QUALITY IMPROVEMENT REPORT

Improving early management of bloodstream infection: a quality improvement project

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Bloodstream infection is a common but serious illness, which occurs in community and hospital settings and has a mortality rate of 20-40%.[1-3] Death is two to three times more likely to occur in people given ineffective antibiotics.[4 5] Surveys of patients with bloodstream infections show that the initial choice of empirical antibiotics often disregards hospital antibiotic policy. In one study, 22% of patients were receiving antibiotics that were ineffective against the micro-organism isolated,[4] and in another study 12% of patients were not receiving antibiotics at all, despite signs of sepsis.[6] Strong evidence for giving antibiotics as quickly as possible in bloodstream infection comes from a large North American study of patients with septic shock in a critical care setting, which showed a clear association between risk of death and delay in starting effective antimicrobials.[7] Early recognition, prompt initiation of appropriate antibiotics, and rapid microbiological diagnosis are therefore key components of effective clinical management. Individual clinical responses to bloodstream infections vary greatly, however, partly because of differences in both pathogen and host.[8 9] Thus, a proportion of patients initially remain relatively well. The clinical status of the patient as part of the decision making process is less well studied.

In 2003, the Surviving Sepsis Campaign (www.survivingsepsis.org) was set up as an international effort to improve awareness and management of severe sepsis, backed by the Institute for Healthcare Improvement. The recommended screening tools and protocols ("bundles") have been widely adopted by intensive care units, but are less well known in general wards.[10]

St James's University Hospital has around 1400 beds and provides a wide range of local acute services, together with several regional and supraregional specialties. Specialised areas like haematology, where the risk of infection is high, have well established protocols for investigating suspected infection and initiating empirical antibiotics. Other areas receive advice on antibiotics if requested or when organisms are detected by microbiology testing.

Abstract

Problem Bloodstream infection is a common but serious illness with high mortality and morbidity, which is seen in many clinical specialties. Errors such as delay in diagnosis and lack of effective treatment often occur.

Design Initial observational study followed by prospective study before and after intervention in a high risk clinical area.

Setting 1400 bed teaching hospital in the United Kingdom where the initial management of all inpatients with bloodstream infections was surveyed over six weeks. This showed 55 major errors in 46 (30%) of 157 episodes of bloodstream infection. Most (44) were in general areas of the hospital without a specific protocol for managing sepsis. 29 of the 55 errors were caused by delay in giving effective antibiotics to critically ill patients. In 19 cases, effective antibiotics were still not given despite advice from infection services based on blood culture results. A diagnosis of bloodstream infection had not been considered in 7 patients already in hospital despite clear signs of sepsis for more than 48 hours.

Strategy for improvement Development of guidelines for recognition and initial management of patients with severe sepsis and bloodstream infection, implementation of an education programme on clinical standards for managing sepsis, and introduction of a bacteraemia service that included feedback.

Key measure of improvement Reduction in incidence of major errors in early management of bloodstream infection.

Effects of change In the second part of the study, major errors were found in 11 of 37 episodes (30%) immediately before the intervention in the main high risk area (medical wards), whereas such errors were found in 6 of 79 episodes (8%) after the intervention.

Lessons learnt The early management of patients with bloodstream infection was often suboptimal. The underlying factors included failure to recognise patients with serious infection; delays in giving antibiotics as a result of poor communication between medical, nursing, and pharmacy teams; and lack of understanding of empirical antimicrobial selection. Introduction of improvement measures was associated with considerable improvement in the early management of severe sepsis caused by bloodstream infection.

Box 1 Criteria for major errors

- Forty eight hours or more delay before bloodstream infection considered as a diagnosis despite presence of two or more of the following signs of sepsis: fever, hypotension, tachycardia, increased respiratory rate, and new confusion
- Delay of six hours or more in giving appropriate antibiotics to critically ill patients (modified early warning score ≥5 or shock (systolic blood pressure <90 mm Hg for more than four hours in a previously normotensive adult without evidence of bleeding))
- No antibiotics or ineffective antibiotics given despite positive microbiology results

Outline of problem

We surveyed the quality of the initial management of patients with confirmed bloodstream infections, as poor clinical practice at this stage may contribute to increased patient morbidity and mortality, prolonged hospital stay, excessive drug costs, and selection of resistant organisms.[11] We looked for errors that we judged serious enough to cause appreciable morbidity and mortality (box 1), and then related these to the clinical condition of the patient.

Key measures for improvement

We aimed to recognise patients with signs and symptoms suggestive of bloodstream infection promptly and to treat critically ill patients rapidly using antibiotics that were appropriate for the suspected site of infection.

