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Research Article

The Most Important Measures in Reducing Infection Control in the Anesthesia Work Environment: An Evidence-Based Study

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ABSTRACT

Background: Anesthesia providers cross-contaminate their work environment. The hands of anesthesia providers are vectors for the transmission of infection between medical equipment in the anesthesia work environment and patients. The high work density of anesthesia providers around the patient has made it important to monitor infection control in the work environment and anesthesia procedures. This research aimed to find the best evidence for preventing or reducing infection in the anesthesia work environment.

Methods: The measures required for the guidelines in the field of infection control in the anesthesia work environment were determined according to the available resources and the use of expert opinions of anesthesiologists and faculty members. Then, the guidelines for infection control in the anesthesia work environment were designed based on the evidence-based method (Stettler model). Also, it has been implemented in a limited way in the operating room. To assess the validity of the approach used in calculating the content validity coefficient (CVR) and the content validity index (CVI), Finally, the Test-Retest method, and Cronbach's alpha coefficient were used to determine reliability.

Results: The guidelines for infection control in the anesthesia work environment were designed using evidence-based methods (Stettler's model). The content validity of anesthesia procedures requiring infection control guidelines was reported with a content validity index (CVI) of more than 0.79 and a content validity ratio (CVR) of more than 0.59. The reliability test was measured by Cronbach's alpha coefficient (0.806).

Conclusion: Based on this study, the use of global infection control guidelines changes the attitude of anesthesia nurses and reduces the rate of infection in the anesthesia work environment. Also, the use of evidence-based methods facilitates the implementation of guidelines in the target environment.

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Introduction

Existing cleaning measures in operating rooms and anesthesia work environments are inadequate. Because of this, environmental surfaces remain contaminated. Removal of drug-resistant microorganisms from operating room surfaces is essential to minimize the risk of HAIs. In addition, HAIs contribute to major public health problems by increasing morbidity and mortality and prolonging the hospitalization time of patients, increasing treatment costs [1-3].

Many efforts have been made to comprehensively examine the environment of the operating room in terms of infection control, especially during the preparation and injection of drugs.

There is still no comprehensive guideline for surface pollution control in emergencies. The adoption and implementation of these guidelines remain challenging. This factor causes biased opinions that can endanger the patient's safety [4-6].

Following the examination of bacterial contamination on the hands of anesthesiologists during general anesthesia, the hands have been contaminated with pathogens in all phases of patient care [7]. The risk of infection in the operating room is higher than in other hospital areas, 7% of patients undergoing surgery suffer from one or more infections. The direct cost of Healthcare-Associated infection is estimated at $45 billion annually [8-10]. Ways to improve hand hygiene are directly related to keeping the anesthesia work environment clean. The maximum contamination of the hands of anesthesia providers is seen during induction and emergency anesthesia, which causes the peak contamination in the anesthesia work environment [10].

Nosocomial infections are one of the problems of hospitals in all countries. These infections are caused in patients as a result of hospitalization or similar places. Nosocomial infections appear within 48 to 72 hours after admission and up to 10 days after discharge. provided that the person does not have clear symptoms of infection at the time of hospitalization. Nosocomial infections cause an increase in the duration of the illness, mortality, and increase in treatment costs [11]. Today, the activities carried out in the path of infection control are considered one of the basic indicators of the quality of patient care and vital components of hospital management [12]. there is a risk of its occurrence even in the most equipped and modern hospitals of developed countries [13].

A large number of previous articles have proven the presence of pathogens in the anesthesia work area. Including stethoscopes, anesthesia tables, laryngeal masks, laryngoscope blades, touch screens, and keyboards of anesthesia machines, as well as the hands of anesthesia providers. which leads to the transmission of healthcare-associated infections and increases the risk of patient mortality [14-18]. Studies have reported problematic practices by anesthesia providers, including using vials for more than one patient, not using 100% gloves for airway management, and not maintaining hand hygiene after Removing gloves and entering the drawers of the anesthesia basket without washing hands [12].

