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The Role of Disinfection in the Prevention and Control of Healthcare Associated Infections in Operation Theatre

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Abstract: ***The present article is a theoretical study of the principle of cleaning and disinfection that aims to promote reflection on the role of care in Healthcare Associated Infections (HCAI) prevention with emphasis on practical recommendations. The source of the infections can be endogenous or exogenous in operation room. By sterile environment in operation theatres major part of such exogenous infections can be controlled. Proper ventilation, air circulation, temperature, maintenance of sterile environment in operation theatres plays key role in prevention of such infections. Steps for maintaining sterile environment include cleaning and disinfection of operation theatres by various means like chemical disinfection or disinfection with ultraviolet radiation [2]. Along with this surgical instruments also can be a source of exogenous infections. So cleaning, lubrication, packing and sterilization of instruments are essential for prevention of surgical site infections [6]. The article outlines a number of challenges faced by health services related to HCAI prevention, highlights key components of HCAI prevention programmes within the disinfection sphere and provides practical recommendations for HCAI control and prevention.***

Keywords: Disinfection, Healthcare Associated Infections (HCAI), operation theatre, prevention, surgical site infections, practical recommendations.

1. Introduction

Health systems must meet ever-increasing performance expectations and, according to the World Health Organisation (WHO), unsafe care is one of the five common limitations of healthcare services [1]. Minimizing the occurrence of healthcare associated infections (HCAIs) is therefore a priority for assuring safe care. Cleaning, disinfection and sterilization are the cornerstones in ensuring operation room asepsis. Surgical site infections (SSIs) are the second most common cause of hospital acquired (Nosocomial) infections. These complications of surgical procedures cause considerable morbidity [2]. The source of SSIs may be endogenous or exogenous, which includes surgical personnel, the operating room environment (including air), and tools, instruments, and materials brought to the sterile field during an operation [5].

Environmental cleaning (EC) is a fundamental principle of preventing infection in the hospital setting. Both porous surfaces (e.g., mattresses) and nonporous surfaces (e.g., bed rails) in patient rooms are highly susceptible to bacterial contamination with dangerous pathogens. The potential for these contaminated environmental surfaces contributing to transmission of pathogens has been most clearly established for certain key health-care-associated pathogens. These nosocomial pathogens can survive on inanimate surfaces for prolonged periods. Appropriate cleaning of these surfaces is an important part of an overall strategy to reduce the risk of health-care-associated infections (HCAIs) [9]. However, little consensus exists for optimal approaches to EC. Both the physical action of cleaning surfaces and applying a disinfectant are critical in reducing microbial burden on surfaces. In this report, we use “cleaning” to refer to removal of general surface debris and “disinfection” to refer to use of agents or technologies designed to kill microbial organisms. The term “environmental cleaning” refers broadly to the organized processes employed by hospitals for cleaning, disinfecting, and monitoring [3].

A wide variety of cleaning agents and disinfection technologies are commercially available, each with potential benefits and disadvantages. Additionally, hospitals often monitor the quality of room cleaning and disinfection to ensure that surfaces have been treated appropriately. Several monitoring strategies exist, which range from simple visual inspection, to microbiologic testing of surface contamination, to technologic innovations that measure the adequacy of surface cleaning. As the variety of options for cleaning, disinfecting, and monitoring grow, hospitals are faced with many choices, but limited evidence exists on the comparative effectiveness of these interventions, especially related to HCAI rates within the hospital [1,5,8]. Cleaning and Disinfection is a set of specific practices and procedures performed under carefully controlled conditions with the goal of minimizing contamination by pathogens. The present article consists of a theoretical study and aims to analyse patient safety within the disinfection sphere focusing on the prevention of HCAIs.

2. Study Development

The focus of this study is the application of cleaning and disinfection procedures in the prevention of HCAIs. The cleaning of hard surfaces in hospital rooms is essential for reducing the risk of healthcare-associated infections. Many methods are available for cleaning and disinfection, but their comparative effectiveness is not well understood. Healthcare and disinfection are a pivotal component of the health system and plays an indirect role in HCAI prevention given that its core function is disease prevention and, consequently, the avoidance of unnecessary hospital admissions. [4] It should also assure timely access to health services according to health needs. Unnecessary health interventions may cause

harm, which is clearly opposed to the ethical precept embodied in the safety principle and adopted worldwide within the healthcare context.

