp. was isolated from 4.5% [Figure 2 and Table 4].

DISCUSSION

The practice of anaesthesia must be made as safe as possible to all patients, anaesthesiologists, and other health-care providers; thus, it is absolutely vital that infection risks to all parties are kept to a minimum.[3] This study aimed to evaluate knowledge of infection control practice and the pattern of bacterial, fungal, and occult blood contamination of reusable laryngoscope at two anaesthesia departments from two university hospitals.

The response rate to the questionnaire was 72% and 94.4% among the physicians and nurses, respectively. This is comparable to the response rate in other studies (75%),[8] about 32.4% and 72.4% response rates among the physicians and nurses, respectively.[2] This is satisfactory compared to lower response rate from other studies; 44% by Tait and Tuttle,[9] 68% by el Mikatti *et al*.,[10] and 61% by Ryan *et al*.[11]

The nurse's questionnaire was conducted in native language. In the response to PPE wearing, for example, 16.5% of respondent nurses, considered wearing goggles for eye protection during suctioning procedures. Kishi and Videira reported routine use of eye protection only by 21.2% of anaesthesiologists.[8] Ryan *et al*. reported that only 37% of their participant routinely use goggles.[11] Regarding the mask, we reported a proportion of 58.8% of respondent nurses who use mask which is lower than other studies: Tait and Tuttle (94.9%),[9] el Mikatti *et al*. (68.3%),[10] and Ryan *et al*. (59.5%).[11] In Taiwan, more than 90% of the responding anaesthesiologists and nurses reported that they frequently or always wear a mask during anaesthesia.[12]

The reasons "tendency to forget" (37.8%) and "discomfort" (35.1%) were most often cited by respondents to justify why they don't wear mask.[13]

The choice between clean and sterile gloves according to the type of procedures was unsatisfactory where 54.1% responded by "I don't know about the type of glove for the peripheral vascular access". But 96.5% were sure about using the sterile gloves for central vascular access. Nearly, the same response was recorded by Kishi and Videira[8] where they got 98.8% yes response for wearing sterile gloves for the neuraxial block.

Also, other studies recorded 54%-86.3% adherence of the respondents to this essential practice during

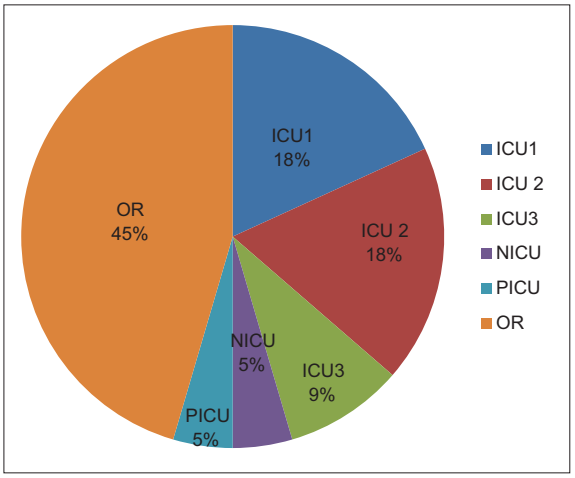

Figure 1: Distribution of laryngoscope samples according to place

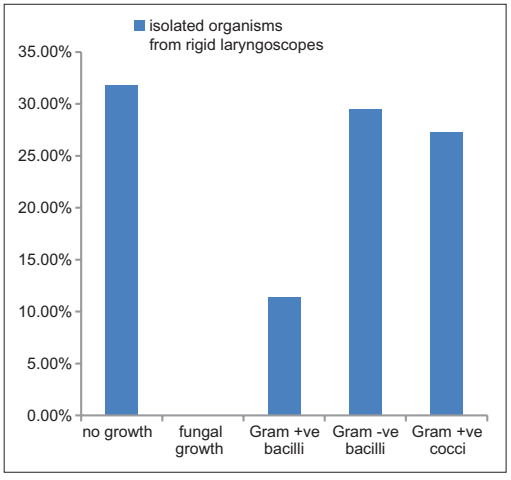

Figure 2: Frequency of the isolated organisms from laryngoscope samples

Table 4: Type of isolated organism from laryngoscopes and occult blood test results

