Pseudomonas in augmented care: should we worry?

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The problem of Pseudomonas as a nosocomial pathogen is not new, with some authors dating its onset to the start of the antimicrobial era, although other factors, such as the growth of intensive or augmented care, have a part to play. This paper outlines the historical and environmental issues that may be associated with a potential increase in the incidence of this difficult-to-treat pathogen.

Keywords: healthcare-associated infections, water systems, intensive care

Introduction

The history of hospital design goes back millennia, but in recent decades we have learnt a number of important lessons with regard to building services and their impact on the vulnerable. In this paper we are concerned with the relationship between water and Pseudomonas aeruginosa, made important by the intimate relationship between the built environment and the vulnerable patient.

P. aeruginosa is inherently resistant to many antimicrobial agents. In 1959, Finland et al. reviewed bacteraemias since the start of the antimicrobial era at a single American hospital and noted a significant rise in pseudomonal bacteraemias and deaths. Rogers, in a comparison of serious infections between two periods, 1938–40 and 1957–58, noted how in a large New York hospital ‘an unusual pathogen, P. aeruginosa’ had superseded Escherichia coli infection rates and he also noted that there had been a shift from community- to hospital-acquired infections. In the 1950s and 1960s there were multiple reports in the literature of nosocomial outbreaks related to fomites and medicaments. The reports came predominantly from neonatal nurseries, burns units and neurosurgery, all early practitioners of augmented care.

In 1961, Wilson et al. reported finding P. aeruginosa in the aerators of taps, presaging by 50 years the similar findings in Northern Ireland nurseries linked to outbreaks of P. aeruginosa infections and newborn deaths. Walker et al. found that P. aeruginosa was confined to the distal parts of the water tap. Ayliffe et al. investigated sink traps as a source of P. aeruginosa in a general hospital and a burns unit in a different hospital, and found colonization in 23% and 40%, respectively. They also looked at the use of sink trap heaters to minimize the risk. It has not been established with certainty that there has been an increase in P. aeruginosa infections, but there have been a number of publications of severe infection that link the source to taps.

Recent data from the HPA (now Public Health England) have also shown a rise in the number of P. aeruginosa bacteraemia cases in England and Wales from the voluntary bacteraemia reporting system (Figure 1; A. P. Johnson, Public Health England, London, personal communication). These seem to exhibit a marked seasonal fluctuation, the reasons for which are not obvious. Published data from the same source have shown a 24% increase in Pseudomonas spp. bacteraemias between 2004 and 2008. Pseudomonal bacteraemias appear to have associated themselves with medical interventions and healthcare premises. In a population-based study of pseudomonal bacteraemias in Canada, Parkins et al. found that 45% of cases were nosocomial, 34% were associated with healthcare in the community and only 21% were community acquired. The overall mortality rate was 29% and the incidence was 3.6 cases per 100 000 population.

Pseudomonas in water systems

P. aeruginosa is not nutritionally exacting. It is an auxotroph and acquires its carbon energy sources from the environment, and is, however, catholic in its nutritional choices. There are a number of examples where polymers have been shown to leach carbon sources and, as such, support and encourage the growth of P. aeruginosa. In 1964, Poynter and Mead following complaints from industry of slime building up in industrial processes and on taps, concluded that it was caused by alcohols used in these processes condensing on cool surfaces and acting as a growth stimulant for Pseudomonas spp. It remains to be seen whether the growth in the use of alcoholic hand rubs has contributed to the carbon available for utilization at the tap in healthcare premises.

Pseudomonads form part of the ecosystem of water, being well adapted to catabolism, extracting energy from many potential sources. That they find their way into water distribution systems should not surprise us. Although there are standards for bottled water and Pseudomonas, the standards for water delivered by a ‘supplier’ to healthcare premises are not so exacting. In general terms, the supplier delivers water suitable for drinking that is ‘wholesome at the time of supply’. This means that it must be free of prescribed organisms (E. coli, Enterococcus faecalis and Clostridium perfringens), which indicate animal or human faecal contamination, and coliform bacteria that may be derived from
animals or plants. There are no standards for total viable counts, often referred to as heterotrophic plate counts. The standard is one of 'no abnormal change', this being based on periodic sampling to assess the norm for that supply. Therefore, providing that the numbers of *Pseudomonas* in the water supply remain constant, and that they have not made the water unacceptable because of taste or odour, there is no limitation on the supply of *Pseudomonas*.