A wide variety of chemical disinfectants have been approved for use in the hospital setting.

The most commonly used surface disinfectants are quaternary ammonium compounds (QACs, often referred to as "quats") and hypochlorites. Other agents that have been introduced for surface disinfection include peracetic acid and accelerated liquid hydrogen peroxide. The effectiveness of chemical disinfectants can depend upon both the antimicrobial activity of the disinfectant and appropriate application, including adequacy of cleaning, contact time, and concentration of the disinfectant [5,6]. In addition to these manually applied chemicals is the use of "no-touch" modalities for hospital room disinfection, including application of ultraviolet light (UV) or fogging with hydrogen peroxide vapour or mist. These processes can be used only for terminal disinfection when patient rooms are empty and must be preceded by adequate room cleaning. Another strategy is the adoption of "self-disinfecting" surfaces that are impregnated or coated with copper, silver, germicides, or other antimicrobial-releasing agents. These surfaces are designed to resist contamination and augment routine cleaning processes [7].

In addition to selecting effective cleaning and disinfection methods, hospitals also assess how effectively such processes are being implemented. Visual inspection is the simplest method for evaluating cleanliness, but concerns about the adequacy of visual inspection alone. One such alternative is to collect specimens from surfaces and measure aerobic colony counts, which is a culture-based method for assessing surface microbial contamination [2,9]. Another technique is the use of invisible fluorescent markers placed on room surfaces before cleaning and disinfection, with UV light inspection afterward. A related and important consideration is the desire to establish standardized criteria for determining "clean" surfaces on the basis of each monitoring modality. While routine cleaning and enhanced disinfection strategies will not result in a sterile environment, consensus is lacking on the threshold of contamination below which pathogen transmission is minimized and can be considered safe. Establishing an evidence-based benchmark for defining a surface as clean will depend on the patient population, current cleaning and disinfection processes, and specific pathogen(s) being targeted [4].

2.1 Basic Structure of Operation Theatres (OT) complex

OT complex consists of 4 zones based on varying degrees of cleanliness, in which the bacteriological count progressively diminishes from the outer to the inner zones (operating area) and is maintained by a differential decreasing positive pressure ventilation gradient from the inner zone to the outer zone [8].

1) Protective zone: It includes change rooms for all medical and paramedical staff with conveniences, toilets, administrative function, transfer bay for patient, Recovery room, material & equipments.
2) Restricted or Clean zone: Connects protective zone to aseptic zone and has other areas also like changing room, patient transfer room, Equipment store room, Anaesthetist room, Maintenance workshop, Kitchen (pantry), Firefighting device room, Emergency exits, Service room for staff, recovery room & Close circuit TV control area.
3) Aseptic zone: Includes Scrub area, preparation room, operation room, area for instrument packing and sterilization.
4) Disposal zone: Area where used equipments are cleaned and biohazardous waste is disposed. Disposal areas from each OR & corridor.

2.2 A practical approach of Disinfection and key elements of HCAI prevention

The main objective is to protect the doctors, patient, healthcare workers and all other individuals in the physical healthcare environment and the public sector should provide the necessary financial resources for the implementation, maintenance and supervision of effective HCAI prevention. Key components can be highlighted and should be part of any set of measures implemented within the disinfection sphere [2].

a) Standard precautions (SPs)

SPs are a set of best practices for prevention that should be adopted with all patients, regardless of suspected diagnosis or confirmed infection. Adherence to SPs is widely recognised as the primary strategy for HCAI prevention. The following procedures are worth highlighting:

(i) Cleaning: Cleaning is most important in maintenance of operation theatres even more than sterilisation and disinfection as it removes contaminants, dust, and organic matter. By keeping the floor clean and dry, bacteria are reduced. Dry areas cause natural death of bacteria except spores. Floor should be cleaned with vacuum cleaner or wet mops. Brooms are not recommended it increases bacterial flora in environment. A simple detergent reduces flora by 80 %. Addition of disinfectant reduces to 95 %. Roofs should not be disturbed unnecessarily, use of ceiling fans should be avoided as they cause aerosol spread. Cleaning of roofs is recommended only when remodeling or accumulation of dust. Walls should be washed with water and disinfectant weekly. In between operative procedures, spot cleaning of operation tables, theatre equipment with disinfectant solution is recommended. In case of spillage of blood / body fluids decontamination with bleaching powder/chlorine solution should be done. Wastes should be discarded in prescribed plastic bags. Soiled gowns must not be discarded in the operation theatre. At the end of the day cleaning of all the table tops sinks, door handles with detergent / low level of disinfectant, floors with detergents mixed with warm water and Finally mop with disinfectant should be done. Air conditioners filter to be removed and washed with soap and water weekly is recommended [5].

