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Introduction

Infection within healthcare has been in the news and has become a high priority recently, particularly as some infections are becoming harder to treat. The resistance of antibiotics and other antimicrobial agents have been reported on along with concerns regarding the rise of methicillin resistant Staphylococcus aureus (MRSA) [1]. Staphylococcus aureus is one of the most common of all bacteria and can cause superficial infections of the skin and serious infections [2]. Epidemic strains exist, which spread easily from person to person and can cause ward closure and disrupt hospital services [3].

Infection control is a high priority within the National Health Service (NHS). Since 2000 over £68 million has been invested nationally in infection control [4]. The risk of infection acquisition in hospital is also seen as an important quality indicator, a measure of the quality of management, clinical and other support functions affecting a patient’s outcome. Prevention is vital to ensure that services provided are of a high standard [2]. Clinical governance is central to this, ensuring that quality of services is continuously improved, upholding high standards of care and creating clinical excellence [2]. Infection control programmes are important measures that should be applied consistently in everyday practice [5].

The Department of Health (DH) code of practice is there to help the NHS plan and implement measures to control and prevent infection. It contains certain core policies that must be followed [5]. Audit should be carried out to ensure that key policies and practices are being implemented and should be revised and updated as appropriate [5]. Mandatory surveillance should also take place. A national surveillance scheme has been set up with the aim of improving patient care by providing information and national statistics on specific types of infection to compare with local results [1].

The purpose of this study was to determine in a radiological setting if infection control is being undertaken sufficiently. The specific area looked at was the cleaning of lead rubber aprons.

Literature Review

Infection Control and Hospital Acquired Infections

Infection control in hospitals is concerned with decontamination; this prevents microorganisms reaching a susceptible site in sufficient quantities to cause infection or potential harm to patients [6].

Hospitals can become contaminated with organic matter and potentially infectious organisms and a safe environment can only be achieved by decontamination in the form of cleaning, disinfection and sterilization, breaking the chain of infection [7].

A major reason for the importance of infection control is to prevent the occurrence of Nosocomial or Hospital Acquired Infections (HAIs). These are infections that occur during a patient's stay in hospital which were not present or incubating at the time of admission [2]. In contrast to community acquired infections these infections usually occur as a result of pathogens taking advantage of patients whose normal defences against infection are contravened [2]. HAIs cost the NHS up to £1 billion a year; due to patients' increased stay, drug therapy in the form of antibiotics and additional or repeat surgery [1].

The Role of Microorganisms

It is not possible to completely eradicate microbes from a hospital environment but the aim should be to reduce the number of microbes present and remove substances that support their growth [7]. Microorganisms that cause disease are referred to as pathogenic organisms and these include amongst others, bacteria, viruses and fungi [7]. Bacteria are the largest cause of HAIs, and pathogenic bacteria usually grow most rapidly under environmental conditions found in the human body. One reason for this is due to the fact that water is essential to the growth of bacteria. However, some bacteria such as Clostridium difficile, which causes diarrhoeal infections, can, in the absence of water form spores which mean they are able to survive for long periods in an environment. They are then able to recommence their multiplication when a source of moisture is accessible [7, 2]. These organisms can survive in dust and so the prevention of dust accumulation is an important infection control measure [2].

The Diagnostic Imaging Department and Infection Control

The diagnostic imaging department (DID) within the hospital deals with a wide variety of patient groups including the very young, elderly and immuno-suppressed. Many of these are susceptible hosts for micro-organisms and are at greater risk of infection [7].

A patient being examined in the DID will come into contact with various types of radiographic equipment. Fox and Harvey [8] carried out a mapping exercise upon an imaging receptor used in mobile radiography over the course of one week and found that during examinations the imaging receptor came into contact with the patient 68.8% of the time, 25% of the time this contact was directly with the patient's skin. On culturing swabs from a number of cassettes they found that 38 cassettes of the total of 40 in their study were contaminated with bacteria, the most common being Staphylococcus aureus. They concluded that imaging receptors were acting as reservoirs for cross infection, this is compounded by the fact that mobile radiography is commonly undertaken in areas where patients are likely to be immuno-suppressed or vulnerable to infection risks [8].