There is thus no prohibition on pseudomonads entering healthcare premises from the supplier and, in addition, no UK quality standard for the presence of pseudomonads in the distribution systems within healthcare. We are therefore left with a situation in which it is left up to good governance practice, as outlined in Department of Health publications, to minimize the risk to patients from *P. aeruginosa*. Much of the good practice is similar to that needed to control the hazards associated with *Legionella pneumophila*, but differences do exist. For a start, *Pseudomonas* may be transmitted from a point source, such as a tap or contaminated equipment, but case-to-case transfer can also occur. And it is the tap in particular that has the highest level of contamination in the distribution system, so that hand hygiene or splashing of sterile goods may be the most significant factor in acquisition. Outbreaks also occur where hand hygiene is at fault but the source has proven to be an individual and a moist dermatological condition the cause of this outbreak. Examples include healthcare workers with false nails or otitis externa.

The use of water from contaminated taps used for purposes other than direct patient care may also add significantly to the risk of acquisition and infection – the thawing of frozen blood products being a particular hazard, as these are delivered directly into the bloodstream. It has been suggested that bathing or cleaning (topping and tailing) of preterm neonates weighing <1500 g with water contaminated with *Pseudomonas* is a potential hazard, because not only is their skin so poorly developed it represents an inadequate barrier but these children will also have vulnerable sites such as umbilical artery and venous cannulae as entry points. A similar situation in adult intensive care units might exist in male patients with neck lines (central lines) who would be wet shaven for aesthetic reasons, the water running from the face directly onto the line (M. Trautmann, Institute for Hospital Hygiene, Stuttgart, personal communication). In addition, the feeding of neonates with contaminated milk would encourage early colonization and represents a risk. It should also be noted that some web sites encouraging the use of frozen breast milk have recommended thawing the feed in warm water; this clearly represents a similar hazard and thawing should be by dry processes only.

Because colonization from the water source may precede infection, other selection pressures, such as antimicrobial prescribing, are clearly relevant. Care practices such as the rinsing of respiratory equipment or the use of tap water in humidifiers have in the past been responsible for nosocomial pneumonias, a lesson easily forgotten. Similarly, such equipment rested or rinsed in a sink might easily contaminate the trap with patient flora, which may then be transmitted to the tap by splashing or cleaning practices and then become established as resident flora.

Although the literature contains many examples, some listed above, of outbreaks associated with water, only those that have been investigated and reported recently have had the benefit of genomic-based typing. Outbreaks of *P. aeruginosa* tend to occur in critical settings where patients may be transferred to other providers of care. The typing scheme most widely employed is variable number tandem repeats (VNTRs), because as a PCR-based method it is both rapid and reproducible. There remains a flaw, however, in that isolates as grouped by VNTRs may be representative of a geographical distribution to a region and not be as indicative of a single

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**Figure 1.** Quarterly numbers of *P. aeruginosa* bacteraemia as reported to the HPA (now Public Health England) via the national voluntary laboratory reporting scheme.
locality clone. Turton et al. recommended that where isolates appear similar by VNTR typing, yet no epidemiological link is known, these should be checked by PFGE. This problem of clonality among Klebsiella pneumoniae has recently been explored and the need for whole-genome sequencing invoked as a necessary requirement to increase the levels of certainty and understanding.

Control measures

There is insufficient space within this short report to elaborate on the control of Pseudomonas in water distribution systems. Suffice it to say, the design and construction of the distribution system is important, and that once the organism has established within a biofilm, eradication is difficult. The reader is drawn to other texts that discuss the design and treatment of contaminated systems more fully.

Transparency declarations

None to declare.

References


