Outbreak of Pseudomonas aeruginosa bacteraemia in a haematology department

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ABSTRACT

INTRODUCTION: Infection by *Pseudomonas aeruginosa* represents a major cause of morbidity and mortality among immunocompromised patients. In Denmark, an increase in *P. aeruginosa* isolates from blood cultures from a haematology department prompted a hygienic audit in 2007.

METHODS: Blood cultures that tested positive for *P. aeruginosa* were collected from the laboratory information system (MADS, Skejby Hospital, Aarhus, Denmark). Environmental samples were obtained from shower heads in the department. The genotype was established by pulse field gel electrophoresis (PFGE). An audit was conducted during the outbreak and 12 months later. The audits were conducted by the method of direct observation.

RESULTS: Several PFGE types were involved with no clear association to isolates from environmental samples. The audit revealed poor hygiene related to the handling of central venous catheters. After optimising catheter hygiene, the number of *P. aeruginosa* bacteraemia cases fell significantly.

CONCLUSION: Since no clear association between patient and environmental genotype was established, it was suspected that central venous catheters were the main portal of entry. This was further supported by a simultaneous decline in bacteraemia cases with coagulase-negative staphylococci. Though several hygienic precautions were taken, the increased focus on disinfection of hubs and injection ports was presumably the more important element.

FUNDING: not relevant.

TRIAL REGISTRATION: not relevant.

Pseudomonas aeruginosa is a major cause of morbidity and mortality in immunocompromised patients and a well-known cause of infection outbreaks in haematology and oncology units [1-4]. In 2007, we observed an extraordinarily high number of blood cultures (BCs) with *P. aeruginosa* from patients admitted to the Haematology Department (HD) at Odense University Hospital (OUH). This raised suspicion of an outbreak, and the infection control team carried out an investigation which pointed to central venous catheters (CVC) as a possible portal of entry. In this paper, we describe the outbreak, the measures taken to contain it, and their effect on BC findings during the following three years.

METHODS

BCs were drawn on clinical suspicion of septicaemia and processed by the local clinical microbiology department using the Bactec 9240 system (Becton Dickinson, NJ, USA). Isolates were identified according to the Danish reference programme [5]. BC isolates were routinely stored at –80 °C.

Bacteriological and clinical data used for the analyses were retrieved from the laboratory information system (MADS, Skejby Hospital, Aarhus, Denmark). To identify whether there was an outbreak or not, we included all BCs (both peripheral and CVC) from January 2006 through December 2007 with growth of *P. aeruginosa*. A patient was considered infected if either peripheral or CVC showed growth of *P. aeruginosa*. To evaluate the effect of interventions, we included all BCs drawn from CVCs from January 2006 through December 2010 with growth of *P. aeruginosa*, coagulase-negative staphylococci (CoNS) and *Enterobacteriaceae* (*EB*). For examination of the effect of the audit, only BCs from CVCs were included. This was done to avoid possible discrepancies between CVC and PVC results due to contamination. Patients were included only with the first positive BC. BCs with different organisms or positive BCs with the same organism separated by more than 30 days were considered to represent unique episodes.

Immediately after recognition of the outbreak, swabs were taken from the interior of shower heads used by patients in the HD and examined for *P. aeruginosa* using standard culture methods [5].

In the period from 1 January 2006 to 31 December 2007, *P. aeruginosa* was detected in BCs from 37 patients. Isolates from 29 patients had been stored and were subsequently genotyped together with four isolates from the shower heads (**Table 1**). Pulse field gel electrophoresis (PFGE) was used for genotyping. The PFGE typing was based on a combination of methods described by Denton et al and Romão et al [6, 7]. The DNA was cut with the restriction enzyme Bcu (Fermentas). Individual isolates were given a unique PFGE type if the PFGE pattern differed by more than one band.

Audits were performed in accordance with the Danish Standards Foundation, "Infection control in the healthcare sector" and the current infection control guidelines at the hospital [8]. The "direct observation"