Swain and Flinton [9] also undertook a study into whether X-ray cassettes could be a cross-infection risk. All 20 swabbed cassettes were found to have Coagulase-Negative Staphylococci present; six were contaminated with Staphylococcus aureus and one with MRSA.

Smith and Lodge [10] investigated the DID's role in the transmission of microorganisms. They argued that the DID is one of the only departments in the hospital where different patient types wait together and that this increases the potential for microorganisms to be transmitted between patients and via personnel and equipment. In this study cultures were taken of 44 potential fomites within the DID. It was found that 50.7% of these grew no microorganisms, with 49.3% growing a range and number of organisms. Staphylococcus aureus was found on a number of pieces of equipment, along with Bacillus and most commonly Coagulase-negative Staphylococcus which is part of normal skin flora but is prevalent in the contamination of biomedical devices [10]. Lead rubber aprons in both A&E and the Special Care Baby Unit (SCBU) were also highlighted as being contaminated with bacteria. The bacteria isolated on the equipment in this study suggested that it is possible for radiographic equipment to become a reservoir for cross infection which could go on to cause HAIs in favourable conditions. Hodges [11] found that the adhesive tape used by radiographers to attach their markers onto an imaging receptor was also a potential fomite. Twenty four cultures were taken and a range of bacteria were present. Staphylococcus aureus was found most extensively. No MRSA was identified but it was concluded that the potential for its presence was there. Although this was a small study it does highlight that this problem may exist in other DIDs.

Lawson et al [12] determined that it is possible for bacteria to survive for long periods on radiographic imaging receptors. Another study which looked into the bacterial survival on adhesive tape used on radiographic markers was carried out in a more natural setting allowing for contamination to occur from the environment. This study also suggested that growth had increased after two weeks when compared to one week, suggesting that survival rates were good [11].

These studies suggest the importance of infection control within the DID. The DH [13] sets out principles of good practice in regards to infection control. Each piece of hospital equipment used for more than one patient should be cleaned following each use.

One study [14] however, looked directly at infection control in the DID and in questioning a number of radiographers it was found that 88% of them suggested that radiographic equipment was not cleaned on a regular basis. 10% estimated that it was done monthly and 7% suggested it was not carried out at all, 67% of the radiographers stated that they cleaned the equipment personally and those that didn't suggested it was due to the fact that there were no set protocols or due to time constraints. Some would only clean it when it came into contact with bodily fluids and this was especially so for imaging receptors and lead rubber aprons, 10% of radiographers did not clean lead rubber aprons at all. Healthcare professionals attitudes towards infection control is the reason that it is not being carried out sufficiently [15]. As both of these studies were carried out at one hospital only, it may be that there were additional factors present which affected the attitudes of the radiographers and the findings can not be generalised to other DIDs. However, it is questionable if this cleaning is apparent in other DIDs.

Lead Rubber Aprons

There is little literature relating directly to infection control and lead rubber aprons. Lead rubber protection is an essential piece of radiographic equipment, used to minimise the radiation exposure to those involved in medical imaging including radiographers, patients and their escorts. Lead protection is used by radiographers and other staff, most notably in theatre work and fluoroscopy where it is usually not possible to use other forms of lead protection.

From the literature it may be inferred that lead rubber aprons have the potential to become reservoirs for cross infection. Lead rubber aprons should be included in routine cleaning procedures, but findings also suggest that this routine cleaning may not be undertaken sufficiently.

Statement of Purpose

Aim

To establish whether lead rubber aprons can become contaminated with micro-organisms and become a potential reservoir for cross infection and if simple, regular cleaning can significantly reduce this cross infection risk.

Objectives

1) To determine whether there is currently a detectable presence of micro-organisms on a sample of lead rubber aprons.

2) To determine any presence of micro-organisms following recommended cleaning with detergent and water and therefore also establish a standard to compare to future practice.