(ii) Disinfection: There are three levels of disinfection: High-level disinfection kills all organisms, except high levels of bacterial spores and prions, and is effected with a chemical germicide cleared for marketing as a sterilant by

the Food and Drug Administration like Aldehyde based agents etc.

Intermediate-level disinfection kills mycobacteria, most viruses, and bacteria with a chemical germicide registered as a tuberculocide by the Environmental Protection Agency (EPA).

Low-level disinfection kills some viruses and bacteria with a chemical germicide registered as a hospital disinfectant by the EPA.

Selecting a chemical agent for routine disinfection of the patient room environment can be a complex process that includes careful consideration of its advantages and drawbacks. For an effective disinfection protocol, consideration should be given to the microorganisms being targeted, type of surface, the characteristics of a specific disinfectant (e.g., compatibility on various surfaces/materials), cost and ease of use, and safety of personnel.

(iii) Hand hygiene: This is considered the most effective measure for preventing infections since it prevents the propagation of microorganisms in all care settings. Currently, the use of alcohol-based hand sanitizers on clean hands is preferred and these should be readily available in the care facility. The use of alcohol based products to clean the hands as opposed to washing with soap and water is preferred for a number of reasons: a) alcohol is more effective as a germicide; b) the antimicrobial action of alcohol is quicker; c) alcohol-based products dry the skin less. Alcohol gel dispensers are recommended in the reception of the health facility to promote hand hygiene among service users on arrival and during waiting. Hand hygiene should be performed during home visits and professionals should always carry alcohol-based hand gel with them [2,7].

(iv) Care with health products: There are two categories of health products: reusable and disposable. The latter, for example syringes, needles and plastic vaginal speculum, should be disposed of and their reuse is unacceptable from a safety perspective and is not justifiable from a cost benefit point of view. With regard to reusable items, the relevant recommendations and norms regarding their use and reuse should be complied.

(v) Use of personal protective equipment (PPE): PPE consists of gloves, facial masks (common surgical masks), eye protection, OT shoes and impermeable gowns that should be readily available in the care facility and used in case of contact with blood or when splashes or sprays of blood/body fluids are expected.

(vi) Caring for the physical environment: it is the public sector's responsibility to provide adequate facilities and equipment for the effective running of primary healthcare centres and ensure their regular maintenance. All furniture, equipment and toys should be made of cleanable and disinfectable materials. Mattresses and mats used for OT table, Recovery room, physiotherapy, relaxation or other physical activities should be cleaned between each use.

(vii) Waste management: infectious waste requires specific treatment in accordance with relevant legislation. The healthcare team should be fully aware of what constitutes infectious waste and special attention should be given to sharps waste. Activities which frequently generate devices or objects used to puncture or lacerate the skin include vaccinations, dressings, blood and bodily fluid sampling, testing for blood glucose levels, and administration of medications. The areas where these activities are carried out should obligatorily contain special disposal units in accordance with relevant regulations: improvised bins to dispose of these items are unacceptable. Waste management related to home care is the responsibility of the health professional that provides care and waste items should be returned to the health facility for correct disposal and devices or objects used to puncture or lacerate the skin should be placed in a hard container carried by the professional [6].

b) Practical approach

Environmental cleaning in surgical settings minimises patients' and healthcare providers' exposure to potentially infectious micro-organisms.

