

Microbial Contamination of Operating Theatres and Intensive Care Units at a Surgical Specialty Hospital in Erbil City

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Abstract

Background: Microbial contamination of operating theater (OT) and intensive care unit (ICU) is the most frequent cause of nosocomial infections in patients. **Objectives:** this study aims to evaluate the prevalence level and variety of microbial contamination in these high-risk areas in the surgical specialty hospital in Erbil city. **Materials and Methods:** Three sampling procedures were employed in this study, which includes swabbing, open plate, and both microbiological and biochemical investigation of water supply in these high-risk areas. Standard microbiological techniques were used for microbiological culture and identification of microbial pathogens. **Results:** 48.3% yielded positive microbial growth. The most common isolates were Gram-positive bacteria (83.1%), of which *Staphylococcus aureus* accounted for 78.6% of bacterial pathogens isolated, followed by Streptococci (33.3%) and Enterococci (28.6%). Whereas, lower rate of Gram-negative bacterial contamination (16.9%) was observed, including *Escherichia coli* (19%) and each of *Pseudomonas aeruginosa* and *Proteus* (4.8%). Air contamination with *Aspergillus* (19%) and *Molds* (14.3%) was observed, respectively. The highest rate of microbial contamination was observed in OT rooms (35.6%) where 50% of environmental hygiene practice was detected using infection control practice audit tool. In addition, 21.4% of positive cultures were identified in ICU rooms where only 9% of environmental hygiene was practiced. **Conclusions:** These findings emphasize the important role of infection control system to prevent the cross-transmission of nosocomial pathogens to cause contamination and infection in the critically ill patients.

Keywords: Infection prevention and control, nosocomial pathogens, surgical-site wound infection

INTRODUCTION

Nosocomial infections are one of the most serious health-care problems and are harmful for inpatients in the intensive care unit (ICU) and operating theater (OT) high-risk areas, as well as it poses a huge economic burden to hospital.^[1] For instance, the nosocomial pneumonia and bloodstream-associated infection are associated with threefold increased risk of mortality in immunocompromised patients. Consequently, a large proportion of patients in the ICU die because of their nosocomial infection, rather than with their own disease.^[2]

Moreover, OT is one of the most important clinical areas in hospital where surgical operations are carried out under relatively sterile environment. The environment of the OT area predisposes patients at high risk despite good surgical performance and high standard instruments, the controlled environment of the operating room remains potentially dangerous for the patient.

The Centers for Disease Control and Prevention reports showed that surgical site infection (SSI) complicates about 5% of surgical operations due to microbial contamination in the high-risk areas of the hospital annually.^[3] Microbial contamination in this high-risk area is one of the major life-threatening sources of SSI for the patient. It is observed that the nosocomial pathogens are the leading cause of surgical site wound infections pathogens while entering the operative wound at the time of operation.^[4]

Multiple risk factors are responsible for microbial contamination of OT and ICU. The contaminating pathogens originate from

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the OT environment, ventilating systems, cleansing and sterilization, drainage of the wounds, transportation of patients between areas in the hospital, or from shedding by the OT health-care personnel, use of personal protective equipment by the health-care staff and patient, or from the patient's skin flora.^[5]

Contamination of the OT and ICU with nosocomial multidrug-resistant bacteria and fungi can be prevented through adequate application of infection control standards. A study reported that reduction of airborne bacteria in the OT would lead to prevent 50% of postoperative wound contamination by compliance to proper cleaning and disinfection standards.^[6]

The major aim of this study is to determine the prevalence and variety of microbial contamination in the high-risk areas, including OT and ICU in the surgical specialty hospital in Erbil city and to identify nosocomial pathogens as a source of cross-contamination in these areas.

MATERIALS AND METHODS

Collection and processing of samples

The surgical specialty hospital consists of four OT and two ICU rooms. Eighty-seven swabs were collected from these high-risk areas from January to September of 2018. Microbial contamination was assessed two times monthly in these high-risk areas in the hospital using swabbing and settle open plate methods.

