An investigation of infection control for x-ray cassettes in a diagnostic imaging department

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Abstract
Introduction: This research was conducted to investigate if X-ray cassettes could be a possible source of pathogens capable of causing nosocomial infections, and if they could be a possible vector for cross infection within the hospital environment.

Method: The research involved the swabbing of X-ray cassettes in a Diagnostic Imaging Department of a large hospital in the east of England. Two areas of the Diagnostic Imaging Department were included in the study. Research concentrated on X-ray cassettes used for mobile radiography, accident and emergency and inpatient use. Forty cassettes were swabbed in total specifically for general levels of bacterial contamination, also for the presence or absence of methicillin-resistant Staphylococcus aureus (MRSA). A mapping exercise was completed following the location of an X-ray cassette typically used in mobile radiography. The exercise noted the level of direct contact with patient’s skin and other possible routes of infection.

Results: The results demonstrated that there were large levels of growth of samples taken from cassettes and developed in the Microbiology Department. Coagulase-negative Staphylococcus, Micrococci, Diptheroids and species of Bacillus were all identified. The mapping exercise in which the journey of a 35/43 cm cassette used for mobile radiography was tracked found that contact with patient’s skin and potential pathogens or routes of cross infection was a common occurrence whilst undertaking mobile radiography.

Conclusion: The research has identified the presence of bacterial contamination on cassettes. The research established that X-ray cassettes/imaging plates are often exposed to pathogens and possible routes of cross infection; also that patient’s skin often comes directly in contact with the X-ray cassette/imaging plate. The research also shows that as cassettes/imaging plates are a potential source of cross infection, the Diagnostic Imaging Department may be partly responsible for adding to the transference of pathogens around the hospital.

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Introduction

A hospital-acquired or nosocomial infection is one which a patient develops during hospitalisation which was not present or incubating at the time of their admission. Hospital-acquired infections (HAIs) are a significant drain on NHS resources and the Government Stationery Office (2000) reported that 9% of people acquire an infection whilst hospitalised. The Department of Health has reinforced these findings by stating that 100,000 people a year contract an infection whilst in hospital. The cost of these infections is estimated at £150 million per year.2 The London School of Hygiene Survey3 reported that patients with hospital-acquired infection remained in hospital an average of 11 days longer and cost on average £2917.00 per patient more than uninfected patients.

Infection control is fundamentally about preventing the transmission of infection throughout the hospital, and is regarded as an essential part of clinical practice. There has been massive investment in infection control plans since the NHS Plan5 when £68 million pounds was invested in hospital cleanliness. In 2001, the first ever cleaning standards for the NHS were issued and patient forums known as Patient Environment Action Teams were set up to assess and monitor the cleanliness of hospitals and considerable improvement has been noted.6 Controlling current and emerging antimicrobial-resistant pathogens has become one of the most important and controversial challenges in healthcare epidemiology.7

The diagnostic imaging department is central within the hospital to the diagnosis of illness and disease. It deals with a large cross-section of patients who may be susceptible to the transference of infections, and as such plays an integral part in infection control. Patients presenting to the department may be post trauma, post theatre, or have a compromised immune system. Patients’ skin will often come into direct contact with X-ray cassettes during examinations. One study found that 33% of X-ray cassettes used for diagnostic imaging were contaminated with potential pathogens, most of which were identified as Staphylococcus aureus.8 Diagnostic procedures provide a number of very efficient artificial direct routes for the introduction of microbes to cause iatrogenic infections.9

‘Hospital-acquired infections’ and ‘nosocomial infections’ are often used synonymously in the literature. Colonisations and infections are caused by microbes which are made up of bacteria, algae, protozoa, and fungi or by members of a group of infectious agents called viroids or prions. Every human is host to an enormous number of microbes. Among these microbes, bacteria cause most of the infections that develop in hospital.8 Such infections may begin when microbes present on colonised surfaces spread to invade other areas. Microbes usually fail to gain a foothold, but sometimes establish themselves and begin to multiply on the host. If the host does not react, the microbe is regarded as a non-pathogen and becomes commensal as part of the host’s normal flora. If the host reacts in an observable way, an infection is established and the microbe is regarded as a pathogen.9

