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Radiographic Equipment and Accessories as a Potential Source of Nosocomial Infection

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Abstract

Background: Nosocomial infections have become a major challenge in healthcare facilities as they affect the quality of medical care. Radiological imaging plays a crucial role in medical diagnosis. However, the equipment and accessories used increase the risk of transmission of nosocomial bacteria. **Objective:** This study aims to reveal the extent and nature of microbiological contamination in four hospital diagnostic imaging departments to determine their potential role in the spread of nosocomial bacteria and to evaluate the effectiveness of routine daily disinfection practices in controlling microorganisms in diagnostic imaging departments. **Methods & Results:** In each department, swabs were taken from the surfaces of selected parts of the equipment and accessories three times a day (early morning, noon, and evening) for five consecutive days. Bacteria were isolated from 65 swabs (36.1% of all samples). The bacteria were isolated 3 times (4.6%) in the morning, 16 times (24.6%) at midday, and 46 times (70.7%) in the evening. The bacteria isolated were *Escherichia coli* (isolated 34 times; 52.3%), *Staphylococcus aureus* (20 times; 30.8%), *Staphylococcus epidermidis* (6 times; 9.3%), and *Klebsiella species* (5 times; 7.7%). **Discussion & Conclusion:** Findings demonstrated that radiology equipment and accessories are not free of bacteria and further improvements in the sterilization and disinfection of radiology equipment and accessories are needed to protect staff and patients from nosocomial infections.

Keywords

Diagnostic Imaging Department, Nosocomial Infection, Radiographic Accessories, Radiographic Equipment

1. Introduction

Providing adequate infection control measures in hospitals is crucial to preventing and reducing infectious disease spread, to ensure the safety of patients, staff, and the environment when implemented effectively. Nosocomial infections (NIs) are infections acquired by patients during their hospital stay or that were not present or incubating at the time of admission and an infection that develops after discharge, in addition to infection contracted by a healthcare worker, both through direct contact between patients and inadequately disinfected medical devices and accessories that are contaminated with body secretions or between patients and staff can spread nosocomial pathogens [1]. Both developed and developing countries report NI rates of 7% and 10%, respectively [1].

There is a 13-fold increase in medical device-associated infections in low- and middle-income countries compared to those in high-income countries [2]. Multiple studies have been conducted to determine the incidence of device-associated NIs (DA-NIs) in Saudi Arabia [3] [4], at King Fahad National Guard Hospital in Riyadh, Balkhy *et al.* demonstrated that 45 (8%) of 562 patients developed NI [3]. They also found that central line-associated bloodstream infections (CLABSIs) were the most commonly reported NI (31.1%), followed by ventilator-associated pneumonia (VAP) (28.9%) and catheter-associated urinary tract infections (CAUTIs) (24.4%). Further, they reported that most NIs occurred in ICUs [3]. In a study of 12 reference hospitals of the Ministry of Health in the Kingdom of Saudi Arabia, Gaid *et al.* showed that VAP was the most frequently reported DA-NI (57.4%), followed by CAUTIs (28.4%) and CLABSIs (14.2%) in 13492 patients [5]. Moreover, Tawfiq *et al.* reported that CAUTIs were the most common DA-NIs (42.2%) followed by CLABSIs (38.5%) and VAP (19.3%) in adult ICUs of the Saudi Aramco Medical Services Organization [6].

Other studies have shown that NIs are particularly high in certain areas of hospitals, such as radiology departments, where there is interaction with large numbers of patients from all areas of the hospital [6]. Studies have confirmed that radiographic equipment, accessories and procedures can cause the spread of NIs [7].

Healthcare services worldwide are also affected by an escalating financial burden associated with increased patient morbidity and mortality due to healthcare-associated infections [8]. Approximately a decade ago, the UK National Health Service's annual expenditure on NIs was one million pounds sterling [9]. During the same period, 1.7 million hospitalized patients in the United States of America developed NIs, resulting in 98,987 deaths [10].

The radiology department provides imaging services to patients from different departments of the hospital. The radiology department has been documented to facilitate the transmission of several healthcare-associated pathogens, including Vancomycin-Resistant Enterococci, *Clostridium difficile*, *Acinetobacter* species, Methicillin Resistant *Staphylococcus aureus* (MRSA) and Norovirus [11]. Therefore, radiology contributes significantly to the potential spread of nosocomial infections.

This study was conducted to determine if radiographic equipment and accessories increased the risk of contracting an NI, to identify the nosocomial bacteria most commonly found on X-ray units in four departments and to assess the effectiveness of routine daily disinfection practices on the control of microorganisms in X-ray units. Findings from this study will help hospital infection control departments in reviewing their hygienic improvement plans.