For swabbing method, sterile swabs were moistened in sterile distilled water, and immediately rolled over the surfaces of floor, doors, telephone hands, walls, wash basin, and medical equipment within both OPT and ICU areas, before and after the operation.

Following sample collection, all collected swabs were immediately cultured on both enrichment medium blood agar and selective medium MacConkey agar by streaking method incubated aerobically at 37°C for 16–24 h.

Air sampling was obtained by placing Sabouraud Dextrose agar plates with opened lids in upside position for 30 min at about 1-m height from the floor at four chosen corner places in each room. After exposure time, the plates were covered with their lids and transported to the microbiology laboratory and the plates were immediately incubated in an inverted position aerobically at 25°C and observed after 3–5 days.

Identification of microbial growth

Standard microbiology techniques for identification of suspected bacterial and fungal growth characteristics were used after incubation, as follows: bacterial culture characteristics were examined such as colony morphology on cultured plates, lactose fermentation, hemolysis, pigmentation, and swarming phenomenon. Moreover, biochemical tests were employed to confirm bacterial identification, including oxidase, catalase, coagulase, methyl red, indol, and Voges–Proskauer tests. In addition, fungal identification was carried out by the

lactophenol cotton blue wet mount method and microscopically examined for the nature of their mycelium and hyphae structure growth characteristics.^[7]

Bacteriological quantification and isolation in water

Ten water samples were collected from the central sterile supply department (CSSD), OT, and ICU areas. Bacteriological analysis of water samples were carried out at the microbiology laboratory of directorate of water and sewage quality control in Erbil city.

Bacteriological quantification was performed by counting total number of viable *Escherichia coli* coliforms and were expressed in CFU/100 ml. Multiple-tube fermentation method was used and the statistical results expressed as most probable number units.^[8,9] Sterile water was used as control.

RESULTS

A total of 87 samples were collected from surfaces, medical equipment, sterilization supplies, air and water, 42 (48.3%) yielded positive microbial growth in these high-risk areas of the hospital using swabbing and open plate methods, as described in Table 1. Among these isolates, 83.1% were Gram-positive cocci and 16.9% were Gram-negative bacilli bacteria, as shown in Table 2.

Thirteen (31.0%) positive microbial growth was detected from surfaces and 11 (26.2%) from medical equipment, followed by 8 (19.0%) positive growth from sterilization supplies, whereas, microbial contamination was not detected from the water supplies. The microbial contamination isolated from air was 23.8%.

The highest rate of microbial contamination was observed in OPT rooms where 15 (35.6%) yielded positive bacterial isolates. In comparison, lower rate of microbial contamination was identified in ICU rooms, in which 9 (21.4%) were positive bacteria isolates and 8 (19%) positive bacterial growth in sterilization department, as shown in Table 3.

Moreover, our findings revealed that the most common isolates were Gram-positive cocci (83.1%), such as *Staphylococcus aureus* was accounted for 78.6% of bacterial

Table 1: Total number and percentage of samples and contaminated samples tested in the hospital

	<i>n</i> (%)
Total number of samples	87 (100)
Number of contaminated (culture-positive) samples	42 (48.3)

Table 2: Number and percentage of isolated Gram-positive and Gram-negative bacteria in the hospital

Microorganisms isolated	<i>n</i> (%)
Gram-positive cocci	59 (83.1)
Gram-negative bacilli	12 (16.9)
Total	71 (100)

pathogens isolated, followed by Streptococci (33.3%) and Enterococci (28.6%). Whereas, lower level of contamination with Gram-negative bacilli (16.9%) was observed, including *E. coli* (19%) and each of *Pseudomonas aeruginosa* and *Proteus* (4.8%). Moreover, air contaminations with *Aspergillus* (19%) and *Molds* (14.3%) were detected, respectively, as described in Table 4.