Methods

This research is a cross-sectional-analytical study and was conducted to design infection control guidelines and find the best measures to reduce infection in the anesthesia work environment in Iran University of Medical Sciences. First, the number of measures requiring infection control instructions in the anesthesia work environment was determined using the opinions of anesthesiologists and faculty members. According to the sources and after searching in reliable journals, infection control guidelines in the anesthesia work environment were designed using an evidence-based method (Stettler model).

Four stages of Stettler's model (preparation, validation, Comparative Evaluation/Decision Making, and application) were used.

Phase I: Preparation (Determining the goals and potential consequences of making a change)

In the first stage, the operating rooms of affiliated hospitals of the Iran University of Medical Sciences were visited, and a need assessment was carried out, based on the priorities of the hospitals, it was decided to design guidelines for infection control in the anesthesia work environment. The PICO model was used to raise clinical questions. 16 items were identified for the design of new guidelines. Then, a search was conducted in authoritative journals (PubMed, Scopus, Google Scholar, Elsevier). The selected items are listed in (Table 1).

Table 1- Actions required by the guidelines in the field of infection control in the anesthesia work environment

1	General principles of infection control	9	Infection control in local anesthesia
2	Infection transmission chain	10	Considerations for infection control in respiratory circuits
۳	Procedures for safe injection of drugs and liquids	11	Prevention of infection related to vascular accesses
4	Hand hygiene	12	Environmental considerations in infection prevention and control

5	Classification of equipment based on the risk of contamination transmission	13	Steps of cleaning the operating room environment
6	Disinfection of anesthetic equipment	14	Infection control precautions in an infectious patient
7	Infection control in airway management	15	Considerations for infection control in respiratory droplets
8	Infection control in regional anesthesia	16	Personal protective equipment

Phase II: Validation (Criticism of research and literature)

After reviewing the studies, a new guideline was designed. To determine the content validity of the guidelines, 10 anesthesiologists and university faculty members were used. We provided them with the newly designed guidelines and after a two-week deadline, we received their comments in writing.

To determine the content validity of this research, the Lawshe method was used. The face validity, content validity ratio (CVR), and content validity index (CVI) of the prepared checklist were evaluated using the opinions of 11 anesthesiologists, medical education, and clinical education. The necessity of questions for CVR, simplicity, clarity, and relevance of questions for CVI was examined.

Phase III: Comparative Evaluation/Decision Making (determining the practicality of the guidelines and examining the benefits and risks)

At this stage, focus group meetings regarding the operationalization of the designed guidelines were held with anesthesia experts who are responsible for providing direct anesthesia care in the operating room. Their comments were received and applied to facilitate the application of the guidelines in the target environment.

Phase IV: Translation/Application

This stage involves actually what knowledge will be used and how that knowledge will be put into practice. By applying anesthesia comments, final instructions for the care of patients under anesthesia are coded and ready to be implemented.

In the end, after the limited implementation of the guidelines in the anesthesia work environment, reliability was checked by the Test-Retest method and Cronbach's alpha coefficient.

Recommendations and the most important influencing factors in reducing infection in an anesthesia work environment

Principles of infection control in anesthesia

A chief member of the anesthesia personnel should be appointed at each hospital to put through with the infection control unit and ensure that infection control best practices are followed in the anesthesia practice and work environment. Ongoing education of anesthesia staff on infection control practices should be considered. Anesthesia team members must ensure that hand hygiene is a routine part of their work and clinical culture. Anesthesia equipment is a strong carrier of infection. Using single-use anesthesia devices is the best measure to prevent infection. Always refer to the manufacturer's instructions to determine the compatibility between the type of disinfectant and anesthesia equipment. Placing an alcohol-based hand sanitizer in the anesthesia work environment prevents the loss of hand hygiene opportunities. Continued research is necessary to obtain new methods to reduce the transmission of contamination in the anesthesia work environment [19-21].

