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Mini Review

Premises Plumbing and Wet Technological Niches as Sources of Healthcare-Associated Infections in Hospital

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Abstract

This short review points the importance of the hospital environment and particularly the technological niches more and more present in hospital wards as sources of healthcare-associated infections. The evolution of the medicine thanks to new technologies and medical devices permits to save more patient's lives but the counterpart is the creation of new niches that favor the emergence, the persistence and the transmission of pathogens. Thus, before building new wards and acquiring new medical devices at hospital, we must interrogate the associated infectious risk and provide protocols to control it.

Keywords: *Healthcare-Associated Infection; Multi-Drug Resistant Bacteria; Water Networks; Pseudomonas Aeruginosa; Technological Niches*

Abbreviations

HAI: Healthcare-Associated Infections; MDR: Multi-Drug Resistant; OPPPs: Opportunistic Premise Plumbing Pathogens; SSI: Surgical Site Infection; XDR: Extensively-Drug Resistant

Introduction

In hospital, care environment has markedly changed during the last decades. The buildings, wards and medical devices tend to become high-tech systems, more and more effective to improve the lives' saving. The prevention of Healthcare-associated infections (HAI) should evolve accordingly. Among the major bacteria involved in HAI, *Staphylococcus aureus, Escherichia coli* and other *Enterobacteriaceae*, and *Acinetobacter baumanii* are human-associated bacteria that become pathogens under certain conditions. Other major HAI agents are *Pseudomonas aeruginosa* and its relatives such as *Stenotrophomonas maltophilia*. Their genuine habitat is aquatic environment and when they transiently colonize patients, they can cause serious HAIs. *Legionella pneumophila* and non-tuberculous mycobacteria are environmental specialists, which occasionally cause HAIs directly from environment without previous patient's microbiota colonization.

HAIs are frequently severe (bacteraemia, surgical site infections (SSI) or pneumonia) and lead to heavy treatments due to the frequent occurrence of multidrug resistant (MDR) and extensively-drug resistant (XDR) bacteria in HAIs. HAI agents are able to epidemic spread sometimes causing major hospital outbreaks. Therefore, prevention and control of HAI remain major concerns in the worldwide healthcare policies. After decades of *S. aureus* threat, this bacterium is controlled when preventive measures mostly based on standard hygiene precautions, hand hygiene in front line, are applied [1]. By contrast, MDR and XDR *Enterobacteriaceae, P. aeruginosa* and *A. baumanii* emerge currently in hospital context and are responsible of long-time and large-expensed outbreaks. Most of these bacteria inhabit (for *P. aeruginosa*) or can persist (for *Enterobacteriaceae* and *A. baumanii*) in the hospital environments, mainly in aquatic and moist environment [2-5].

Beside standard hygiene precautions, the environment should be considered as an amplificatory reservoir fully involved in the epidemiological cycle of HAI outbreaks [6-8]. This minireview aims to present some apposite examples giving insights into the role of premises plumbing and wet technological niches as reservoir and source of HAIs.

Opportunistic premises plumbing pathogens in hospital water networks

Increasing complexity of water networks in hospital buildings creates niches for Opportunists Premises Plumbing Pathogens (OPPPs) such as *P. aeruginosa, Legionella pneumophila*, or non-tuberculous mycobacteria. OPPPs of water network are at the origin of severe infection and outbreaks like peripheral venous catheter and bloodstream *P. aeruginosa* infection [9,10], *Mycobacterium avium* pulmonary disease [11], or outbreak of Legionnaires' disease [12]. Indeed, lot of water treatment systems such as water softeners, osmose-systems, biocide injectors and filtration systems disrupt the water flow and favor biofilm formation that can cause the retrograde contamination of the water network. It is also the case for changes in ward usage that can lead to pipes containing dead waters. Plumbing systems at water point-of-use such as electronic sensor taps, or faucet aerators, also constitute niches for OPPPs [5,13-16]. To prevent HAI, it is recommended to limit technological niches by the construction of simple networks that allows water flowing as freely as possible and to circularize pipes in small closed systems in order to facilitate biocide decontamination. Complex faucets with electronic sensors should be avoided and replaced by simpler systems such as elbow or knee operated faucet [13]. Facing persistent water network contamination, antimicrobial filter placed onto faucets or showers is necessary to control the water quality and to prevent water-borne HAI [9,17,18].