ORIGINAL ARTICLE

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Dan Med J 2015;62(4):A5040

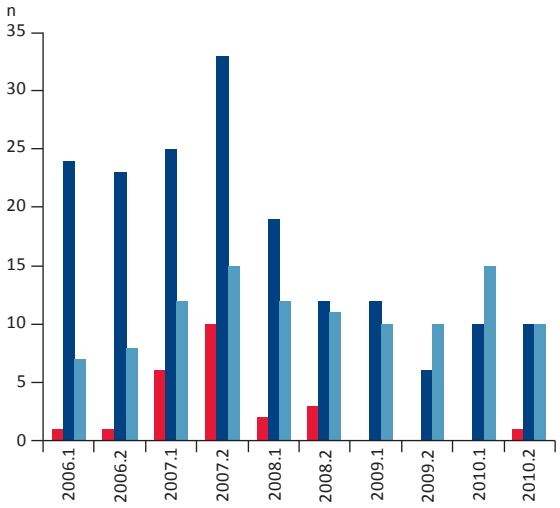
TABLE 1

Distribution of pulsed-field gel electrophoresis (PFGE) genotypes in *Pseudomonas aeruginosa* blood isolates from patients in the Haematology Department at Odense University Hospital, 2006-2007, and isolates from shower heads sampled ultimo 2007. The values are numbers.

Isolates	2006	2007
Blood samples		
PFGE type I	3	4
PFGE type III	3	14
PFGE type non-I/III	1	5
Not available for typing	1	6
Shower head samples		
PFGE type I	–	2
PFGE type III	–	0
PFGE type non-I/III	–	2

FIGURE 1

Semi-annual occurrence of blood cultures of *Pseudomonas aeruginosa* (■), coagulase-negative staphylococci (■), and *Enterobacteriaceae* (■) in blood cultures drawn from central venous catheters of patients treated in the Haematology Department at Odense University Hospital 2006-2010.



method was used. Local guidelines were based on national guidelines issued by the National Centre of Infection Control and national standards DS 2450 and the DS 2451-series issued by the Danish Standards Foundation [9, 10].

Trial registration: not relevant.

RESULTS

From 2006 to 2007, the number of patients with *P. aeruginosa* bacteraemia (from both peripheral venipunctures and CVCs) at the HD increased from 8 to 29 at which point the outbreak was clinically recognised ($p < 0.01$, Pearson's chi-squared test with Yates' continuity correction). All patients were immunocompromised and had venous catheters for administration of antineoplastic chemotherapy.

A similar increase in *P. aeruginosa* bacteraemia cases was not observed in the rest of the hospital, where the level was much lower. A regression model for *P. aeruginosa* blood isolates from CVCs showed that on average the infection rate for the HD was 0.12 (95% confidence interval (CI): –0.16-0.40) per 100 BCs (CVCs) higher than in the rest of the hospital. During the outbreak period, the average infection rates increased by 1.5 (95% CI: 1.06-1.95) per 100 BCs (CVCs).

PFGE of stored blood *P. aeruginosa* isolates from 2006 and 2007 revealed eight different PFGE types, with only PFGE types I and III accounting for more than one isolate. The accumulation of isolates in 2007 could argely be ascribed to an increase in PFGE type III, which accounted for 14 of 23 isolates (Table 1). Sampling from shower heads performed as an early step in outbreak detection resulted in four isolates, none of which belonged to the dominant PFGE type III. Based on these findings, it was decided to perform a more comprehensive audit of clinical routines in the HD.

This audit revealed the following problems: Administration of intravenous (IV) fluids and medications were not consistently preceded by disinfection of injection membranes and hubs. Frequent disconnections of CVCs and peripheral venous catheters were observed. Drop sets were often placed near sinks or placed randomly around the bed. Flower vases were often located on patient tables where nurses handled syringes and other equipment prior to IV administration. Overall, the access to alcohol disinfectants was poor, and routines for the disposal of needles and dirty dishes were below standard.