Many studies have demonstrated that the hospital environment frequently becomes contaminated with pathogenic microorganisms. Nosocomial infections need a vector by which to be transmitted.7 Direct contact is one of the main ways of transmitting bacteria between patients and members of staff. A study which examined the frequency of pathogens on the hands of investigators after direct contact with patients, found that hand imprint cultures were positive for one or more pathogens, including Staphylococcus aureus and vancomycin-resistant Enterococcus for 53% of the time.10 Similarly, another study demonstrated that nurses frequently acquired MRSA on gloves after touching surfaces near patients.11 Studies such as these demonstrate the potential for the spread of pathogens in this way, although it must be acknowledged that the patients used in the studies were known to be colonised with pathogens.

The potential for cross infection in the diagnostic imaging department was recognised during an investigation of the microbial cross-contamination potential during mobile X-ray examinations.12 It was found that mobile X-ray cassettes were colonised with Staphylococcus aureus, E. coli, Staphylococcus epidermis and E. aerogenes and concluded that that most pieces of equipment used in the department could act as possible reservoirs for bacteria and fungi. Swain and Flinton13 undertook a study to investigate whether potential pathogens were present on the patient contact surface of cassettes, and to establish which cleaning agents would be most effective in removing them. The findings reported that 33% of cassettes were contaminated with potential pathogens, most of which were identified as Staphylococcus aureus and Streptococci. The alcohol wipes were found to be 100% effective at eradicating bacteria from cassettes. The study concluded by recommending the cleaning of cassettes after each patient contact in order to reduce any risk of cross infection. The study does not prove that cross infection occurs via the X-ray cassettes, but it does demonstrate the possibility that populations of bacteria do exist, and that cassettes can be a host for these bacteria.

In a study undertaken to determine the life span of three nosocomial pathogens, Escherichia coli, Enterococcus faecalis and Staphylococcus aureus on X-ray cassettes13 it was concluded that that pathogenic bacteria can not only survive for long periods, but also multiply on X-ray cassettes. In this study, the bacteria were directly inoculated onto the cassettes and cultured for a period of two weeks in the Microbiology Department. After this period, the cassettes were recorded as having confluent growth, i.e. specific colonies could not be counted due to the large amount of bacterial growth. The X-ray cassettes used were subject to a high turnover of handling and use, which may have affected how potential bacteria would develop. It was also observed that the cassettes had minimal airflow, were stored in a horizontal position and the bacteria had been cultured under laboratory conditions. This does not reflect reality as in practice, X-ray cassettes or imaging plates in a diagnostic imaging department are often stored vertically, subject to increased airflow and at lower temperatures.

The Department of Health has commissioned a national evidenced-based set of guidelines for preventing healthcare associated infections. The Epic Project14 has developed...
principles of good practice and amongst the recommendations is that each piece of equipment used for more than one patient should be cleaned following each episode of use. Even an approach such as this can be ineffective if departments are not being given sufficient or correct materials for satisfactory decontamination. This was demonstrated by a study which highlighted widespread contamination of seemingly clean X-ray cassettes, with 42% of cassettes testing positive for traces of blood, a known portal of exit (i.e. droplets) in a chain of infection. The study also shed doubt on the effectiveness of alcohol based wipes provided for cassette cleaning as it concluded that ‘alcohol based products were ineffective and inappropriate for cleaning and disinfecting blood soiling, actually appearing to fix blood onto the surface’.