Medical devices as reservoir for pathogenic bacteria responsible for HAIs

The control of microorganisms in hospital environment enforces the survey of technological niches mostly when associated to water, and the prevention of the formation of biofilm, which is a major reservoir for pathogenic bacteria. Beside critical and semi-critical medical devices that enter in sterile tissues or in contact with mucosa such as endoscopes, lot of machines containing water lines or reservoir are placed near the patients and are considered as non-critical devices according to the Spaulding classification [19]. For instances, heater-cooler units for extra-corporal circulation, dialysis machines, dental units and various systems need water for their use or their disinfection. These water-containing non-critical devices form technological niches particularly problematic to manage because they are usually composed of complex systems of tubes and tanks, favoring the biofilm formation and not easy-to-access for their disinfection [20,21]. If the water is contaminated, the transmission of bacteria can occur by direct contact or by aerosolization. Several studies report cardiac SSIs and outbreaks of SSIs, caused by *Mycobacterium chimaera*, related to contaminated heater-cooler units for extra-corporal circulation [22-24]. The dental care unit waterlines are reported as technological niches, because of their complexity leading to the biofilm formation and constituting a reservoir for OPPPs such as *P. aeruginosa* and *Achromobacter* sp., [25] *Legionella* sp. and non-tuberculosis mycobacteria [26,27].

Different HAIs due to technological niches led to the improvement of the disinfection process and the microbiological control of devices. For instance, the revision of the management of heater-cooler units for extra-corporal circulation led to an increased frequency of water change and decontamination according to an improved protocol based on the use of recommanded biocides as well as the implementation of monthly microbiological controls of the tank water.

Role of hospital moist and wet surfaces in HAIs

Bacteria can persist during months on inanimate surfaces which can be considered as a reservoir for outbreaks of HAI [28]. The persistence of the bacteria onto surfaces depends on the type of surface and the bacterial species and it can be very long, from 1 day to 4.5 years [28]. Moreover, several parameters including humid conditions, low temperature and high inoculum promote the persistence of bacteria [29]. The hospital environment is mostly contaminated by pathogenic bacteria and several studies show that resistant bacteria preferentially contaminate the surfaces surrounding the patient, which are touched by the patient or care workers. These surfaces became moist or humid due to the skin maceration like the bed and mattress surfaces, the oxygen masks, the SpO_2 sensors [30-34].

The risk of acquiring bacteria is higher when a patient is admitted into a room previously occupied by an infected patient [35-37]. For example, blaOXA-51-like- and blaOXA-66 *A. baumannii* ST208 contaminated an air fluidized bed during 1.5 year and was responsible of an outbreak of seven patients [38]. Reservoirs of glycopeptide-intermediate *S. aureus* in SpO_2 sensors sustained a 5-months outbreak that has been controlled by improving the decontamination of the SpO_2 sensors [34]. Others studies report that persistence of carbapenemase-producing *Enterobacteriaceae* until one year within U-bend led to the transmission among patients of these XDR bacteria. The simple change of the U-bend led to the outbreak control [4,38-40].

Conclusion

This review points the importance of infectious risk assessment and microbiological control of the hospital environment. The technological niches associated to complex and invasive cares need a particular intention because they constitute potential reservoirs for pathogens responsible for HAIs and HAIs outbreaks.

When a new ward is built, several points about the premises plumbing should be questioned: Does the new water network create complex technological niches? Will each water points-of-use be necessary and used regularly? Are water treatment systems needed? Which points should be checked and at which frequency?

When the hospital buys a new medical device, the infectious risk linked to the new device must be evaluated in order to provide immediately human and technical resources for their surveillance, maintenance, decontamination and microbiological controls as well as precisely written up-to-date protocols. This is particularly true for non-critical medical devices, which are not submitted to strict regulations. The main questions in front of a new non-critical medical device entering a hospital are: Does the device contain water or have an irrigation system? Are main parts of the device suitable for disinfection? How to process the disinfection? What are the appropriated frequencies and methods for decontamination and microbiological control?

Conflict of Interest

The authors declare that they have no competing interests.

Bibliography

1. Pittet D., *et al*. "Effectiveness of a Hospital-Wide Programme to Improve Compliance with Hand Hygiene. Infection Control Programme". *Lancet (London, England)* 356.9238 (2000): 1307-1312.

2. Bédard Emilie., *et al*. "Pseudomonas Aeruginosa in Premise Plumbing of Large Buildings". *MicrobiologyOpen* 5.6 (2016): 937-956.

3. Zhou ZhaoYan., *et al*. "Sources of Sporadic Pseudomonas Aeruginosa Colonizations/Infections in Surgical ICUs: Association with Contaminated Sink Trap". *Journal of Infection and Chemotherapy: Official Journal of the Japan Society of Chemotherapy* 22.7 (2016): 450-455.