(i) First cleaning of the day (before cases begin)

- This should be performed first, every morning irrespective of whether the OT will be used or not.
- Wear a clean gown, cap, mask and clean utility gloves.
- The surgeon/anaesthetist should not enter the OT before cleaning is complete.
- Clean all horizontal surfaces by wet wiping with an HLD Every horizontal surface should be cleaned.
- Follow the sequence of cleaning as mentioned previously (top to down; in to out).
- Clean all antiseptic bottles and the trays in which they are kept. Clean the sterile containers.
- Ensure colour coded waste collection bags are placed in the waste bins.
- Keep the OT closed for 10-15 min with ventilation equipment on after cleaning.
- Wash the scrub basin and tap with soap and water. Check for leakage and report immediately if seen. Clean the soap and antiseptic bottles at the scrub basin. Replace the bottles if empty.
- All OT equipment e.g. carm, Laproscopic case monitor, light source, etc. to be cleaned with Disinfectant wipes & then taken for use.
- During cleaning, only cleaning personnel should be present in the OT and the doors should be kept closed.
- After cleaning is over, wash and remove utility gloves, gown and cap. Wash hands and disinfect them by using an alcohol hand rub before proceeding to other work.

(ii) Cleaning Operating Rooms in between Cases

- Keep ventilation equipment on and OT door closed.
- Wear OT dress, footwear and a cap.
- Place a cautionary 'Wet Floor' sign at the entrance of the room.
- Prepare fresh disinfectant solution according to manufacturer's instructions & wipe the floor and OT table.
- Clean hands and put on gloves.
- Collect and remove waste.

- Collect and remove all soiled linen segregating soiled and dry linen.
- Remove gloves and clean hands. Wear a different set of gloves.
- Use a cloth dampened in hospital-approved disinfectant solution to clean and disinfect surfaces that have come in contact with a patient or body fluids, including tops of surgical lights, blood pressure cuffs, tourniquets and leads.
- Clean suction canisters, reflective portion of surgical lights.
- Clean and disinfect OT table.
- Clean electronic equipment (i.e., monitors) according to manufacturer's instructions.
- Damp mop floor in a 1 to 1.3 metre (3 to 4 feet) perimeter around the OT table (larger area if contamination present).
- Insert colour coded bags in waste bins.
- Damp-dust equipment from other areas such as X-ray machines, C-arm etc. before being brought into the operating room and prior to leaving.
- When cleaning is complete, remove gloves and clean hands.
- Try to fog the room with disinfectants before taking a new case.

(iii) Procedure for Terminal Cleaning of Operating Rooms

- Place a cautionary 'Wet Floor' sign at the entrance of the room.
- Prepare fresh hospital approved disinfectant solution according to manufacturer's instructions.
- Clean hands and put on gloves.
- Collect and remove waste.
- Collect and remove all soiled linen.
- Clean hands and change gloves.
- Clean and disinfect lights and ceiling-mounted tracks.
- Clean and disinfect all door handles, push plates, light switches and controls.
- Clean and disinfect telephones and computer keyboards.
- Spot-check walls for cleanliness.
- Clean and disinfect all exterior surfaces of machines and equipment (e.g., anaesthesia carts), allowing adequate drying time for the disinfectant before storage.
- Clean and disinfect all furniture including wheels/casters.
- Clean and disinfect exterior of cabinets and doors, especially around handles.
- Clean and disinfect all surfaces.
- Clean scrub sinks and surrounding walls.
- Mop floor, making sure the OT table is moved and the floor is washed underneath; move all furniture to the centre of the room and continue cleaning the floor; apply a sufficient amount of disinfectant/detergent to ensure that the floor remains wet for five minutes; use a fresh mop/mop head and fresh solution for each room.
- Replace all furniture and equipment to its proper location.
- Wash the colour coded bins, dry them and put colour coded bags once it is dried.
- Report any needed repairs.
- Clean and store cleaning equipment. Wash footwear & keep it for drying.
- Remove gloves and clean hands.
- Fumigate the rooms (OT).

(iv) Detailed Wash-down of the OT Complex

- A detailed wash-down should be done at least once a week for OTs that are used daily.
- For OTs that are used less frequently, detailed wash-down should be done at least once a month and before any camp patients are operated.

