



AEROSOLIZATOR OPTI-JET CS MD1MR A NEW DEVICE FOR BIOCIDAL AEROSOLISATION IN MAGNETIC RESONANCE

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KEYWORDS: Biocide, electrolyzed oxidizing water (EOW), disinfection, microorganisms, OPTI-JET CS MD1MR.

ABSTRACT

Introduction: This work is aimed to represent the use of the OPTI-JET CS MD1 MR prototype for application of neutral electrolyzed oxidizing water (NEOW) in magnetic resonance rooms. **Material and methods:** We produced and used OPTI-JET CS MD1 MR aerosolizer whereby was performed aerosolization. The presence of microorganisms before and after the aerosolization was recorded with the help of cyclone air sampling. Colony formed units (CFU) was counted. **Results:** The number of microorganisms in magnetic resonance room was low as expected. Nevertheless, a possible CFU reduction of 87% was recorded. **Conclusions:** The research has shown that the use of EOW for the air and hard surface disinfection can considerably reduce the presence of microorganisms and consequently the possibility of hospital infections. It has also demonstrated that the use of OPTI-JET CS MD1 MR is very good. With this research we started new guidelines for aerosolization in magnetic resonance rooms. **Future work:** We predict that presented technique works very good but we must focus also on time capacity sensors, and new appropriate toxicological studies.

INTRODUCTION

Pathways and possibility of infection at MRI

The number of inspections and interventions on patients is increasing, while the time required for the disinfection of surfaces, premises and equipment is shortened. With larger microbial loads of surfaces and patients as well as medical personnel are increasingly exposed to microbial contamination, especially by-resistant strains of microorganisms. In doing so, highlighted diagnostic in modern electronic equipment, which is difficult to quickly and successfully disinfected (Aubert et al., 1991; Baffoy-Fayard et al., 2003; Balonov et al., 1999; Buerke et al., 2012; Chaoui et al., 1995; Grabsch et al., 2006). The market does not offer an adequate, reliable, rapid and safe disinfection process 3T magnetic resonance devices. The main factor of successful disinfection is time itself. Selection of a suitable disinfectant is largely dependent on the overall process of disinfection procedure. It basically has a disinfectant reflect the speed of effect and free radicals on the surfaces. On the market, there are more than 250 substances having a biological effect which cause disinfection. On the bigger problem we encounter when we want to use such assets on surfaces in hospitals for hospital-acquired infections such as MRSA (methicillin-resistant staphylococcus aureus) and other infections (Chan et al., 2012; Guerini et al., 2012; Kim et al., 2012; Martinez et al., 2003; Cabanis et al., 2009; Ramli et al., 2009; Bibbolino et al., 2009; Astagneau et al., 1999; Garcin et al., 1998; Cowan et al., 1993). Patient couches of computer tomography (CT) and magnetic resonance imaging (MRI) scanners are very hard to access when it comes to cleaning and disinfection (Cabanis et al., 2009; Kim et al., 2012; Ramli et al., 2009). Consequently, new approaches to disinfection procedures have been studied.

The new biocide electrolyzed oxidizing water and use on MRI

Thanks to its mechanism of action, neutral electrolyzed oxidizing water (NEOW) has been considered as a possible biocide of the new generation (Meakin et al., 2012; Meakin et al., 2011; Wu et al., 2008; Landa-Solis et al., 2005; Vorobjeva et al., 2004). The principle of the NEOW production has been known for some time now. Basically, the alkaline ionized water and acid oxidized ionized water are generated from diluted non-iodised cooking salt (NaCl solution), whereby the alkaline fraction reaches a pH of 11–12, while the acid one has a pH of 1–3. While the alkaline ionized water is considered to have a cleaning effect, the acid one has extremely biocidal effect. Mostly, the effect of the EOW action has been attributed to the pH change only. However, more detailed analysis has revealed that electro-oxidized water works through several mechanisms. Most patients with serious infections typically have some type of imaging procedure performed during the course of their treatment. Radiology departments and outpatient imaging centers must take appropriate action to assure patients that their MRI scanner is not a significant hub for microorganisms capable of causing infectious diseases. However, for a multitude of reasons, MRI suites often lack the most basic of safeguards against infection, where, due to its unique environment, it is extremely difficult to implement and maintain an effective infection control policy (Pintaric et