4. De Geyter Deborah., *et al*. "The Sink as a Potential Source of Transmission of Carbapenemase-Producing Enterobacteriaceae in the Intensive Care Unit". *Antimicrobial Resistance and Infection Control* 6 (2017): 24.

5. Umezawa Kazuo., *et al*. "Outbreak of Drug-Resistant Acinetobacter Baumannii ST219 Caused by Oral Care Using Tap Water from Contaminated Hand Hygiene Sinks as a Reservoir". *American Journal of Infection Control* 43.11 (2015): 1249-1251.

6. Boyce John M. "Environmental Contamination Makes an Important Contribution to Hospital Infection". *The Journal of Hospital Infection* 65.2 (2007): 50-54.

7. Weber David J., *et al*. "The Role of the Surface Environment in Healthcare-Associated Infections". *Current Opinion in Infectious Diseases* 26.4 (2013): 338-344.

8. de Oliveira., *et al*. "[Surfaces of the hospital environment as possible deposits of resistant bacteria: a review]". *Revista Da Escola De Enfermagem Da U S P* 44.4 (2010): 1118-1123.

9. Romano Sara., *et al*. "Peripheral Venous Catheter and Bloodstream Infection Caused by Pseudomonas Aeruginosa after a Contaminated Preoperative Shower". *Infection Control and Hospital Epidemiology* 34.5 (2013): 544-546.

10. Loveday HP., *et al*. "Association between Healthcare Water Systems and Pseudomonas Aeruginosa Infections: A Rapid Systematic Review". *The Journal of Hospital Infection* 86.1 (2014): 7-15.

11. Falkinham Joseph O., *et al*. "Mycobacterium Avium in a Shower Linked to Pulmonary Disease". *Journal of Water and Health* 6.2 (2008): 209-213.

12. Francois Watkins Louise K., *et al*. "Lessons From an Outbreak of Legionnaires" Disease on a Hematology-Oncology Unit". *Infection Control and Hospital Epidemiology* 38.3 (2017): 306-313.

13. Yapicioglu Hacer., *et al*. "Pseudomonas Aeruginosa Infections due to Electronic Faucets in a Neonatal Intensive Care Unit". *Journal of Paediatrics and Child Health* 48.5 (2012): 430-434.

14. Walker JT., *et al*. "Investigation of Healthcare-Acquired Infections Associated with Pseudomonas Aeruginosa Biofilms in Taps in Neonatal Units in Northern Ireland". *Journal of Hospital Infection* 86.1 (2014): 16-23.

15. Rogues AM., *et al*. "Contribution of Tap Water to Patient Colonisation with Pseudomonas Aeruginosa in a Medical Intensive Care Unit". *The Journal of Hospital Infection* 67.1 (2007): 72-78.

16. Weber DJ., *et al*. "Faucet Aerators: A Source of Patient Colonization with Stenotrophomonas Maltophilia". *American Journal of Infection Control* 27.1 (1999): 59-63.

17. Aumeran C., *et al*. "Pseudomonas Aeruginosa and Pseudomonas Putida Outbreak Associated with Contaminated Water Outlets in an Oncohaematology Paediatric Unit". *The Journal of Hospital Infection* 65.1 (2007): 47-53.

18. Teare L and S Millership. "Legionella Pneumophila Serogroup 1 in a Birthing Pool". *The Journal of Hospital Infection* 82.1 (2012): 58-60.

19. McDonnell G and P Burke. "Disinfection: Is It Time to Reconsider Spaulding?" *The Journal of Hospital Infection* 78.3 (2011): 163-170.

20. Guimarães Thaís., *et al*. "Pseudooutbreak of Rapidly Growing Mycobacteria due to Mycobacterium Abscessus Subsp Bolletii in a Digestive and Respiratory Endoscopy Unit Caused by the Same Clone as that of a Countrywide Outbreak". *American Journal of Infection Control* 44.11 (2016): e221-e226.

21. Jørgensen SB., *et al*. "Heat-Resistant, Extended-Spectrum β-Lactamase-Producing Klebsiella Pneumoniae in Endoscope-Mediated Outbreak". *The Journal of Hospital Infection* 93.1 (2016): 57-62.

22. Haller Sebastian., *et al*. "Contamination during Production of Heater-Cooler Units by Mycobacterium Chimaera Potential Cause for Invasive Cardiovascular Infections: Results of an Outbreak Investigation in Germany, April 2015 to February 2016". *Euro Surveillance: Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin* 21.17 (2016).