In comparison, another study investigated whether radiology equipment can be a reservoir for microorganisms which subsequently aid the spread of infections to patients. The study took a total of 132 cultures from various areas of the diagnostic imaging department using a swabbing method for data collection. The results showed the presence of coagulase-negative Staphylococcus, Bacillus and Saprophytes on X-ray cassettes. The most common bacterium to be isolated from equipment was coagulase-negative Staphylococcus. These are relatively harmless environmental organisms that are commonly found on the skin but although they do not pose a problem in the majority of patients, they are beginning to be recognised as an important pathogen with their colonisation and subsequent infection of biomedical devices. The study detected a low number of colonies of bacteria on cassettes, with the mean number being 1.6 colonies as opposed to the chest stand which had a mean number of 97 colonies. The study also highlighted that most bacteria isolated were not highly pathogenic but could cause a nosocomial infection if conditions were favourable in the susceptible patient. Studies such as this demonstrate that the quality of infection control care is dependent on risk identification and management within the hospital environment. The majority of the literature highlights that pathogens can grow on inanimate objects, and more specifically, that radiographic equipment including X-ray cassettes can act as a host for these organisms. There is contradictory evidence as to the effectiveness of the alcohol wipes used to disinfect cassettes. All studies however, agree on the need for infection control.

**Method**

This empirical, cross sectional study may be described as a surveillance study. These are often used for the subject of infection control and can be described as ‘the continuing scrutiny of all aspects of occurrence and spread of disease that are pertinent to effective control’. They are also depicted as ‘an effective system based on sound epidemiological principles, and as useful for identifying factors that contribute to hospital-acquired infections’. It is thought that surveillance is the foundation of good practice with regards to infection control.

There are two parts to this study; the undertaking of bacterial swabs from X-ray cassettes, and a mapping exercise in which the journey of a 35/43 cm cassette used for mobile radiography was tracked. Local Trust Ethics and Research and Development Committee approval was granted for this research.

Two areas within the local diagnostic imaging department, ‘Accident and Emergency’, and ‘Inpatients’, were selected to participate in the study. This was due to the high turnover of patients being radiographed who may be susceptible to cross contamination either post trauma, or post theatre, and also because the patient’s skin will often come into direct contact with cassettes in these areas.

Forty X-ray cassettes were swabbed comprising of: one 30/40 cm, nine 35/43 cm, five 35/35 cm, seven 18/43 cm, eight 24/30 cm and ten 18/24 cm. All the cassettes were swabbed by the researcher to ensure consistency of technique. This was undertaken in the morning after a night shift as observational anecdotal evidence suggested that radiographers were often busy during the night and working alone, and thus had less time to clean cassettes.

The swab was moistened in a maximum recovery diluant that enables organisms to grow. It was then swabbed with a rolling motion over the whole surface area of the cassette that comes into contact with the patient. The swabs were then placed immediately into a charcoal transport medium and delivered to the Microbiology Department. Gloves were worn by the researcher and changed between each cassette swabbing to reduce the potential of cross infection between cassettes, and from hands to the swab.

The samples were immediately plated on to Cystine Lactose Electrolyte Deficient Agar plates (CLED) incorporating Tween 80, and Mannitol Salt Oxacillin Agar (MSOX) plates. They were then incubated at 37 °C in 5% carbon dioxide and air for 48 h. CLED Agar plates identify general bacterial infection and MSOX plates look specifically for MRSA. The cultures were read and isolates identified using standardised bacterial methods. This is the method suggested by Cowan and Steels: The Identification of Medical Bacteria and is still the standard bacteriological method used in clinical microbiology. This process was repeated for all cassettes.

After incubation, the plates were read with experienced Microbiology staff supervision and a quantitative assessment obtained of the colonial morphology. Any bacteria present were represented by and recorded as the number of colony forming units. This is a working term used by Microbiology scientists to describe distinct visible populations of bacteria.