al., 2015). Because of the dangers from extremely strong magnetic fields (Chaljub et al., 2001), as demonstrated by a well-publicized patient death from an accident in an MRI (ECRI Hazard Report et al., 2001, Peck et al., 2001), housekeeping staff and most cleaning equipment are usually prohibited from entering the MRI suite. The resultant lack of thorough cleaning was clearly demonstrated in a recent study from Ireland that cultured MRSA from within the bore of the MRI system [Understanding MRSA et. al. 2008].

Pathways of MRSA on MRI systems and infection control

MRSA was originally identified in 1961 and is now widespread throughout healthcare facilities, both hospital and outpatient settings (Vorobjeva et al., 2004). The most common source for transmission of MRSA is by direct or indirect contact with people who have MRSA infections or are asymptomatic carriers. In 1972 MRSA accounted for only 2% of all Staphylococcus aureus infections, but now it is responsible for 50 to 70% of these infections (Vorobjeva et al., 2004). MRSA is among those microorganisms commonly referred to as a “super bug”. MRSA may be community associated, CAMRSA, or healthcare associated HA-MRSA (Healthcare-associated infections (HAIs) et al., 2006). The morbidity and mortality of these bacteria is staggering. On average, hospitalizations for the treatment of MRSA versus other infections have a length of stay approximately 3 times longer and are 3 times more expensive (Kihlstrom et al., 2006). Additionally the risk of death is 3 to 5 times greater for patients infected with MRSA versus methicillin sensitive Staphylococcus aureus (Kihlstrom et al., 2006, Wu et al., 2008). A major concern for imaging centers is that MRSA can be carried by asymptomatic persons. Worldwide, it is estimated that up to 53 million people are asymptomatic carriers of MRSA (Martinez et al., 2003; Scanlon et al., 2006); of these it is estimated that 2.5 million reside in the United States. Approximately 1% of the US population is colonized with MRSA (Whitby et al., 2001). Both infected and colonized patients contaminate their environment with the same relative frequency (Whitby et al., 2001). Therefore, any patient lying on an imaging table could be a carrier capable of contaminating surfaces in the radiology suite. MRSA and other pathogens can live on inanimate surfaces including common table pads and positioners for periods as long as several months (Dietze et al., 2001, Hardy et al., 2006; Blythe et al., 1998). The MRI Suite The area of greatest challenge for preventing the transmission of MRSA and other infections in Radiology is clearly the MRI suite. Due to the high magnetic field, posing a danger to both the personnel and to damaging the MRI itself, and to comply with the American College of Radiology recommendations (Blythe et al., 1998) it is the author’s experience, that many free standing imaging centers and hospitals do not allow cleaning crews to enter the MRI suite. Therefore these MRI suites are rarely, if ever properly cleaned. This is a risk to staff and patients because MRSA can be transmitted by contact with contaminated surfaces such as mattress pads (Blythe et al., 1998, Boyce et al., 1997). It has been proven that MRSA can survive on surfaces such as tabletops and charts for up to 11-12 days (Huang et al., 2006). Similarly, Vancomycin-resistant enterococci (VRE) had a 50% survival at seven days on upholstery, furniture and wall coverings and could easily be transferred by touching contaminated surfaces (Lankford et al., 2006). There is an increased risk of VRE/MRSA for patients in the presence of environmental contamination, 5.1% increased risk for MRSA and 6.8% for VRE (Martinez et al., 2003, Huang et al., 2006). There is an increased risk of an MRSA acquired infection for patients admitted to a room that was previously occupied by a patient colonized with MRSA (Huang et al., 2006). At many MRI centers, there exists a false belief that merely placing a clean sheet over the table pads, without actually cleaning them between patients, will prevent the spread of infectious agents. What is most concerning is that very few MRI centers clean their pads even once a day, much less between patients. Cleaning pads during working hours typically has a very low priority, because it is time consuming, decreases throughput and thereby decreases the center’s productivity and negatively impacts the financial well being of the center. Additionally, MRI technologists, especially those who trained in the 1970’s and 1980’s, had little training in infection control or proper cleaning procedures. An average MRI may scan 3,000 to 5,000 patients a year. CT scanners usually scan double or triple that number. The probability is that at least 50 – 100 of these patients are infected with MRSA or other HAI (Cosgrove et al., 2005), and many more are carriers. Another area of potential exposure to infectious agents is the use of IV contrast material for both CT and MRI, which significantly increases the risk of blood contamination. The simple task of removing a needle from a patient’s arm and placing it into the sharps container has great risk. Blood can drip from the needle or from the puncture wound onto the pads, table and floor. This blood can often be unnoticed by a busy technologist or doctor performing the injection resulting in a contamination risk. It is not uncommon to find dried blood in an imaging suite which is an excellent culture medium for MRSA. There is also concern for spreading infectious bacteria by direct or indirect contact among the imaging staff and patients within the imaging department or center. MRSA infections can be acquired by staff members through a simple cut or other break in the skin that may not be noticed during a busy day. Therefore, hand-washing between patients as well as hand sanitizer use for the entire staff is of crucial importance (Boyce et