3) To evaluate the findings and make suggestions for future practice, including recommendations for re-audit.

Methodology

Due to the lack of research in this area, this study has been carried out in order to establish if lead rubber aprons can be a reservoir for infection.

Trust policy in the department audited reinforces these recommendations and states that radiography equipment should be cleaned with detergent and hot water. The detergent used is Hospec general purpose neutral liquid detergent. These recommendations are clearly set out for radiographers to follow.

This study took the form of a quantitative clinical audit in one clinical centre. An audit tool was designed, consisting of structured criteria, stating the number, location within the department and identity of the lead rubber aprons to be used in the sample. The location of the areas on the aprons to be swabbed and the number of swabs taken was also identified (see Figure 1).

Fifteen lead rubber aprons were swabbed, from different areas within the department. These included general X-ray rooms for inpatients and outpatients, theatre, mobile radiography and those in the intensive care unit and SCBU. Randomisation of the sample was not practical, as it was necessary to ascertain data from each area. It was possible to swab all of the lead rubber aprons from the main department and those used for mobile radiography. For the lead aprons used in theatre a convenience sample was drawn (of half the aprons) as these aprons were in use more often. Each apron was marked with a unique identification.

Each apron was swabbed to determine the current level of microorganism contamination. Following observation in practice and discussions with radiographers it was decided that the aprons should be swabbed on the underside of the shoulders as this area is always grasped when handling aprons and on the upper side at the front in the middle of the apron as it was felt this area comes into substantial contact with patients and beds. A template ensuring that each apron was swabbed in the same place was rejected as each apron was of a different type with varying sizes. A template could also have introduced or passed on infection. It was decided to take two swabs from each area in order to culture the samples at both room temperature and 37° (body temperature) because different microorganisms grow at different temperatures [2]. It was decided just to concentrate on these two locations, and not other parts of the aprons that can be touched.

Swabbing was carried out with Tryptic Soy Agar contact plates which are used to sample flat surfaces of equipment. They consist of a domed surface which is placed gently upon the area causing any microorganisms to be transferred onto the agar [16]. Each plate sampled the general bacterial presence of a $16cm^2$ area of the lead rubber apron [16]. Each sample was taken by the author, wearing new disposable gloves for each apron, minimizing cross-contamination. The plates were taken to the microbiology laboratory for culturing.

The current level of microorganism contamination on the sample of lead rubber aprons is known as baseline data, which provides an initial starting point from which the audit can progress [17]. It is important that baseline data is collected in the same way as future data so that comparisons can be made [17].

Following the collection of baseline data, each lead apron in the sample was cleaned according to recommended guidelines and swabbing was repeated. Data collected from this part of the audit was to identify a standard to compare to future practice and any future audit. This standard is important as a means for comparison between an accepted standard and the effectiveness of the infection control carried out on the lead rubber aprons within the department. This is especially important, as under normal circumstances it is not possible to completely eradicate all micro-organisms. In this particular case, comparison was made between the presence of microorganisms at the baseline stage with the absence of cleaning and with the presence of recommended cleaning. The investigation was of a matched or paired design, this is used to compare results on the same subject over time or in differing circumstances.

Trust policy recommends that radiography equipment should be cleaned with detergent and hot water; this was the type of cleaning performed in this audit. Future audit will always be compared to the standard to monitor if this recommended cleaning is being undertaken in future.

The acquisition of statistical data was achieved by determining the number of micro-organism colonies or colony forming units present once culturing had taken place for four days. A systematic data collection sheet was designed for this in order to reduce bias and increase validity [17].

Ethical issues

There were no participants within the study, and therefore ethical approval was not required. All members of staff who may have had any involvement remained anonymous. Permission was granted by the manager of the DID.