The second part of the study involved a mapping exercise. The purpose of this was to track a 35/43 cm cassette during mobile radiography. This cassette size was chosen because it is typically used when mobile X-ray examinations are undertaken. The purpose of this exercise was to ascertain the level of anticipated contact between patients and cassette, the extent of contamination that may occur with this contact, and the susceptibility of the patient. The period for the mapping exercise was one week, chosen to reflect the typical use of an X-ray cassette.

Typically, mobile examinations are carried out in Intensive Therapy Units, Cardiac Monitoring Units and general wards where patients are not able to visit the department due to the need for specialist care. All departments where mobile examinations are carried out were included in the
study except for the Special Care Baby Unit, because a different cassette size is used and it rarely comes into contact with the neonate.

A convenience sample of radiographers was drawn from those already undertaking mobile radiography as part of their duties. Prior to the commencement of the data collection, each radiographer was given an information sheet and consent form to ensure that they were an informed, willing participant. A data sheet was filled out after each mobile X-ray examination to determine if the cassette had come into contact with any potential pathogens or obvious routes of infection. The categories used in the tick sheet were drawn from Horton and Parker’s Infection Control Chain.7

Results and discussion

It is evident from Fig. 1 that 38 out of the 40 (95%) of cassettes swabbed were contaminated with bacteria. The most common bacteria to be isolated were Staphylococcus aureus, Micrococcus luteus, coagulase-negative Staphylococcus aureus and Diptheroids. These microbes do colonise on healthy humans, however, these bacteria cause most of the infections that develop in hospital.9 Methicillin-resistant Staphylococcus aureus was tested for, but not identified on any of the cassettes.

Of the cassettes swabbed, the highest level of bacteria was found on a 35/43 cm cassette as shown in Fig. 1. This is the largest and most commonly used cassette in mobile X-ray examinations. The greater level of bacterial contamination may be due to a number of factors:

- The size of the cassette may inhibit a thorough cleaning.
- Frequency of use.
- The type of exposure the cassette gets to bacteria when used.
- This cassette size has a greater surface area to harvest bacteria.

The 35/43 cm cassette often comes into direct contact with patients’ skin when undertaking chest X-rays particularly on males. The highest colony count on this size cassette was 194 colony forming units. Microbiologists suggest that a colony count approaching 100 is considered to be heavy contamination and therefore, the results demonstrate that five of the cassettes are in this category. The high colony counts indicate that the cassettes have not been cleaned effectively therefore, this has infection control implications for the diagnostic imaging department.  

Staphylococcus aureus was one of the most common bacteria located on the swabbed cassettes. This is inevitable since it does form part of the skin’s natural flora and is found in up to 40% of healthy people. It has been found in several studies that if cassettes were routinely cleaned with alcohol wipes after each patient, then the presence of this organism could be significantly reduced.5,12,18 However, it is important to note that it has been found that alcohol based products were ineffective and inappropriate for cleaning and disinfecting cassettes soiled with blood.15

Coagulase-negative Staphylococcus aureus was also identified in the swabbing exercise. As discussed, this is an organism that is not highly pathogenic but still has the ability to cause nosocomial infection. The presence of Staphylococcus aureus is an infection control issue. It is being recognised as an important pathogen that can colonise and cause infection of biomedical devices.19

The 35/43 cm cassette is most often used in mobile X-ray examinations. Three of the cassettes samples of this size had a colony count defined as heavy contamination (100–194), although it did not have the highest mean colonies per cm2 (Fig. 2). The results of the mapping exercise in Fig. 3 demonstrate that the cassettes came into contact with patients’ skin in 25% of mobile examinations. Since the highest colony counts were identified on this size of cassette, it would appear to pose a risk of being a vector for cross infection, especially with patients in areas such as Intensive Therapy Units. This theory is reinforced by a study which identified that most pieces of equipment in the diagnostic imaging department were possible reservoirs for bacteria, including the discovery that X-ray cassettes used for mobile radiography were colonised with Staphylococcus aureus.12 The second highest colony count came from a 30/40 cm cassette. However, only one cassette was sampled and therefore this provides an unrepresentative sample for the results as no comparison can be drawn between cassettes.