To demonstrate the possible source of microbial contamination, the distribution of microbial isolates according to each high-risk area including OPT, ICU, and CSSD were determined. As shown in Table 5, the *S. aureus* showed the highest rate among contaminant isolates in all high-risk areas, as 13 (30.9%) of the *S. aureus* isolates were obtained from OPT rooms, 9 (21.4%) from ICU, and 7 (16.6%) from CSSD. However, high-level contamination of Streptococci (19%) and Micrococci (16.6%) isolates were detected in ICU compared to other areas such as OPT and CSSD.

Other species of Gram-negative bacilli such as *Pseudomonas* and *Proteus* were found in very low numbers in OPT, ICU, and CSSD. In our study, 8 (19%) positive *Aspergillus* isolates

and 6 (14.3%) of *Molds* isolates were obtained from the open culture plate technique, revealing high level of air contamination in these high-risk areas. However, no bacterial isolates were detected in water supply, as described in Figure 1.

Furthermore, this study also assessed the level of environmental hygiene and cleanliness in these high-risk areas through monitoring the environmental hygiene practice audit system. Results showed that 50% of environmental hygiene practice was observed in OT rooms where 35.6% contamination was detected, as shown in Table 5.

Low level of environmental hygiene practice (9%) was identified in ICU rooms where 21.4% of positive cultures was detected, as described in Table 6. Moreover, only 14% of hygiene was observed in CSSD where 19% of positive culture isolates detected, as shown in Table 7.

DISCUSSION

SSI is one of the most common and serious complications for patients who undergo surgical operations. Patients with SSI are more likely to stay in the hospital twice as long in the ICU compared with those without SSI and six times at higher risk of readmission.^[10] Most importantly, these patients are at greater risk of death during their long hospital stay as compared to those without SSI. Recent studies have shown that microbial contamination of the OT and ICU environment can lead to colonization and infection of patients. Therefore, compliance to infection control measures in the clinical practice is important for the effective prevention, reduction, and treatment of postoperative wound infections caused by multidrug-resistant bacteria and fungi.^[11]

In this study, we used the infection prevention and control audit tool called Environmental Cleanliness Audit Score system for evaluating the level of health-care environmental hygiene, general cleanliness in these critical areas. This audit tool defines the acceptable standards for a managed hospital environment which reduces the risk of contamination and infection to inpatients, health-care workers, and visitors.^[12]

Table 3: Distribution of the number and percentage of the total samples and culture-positive samples isolated from different high-risk areas in the hospital

Site	Total culture, n (%)	Total number of positive culture, n (%)
OPTs		
OPT-1	9 (10.3)	5 (11.9)
OPT-2	9 (10.3)	4 (9.5)
OPT-3	8 (9.2)	3 (7.1)
OPT-4	8 (9.2)	3 (7.1)
Total	34 (39)	15 (35.6)
ICUs		
ICU-1	14 (16.1)	3 (7.1)
ICU-2	10 (11.5)	6 (14.3)
Total	24 (27.6)	9 (21.4)
CSSD	12 (13.7)	8 (19)
Water	7 (8.0)	0 (0.0)
Air	10 (11.5)	10 (23.8)
Total	87 (100)	42 (100)

OPTs: Operating theaters, ICUs: Intensive care units, CSSD: Central Sterile Supply Department

Table 4: Number and percentage of microbes identified in the high-risk areas of the hospital

Microorganism isolates	n (%)
<i>Staphylococcus aureus</i>	33 (78.6)
Streptococci	14 (33.3)
Micrococci	12 (28.6)
<i>Escherichia coli</i>	8 (19.0)
<i>Pseudomonas</i>	2 (4.8)
<i>Proteus</i>	2 (4.8)
<i>Molds</i>	6 (14.3)
<i>Aspergillus</i>	8 (19.0)

