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 health-care 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].

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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 opposite 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 recommended 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 SpO₂ sensors [30-34].

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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 SpO₂ sensors sustained a 5-months outbreak that has been controlled by improving the decontamination of the SpO₂ 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


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