2. Methods

All X-ray equipment and accessories from four diagnostic imaging departments at different hospitals in Riyadh were swabbed. Accessories, such as X-ray couches, chest stands, X-ray cassettes/imaging plates, handles of X-ray tube heads, control panels, and/or exposure buttons, were first swabbed with sterile swab sticks. The swab sticks and swabbed surfaces were dry; therefore, they were moistened with a nutrient broth. Then, the entire surface of the radiographic apparatus and accessories were swabbed with a rolling motion. Swabs were taken three times a day at the same time (morning, noon, and evening) for five consecutive days. The swabs were transported to the microbiology laboratory for culture and identification using standard biochemical tests. Samples collected at different times of the day were compared using paired t-tests [12]. All statistical analyses were performed using SPSS for Windows software (version 16.0; SPSS Inc., Chicago, IL, USA), and $P \leq 0.05$ was considered statistically significant. The study protocol was approved by the King Saud University Scientific Committee (ethics number: CAMS 063-3839).

3. Results

A total of 180 swab samples were collected from X-ray equipment and accessories in four diagnostic imaging departments. Bacteria were isolated from 65 swabs (36.1% swab samples); three bacterial isolates (4.6%) were obtained in the morning, 16 (24.6%) at midday, and 46 (70.7%) in the evening (**Table 1**).

Table 1. Timing of bacterial isolation and percentages.

	Morning	Midday	Evening	Total
Cultured isolates, n	03	16	46	65
Isolates, %	04.6 %	24.6 %	70.7 %	

The bacteria isolated from four different diagnostic imaging departments were:

From the first department, only *Staphylococcus aureus* and *Staphylococcus epidermidis* were isolated. From the second department *Escherichia coli*, *Staphylococcus aureus*, and *Staphylococcus epidermidis*, were isolated. From the third and fourth department *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Klebsiella* spp. were isolated.

The number of bacterial isolates in the samples from the fourth and third diagnostic imaging departments (n = 23 and n = 19, respectively) was higher than the numbers of bacterial isolates in samples from the first and second diagnostic imaging departments (n = 12 and n = 11, respectively). *E. coli* was the most commonly isolated bacteria (n = 34; 52.3%) followed by *S. aureus* (n = 20; 30.8%), *S. epidermidis* (n = 6; 9.3%), and *Klebsiella* spp. (n = 5; 7.7%; **Table 2**).

Table 2. Bacterial isolates and their prevalence.

Bacterium	Prevalence, n	Percentage
Escherichia coli	34	52.3
Staphylococcus aureus	20	30.8
Staphylococcus epidermidis	6	9.3
Klebsiella spp.	5	7.7

There were significant differences in the prevalence of bacterial isolates between morning and midday samples, midday and evening samples, and morning and evening samples at all four hospitals, ($P < 0.001$) (**Table 3**).

Table 3. Comparison of the prevalence of bacterial isolates collected at different times in four radiology departments.

	Comparison	Paired *t*-test (P-value)
All hospitals	Morning vs midday	$\alpha = 0.000$ - significant difference
	Midday vs evening	$\alpha = 0.000$ - significant difference
	Morning vs evening	$\alpha = 0.000$ - significant difference

There were no significant differences between the samples collected in the morning and those collected at midday or between those collected at midday and those collected in the evening at hospitals 1 and 4, ($P = 0.082$, $P = 0.719$) respectively (**Table 4**).

Table 4. Comparison of the prevalence of bacterial isolates obtained at different times in four different hospitals.

	Comparison	Paired *t*-test (P-value)
Hospital 1	Morning - midday	$\alpha = 0.082$ - no significant difference
	Midday - evening	$\alpha = 0.009$ - significant difference
	Morning - evening	$\alpha = 0.000$ - significant difference
Hospital 2	Morning - midday	No difference at the sample level
	Midday - evening	$\alpha = 0.000$ - significant difference
	Morning - evening	$\alpha = 0.000$ - significant difference
Hospital 3	Morning - midday	No difference at the level of sample
	Midday - evening	$\alpha = 0.000$ - significant difference
	Morning - evening	$\alpha = 0.000$ - significant difference

Continued

Hospital 4	Morning - midday	$\alpha = 0.000$ - significant difference
	Midday - evening	$\alpha = 0.719$ - no significant difference
	Morning - evening	$\alpha = 0.000$ - significant difference
All hospitals	Morning - midday	$\alpha = 0.000$ - significant difference
	Midday - evening	$\alpha = 0.000$ - significant difference
	Morning - evening	$\alpha = 0.000$ - significant difference

4. Discussion

The radiology department and its equipment are a potential source of NIs including patients; who act as a source of infection and are susceptible to infection, or both [7] [13]. Research has shown that radiology equipment and its accessories are potential sources of pathogens that can cause NIs and are ideal vectors for the transmission of pathologic organisms from one patient to another [14] [15].