al., 2002; Delaney et al., 2005, Kihlstrom et al., 2008). Regarding mobile MRI, ensuring proper hygiene is even more difficult since they do not have a sink or running water.

Justification of research

A recent study, from Ireland, confirmed the type of contamination in MRI suites by culturing the Superbug MRSA from the bore of an MRI. This raised great concern, because this is an area that is rarely, if ever, cleaned, but frequently is in very close contact with patients. because of this we have introduced a solution with aerosolizer OPTI-JET CSC MD1 MR and biocide NEOW, which is compatible with the requirements of MRI.

MATERIALS AND METHODS

Objective of research

In research (the possibility of using neutral electrolyzing oxidizing water - NEOW) carried out in 2012 at University Medical centre Maribor Department for Radiology we come to the important positions that indicate the potential for rapid and reliable disinfection without delays on surfaces. Depending on the specific environment in the operation of the device MRI, we consider to introduce, customize and upgrade with the corresponding modified equipment that can be used in an environment with a 3T magnetic resonance energy allowing it to run.

Aerosolizer OPTI-JET CSC MD1 MR

For this purpose we have developed aerosolizer OPTI-JET CSC MD1 MR with special nozzles for cold fogging, which are compatible with 3T energy. The aerosolizer we will set up as part of the device software 3T magnetic resonance taking into account the manufacturer's instructions for magnetic resonance. With the help of the air sampling method we will be tested reliability of the process cold fogging, including air and surfaces disinfection. By placing of OPTI-JET CSC MD1 MR aerosolizer will facilitate the smooth application NEOW in the space of the magnetic resonance device. At regular aerosolization we sampled air and surfaces in magnetic resonance once a month or if necessary several times. By means of taking samples in the area, we will test the reliability of the procedures NEOW cold fogging, which allows for the disinfection of surfaces including air disinfection. To examine the effectiveness of disinfection of air will make a cyclonic air sampling. The importance of cold fog and the possibility of practical application of the modified model OPTI-JET CS MD1 MR is that the aerosolizer is all the time located inside of the magnetic resonance suite.