Education and Training

Increasing understanding and awareness of the transfer of bacterial organisms during surgery can lead to effective preventive measures [22]. According to the existing infection control guidelines and auditory and visual reminders, many hand hygiene opportunities are still missed, which indicates that hand hygiene is not part of the clinical culture of the anesthesia team and needs more training [23]. Audible reminders increase hand hygiene compliance by anesthesia personnel 27 times and reduce infection [16]. Additionally, there are many challenges to influencing the clinical culture of anesthesia providers. Center managers must actively communicate with anesthesia team leaders to achieve an effective, comprehensive, timely, and effective implementation plan and provide adequate resources to train anesthesia personnel and implement new infection control guidelines [21, 24]. Reminder signs in the anesthesia work environment encourage personnel to follow infection control guidelines [17]. Visual reminders, education, and implementation of approved infection control guidelines further align the anesthesia team's practices with the best infection control evidence [20].

Hand hygiene

Hand hygiene is one of the most effective methods of infection control. Hand hygiene is a measure to remove microorganisms from the hand. Performing proper hand hygiene significantly reduces the incidence of infection [21, 25]. There are 2 main categories of hand sanitizer products: alcohol-based products and soaps. Soaps are available in two forms, antimicrobial or simple formulations, and antimicrobial soaps are more effective than simple soaps, As shown in (Table 2) [26].

Table 2- Basic and secondary indications of hand hygiene

Basic hand hygiene Indications	Secondary hand hygiene indications
Before direct contact with the patient	Before wearing sterile gloves
Before performing aseptic procedures	Before contact with a clean place and after contact with a contaminated environment.
After contacting the patient	After touching surfaces with a high probability of touching (door handle, monitoring key, and anesthesia machine)
After contact with the surrounding environment of the patient	After removing the gloves
After the potential risk of contact with patient fluids	Before eating or drinking

Needles and syringes

Needles and syringes are sterile tools that can only be used for one patient. Syringes and needles are considered contaminated after contact with any prescription set, or infusion bag, including syringes used in the infusion pump and also contact with the patient. Medicines should not be given from the same syringe to different patients, even if contaminated needles are removed between patients and sterile needles are used. The used needle should not be put back into the infusion solution vial or bag (even for the same patient) or multi-dose vial. Using a syringe or injection pump connection and the presence of a one-way valve does not reduce the risk of blood contamination, so syringes and their contents should not be reused.

Syringes should be capped before use to avoid contamination of the syringe. Recap is not recommended, and if necessary, use the one-handed technique. Never store or carry syringes in clothing pockets. at the end of anesthesia or after use, used needles and syringes should be disposed of properly [27-29].

single-dose ampoules or vials

Single-dose vials and ampoules are used for one patient and are single-use items. Do not use single-dose vials and ampoules for several patients and do not save the remaining medicine for later use. After preparing the drug dose, throw away the ampoule or single-dose vial and do not save it for future use. Before use, clean the neck of the glass ampoules and the rubber cap of the vials with a sieve swab and let it dry use [27, 30].

Multi-dose vials

If possible, use single-dose vials. when using multi-dose vials, clean the vial cap with an alcohol swab and allow it to dry completely before use. When using vials for the first time, clean their caps, as caps do not guarantee sterility. If possible, multidose vials should be used for a single patient. Use the needle or syringe only once to withdraw the medicine from the multi-dose vials. After opening multi-dose vials, note the date on which the vial was opened. In the immediate patient care area (e.g., anesthesia cart, operating rooms, patient environment), discard the multidose vials after the patient. If you kept the multi-dose vial in the emergency room, follow the instructions for the single-dose vial. If you doubt whether a sterile multi-dose vial has been compromised, discard it. Follow the manufacturer's recommendations for how long to use multidose vials. Never leave a needle or syringe in a multi-dose vial. Immediately after taking the medicine, remove the needle or syringe [27-28, 30].

Infusion pumps, injection sets, and serum bags

Serum sets, serum bags, and other items that come into contact with the body's vascular system or other sterile parts of the body are considered single-use items. Never use injection bags as a common source for diluting medications for multiple patients. Use sterile disposable containers to use the washing solution. Before injecting infusion solutions, clean the injection valve with alcohol and let it dry completely. After injection, cover the injection valve with a sterile cover. Discard the propofol syringe and connecting tube during infusion if not used after 12 hours. Clean the injection pump syringes between each patient according to the manufacturer's recommendations [28-29].