Results

Raw data for this audit is summarised in Figures 2, 3 and 4. Figures 2 and 3 both demonstrate that all lead rubber aprons pre-cleaning were contaminated with microorganisms. Figure 2 shows pre and post cleaning results for location A with apron HB2 contaminated to the greatest extent with 16 colony forming units per cm^2. This apron was found within one of the general X-ray rooms. Both HB4 and HB10 had 9 colony forming units per cm² and were from inpatients and A&E, and the intensive care unit. Figure 3 shows pre and post cleaning results for Location B with Apron HB3 being the most highly contaminated with 10 colony forming units per cm², an apron used in mobile radiography.

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Figure 5 shows where all of the lead rubber aprons used in the study came from.

Post cleaning data demonstrates that on most of the lead rubber aprons the number of colony forming units was reduced after cleaning. At location A; aprons HB7, HB9 and T1 had less than 1 colony forming unit per cm² of microorganism growth, from the general X-ray room, SCBU and theatre. At location B aprons HB7, HB8, HB10, T1, T2, T3, T4 and T5 had less than 1 colony forming unit per cm² from the general X-ray room, SCBU , intensive care unit and theatres.

The undertaking of a t-test on the pre and post-cleaning data suggests that the difference between the number of microorganisms present pre and post cleaning is significant (Location A - P= 0.00018, Location B - P = 0.00725).

All plates were inspected by microbiology staff to identify the range of microorganisms present. Species of microorganisms found across the samples included most significantly Gram positive cocci in the form of

Staphylococci both coagulase positive and negative, this pertains to whether they produce the enzyme coagulase which clots plasma, Bacillus, Fungi and Diphtheroids.

All plates when checked for MRSA, this was negative across all plates.

Figure 4 compares the post – cleaning results of Location A and Location B. Location B is demonstrated as having lower levels of microorganisms post cleaning than location A. On carrying out a t-test on this data this difference was also found to be significant (P = 0.00028).

Discussion

Despite the fact that no MRSA was present upon the lead rubber aprons sampled, microorganism growth was found on all aprons. This compares with other studies [8, 9, 10, 11] which also found bacteria akin to those in this audit within other DIDs in the UK, reinforcing that this may be a nationwide problem worth investigation.

Coagulase negative staphylococci are found as normal skin flora and include for example Staphylococci epidermis. These bacteria rarely cause infection [2, 6]. It has however recently been recognised that Staphylococci epidermis can be an important cause of HAIs as it produces an extracellular polysaccharide, a type of slime that enables it to adhere to plastics and metals [2, 18]. The potential here is that it has the ability to cause infections associated with invasive devices such as catheters and orthopaedic joints (post recent surgery)[18]. Staphylococci also have a natural resistance to many antibiotics which also makes these infections difficult to treat [3].

Staphylococcus aureus was also identified and is a coagulase positive staphylococci. One third of the population carry it on their skin or in their nose and throat asymptomatically [3]. However, it is an important pyogenic pathogen, causing pus to form, which can cause a range of superficial infections of the skin if it penetrates the dermis such as septic spots, boils and abscesses and other more serious problems such as osteomyelitis, septicaemia and pneumonia [2, 3, 18]. It is also an important cause of HAIs, being responsible for around 40-50% of surgical wound infections and approximately 25% of bloodstream infections [2], and is particularly capable of developing resistance to antibiotics. Methicillin resistant strains exist (MRSA), which are found in greatest abundance in the hospital setting as many patients receive antimicrobial therapy and are vulnerable to serious infection [2]. It is also becoming recognised as an important pathogen due to its ability to colonise and cause infection of biomedical devices [1]. Staphylococci released in skin scales will collect in dust and survive for long periods of time in the environment [2].

In addition, other bacteria found were bacillus which are aerobic bacteria that form spores. These come from environmental sources such as soil and dust and infection if it occurs is via contamination of a wound [2, 18]. These bacteria do not usually cause problems in the UK. One previous important bacilli was Clostridium tetani but this is relatively rare now due to immunisation programmes [6]. Diphtheroids also known as Corynebacteria were also found and these are also carried by the population in the upper respiratory tract, mucous membranes and skin [2]. On rare occasions they can cause infections postoperatively following cardiac surgery or to other immunocompromised patients. The main important human pathogen is Corynebacterium diptheriae where infection occurs due to respiratory droplets but in the UK immunisation of children has meant that cases of diphtheria are extremely rare [2].