23. Cai Yi., *et al*. "Mycobacterium Infection from a Cardiopulmonary Bypass Heater-Cooler Unit in a Patient with Steroid-Induced Immunosuppression". *Canadian Journal of Anaesthesia* 64.5 (2016): 513-516.

24. Dupont C., *et al*. "Source-Case Investigation of Mycobacterium Wolinskyi Cardiac Surgical Site Infection". *The Journal of Hospital Infection* 93.3 (2016): 235-239.

25. Abdouchakour Fatima., *et al*. "Pseudomonas Aeruginosa and Achromobacter Sp. Clonal Selection Leads to Successive Waves of Contamination of Water in Dental Care Units". *Applied and Environmental Microbiology* 81.21 (2015): 7509-7524.

26. Dutil Steve., *et al*. "Aerosolization of Mycobacteria and Legionellae during Dental Treatment: Low Exposure despite Dental Unit Contamination". *Environmental Microbiology* 9.11 (2007): 2836-2843.

27. Schulze-Röbbecke R., *et al*. "Dental Units: An Environmental Study of Sources of Potentially Pathogenic Mycobacteria". *Tubercle and Lung Disease: The Official Journal of the International Union Against Tuberculosis and Lung Disease* 76.4 (1995): 318-323.

28. Kramer Axel., *et al*. "How Long Do Nosocomial Pathogens Persist on Inanimate Surfaces? A Systematic Review". *BMC Infectious Diseases* 6.1 (2006): 130.

29. Lemmen SW., *et al*. "Distribution of Multi-Resistant Gram-Negative versus Gram-Positive Bacteria in the Hospital Inanimate Environment". *The Journal of Hospital Infection* 56.3 (2004): 191-197.

30. Lerner A., *et al*. "Environmental Contamination by Carbapenem-Resistant Enterobacteriaceae". *Journal of Clinical Microbiology* 51.1 (2013): 177-181.

31. Dancer, Stephanie J. "Importance of the Environment in Meticillin-Resistant Staphylococcus Aureus Acquisition: The Case for Hospital Cleaning". The Lancet Infectious Diseases 8.2 (2008): 101-113.

32. Tajeddin Elahe., *et al*. "The Role of the Intensive Care Unit Environment and Health-Care Workers in the Transmission of Bacteria Associated with Hospital Acquired Infections". *Journal of Infection and Public Health* 9.1 (2016): 13-23.

33. Yu Monica., *et al*. "Crib Mattress Investigation: A Quality Improvement Study to Assess Mattress Cover Permeability and Bacterial Growth in Crib Mattresses". *American Journal of Infection Control* 44.7 (2016): 837-839.

34. Parer Sylvie., *et al*. "An Outbreak of Heterogeneous Glycopeptide-Intermediate Staphylococcus Aureus Related to a Device Source in an Intensive Care Unit". *Infection Control and Hospital Epidemiology* 33.2 (2012): 167-174.

35. Nseir S., *et al*. "Risk of Acquiring Multidrug-Resistant Gram-Negative Bacilli from Prior Room Occupants in the Intensive Care Unit". *Clinical Microbiology and Infection* 17.8 (2011): 1201-1208.

36. Ajao Adebola O., *et al*. "Risk of Acquiring Extended-Spectrum β-Lactamase-Producing Klebsiella Species and Escherichia Coli from Prior Room Occupants in the Intensive Care Unit". *Infection Control and Hospital Epidemiology* 34.5 (2013): 453-458.

37. Huang Susan S., *et al*. "Risk of Acquiring Antibiotic-Resistant Bacteria from Prior Room Occupants". *Archives of Internal Medicine* 166.18 (2006): 1945-1951.

38. Asai Satomi., *et al*. "An Outbreak of blaOXA-51-like- and blaOXA-66-Positive Acinetobacter Baumannii ST208 in the Emergency Intensive Care Unit". *Journal of Medical Microbiology* 63.11 (2014): 1517-1523.

39. Pantel Alix., *et al*. "Environmental Persistence of OXA-48-Producing Klebsiella Pneumoniae in a French Intensive Care Unit". *American Journal of Infection Control* 44.3 (2015): 366-368.

40. Clarivet Béatrice., *et al*. "Persisting Transmission of Carbapenemase-Producing Klebsiella Pneumoniae due to an Environmental Reservoir in a University Hospital, France, 2012 to 2014". *Euro Surveillance: Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin* 21.17 (2016).

Volume 7 Issue 6 April 2017