Management of contaminated laryngoscope blades and handles in intubation

The laryngoscope handle and blade are classified as semi-critical tools based on the risk of contamination transmission and they need at least a high level of disinfection [31-32]. Although the laryngoscope handle is not in direct contact with the patient, it can be contaminated by the laryngoscope blade when it is off [33-34]. The contact point of the laryngoscope handle with the blade is a path for the transfer of blood and organisms from the oropharyngeal space. When the contaminated laryngoscope handle is touched by the anesthetist, there is a risk of contamination to the patient. High contamination of the laryngoscope handle has been proven in recent studies [34-36]. Laryngoscope handles with a knurled surface provide a better surface for organisms to grow than a smooth surface [37]. Studies have called for a reexamination of disinfection recommendations for laryngoscope handles, recommending at least high-level disinfection [38-39].

During the induction of anesthesia, the anesthesiologist wears double gloves. Immediately after the endotracheal tube is placed, the blade of the laryngoscope is kept in the outer glove and covers the dirty blade. The outermost gloves are removed, leaving

the anesthetist with clean gloves. This method ensures that the contaminated laryngoscope blade does not come into contact with the anesthesia work environment [21]. Disinfect the laryngoscope handle after each patient. After use, immediately remove the contaminated laryngoscope blade from the handle and place it in gloves or a special container. Never attach a contaminated blade to the handle [21, 40].

Limiting or preventing transmission of infection in airway management

There are many challenges for the anesthesia team to control or limit the transmission of contamination in airway management [19]. Ventilating the patient and maintaining saturation is a priority over all issues [41]. Ventilate the patient immediately after handling the airway and performing the desired action. Monitor breath sounds and ensure the patient's exhaled carbon dioxide is within the normal range [19]. The anesthesiologist is advised to consider double-gloving for airway manipulation [42]. After intubation or other airway devices, remove the outer layer of gloves and ensure that the patient's airway is open and that ventilation is adequate. Remove the inner layer of gloves if the condition is stable, perform hand hygiene, and put on new gloves to continue patient care. Targeted disinfection of the anesthesia work environment after each patient and ongoing research to obtain the best methods to limit the transmission of contamination [43-44].

Results

16 items were determined using expert opinions of anesthesiologists and university faculty members. The designed guideline should have at least 16 selected items. Then, the guidelines for infection control in the anesthesia work environment were designed using evidence-based methods (Stettler's model).

According to Lawshe’s table for 10 experts, the CVR should be 0.62 or more. The content validity of the guidelines designed for infection control in the anesthesia work environment was reported using a content validity index of more than 0.79 and a content validity ratio of more than 0.62. for 16 items of the tests, CVR above 0.62 and CVI above 0.79 were reported, which according to Lawshe’s table have favorable validity and content validity and were accepted. All the test items had CVR and CVI values higher than the specified limit, so no item was removed.

The importance of each item of the checklist was evaluated by the participants on a 5-point Likert scale from one (not at all important) to five (completely important). Then their impact score was calculated. To accept the face validity of each item, only questions whose score is higher than 1.5 are acceptable in terms of face validity. According to the table, it can be seen that the results of the impact scores of all questions were more than 1.5. Therefore, all the questions had good formal validity.

To check the reliability, 24 nurse anesthetists were selected in the operating room department by the available sampling method. The guideline was taught to them and the guideline file was emailed to them. Using a questionnaire their actions in the anesthesia work environment were calculated with a Test-Retest method and Cronbach's alpha coefficient at a time interval of three weeks. Its value was 0.806, which indicates the appropriateness of the reliability of the guidelines designed for infection control in the anesthesia work environment using the evidence-based method. The most effective factors in reducing anesthesia work environment infection are shown in (Figure 1).