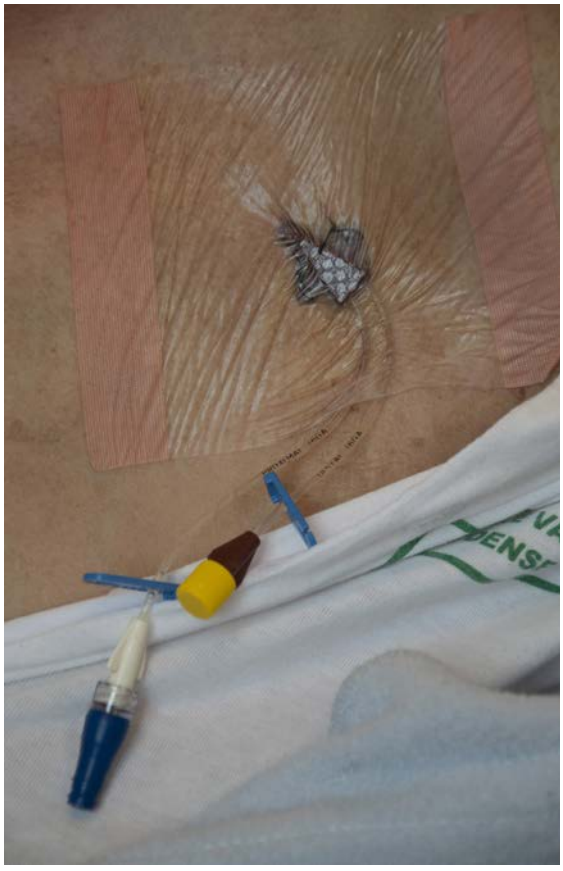
Consequently, the following actions were recommended: consistent disinfection of injection sites, keeping disconnected or prepared drop sets away from sinks, placing flowers in windowsills rather than on the bedside tables, adding chlorhexidine to flower water, and cleaning and descaling shower heads and aerators. It was recommended to replace shower heads with units with built in filters. The main results from the audit were given to the staff directly after the audit. Shortly after the audit, all the results were written in a report and sent to the head of the department and associated staff.

A second audit performed 53 weeks later showed improvements in most areas covered by the recommendations. Flowers were banned from the department and easy access to alcohol disinfection was ensured. Shower heads were not replaced. Instead the HD implemented a routine according to which the shower heads were heat-

disinfected once a week and faucets were cleaned according to hospital guidelines. No quantitative data were available for measures of improvement of hand hygiene among staff.

As seen in **Figure 1**, the number of *P. aeruginosa* blood isolates (from CVCs) dropped rapidly after implementation of the actions recommended by the audit. This suggests that the outbreak may have been linked to improper use of CVCs. To elucidate this in further detail, CoNS and *EB* found in BCs drawn from CVCs were included in the analysis. We hypothesised that if the decline in *P. aeruginosa* could be attributed to improvement of catheter hygiene, a similar decline would be seen with CoNS, whereas the prevalence of *EB* would remain unaffected. As displayed in Figure 1, this is actually what we found.

The regression model for CoNS infections showed that the average infection rate for the HD was 2.5 (95% CI: 1.64-3.38) per 100 BCs from CVCs higher than the rest of OUH. The average infection rate during the outbreak period rose by 1.86 (95% CI: 0.46-3.26) per 100 BCs (CVCs). The infection rate for *EB* showed a steady incline from 2006 to 2010 with no discernible fluctuation after the intervention in 2007. In the regression model for *EB*, no decrease in rate of infections was found.



Central venous catheter in a haematology patient.

DISCUSSION

P. aeruginosa is a well known cause of septicaemia in haematology patients; however, the role of CVCs as a portal of entry is sparsely elucidated [11]. We initially suspected that water was a probable source of the outbreak, but typing results of shower heads and patient isolates could not verify this. At least two different PFGE types were involved, and the more prevalent PFGE type, accounting for more than half of the bacteraemia cases, was not detected among the shower head samples. This made us hypothesise that the outbreak did not originate from a common source, but was rather due to cross transmission of strains from different sources. At the same time, the audit revealed that catheter hygiene was well below standard. Consequently, we decided to concentrate on improving catheter hygiene rather than looking more systematically for sources of *P. aeruginosa* in the environment. Therefore, sampling of sink taps was not warranted. All of the implemented measures were aimed at sources for which it was known that they could be contaminated with *P. aeruginosa* [4, 12-16].

The outbreak subsided after multiple interventions aimed at improving catheter hygiene. In itself, this is not proof that the outbreak was catheter-related. However, the absence of other issues during the audit suggests that it may have been catheter-related. Furthermore, the simultaneous decline in CoNS isolated from BCs indicates that the measures taken to improve catheter hygiene were indeed effective. Despite these arguments, a more thorough sampling of the environment during and after the outbreak would have provided us with a more precise conclusion. Unfortunately, this was not possible.

CONCLUSION

Our results is a reminder that clinical procedures for use of catheters should always be in focus when investigating outbreaks of blood stream infections in haematology units, even with organisms that are not immediately considered catheter-related.

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ACCEPTED: 21 January 2015

CONFLICTS OF INTEREST: none. Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk

ACKNOWLEDGEMENTS: *Mette Detlefsen*, Department of Clinical Microbiology, Odense University Hospital, has contributed with clarification of questions regarding the audit. *Benjamin Schnack Rasmussen* & *Nikolas Christensen* contributed equally to the first-authorship.

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