Fungi was found on three of the plates. These come from environmental sources. There are over 70, 000 species of Fungi of which only a few are pathogenic with most causing superficial infections of the skin, nails and hair [2].

It is impossible to be certain why some aprons were more highly contaminated than others but it may be inferred that these aprons are either used more frequently and cleaned less due to the busy nature of the environment in which they are kept or they are used less often and as a result are left in the environment accumulating dust particles. Further investigation into the extent of use may allow this to be determined. Those aprons with the least contamination were from SCBU and theatre, which are perhaps areas where greater attention is paid to infection control in general.   It may also be that the storage of the lead aprons around the hospital has a link to the infection levels on the aprons due to their exposure to infection in their place of storage.

It can be seen that Location A is both more highly contaminated pre-cleaning and post-cleaning when compared to Location B. This may be because the area on the underside of the shoulders is handled most frequently. However, as it is also more highly contaminated post cleaning it may be due to the fact that on a number of aprons this part of the apron is made from different material to the front of the apron. It may be possible that this material is more appropriate for the growth of microorganism or that an alternative cleaning method may be needed. Swain and Flinton [9] compared the use of soap and water with alcohol wipes and phenolic disinfectant for the infection control of X-ray cassettes and concluded that all cleaning methods had a significant reduction in bacterial numbers. However, the alcohol wipes were found by the authors to be 100% effective, because of this and ease of use they were recommended as the cleaning method of choice. Another study shed doubt on the use of alcohol wipes, forensic tools were used to look for the presence of blood on seemingly clean cassettes and results suggested that if alcohol wipes were used universally to clean cassettes they are ineffective in cleaning any that are blood soiled [19]. There is potential here for further investigation.

Limitations

The small sample size is a limitation of the study. It could not be established if the aprons were cleaned before the study, so there could have been some bias in the sample.

The lead rubber aprons found throughout the department are not identical and it may be possible that the material on the underside of the shoulders on some aprons may harbour microorganisms to a greater extent than others, limiting the consistency of the comparisons made.

Additionally, the fact that the lead rubber aprons were not identical meant that the sampling area could not be the same for all aprons. If the aprons were identical then a template could have been designed to ensure that samples were taken at identical places on all the aprons increasing the reliability of comparisons made.

Another possible limitation was that on some occasions it was not possible to say which side was the front of the apron. On a number of occasions it was observed that aprons were being worn back to front. In this case it will be the back that has the potential to come into contact with the patient and equipment. It was not practicable to swab every part of the lead rubber apron in the same way.

The results from this audit cannot be generalised to other DIDs in the UK, but they can be used to gain further insight into the potential infection control issues that exist with lead rubber aprons.

Conclusion and Recommendations

The results of the audit suggest that the lead rubber aprons were not cleaned effectively. Although the microorganisms identified are quite harmless in the majority of cases, all have the potential to be pathogenic when coming into contact with the variety of patients that present for examination in the DID. This possibility is increased in cases where for example, there are damaged sites of skin such as wounds or cannula insertion sites [2].

An effective infection control policy for the cleaning of lead rubber aprons should be established as an essential method to reduce cross contamination. It can be concluded that cleaning with soap and water as recommended can significantly reduce the number of microorganisms present and it should be carried out routinely. Additionally, it can also be concluded that it is beneficial that aprons should not only be cleaned after each use but also when they have been present in the environment and have become contaminated with dust. Particular care should be taken when cleaning around the shoulder area of the aprons to remove as much contamination as possible.

The findings of this audit should be disseminated to the staff working within the department. Re-audit should be undertaken, using the standard obtained with the collection of post-cleaning data. A possible time frame of six months may be sufficient.

Future research into the potential for infection transmission from other parts of lead rubber aprons could be investigated. Also, further research is needed into the effectiveness of alcohol wipes as a cleaning method.

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