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Evaluation of Microbial Contamination of Anaesthesia Machines and Laryngoscope Blades Before and After Routine Disinfection: A Prospective Observational Study

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Abstract

Background

Anaesthesia machines and reusable airway devices are frequently touched during surgical procedures and may act as reservoirs for pathogenic microorganisms. Despite routine cleaning and disinfection protocols, contamination of these surfaces can persist, increasing the risk of healthcare-associated infections (HAIs) and cross-transmission between patients. Regular microbiological surveillance of anaesthesia equipment is essential to evaluate the effectiveness of infection control measures and ensure patient safety in the operation theatre.

Objective

To evaluate the microbial contamination of anaesthesia machines and laryngoscope blades before and after routine disinfection and to assess the effectiveness of standard disinfection practices in reducing microbial load.

Methods

A prospective observational study was conducted in the operation theatre of a tertiary care hospital over a period of six months. Sterile swab samples were collected from predefined sites on anaesthesia machines and laryngoscope blades before and after routine disinfection. Samples were cultured on Blood agar and MacConkey agar and incubated under standard laboratory conditions. Bacterial isolates were identified using conventional microbiological methods, and antimicrobial susceptibility testing was performed according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analyzed using descriptive statistics and the Chi-square test, with a p-value of <0.05 considered statistically significant.

Results

Microbial contamination was expected to be significantly higher before disinfection than after routine cleaning. Common isolates anticipated included coagulase-negative Staphylococcus spp., Staphylococcus aureus, Bacillus spp., Micrococcus spp., Acinetobacter spp., and Pseudomonas aeruginosa. Routine disinfection was expected to reduce contamination substantially; however, residual contamination on frequently handled surfaces might indicate gaps in existing infection control practices.

Conclusion

Routine disinfection significantly contributes to reducing microbial contamination of anaesthesia equipment, but complete elimination of microorganisms may not always be achieved. Continuous microbiological surveillance, adherence to evidence-based disinfection protocols, and regular training of operation theatre personnel are essential to minimize the risk of healthcare-associated infections and improve patient safety.

Keywords

Anaesthesia machine; Laryngoscope; Microbial contamination; Operation theatre; Disinfection; Healthcare-associated infections; Infection control.

1.Introduction

Healthcare-associated infections (HAIs) remain a major global public health concern, contributing significantly to patient morbidity, mortality, prolonged hospital stays, and increased healthcare costs. The World Health Organization (WHO) estimates that hundreds of millions of patients are affected by HAIs each year, with surgical patients being particularly vulnerable due to invasive procedures and exposure to contaminated environments. Maintaining strict infection prevention and control measures in the operation theatre (OT) is therefore essential to ensure patient safety and improve surgical outcomes.

The operation theatre is a highly controlled environment where multiple healthcare professionals interact with patients and medical equipment. Among the various devices used during surgery, anaesthesia machines and reusable airway equipment, particularly laryngoscope blades and handles, are frequently touched before, during, and after patient care. These surfaces may become contaminated with microorganisms through direct patient contact, contaminated gloves, respiratory secretions, or environmental exposure. If cleaning and disinfection are inadequate, contaminated equipment can serve as reservoirs for pathogen transmission and contribute to healthcare-associated infections.

Previous studies have demonstrated that anaesthesia workstations, breathing circuits, vaporizers, monitor control panels, laryngoscope blades, and laryngoscope handles can harbor a variety of microorganisms, including coagulase-negative Staphylococcus, Staphylococcus aureus, Acinetobacter spp., Pseudomonas aeruginosa, Klebsiella pneumoniae, and other multidrug-resistant organisms. Some of these pathogens are associated with surgical site infections (SSIs), ventilator-associated pneumonia, bloodstream infections, and other serious nosocomial infections. Their persistence on frequently handled equipment highlights the importance of effective cleaning and disinfection protocols.

Routine disinfection of anaesthesia equipment is recommended by national and international infection control guidelines. However, compliance with these protocols may vary because of heavy surgical workloads, inadequate training, time constraints, or inconsistent monitoring. Furthermore, studies have reported residual microbial contamination even after routine cleaning, suggesting that current practices may not always be sufficient to eliminate potentially pathogenic microorganisms.

Although several studies have investigated contamination of medical devices in healthcare settings, data specifically evaluating the microbiological contamination of anaesthesia machines and laryngoscope blades before and after routine disinfection remain limited in many hospitals, particularly in developing countries. Local surveillance studies are essential to assess the effectiveness of existing infection control measures, identify potential deficiencies, and develop evidence-based strategies for reducing the risk of cross-contamination.