Aerosolization of air and use of NEOW

To determine the effectiveness of disinfection of air to be performed cyclonic air sampling. However you can use it if necessary without any loss of time. Cold fogging is shown as the method of choice, because this once obscure disinfected and reach the tunnel surface of apparatus, appliances and room air of magnetic resonance. In its search for a possible solution, the Radiology Department of the Maribor University Medical Centre (UKC) decided to test the air samples and the samples taken from the test surfaces of the various types of diagnostic equipment in order to establish the actual condition and the scope of the micro-organism presence in the air and their significance for the surface contamination. Additionally, the possibility of the air aerosolization with the NEOW was tested. More specifically, the product tested was NEOW Steriplant® N produced by OBISAN – Institute for Biotechnological Research and Development from Murska Sobota, Slovenia. The available commercial form of the product contains sodium hypochlorite, chlorate, chlorine dioxide and ozone. Its pH value ranges between 6 and 8 and its redox potential is $+800 \pm 100\text{mV}$. The research involved MRI 3T room. The purpose of the research was to establish the efficacy of the applied NEOW biocidal action on the present bioaerosol. The identification of the micro-organism presence in the air and on surfaces was carried out to establish the level of the contamination in order to be able to determine the importance of the reduction of the micro-organisms present in the air with the NEOW aerosolization. For air sample collection method we used Coriolis Air Sampler (produced by Coriolis, France) using cyclone technology. Through the whirling motion of the medium and with the help of the centrifugal force, the samples were collected to a bioaerosol and prepared for further treatment. With the air flow rate of 300 litres per minute, altogether 1,200 litres of air were pulled through the liquid collection media during the collection time of 4 minutes. As a liquid medium, the sterile physiological saline was used in which the bioaerosol from the air was collected. All collected samples were taken while the air ventilation system and 3T system was on and they were transported to laboratory for further treatment at the temperature of 4°C . Following the expiry of that time, the grown colonies were counted (ISO 132697/2002). Air samples collected in the suspension of the physiological saline were first diluted and then sown to a medium. Depending on the cultures grown, further determination was carried out (ISO 4833/2003). What followed was the counting of micro-organisms and the determination of their actual total number.



RESULTS

After we have done air sampling in the diagnostic rooms of the Radiology Department of the Maribor University Medical Centre (UKC) we can conclude the following. As anticipated, the number of microorganisms present in the diagnostic room air was low because of good cleaning workflow. Clearly, to get a more reliable confirmation of the decrease in the number of microorganisms it is preferable – from the point of view of the aerosol biocidal action efficiency – to ensure as high initial number of microorganisms as possible. However, this research was determining the reliability of action in actual conditions. As a result, the recorded decreases were smaller than they might have been in experimental conditions. The air condition was all the time on between air aerosolization and the sampling method. The samples were analyzed by the method of ISO 132697/2002 and ISO 4833/2003. The results are presented in the following table 1. We counted the number of colony formed units (CFU) in m^3 .

Table 1: The influence of air sampling with respect to time

Sample taken before aerosolization	240 CFU/ m^3 of air
Sample collected immediately after aerosolization	31 CFU/ m^3 of air
Sample collected 30 minutes after aerosolization	50 CFU/ m^3 of air

We note that aerosolisation reduced the presence of microorganisms in the air by 87% but concentration increases over time because of the working air conditioning system. We believe that the use of the biocide aerosol Steriplant® N in practical terms in prepared space in which substantially reduces the burden of microorganisms. We believe that this helps to establish a bio-security between operational and diagnostic interventions. Considering the fact that the biocide aerosolisation needs 6 – 8 ml of biocide solution / m^3 of air can reach very small amounts of disinfectant effects in operation rooms and equipment. Important features of the biocide Steriplant® N hospital environment is based on the research data gathered, one can conclude that there is a constant presence of microorganisms in all diagnostic rooms, which is most likely a result of the air conditioning room ventilation that is based upon a forced overpressure system. The use of Steriplant® N proved to be efficient and safe in all applied ways. Also, no eventual damage to exposed devices or staff was recorded. The results have shown that the diagnostic room aerosolisation reduced the total number of microorganisms by 87%. During the counting of CFU units, we also observed some suspicious colonies which were subject to further determination. However, in none of the cases studied were there discovered any particularly dangerous agents to health.

