ORIGINAL ARTICLE BACTERIOLOGY

Utilization of blood cultures in Danish hospitals: a population-based descriptive analysis

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Abstract

This national population-based study was conducted as part of the development of a national automated surveillance system for hospital-acquired bacteraemia and ascertains the utilization of blood cultures (BCs). A primary objective was to understand how local differences may affect interpretation of nationwide surveillance for bacteraemia. From the Danish Microbiology Database, we retrieved all BCs taken between 2010 and 2013 and linked these to admission data from the National Patient Registry. In total, 4 587 295 admissions were registered, and in 11%, at least one BC was taken. Almost 50% of BCs were taken at admission. The chance of having a BC taken declined over the next days but increased after 4 days of admission. Data linkage identified 876 290 days on which at least one BC was taken; 6.4% yielded positive results. Ten species, *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus pneumoniae, Enterococcus faecium, Enterococcus faecalis, Pseudomonas aeruginosa, Candida albicans, Enterobacter cloacae* and *Klebsiella oxytoca,* accounted for 74.7% of agents for this purpose classified as pathogenic. An increase in BCs and positive BCs was observed over time, particularly among older patients. BCs showed a seasonal pattern overall and for *S. pneumoniae* particularly. A predominance of male patients was seen for bacteraemias due to *S. aureus, E. faecium* and *K. pneumoniae.* Minor differences in BCs and positive BCs between departments of clinical microbiology underpin the rationale of a future automated surveillance for bacteraemia. The study also provides important knowledge for interpretation of surveillance of invasive infections more generally.

Keywords: Blood cultures, Denmark, epidemiology, hospital admissions, utilization
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Introduction

Bacteraemia is a severe condition associated with high mortality [1–5]. Blood cultures (BCs) continue to be the only practical method to diagnose bacteraemia [6]. Since 1 January 2010 the

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Danish Microbiology Database (MiBa) has collected microbiological test results from all departments of clinical microbiology (DCMs) in Denmark [7]. This provided the unique opportunity to study BC utilization on a national level. Combining these data with administrative information from the National Patient Registry (NPR [8]) allowed us to also study BCs in relation to hospital admissions.

It is of fundamental interest to study the epidemiology and utilization of BCs to evaluate clinical practices and to understand trends observed in surveillance for invasive infections, including those acquired in healthcare. Differences in BC utilization, e.g. between laboratories, patient populations and changes over time, may give rise to artefacts in surveillance systems due to different levels of ascertainment. We conducted a national population-based study describing the utilization of BCs in Denmark to understand to which extent local differences may affect the interpretation of surveillance of bacteraemia. This assessment was done as part of the development of an automated surveillance system for hospital-acquired infections in Denmark; such a system will depend on a meaningful pooling of data from various DCMs.

Methods

Data sources

MiBa is a real-time database that automatically receives a copy of every electronic microbiology report delivered by all Danish DCMs [7]. An extract from MiBa was obtained comprising all BCs with a sampling date between 1 January 2010 and 31 December 2013. This extract included the sampling date and time (the latter if available), cultured microorganisms and the DCM that carried out the test. Each patient was identified in MiBa through the civil registration (CPR) number, a unique identifier given to each person living in Denmark encrypting date of birth and sex [9].

In January 2010 Denmark had 13 DCMs. Although remaining independent DCMs, the laboratory information systems of the DCMs in Herlev and Hvidovre merged in May 2012, and the DCM in Hillerød joined this mutual data server in May 2013. In January 2013 the DCMs in Herning and Viborg merged. For this article, the DCMs were analysed in the new composition (named by their geographic location).

The NPR includes administrative data on somatic inpatients since 1977 [8]. Individual patients were identified through the CPR number. We used an extract comprising patient administrative data between 1 January 2010 and 31 December 2013. Only those patients who were admitted and discharged within this period were selected; others were excluded, as these would affect analyses on BCs in relation to the number of days since admission. Data included date and time of admission and discharge and the responsible departments and hospitals. The NPR included one record for each admission to a department; each time a patient was transferred to another department, this was registered as a new record. We developed an algorithm relating these inpatient transfers to form a complete course of admission, here referred to as an admission.

The data from MiBa and NPR were linked using the CPR number. Patients with temporary CPR numbers, such as foreign travellers, were excluded from analysis. Similarly, those CPR numbers derived from MiBa which led to an age calculation of <0 or ≥ 100 years were excluded, as we could not confirm whether these CPR numbers were correct.

Definitions

To enable automatic classification and avoid misclassification of contaminants as pathogens, we considered the following microorganisms as contaminants: *Acinetobacter* spp., *Aerococcus* spp. (except *A. urinae*), *Bacillus* spp. (except *B. anthracis* and *B. cereus*), *Corynebacterium* spp. (except *C. diphtheriae*), *Lactobacillus* spp., *Lactococcus* spp., *Micrococcus* spp., *Moraxella* spp. (except *M. catarrhalis*), *Neisseria* spp. (except *N. animaloris, N. canis, N. elongate, N. gonorrhoeae, N. zoodegmatis* and *N. meningitidis*), *Propionibacterium acnes, Staphylococcus* spp. (except *S. aureus, S. saprophyticus, S. lugdunensis* and *S. schleiferi*). Most DCMs identify *Streptococcus* spp. and nonhemolytic streptococci to the species level, especially if the microorganism is considered the etiological agent for bacteremia. Thus, when reported at the genus level, findings were assessed as contaminants.

Microorganisms not listed as contaminants were considered pathogens.

A blood culture day (BCD) was defined as a day on which a patient had at least one blood sample taken for culture. The reason for this measure was the practice in some DCMs to register each bottle of a BC set as an individual sample, while other laboratories registered a set of bottles. The time of sampling was not always available, making it impossible to distinguish between multiple bottles from one set and sets of bottles drawn at different moments in time on the same day.

A positive BCD was defined as a BCD on which at least one culture yielded growth of at least one pathogenic microorganism.

Data analysis

General demographics were described for patients who had BCs taken. Age at first blood sample and sex were derived from the CPR number. BCDs and positive BCDs were observed over time and by sex and age groups (0–4, 5–24, 25–44, 45–64, 65–74, 75–84 and 85–99 years). When stratifying by

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