Discussion

Understanding the dynamics of bacterial transmission is critical in addressing contamination risks. Anesthesia providers must be aware of how pathogens are spread in their work environment and the potential impact on patients. This includes recognizing common routes of transmission, such as contact with contaminated surfaces or equipment, and taking preventive measures to break chains of transmission [45]. Certain environmental factors contribute to contamination in the anesthesia environment, these factors can include considerations such as the presence of high-touch surfaces, and airflow patterns in operating rooms that may harbor pathogens, It also causes challenges related to maintaining cleanliness in anesthesia equipment. Identifying and addressing these environmental factors can help reduce contamination risks in the anesthesia work environment [3]. The high percentage of contamination in the anesthesia work environment shows that even though the anesthesia team does not have direct contact with the surgical site, their potential to transmit the infection to the patient is very high. The professional association confirmed this high level of contamination and led to the design of control guidelines. The infection was under anesthesia. (Infection Prevention Control Guidelines for Anesthesia Care, 2017) While anesthesia providers know the importance of surface cleaning and hand hygiene, cultural and environmental issues hinder their implementation [46-47]. The risk of transmission of infection in the operating room is not less than in other hospital departments and depends on the regard of preventive measures rather than the surrounding environment [27]. Anesthesia providers must be at the forefront of patient care in the safest possible situation. Maintaining the sterility of the anesthesia work environment is one of the main duties of the anesthesiologist, it is interesting to know that they have very little interest in it. Understanding the dynamics of bacterial transmission and increasing awareness among personnel in the anesthesia work environment can help prevent infection transmission during surgery and improve patient safety [16]. Ultraviolet fluorescent detectors show a 27% reduction in anesthesia work area

contamination with an infection control bundle including the use of double gloves, limiting airway equipment to a specific location, and increasing hand hygiene [23]. Even though anesthesia providers routinely contaminate their work environment, increasing the likelihood of infection transmission. Several kinds of literature have shown that anesthesia work environment contamination can be modified by providing multimodality approaches, anesthesiologist training and monitoring, use of disposable instruments, easy access to alcohol-based disinfectants, and increased adherence to guidelines [48].

Interdisciplinary Collaboration: Addressing contamination risks in the anesthesia work environment often requires collaboration across multiple disciplines within healthcare settings. This may involve coordination between anesthesia providers, surgeons, infection control specialists, environmental services staff, and hospital administrators. By fostering interdisciplinary collaboration, healthcare organizations can leverage diverse expertise and resources to implement comprehensive infection prevention strategies and enhance patient safety.

Continuous Quality Improvement: Infection prevention and control efforts in the anesthesia work environment should be viewed as an ongoing process of continuous quality improvement. This involves regularly evaluating current practices, identifying areas for improvement, implementing evidence-based interventions, and monitoring outcomes to assess effectiveness. By embracing a culture of continuous improvement, healthcare organizations can adapt to evolving challenges and maintain a proactive stance against contamination risks.

Nurse anesthetics Education and Engagement: Engaging Nurse anesthetics in infection prevention efforts can also contribute to reducing contamination risks in the anesthesia work environment. Educating nurse anesthesia about the importance of hand hygiene, proper wound care, and adherence to post-operative instructions can help minimize the risk of surgical site infections. Additionally, involving nurse anesthesia in shared decision-making processes regarding patient care can promote collaboration and accountability in infection prevention efforts.

Global Perspectives: While the discussion may focus primarily on practices and challenges within a specific healthcare setting, it's essential to consider broader global perspectives on infection prevention and control. Lessons learned from international initiatives, research studies, and collaborative efforts can offer valuable insights and inform best practices in addressing contamination risks in anesthesia care on a global scale.

By exploring these additional dimensions, the discussion can provide a more comprehensive understanding of contamination in the anesthesia work environment and the multifaceted strategies required to mitigate risks and safeguard patient safety.

Figure 1- The most important effective factors of infection control in the anesthesia work environment

Conclusion

Based on the findings of this study, the anesthesia team is in a good position to cooperate with the surgical team and reduce the infection rate in the anesthesia work environment, which leads to greater patient safety. Continuous monitoring of anesthesia nurses, training, and use of internationally recognized guidelines will change the attitude of the anesthesia team and reduce infection in the anesthesia work environment.

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