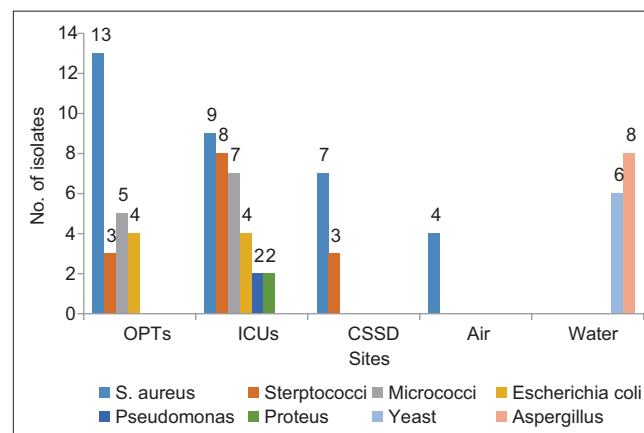


Figure 1: Number and type of microorganism isolates identified from the different high-risk areas in the in the hospital

Table 5: Environmental hygiene and cleanliness audit system for operation theaters area																			
Functional area: OT																			
Room name	Operating lamp	Transfer table	Doors, trolley	door frames	Suction apparatus	Floor	Telephone hand	Waste receptacles	Instrument table	Counter/Ventilator stand	Sheet Infusion stand	Perfusion machine	Perfusion set	Multipara monitor	Anesthesia machine	cautery apparatus	Air score	Actual Percentage attained	
OT 1	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	8	40
OT 2	0	1	1	0	1	0	1	0	1	0	0	0	1	1	1	1	0	9	45
OT 3	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	5	25
OT 4	1	1	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0	13	65
Achievable Score	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	80	
Total Score	3	3	1	0	2	0	1	0	4	1	2	2	2	3	3	8	0	40	

Hospital environmental hygiene and cleanliness: 50%. OT: Operation theaters

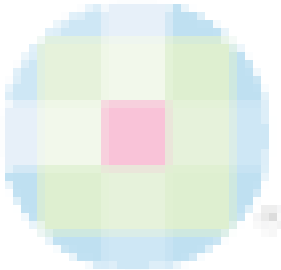


Table 6: Environmental hygiene and cleanliness audit system for intensive care units area																
Functional area: ICUs																
Room name	Patient's bed	transfer trolley	Doors, frames	Floor	Telephone hand	Waste receptacles	Counter/Ventilator	Endotracheal tube (used)	Endotracheal tube	IV stand	Inspiratory valve	Expiratory valve	Water bath (warmer)	Bedside monitor	Air score	Percentage attained
ICU 1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
ICU 2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Achievable score	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	34
Total score	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3

Hospital environmental hygiene and cleanliness: 9%. ICU: Intensive care unit

Table 7: Environmental hygiene and cleanliness audit system for central sterile supply department area

Room name	Functional area: CSSD											Actual score	Percentage attained
	Autoclaves	Plasma autoclave	shelves	instrument table	Wall	Water	Washer	Handwash basins	door and door hand	Telephone hand	Floor	Air	
Cleaning zone	x	x	0	0	0	1	0	0	0	0	0	0	10
Sterilization + preparation + packaging + storage zone	0	1	0	0	0	1	x	0	0	0	0	0	18
Achievable score	1	1	2	2	2	2	1	2	2	2	2	2	21
Total score	0	1	0	0	0	2	0	0	0	0	0	0	3

Hospital environmental hygiene and cleanliness: 14%. CSSD: Central sterile supply department

Findings of this study showed moderate level of significant microbial contamination in the OT (35.6%) and ICU (21.4%) areas in the hospital. This was reflected by the low adherence and compliance to infection control and prevention measures by 50% in the OTs and 9% in the ICUs. Surprisingly, the level of microbial contamination in OT observed in this study was considerably lower as compared to findings of a recent study^[13] which showed higher contamination (41.01%) in one of the Musel hospitals. While another study similarly reported a very low level of bacterial contamination in the OT area in Baghdad hospital (4.0%).^[14]

The highest rate of contaminant bacteria was for *S. aureus* (78.8%) and the contamination source was detected from the surgical staff and health-care workers, or from the patient's own skin flora. This result was similar to that obtained by Tagnouokam study,^[15] which observed predominance of *S. aureus* contamination of the surfaces in the OT and ICU. Furthermore, *Streptococcus* spp. (33.3%) was the most predominant isolate from the wound specimens.