FUTURE WORK

Prediction of Advanced technique

It is important to precise dosing of the biocide. The use of the biocide with special sensors that detect the saturation of the biocide in the air is our next step.

New studies and research on NEOW

Generally the main advantages of EOW compared to other biocides are in its broad spectrum of activity against microorganisms and in its universal applicability. It is residue-free requiring no surface washing, environment-friendly – it is not ecotoxic and safe to use (no protective equipment is needed). All this represents an important advantage compared to other biocide groups. Of particular importance regarding the application of EOW for disinfection in operating and diagnostic rooms is its activity against methicillin-resistant microorganisms (MRSA). Steriplant® N can be potentially used also during the diagnostic or operating procedures, however to ensure the safety for medical staff and patients, appropriate toxicological studies need to be performed.

DISCUSSION

Patient safety should be the primary concern of any healthcare organization. Protecting patients and staff takes a concerted effort by all the parties involved in diagnostic imaging. There is no question that infection control has not received the attention it deserves. There is a growing concern that at least some of the spread of infectious agents could be coming from outpatient imaging centers and radiology departments in hospitals. However, almost no attention has been paid to infection control inside these MRIs. This is demonstrated by the fact that there has been only one published research project ever to even explore the possibility of infectious disease inside an MRI and this study was performed in Ireland and presented in 2006. The study only tested one magnet, but found that there was MRSA present in the magnet. It is quite telling that there have been no follow-up studies since that time. Further research is now required to determine the percentage of MRIs in this country that harbor MRSA. It is crucial that we assure patients that proper infection control procedures are being performed in the MRI suite to



ensure the future success of MRI. It is understandable that this would be somewhat painful and expensive for MRI centers and hospitals, however in the long run, it will be crucial to address this issue before it becomes a national problem requiring government intervention and regulations. Imaging centers and hospitals owe it to their patients, to assure that their safety is the top concern during their MRI experience.

CONCLUSION

To conclude, the applied liquid proved to be an efficient disinfection agent. No unwanted effects on material means or people were recorded. Its application is recommended also from the economic point of view. While its applicability has certainly been proved, a further benchmark research comparing efficiency of Steriplant @N with the usual disinfecting agents used in the hospital would be advisable. The main advantage of NEOW compared to other biocides is in its broad spectrum of activity against microorganisms and in its universal applicability. It is resistance and residue-free requiring no surface washing, environment-friendly – it is ecotoxic and safe use (no protective equipment is needed). Surface application requires a solution of 6-8ml/m² only. In brief, there are numerous NEOW application possibilities which are mostly a result of its broad spectrum of activity, environmental friendliness, safe use, possible application in the presence of animals and residue-free application (no additional surface washing needed). All this represents an important advantage compared to all other biocide groups. Broad spectrum of activity mainly in the form of resistant microorganisms (metycillin resist with *S. aureus*, *E. coli*) uncorrosivity, security for operators disinfection, medical staff and patients, and that does not remain on the surfaces of the biocide residues (not required disposal of residues). We also wish to highlight the importance of the choice of the methodology air sampling for the presence of microorganisms.

RESEARCH HIGHLIGHTS

We created and use aerosoliser OPTI-JET CSC MD1 MR with special nozzles for cold fogging, which are compatible with 3T energy. The possibility of the air aerosolisation with the NEOW was tested.

AUTHORS' CONTRIBUTION AND COMPETING INTERESTS

All authors participated in conception and design, generation, analysis and interpretation of data also revision of manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

ACKNOWLEDGEMENTS

This research was supported by University Medical Centre Maribor and Institute Obisan

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