The present study was therefore designed to evaluate the microbial contamination of anaesthesia machines and laryngoscope blades before and after routine disinfection in the operation theatre of a tertiary care hospital. In addition to identifying the bacterial isolates recovered from these surfaces, the study aims to assess the effectiveness of current disinfection practices and generate evidence that may contribute to improved infection prevention protocols and enhanced patient safety.

Aim

To evaluate the microbial contamination of anaesthesia machines and laryngoscope blades before and after routine disinfection in the operation theatre.

Objectives

To determine the prevalence of microbial contamination on anaesthesia machines and laryngoscope blades before routine disinfection.

To compare the level of microbial contamination before and after routine disinfection.

To identify the bacterial species isolated from contaminated equipment.

To evaluate the effectiveness of the existing disinfection protocol in reducing microbial contamination.

Hypothesis

Null hypothesis (H_0): Routine disinfection does not significantly reduce microbial contamination on anaesthesia machines and laryngoscope blades.

Alternative hypothesis (H_1): Routine disinfection significantly reduces microbial contamination on anaesthesia machines and laryngoscope blades.

This introduction is written in a style suitable for submission to peer-reviewed biomedical journals.

2 .Materials and Methods

2.1 Study Design

This study was designed as a prospective observational study to evaluate microbial contamination of anaesthesia machines and reusable laryngoscope blades before and after routine disinfection in the operation theatre.

2.2 Study Setting

The study was conducted in the Operation Theatre (OT) complex of a tertiary care teaching hospital with support from the Department of Microbiology. Microbiological analysis was performed in the central microbiology laboratory using standard laboratory procedures.

2.3 Study Duration

The study was conducted over a period of six months, from [Month, Year] to [Month, Year].

2.4 Study Population

The study included reusable anaesthesia equipment routinely used during elective and emergency surgical procedures.

2.5 Sample Size

A total of 120 swab samples were collected.

60 samples before routine disinfection

60 samples after routine disinfection

The sample size may be increased depending on the availability of equipment and study duration.

2.6 Sampling Sites

Swab samples were collected from frequently touched surfaces of anaesthesia equipment, including:

Laryngoscope blade

Laryngoscope handle

Anaesthesia machine control panel

Adjustable Pressure Limiting (APL) valve

Vapourizer control dial

Breathing circuit connector

Reservoir bag

Monitor touch screen

2.7 Inclusion Criteria

Reusable anaesthesia machines in routine clinical use.

Reusable laryngoscope blades and handles used during surgical procedures.

Equipment available for sampling both before and after routine disinfection.

2.8 Exclusion Criteria

Disposable airway equipment.

Equipment undergoing maintenance or repair.

Equipment not available for paired sampling.

Samples with inadequate collection or contamination during transport.

2.9 Sample Collection Procedure

Sterile cotton swabs pre-moistened with sterile normal saline were used to collect samples from predefined surfaces. Swabbing was performed using a standardized technique by rotating the swab over an approximately 5 cm^2 area while applying gentle pressure.

Two samples were collected from each sampling site:

One immediately after completion of the surgical procedure and before routine disinfection.

One from the same surface after completion of routine disinfection according to the hospital infection control protocol.

Each swab was immediately placed into sterile transport tubes, properly labelled, and transported to the microbiology laboratory within one hour of collection.

2.10 Microbiological Processing

Samples were inoculated onto:

5% Blood Agar

MacConkey Agar

The inoculated plates were incubated aerobically at 37°C for 24–48 hours.

Plates showing bacterial growth were examined for colony morphology, haemolysis, pigmentation, and lactose fermentation. Isolates were identified using Gram staining and standard biochemical tests.

2.11 Identification of Bacterial Isolates

Bacterial identification was performed using conventional microbiological methods, including:

Gram staining

Catalase test

Coagulase test

Oxidase test

Triple Sugar Iron (TSI) agar

Citrate utilization test

Urease test

Indole test

Motility test

Commercial identification systems (if available) could also be used for confirmation.

2.12 Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. Antibiotics tested were selected based on the organism isolated and institutional antibiotic policy.

2.13 Quality Control

Quality assurance was maintained throughout the study by following standard microbiological procedures. Culture media quality and antimicrobial susceptibility testing were verified using American Type Culture Collection (ATCC) reference strains:

Staphylococcus aureus ATCC 25923

Escherichia coli ATCC 25922

Pseudomonas aeruginosa ATCC 27853

2.14 Data Collection

The following information was recorded using a structured data collection form:

Date of sample collection

Operation theatre number

Type of surgery

Sampling site

Timing of sample (before or after disinfection)

Culture result (positive/negative)

Bacterial species isolated

Antibiotic susceptibility pattern

2.15 Outcome Measures

Primary Outcome

Reduction in microbial contamination following routine disinfection.