The third highest colony count came was on the 18/24 cm cassette. This size of cassette is the most commonly used for extremity examinations, therefore the colony count may be due to high numbers of organisms on the hands or feet of patient as these will often come into direct contact.
with these cassettes. This is evidenced in Fig. 2 which demonstrates that the 18/24 cm cassettes had the highest mean colony count of 0.1 per cm². The fourth highest count was a 35/35 cm cassette, typically used when chest X-rays are undertaken on women. Although, one of these cassettes had a colony count of 150, the others sampled were comparatively low. It is usual with chest X-rays that light clothing or a hospital gown is worn, so direct patient skin contact is low. It has been suggested that because pathogens such as MRSA have the potential to shed into the dry environment, that contact with hospital gowns or patient’s clothing still has the potential to harbour pathogens and potentially spread them on to X-ray cassettes. The fifth highest colony count was on the 24/30 cm cassettes. The least number of colonies were taken from the 18/43 cassettes. This size of cassette is typically used when undertaking X-ray examinations of the lumbar and thoracic spines. The cassette is only used in the Bucky part of the X-ray table and rarely comes into contact with the patient. This may explain why there are low colony counts from this type of cassette. This would directly contrast with studies suggesting that colonisation may be a question of poor infection control on the hands of healthcare workers rather than the radiographic cassettes or films.

The mapping exercise figures were taken from 28 mobile X-ray examinations conducted over a one-week period by fourteen radiographers in total. From these 28 examinations, there were 32 separate occasions when the cassette came into contact with one of the listed categories.

From the categories illustrated in Fig. 3, five represent physical barriers which include: no contact, gowns, sheets, pillowcases, and clothing. This accounted for 31.2% of contact, again highlighting the potential for pathogens to shed into the dry environment and survive; thus indicating that cassettes should be routinely cleaned before each use. Contact in some form between the patient and the cassette, providing a direct route of transmission of pathogens, represents 68.8%, highlighting that contact between patient and cassette is more likely than not.

Direct contact with patient skin was the single highest percentage category at 25%. Contact with skin is only a problem if there are open wounds, or if the patient is immunosuppressed. The “no contact category” was defined on discussion with the radiographers, and accounted for cassettes that were used in the trays built into certain hospital beds to allow for minimal patient contact when X-ray examinations are undertaken. This occurred in 12.5% of examinations. 43.8% of cassette contact was with open wounds, urine, faeces, blood, known MRSA patients, and patients with known infectious conditions providing routes for the transmission of pathogens. This clearly demonstrates the potential for these organisms to be transferred onto the cassette. The use of disposable and impervious cassette covers would avoid direct contact between patient and cassette and therefore reduce routes for transmission of infection. In addition, an effective method for cassette cleaning and decontamination is essential to ensure that cross infection is kept to a minimum.

In conclusion, this research has identified that bacteria, including potential pathogens such as Staphylococcus aureus were present on a number of X-ray cassettes. It also demonstrated the potential for these organisms to be transferred via a 35/43 cm X-ray cassette, to areas where patients are often immuno-suppressed or vulnerable to cross infection. When linking the mapping exercise to the swabbing exercise, it becomes clear that X-ray cassettes have the potential to act as a vector for cross infection between patients and departments.

As a result of this study the following recommendations can be made:

- The use of disposable and impervious cassette covers is recommended for X-ray examinations of all ward patients.
- An effective method of cleaning should be established using a suitable cleaning agent to ensure effective decontamination of all X-ray cassettes.
- A six monthly swabbing audit should be undertaken on a range of X-ray cassettes.
- A mapping exercise using a larger sample size should be undertaken to identify levels of contact with patient’s skin, pathogens and routes of infection.
- An investigation should be undertaken into the current methods of infection control used by staff in order to identify any future training needs.

References