Location	Isolated organism	Occult blood testing
OR 1	*Citrobacter* spp.	Positive
	S. epidermidis	Positive
	No growth	Negative
	No growth	Negative
OR 2	No growth	Negative
	S. aureus	Negative
	Klebsiella spp.	Positive
	NO growth	Positive
OR 3	Gram-positive bacilli	Positive
	Gram-positive bacilli	Positive
	S. epidermidis	Negative
	S. epidermidis	Negative
OR 4	No growth	Negative
	No growth	Positive
	S. epidermidis	Positive
	S. epidermidis	Positive
OR 5	*Klebsiella* spp.	Positive
	No growth	Positive
	S. epidermidis	Positive
	Pseudomonas aeruginosa	Negative
ICU 1	*Acinetobacter baumannii*	Positive
	Gram-positive bacilli	Positive
	No growth	Negative
	S. aureus	Negative
	S. epidermidis	Negative
	Citrobacter spp.	Negative
	Gram-positive bacilli	Negative
	Klebsiella spp.	Negative
ICU 2	*Pseudomonas aeruginosa*	Positive
	Pseudomonas aeruginosa	Positive
	No growth	Negative
	No growth	Negative
	S. aureus	Negative
	S. aureus	Negative
	No growth	Negative
	No growth	Negative
ICU 3	No growth	Positive
	No growth	Positive
	S. epidermidis	Negative
	Gram-positive bacilli	Negative
NICU	*Klebsiella* spp.	Negative
	Klebsiella spp.	Negative
PICU	*A. baumannii*	Positive
	A. baumannii	Positive

S. epidermidis – Staphylococcus epidermidis; S. aureus – Staphylococcus aureus; A. baumannii – Acinetobacter baumannii; OR – Operating room; ICU – Intensive Care Unit; PICU – Paediatric intensive Care Unit; NICU – Neonatal Intensive Care Unit

invasive procedures, either application of central line or neuraxial procedure.[9-11]

But Kishi and Videira found better understanding from the respondents (84.1%) for wearing general procedure gloves for venous cannulation.[8] In another study, 82% of nurses and 65.3% of anaesthesiologists reported that they frequently wear gloves during anaesthesia. More than 90% of anaesthesiologists and nurses reported frequently wearing a mask during anaesthesia.[12]

Washing hands between cases, a simple procedure that can prevent transmission of microorganisms with the best cost/benefit relationship, was practised by 95.1% of anaesthesiologists,[8] 83.9%,[10] and 93.7%.[11]

Or *et al*. reported that 70.4% of nurses and 52.6% of anaesthesiologists frequently wash their hands before performing anaesthesia.[12] The current study reported 100% agreement from the respondents to the indication of hand hygiene after patients contact and before touching the environment. This reflects the impact of the continuous hand hygiene campaign that took both financial and administrative support from top management at university hospitals and the effort of the infection control team to convey the message to the health-care workers.

The difference between different studies can be explained by a responder bias. Those who responded may have more interest in infection control. Those who did not respond may have less compliant behaviour.[14]

In their response to the availability of written policy, 70.6% of nurses responded positively compared to response reported by Halkes and Snow.[15] Only 13% of consultants reported they had knowledge of any guidelines.

Or *et al*. reported compliance with disinfection protocols for laryngoscope blades 80.6% and 68.8% in their two study groups. About 89% and 79.6% chose sterilising laryngoscope blades as the accepted level of reprocessing this equipment.[12] In the current study, nurses' responses varied. Laryngoscopes are an essential component of anaesthetic practice and are at risk of microbial contamination by both patients and health-care workers. It is well recognised and documented that laryngoscopes are a potential source of horizontal transmission leading to development of hospital-acquired infections. As a semicritical item according to the Spaulding classification, sterilisation or high-level disinfection is required. Another option is to use disposable blades. Cost is then an issue, and it does not eliminate the problem of the handle.[16]

To test the efficiency of the reprocessing of reusable laryngoscopes, testing for occult blood was done and 20 out of 44 samples were positive for occult

blood (45.5%). This is significantly higher than 5.1% reported by Chen *et al*.[17] Morell *et al*. reported 50% of handles and 10.5% of blades.[18] Phillips and Monaghan found 20% of blades and 40% of handles positive for occult blood.[19] Two studies reported that none of the samples tested positive for occult blood.[6,20]