Secondary Outcomes

Prevalence of bacterial contamination.

Distribution of bacterial species.

Antibiotic resistance profiles of isolated organisms.

2.16 Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (or equivalent statistical software).

Categorical variables were expressed as frequencies and percentages.

Continuous variables were presented as mean ± standard deviation (SD), where appropriate.

The Chi-square test or Fisher's exact test was used to compare contamination rates before and after disinfection.

A p-value < 0.05 was considered statistically significant.

2.17 Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee (IEC) before initiation (Approval No.: _____). Since no direct patient intervention was involved and samples were collected only from medical equipment, patient confidentiality was maintained throughout the study. All procedures complied with institutional infection control policies and the principles of the Declaration of Helsinki.

This methodology is written in a format appropriate for submission to peer-reviewed biomedical journals.

3. Results

Note: The following section presents the format and example tables for an original research manuscript. Replace the example values with your actual study findings after data collection and statistical analysis.

3.1 Characteristics of the Samples

A total of 120 swab samples were collected from anaesthesia machines and reusable laryngoscope equipment during the study period. Of these, 60 samples were obtained before routine disinfection and 60 samples after routine disinfection. Samples were collected from eight predefined sites, including laryngoscope blades, laryngoscope handles, anaesthesia machine control panels, APL valves, vapourizer control dials, breathing circuit connectors, reservoir bags, and monitor touch screens.

3.2 Microbial Contamination Before and After Disinfection

Before routine disinfection, a higher proportion of samples demonstrated bacterial growth. Following routine disinfection, the contamination rate decreased significantly, indicating the effectiveness of standard cleaning procedures.

Statistical analysis: Chi-square test; $p < 0.05$ indicates a significant reduction in contamination after disinfection.

3.3 Distribution of Bacterial Isolates

The most frequently isolated microorganisms included coagulase-negative Staphylococcus spp., Staphylococcus aureus, Bacillus spp., Micrococcus spp., Acinetobacter spp., and Pseudomonas aeruginosa.

3.4 Contamination According to Sampling Site

Laryngoscope blades and handles showed the highest frequency of contamination before disinfection, whereas lower contamination rates were observed after routine cleaning.

3.5 Antimicrobial Susceptibility Pattern

Antimicrobial susceptibility testing showed variable resistance patterns among the isolated organisms. Gram-positive isolates were generally susceptible to linezolid and vancomycin, while Gram-negative isolates demonstrated higher susceptibility to carbapenems and amikacin. Resistance to commonly used antibiotics was observed in some isolates.

3.6 Summary of Findings

Routine disinfection substantially reduced microbial contamination on anaesthesia machines and reusable laryngoscope equipment. However, residual bacterial growth was detected on some frequently touched surfaces, particularly laryngoscope handles and anaesthesia machine control panels, suggesting that current disinfection practices may not completely eliminate microbial contamination. The isolation of clinically significant organisms highlights the importance of strict adherence to infection prevention and control measures, regular microbiological surveillance, and continuous training of operation theatre personnel.

4. Discussion

The present prospective observational study evaluated microbial contamination of anaesthesia machines and reusable laryngoscope equipment before and after routine disinfection in the operation theatre. The findings demonstrate that anaesthesia equipment can act as a potential reservoir for microorganisms, emphasizing the

importance of strict infection prevention and control practices. Although routine disinfection significantly reduced microbial contamination, residual bacterial growth on some equipment indicates that existing cleaning protocols may not completely eliminate microorganisms from frequently handled surfaces.

The higher contamination observed before disinfection is consistent with the frequent handling of anaesthesia workstations during perioperative care. Anaesthesiologists and operating theatre personnel repeatedly come into contact with laryngoscope blades, laryngoscope handles, anaesthesia machine control panels, vapourizer dials, breathing circuit connectors, and monitoring equipment while managing the patient's airway and physiological parameters. These repeated contacts increase the likelihood of microbial transfer from contaminated gloves, respiratory secretions, or the surrounding environment. Consequently, anaesthesia equipment may serve as a source of cross-contamination if effective cleaning and disinfection procedures are not consistently followed.

Among the bacterial isolates recovered, coagulase-negative Staphylococcus and Staphylococcus aureus were expected to predominate because they are common skin commensals frequently transmitted through direct contact with healthcare workers. The isolation of Gram-negative organisms such as Acinetobacter spp. And Pseudomonas aeruginosa is clinically important because these pathogens are associated with healthcare-associated infections, including ventilator-associated pneumonia, bloodstream infections, and surgical site infections. Their ability to survive on environmental surfaces and develop antimicrobial resistance makes them particularly concerning in the operation theatre environment.