For Gram-negative bacteria, such as *E. coli*, *P. aeruginosa*, and *Proteus mirabilis* were the most frequent isolates from inanimate surfaces and equipment in the ICU. In fact, contamination and cross-transmission of nosocomial pathogens occur either indirectly by touching contaminated surfaces of water bath, bloodsucker, ventilating instrument, respiratory tubes, and near-by patient's equipment in the ICU (exogenous source of contamination), or directly by hands of health-care staff, which become contaminated directly from the patients contact (endogenous source of contamination).

The nosocomial pathogens that circulate in the high-risk areas are considered as the most common source of contamination and infection due to their ability to survive for a long time in the hospital environment and on dry inanimate surfaces and are also favored by the formation of biofilms to persist adverse environmental conditions.^[16,17] Moreover, sterilization of surgical and disinfection methods of OT are not efficient, thus putting patients at greater risk for postoperative wound infection.

Other risk factors poses greater challenge, such as the hand-hygiene compliance, education level, and awareness by the health-care professionals, ICU and OT structural features play important roles in minimizing the cross-transmission risk of nosocomial pathogens to patients, probably through contaminated hands, gloves, and equipment due to low compliance to handwashing and disinfection, or directly from the environment.^[18]

In fact, a common barrier exists in the communication difficulties between the clinical microbiology service and clinicians in practice for management and prescription of antibiotics for the treatment of critically ill patients. This could be because the tasks and purposes of clinical microbiologists may not always be fully understood by clinicians.

Inappropriate or excessive use of antibiotics usually stems from inappropriate interpretation or use of microbiological

test results, such as deficit of a microbiologically confirmed diagnosis.^[19] The most common challenge is that most postoperative wound infections in the critically ill patients in the ICU are treated with broad-spectrum and strong antimicrobial drugs immediately without supporting evidence of microbiologic culture and antibiotic susceptibility reports. Consequently, the effect of this could attribute to increased antibiotic selective pressure and emerging antibiotic-resistant nosocomial pathogens.

Recent studies showed that antimicrobial stewardship practice in the hospital is a major element of combating against antimicrobial resistance. The clinical microbiologist can play a key role in implementation of antimicrobial stewardship programs through their contribution in antimicrobial susceptibility reports for ultimate aim to improve antibiotic use and optimize the treatment of infection in critically ill patients.^[20]

For these reasons, improving the compliance to infection control and prevention by the health-care professionals and cleaners working in these very high-risk areas and continuous professional training on cleaning and disinfection measures are very important key elements to reduce the level of microbial contamination in these areas.

In addition, verification of hospital-acquired infection is very important aspect of patient care through microbiological culture identification of nosocomial pathogens from the patient's sample and early initiation of treatment with appropriate antibiotics lead to minimize patient's stay at the ICU and reduce financial burden.