The current study confirmed that X-ray equipment and accessories harbor nosocomial bacteria. Additionally, our results showed that 36.1% of samples were contaminated with bacteria. This percentage is consistent with a study conducted by Ochie *et al.* who reported that the prevalence of bacteria on X-ray equipment and accessories was 47.2% [16]. Findings from the present study demonstrated that *E. coli* was the most commonly identified micro-organism on X-ray equipment and accessories, followed by *S. aureus*, *S. epidermidis*, and *Klebsiella* spp. Results from a similar study revealed that *S. aureus*, *Klebsiella* spp., and *S. epidermidis* were identified in 142 swabs from X-ray equipment and accessories [16]. Moreover, another study found that mobile X-ray cassettes were colonized with *S. aureus*, *E. coli*, *S. epidermidis*, and *Enterobacter aerogenes* [17]. It has also been reported that some nosocomial pathogens, such as *E. coli*, *Enterococcus faecalis*, and *S. aureus*, not only survive for long periods on surfaces, but multiply on X-ray cassettes. These pathogens can be transmitted to patients, radiologic technologists, and other health care personnel [18].

Although the above-mentioned microbes colonize only healthy people, they cause most infections that occur in hospitals [1]. *E. coli* is a commensal bacterium that colonizes the gastrointestinal tract of humans and other mammalian species. Studies have shown that this microorganism can cause many pathologic conditions, including urinary tract infections, septicemia, pneumonia, neonatal meningitis, peritonitis, and gastroenteritis [19].

S. aureus was the second most common bacterium found on the radiographic equipment and accessories in this study. This organism is the most common causative agent of infectious diseases, severe illness, and death in humans [20]. *S. aureus* is part of the normal flora that colonizes the nose and skin in healthy people; however, in some cases, infection can occur, especially in immunocompromised patients [19]. *S. epidermidis* and *Klebsiella* spp. were also isolated in this study. All of these pathogens are a known cause of NIs to most physicians. *S.*

epidermidis and *S. aureus* are potentially harmful because they colonize the skin as normal flora, but they can invade the body and progress to infection in certain circumstances, such as in immunocompromised patients and those with skin wounds or surgical wounds [21]. Patients who suffer from chronic pneumonia caused by *K. pneumoniae* or *K. oxytoca* may visit the radiology department for chest X-ray examinations [22].

MRSA isolates are resistant to the antibiotics used to treat staphylococcal infections. MRSA is a major cause of skin, wound, soft tissue, respiratory, endovascular, and hospital-acquired infections [20] [23]. This organism is transmitted via direct contact, open wounds, and contaminated hands [1] [19] [24]. MRSA was not tested in this study but should be tested in future studies.

In our study, pathogenic bacteria were found on radiographic equipment and accessories, confirming that the sterilization methods used were inadequate. This study also demonstrated a correlation between collection times and bacterial growth. Bacterial counts were higher in the evenings than in the mornings, suggesting that a reasonable decontamination protocol was used after working hours but not between patients.

This finding underscores the importance reducing the potential risk of transfer from equipment to patient. One limitation to this study is its dedication to isolation of bacteria only, further work to include fungal cultures is needed. Given the high demand for diagnostic imaging, we recommend that all radiology departments implement a time-efficient protocol for equipment decontamination.

5. Conclusion

Current infection control protocols may need to be revised, as the results of this study have shown that further efforts are needed to reduce NIs; the frequency of disinfection should be increased to limit the transmission of infections in hospitals. Radiographic equipment and accessories should be properly disinfected immediately before and after use.

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Declarations

Ethics approval and consent to participate:

Experimentation guidelines:

- Accessories, such as X-ray couches, chest stands, X-ray cassettes/imaging plates, handles of X-ray tube heads, control panels, and/or exposure buttons, were first swabbed with sterile swab sticks.

- The swab sticks and swabbed surfaces were dry; therefore, a nutrient broth was used to moisten them.
- The whole surface area of the X-ray equipment and accessories was swabbed using a rolling motion.
- Triplicate sample swabs were collected three times daily at the same time (morning, midday, and evening) for five consecutive days.
- The swabs were taken to the microbiology laboratory for culture and identification using standard laboratory.

The study protocol was approved by the King Saud University Scientific Committee (ethics number: CAMS 063-3839).

Authors' Contributions

LFH and EHM devised and designed the study and contributed to both the preliminary manuscript and the final draft. MEZ contributed to the preliminary manuscript and supervised data collection, lab work and analysis and interpreted the data. HTA drafted the first draft. SA and HS contributed to both the preliminary manuscript and the final draft. All the authors read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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