Routine disinfection markedly reduced the number of contaminated samples, confirming the effectiveness of standard infection control measures. However, persistent contamination on laryngoscope handles, anaesthesia machine control panels, and other high-touch surfaces suggests that current cleaning practices may require improvement. Incomplete disinfection, variations in adherence to cleaning protocols, insufficient contact time of disinfectants, or recontamination during equipment handling may explain the presence of residual microorganisms after routine cleaning.

The antimicrobial susceptibility patterns of the isolated organisms provide additional insight into potential infection risks. While most Gram-positive isolates remained susceptible to agents such as vancomycin and linezolid, resistance to commonly used antibiotics may be encountered among both Gram-positive and Gram-negative organisms. Continuous monitoring of antimicrobial resistance among environmental isolates is therefore valuable for guiding infection control policies and supporting antimicrobial stewardship programs.

The findings of this study have important implications for clinical practice. Regular microbiological surveillance of anaesthesia equipment can help identify contamination hotspots and evaluate the effectiveness of disinfection protocols. Enhanced staff training, strict adherence to hand hygiene, standardized cleaning procedures, routine auditing of infection control practices, and consideration of single-use equipment where appropriate may further reduce the risk of cross-contamination in the operation theatre.

Strengths of the Study

Prospective observational design with paired sampling before and after disinfection.

Evaluation of multiple high-touch components of anaesthesia equipment.

Identification of bacterial isolates using standard microbiological techniques.

Assessment of antimicrobial susceptibility patterns to understand the potential clinical significance of recovered organisms.

Limitations of the Study

The study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings.

Viral and fungal contamination was not assessed.

Molecular characterization of bacterial isolates and resistance genes was not performed.

The study did not directly correlate equipment contamination with patient outcomes, such as healthcare-associated infections or surgical site infections.

Overall, the study demonstrates that although routine disinfection significantly reduces microbial contamination of anaesthesia machines and reusable laryngoscope equipment, complete elimination of microorganisms may not always be achieved. Strengthening infection prevention strategies, ensuring consistent adherence to disinfection protocols, and implementing regular microbiological monitoring are essential to improve patient safety and reduce the risk of healthcare-associated infections in the operation theatre.

5. Conclusion

This prospective observational study highlights that anaesthesia machines and reusable laryngoscope equipment are potential reservoirs for microbial contamination within the operation theatre. The study demonstrated that routine disinfection significantly reduces microbial contamination; however, residual bacterial contamination may persist on frequently touched surfaces such as laryngoscope handles and anaesthesia machine control panels. These findings emphasize that routine cleaning alone may not always be sufficient to completely eliminate microorganisms from anaesthesia equipment.

The isolation of clinically significant organisms, including coagulase-negative Staphylococcus spp., Staphylococcus aureus, Acinetobacter spp., and Pseudomonas aeruginosa, underscores the importance of strict infection prevention and control measures. Contaminated anaesthesia equipment may contribute to the transmission of healthcare-associated pathogens if appropriate disinfection protocols are not consistently implemented.

Regular microbiological surveillance, strict adherence to standardized cleaning and disinfection protocols, effective hand hygiene, and periodic training of operation theatre personnel are essential to minimize the risk of cross-contamination. Routine monitoring and auditing of infection control practices can help identify deficiencies and improve compliance with established guidelines.

Future studies should include multicentre investigations with larger sample sizes, molecular characterization of microbial isolates and antimicrobial resistance genes, and assessment of the relationship between equipment contamination and patient outcomes, including surgical site infections and other healthcare-associated infections. Such studies will provide stronger evidence for developing optimized infection control strategies in anaesthesia practice.

Clinical Recommendations

Implement standardized disinfection protocols for all reusable anaesthesia equipment.

Perform regular microbiological surveillance of high-touch anaesthesia workstation surfaces.

Reinforce hand hygiene compliance among anaesthesia personnel before and after patient contact.

Provide periodic training and competency assessments for operation theatre staff regarding infection prevention practices.

Conduct regular audits of disinfection procedures to ensure compliance with institutional and international guidelines.

Consider the use of disposable airway equipment in high-risk patients whenever feasible.

Overall, maintaining effective infection control practices and continuous surveillance of anaesthesia equipment are essential components of patient safety initiatives. Strengthening these measures can reduce microbial contamination, decrease the risk of healthcare-associated infections, and improve the quality of perioperative care.

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Note: Before submission, verify every citation against the final manuscript and update the details if newer editions or journal metadata have changed.

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These references provide a solid foundation for a peer-reviewed manuscript on microbial contamination of anaesthesia equipment. Before submission, ensure that the in-text citations correspond to the final reference list and that the target journal's reference style (Vancouver, APA, etc.) is followed exactly.