The finding of occult blood can be explained by the fact that the laryngoscope handle has a knurled finish that improves grip; however, this surface favours dirt accumulation. Also, the blade is complex, consisting of removable parts, joints, grooves, and recesses that facilitate the accumulation of organic material during use. Cleaning, disinfection, drying, and storage failures may allow the persistence of potentially pathogenic microorganisms, representing a risk to the patient or to the health team handling the equipment.[21]

The presence of occult blood on the surfaces of the rigid laryngoscope blade is unacceptable keeping in mind the following two facts: first laryngoscope may produce trauma when introduced into the patient's mouth and pharynx. This carries risk of transmission of blood borne pathogens. Second according to the U.S. Centers for Disease Control and Prevention, HCV can survive on environmental surfaces at room temperature for at least 16 h but no longer than 4 days while HBV has been found to remain infective on such surfaces for over 7 days.[22]

The sampled laryngoscopes all were subjected to different reprocessing operation that include (cleaning, disinfection) the persistence of occult blood on the surface indicates defect at the reprocessing manoeuvre that is to be checked and corrected. The importance of the cleaning phase has previously been underestimated and substance used for cleaning that does not contain detergent is not effective for the total removal of blood and organic matter.[21]

Another aspect to be considered is that after intubation, the blade is folded along the length of the handle in order to switch off the light. This contact point allows the handle to be contaminated with organic matter, debris, and eventually blood from the patient's oropharynx. For this reason, the reprocessing of both parts should be the same to avoid potential patient-to-patient transmission of microorganisms; so, the Spaulding recommendation (high-level disinfection) should be followed for both the handle and blade. Another issue to be considered is the sound choice of disinfectant.[21]

The presence of the microorganisms on the surface of ready-to-use rigid laryngoscopes could have serious health hazards. In the current study, no fungal growth was found – the finding also reported by previous study;[7] however, other researchers detected *Candida* spp. from one sample (0.9%).[16] Fourteen (31.8%) samples were negative for bacteriological contamination; this is the same as reported by previous studies where 30.5% and 25% of samples were culture–negative,[20,23] whereas Williams *et al*. found only 14% of the handles negative for bacterial growth.[7] Growth of *S. aureus* appeared in 9.1% of the total samples compared to 7% of blades and 10% of handles tested in another study.[7] Contact of health-care worker with an infected patients or contaminated devices are the common routes of transmission of *S. aureus* which can survive on dry surfaces for prolonged period of time.[24] *S. epidermidis* contaminated 18.2% of the total samples. This is much lower than that reported before where coagulase-negative staphylococci was isolated from 71.7% and 62.5%.[20,23] Coagulase-negative staphylococci isolated may suggest contamination by personnel, as these are common skin commensals.[16] Gram-positive bacilli was isolated from 13 samples (29.5%) of which *Klebsiella* spp. got the largest share (11.4%) and *Citerobacter* spp. was isolated from 4.5%, whereas *A. baumannii* was isolated from 6.8% of samples. This is of particular concern given that these are typical hospital pathogens that imply a significant risk of nosocomial transmission.[23]

P. aeruginosa was isolated from 6.8% in the current study. Previous studies[25,26] linked laryngoscope contamination by *P. aeruginosa* to outbreaks of septicaemia in paediatric settings.

Potential risk factors for microbial transmission associated with the reprocessing of rigid laryngoscopes could be summarised as follows: the lack of a published consensus statement or endorsed guideline for reprocessing rigid laryngoscopes; the publication of inconsistent and inadequate reprocessing guidelines, some of which recommend low-level disinfection of rigid laryngoscopes after each use; and reprocessing instructions provided by different manufacturers of rigid laryngoscopes that vary in detail, scope, and content.[27]

It should be noted that organic matter may protect microorganisms against cleaning, disinfecting, and sterilising agents. Direct contact between the antimicrobial agent and the entire surface of the

instrument is essential; however, organic residues impede this contact.[28]

CONCLUSION

This study showed that the knowledge of anaesthiologists and nurses about infection control practices is not satisfactory and that there is contamination of ready to use laryngoscopes in operative theatres and ICUs.

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Conflicts of interest
There are no conflicts of interest.

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