3. Method

- Wear utility gloves.
- Shift all movable equipment and materials out of the OT.
- Inspect the OT surfaces for cracks, loose tiles etc. If any maintenance work is required, perform the maintenance before proceeding.
- In case the maintenance involves civil work that generates dust, then the cleaning and disinfection protocol for cleaning and disinfection new OT should be followed after the maintenance work is completed.
- Wipe all surfaces of the OT liberally with soap and water & disinfection solution.
- Begin at the ceiling. Use a long handled mop to wipe the ceiling.
- Proceed down the walls. Clean all wall fixtures on the way down.
- Clean all ceiling mounted fixtures e.g., OT lamp.
- Then clean all fixed floor based equipment.
- Lastly scrub the floor with soap and water & disinfection solution.
- Repeat cleaning until all visible dust is removed.
- Allow the OT to dry naturally.
- Then wipe all surfaces with HLD. Allow the disinfectant to dry naturally.
- Meanwhile, clean all the equipment moved outside with soap and water. Remove all dirt and dust. Clean every surface of the equipment.
- Remove all materials stored on trolleys and clean the entire trolley. Also clean the bottles, containers, etc. by wiping them on the outside to remove all soiling.
- Clean the wheels by running them 10-15 times over a Turkish towel soaked with soap and water.
- Wipe the equipment with HLD and allow to air dry. Do oiling of wheels.
- Move the equipment back into the OT. Wipe equipment with high-level disinfectant.
- Cover electronic equipment with properly fitting plastic covers and fog the OT with high-level disinfectant until a fog is seen in the air.
- Keep the OT closed for at least one hour.
- Meanwhile, clean the rest of the OT complex (passages, other rooms) with soap and water followed by wiping with high-level disinfectant. Clean and wipe from ceiling to floor. Clean all furniture.
- The OT may be used after it has remained closed for at least one hour.

(v) Cleaning and Disinfection of New OT and after any Civil Work

- First ensure all civil work is completed.
- Ensure all movable equipment has been shifted out.
- Wear utility gloves.

- Wipe all surfaces of the OT using liberal amount of soap and water. Repeat wiping until all visible dust is removed.
- Clean all fixed equipment like OT lamp with soap water until all visible dust is removed.
- *The mechanical action of wiping is very important to remove spores and improve the action of disinfectants used subsequently.*
- Allow all surfaces to dry completely.
- Wipe all surfaces (including the ceiling) with a high-level disinfectant. Allow to dry completely.
- Wipe down all equipment to be moved into the OT with soap and water to remove all visible dust. Allow to dry completely. Clean the wheels by running them 10-15 times over a towel soaked with soap and water. This equipment cleaning is to be done outside the OT.
- Move the cleaned equipment into the OT.
- Wipe all surfaces (excluding the ceiling and walls up to the height the hands can reach) with high level disinfectant.
- Allow to dry completely.
- Fog the OT with high-level disinfectant until a fog is seen in the air.
- Stop and remove the fogger and close the OT for at least one hour with any ventilation system/AC off .
- After 1-2 hours open the OT and take post fogging swabs. Change into OT dress, cap, mask and use sterile gloves when performing the sampling. Only the person taking the samples should enter the OT.

Sample the following sites at the minimum

- OT table upper surface.
- OT lights lower glass surface.
- Anesthesia machine (swab the area where medications are placed during use).
- Sterile instruments trolley surface.
- Any two walls (sample sites above OT table height).
- Floor (two samples on either side of the OT table.
- Air conditioner outlet louvers (if AC present).
- After sampling close the OT. No one should enter the OT until next day.
- On second day, wear OT dress, footwear and cap; wipe all surfaces (including ceiling with a long handled mop) once with soap water, allow drying and then wiping once with a high-level disinfectant (HLD).
- Keep OT closed for at least one hour with ventilation system/AC off.
- Repeat the OT swab sampling as mentioned above.
- On third day, repeat the entire procedure (third time) and sample the swabs (third sampling).
- Wait for the OT swab reports. The OT can be used if all the three swabs reports show no growth of any organisms OR sparse growth of skin commensals in any one out of nine swabs taken per sampling.
- In case growth of spore bearing organisms, pathogens, aerobic gram negative bacilli or fungus is seen, disinfectant wiping of the entire OT and fogging should be repeated and swabs sampled again (once only).
- If results are not satisfactory even now, seek help of an expert in infection control.

4. Final Considerations

The present study aimed to broaden the perspective of HCAIs prevention and highlight important components that deserve further research in the nursing field in order to overcome the challenges outlined by this study. The practical approach proposed by this study could provide a useful contribution to the development of guidelines that provide comprehensive recommendations for preventing HCAIs within healthcare settings.

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