CONCLUSIONS

The prevalence of microbial contamination in these high-risk areas is found to be moderate, and the most commonly isolated contaminated pathogens were *S. aureus*, Streptococci, and Micrococci. The adherence to environmental and cleanliness audit system has aided in assessing the rate of infection control and prevention standards compliance by the health-care workers in this hospital. Hence, this prompts to improve and strict adherence to standard precautions to reduce microbial contamination and any risk of transmission of nosocomial infection in this hospital.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Weinstein RA. Nosocomial infection update. *Emerg Infect Dis* 1998;4:416-20.
- Pittet D, Harbarth S. The intensive care unit. In: Bennett JV, Brachman PS, editors. *Hospital Infections*. 4th ed. Boston, MA: Little, Brown & Company; 1998. p. 381-402.
- Weigelt JA, Lipsky BA, Tabak YP, Derby KG, Kim M, Gupta V. Surgical site infections: Causative pathogens and associated outcomes. *Am J Infect Control* 2010;38:112-20.
- Astagneau P, L'Hériveau F. Surveillance of surgical-site infections: Impact on quality of care and reporting dilemmas. *Curr Opin Infect Dis* 2010;23:306-10.
- Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, *et al.* Multistate point-prevalence survey of health care-associated infections. *N Engl J Med* 2014;370:1198-208.
- Fleischer M, Bober-Gheek B, Bortkiewicz O, Rusiecka-Ziółkowska J. Microbiological control of airborne contamination in hospitals. *Indoor Build Environ* 2006;15:53-6.
- Baron E, Finegold SM. *Bailey and Scott's Diagnostic Microbiology*. 8th ed. Baltimore: Mosby; 1990.
- Barrell RA, Hunter PR, Nichols G. Microbiological standards for water and their relationship to health risk. *Commun Dis Public Health* 2000;3:8-13.
- American Public Health Association, American Water Works Association and Water Environment Federation. *Standard Methods for Examination of Water and Waste Water Standard Fecal Coliform (Thermotolerant Coliform) Procedure*. Washington, DC: American Public Health Association. American Water Works Association, Water Environment Federation; 2012. p. 9-74.
- Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: Attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol* 1999;20:725-30.
- Carling PC, Von Behren S, Kim P, Woods C; Healthcare Environmental Hygiene Study Group. Intensive care unit environmental cleaning: An evaluation in sixteen hospitals using a novel assessment tool. *J Hosp Infect* 2008;68:39-44.
- Pratt RJ, Pellowe C, Loveday HP, Robinson N, Smith GW, Barrett S, *et al.* The epic project: Developing national evidence-based guidelines for preventing healthcare associated infections. Phase I: Guidelines for preventing hospital-acquired infections. Department of health (England). *J Hosp Infect* 2001;47 Suppl:S3-82.
- Al-Juboory W, Abdul Aziz ZA. Bacterial contamination of operating room in some of Mosul hospitals and the effect of ultraviolet light on selected bacteria. *Tikrit Med J* 2017;22:298-310.
- Ensayef S, Al-Shalchi S, Sabbar M. Microbial contamination in the operating theatre: A study in a hospital in Baghdad. *East Mediterr Health J* 2009;15:219-23.
- Tagnouokam NP. Qualification and quantification of flora of the hospital environment (Air, water and surfaces) of the Yaoundé University Hospital. Master memory medical microbiology FMSB: University of Yaoundé I; 2008.
- Talon D. The role of the hospital environment in the epidemiology of multi-resistant bacteria. *J Hosp Infect* 1999;43:13-7.
- Verdeil X, Bertrand M, Roche R, Lareng M, Pous J. Clinical and microbiological epidemiology of nosocomial infections in surgical wards: Results of 3422 patients. Prospective surveillance study in a Toulouse hospital. *Med Infect Dis* 1990;20:222-8.
- Dancer SJ. Hospital cleaning in the 21st century. *Eur J Clin Microbiol Infect Dis* 2011;30:1473-81.
- Society for Healthcare Epidemiology of America, Infectious Diseases Society of America, Pediatric Infectious Diseases Society. Policy statement on antimicrobial stewardship by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), and the Pediatric Infectious Diseases Society (PIDS). *Infect Control Hosp Epidemiol* 2012;33:322-7.
- Davey P, Brown E, Charani E, Fenelon L, Gould IM, Holmes A, *et al.* Interventions to improve antibiotic prescribing practices for hospital inpatients. *Cochrane Database Syst Rev* 2013;30:CD003543.