Process of gathering information

All episodes of bacteraemia from St James's University Hospital were studied over six weeks. Blood cultures were incubated in either Lytic/10 Anaerobic/F with Bactec Plus Aerobe/F bottles for adults or Peds Plus/F for children using a Bactec 9240 system from BD (MD, USA) for at least five days. We excluded cases where the isolated micro-organism was part of the normal skin flora or environmental flora and likely to be a contaminant unless such organisms were isolated on three or more occasions. Data were collected on age, sex, specialty, micro-organism, likely source of infection, whether the infection was the reason for hospital admission, other comorbidities, C reactive protein and white blood cell count at the time blood cultures were taken, and the modified early warning score in adults.[12] We recorded the antibiotics prescribed, how they were given, whether they were appropriate (usually effective against the expected micro-organisms at that infection site), and any delay before appropriate antibiotics were given. We calculated the time interval before antibiotics were given from the time of arrival in the accident and emergency department for community acquired infections and from the first documented time of clinical deterioration for hospital acquired infections. The time of antibiotic administration was obtained from the prescription chart. We also noted whether antibiotics recommended by the microbiology department were given. Major clinical errors that might carry a risk of death or serious morbidity (see box 1) were recorded, excluding cases where the clinical team had decided that the patient was not for active treatment. One author (JM) reviewed all cases and made the final decision as to whether a major error had occurred.

Table 1 | Frequency of major errors in diagnosing or treating bloodstream infections according to criteria (see box 1)

Criterion	No
Six hour delay before antibiotics in critically ill patients*	29
Ineffective antibiotics despite blood culture result	19
48 hour delay in diagnosis of bloodstream infection	7
Total†	55

*Modified early warning score ≥5 or shock.
†9 patients met 2 criteria.

Analysis and interpretation

We identified 158 episodes of bloodstream infection in 148 patients; the case notes were available for review in 157 episodes. We found major errors in 46 episodes (30%) according to our criteria (table 1). Nine episodes met two criteria, giving a total of 55 major errors. Most errors (29) occurred because of a delay of six or more hours in giving appropriate antibiotics to critically ill patients. It was not always possible to determine the underlying reasons for the delay because of lack of documentation. Although delay was often the result of inadequate clinical assessment, 10 cases had problems such as lack of intravenous access or the prescribed drug being unavailable on the ward. In 17 cases, the initial antibiotics given were inappropriate (likely to be ineffective against the expected micro-organisms in that particular clinical situation). In 19 cases, ineffective antibiotics were given despite microbiology advice based on blood culture results. In three such cases we documented recurrent bloodstream infection within the next six weeks. In seven cases a diagnosis of bloodstream infection was not considered for more than 48 hours (often at a weekend when staffing levels were lower) despite clear signs of sepsis.

Most errors (44/55) occurred in areas of the hospital with no specific infection protocols, and about two thirds of the positive blood cultures came from these areas. The medical wards had the most bloodstream infections and the highest rate of major errors. Table 2 shows the characteristics of the patients with and without major errors.

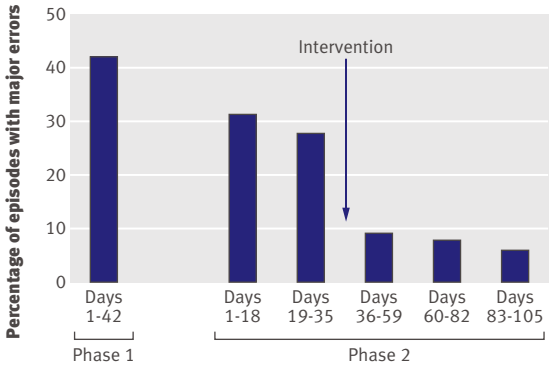
We defined a major error as one that might result in serious morbidity or death. A six hour delay was classed as a major error—this is generous as the Surviving Sepsis Campaign recommends starting antibiotics within an hour of presentation in severe sepsis. Cases with unusual isolates where the chosen antimicrobial was unexpectedly ineffective were not counted as major errors, and neither were departures from the hospital antimicrobial guidelines, provided the antibiotics were likely to be effective for the clinical situation. We expected the antibiotic regimen to include appropriate cover for a patient already colonised with a resistant organism such as methicillin resistant *Staphylococcus aureus* and that antibiotics should be given intravenously for critically ill patients.

The groups with and without major errors differed. The mean age of those with major errors was higher than that of those without serious errors, mainly because the second group contained more paediatric oncology patients in whom antibiotics were usually started promptly. One of our definitions of a major error partly depended on the modified early warning score being ≥5, which resulted in a higher mean modified early warning score for the major error group, and may have contributed to the higher mortality in this group. Our study recruited only patients with positive blood cultures so we may have missed cases of bloodstream infection where blood cultures were not taken at all or were taken after antibiotics were started.

Strategy for change

For the second part of our study we chose to target the medical wards as they had the highest numbers of bloodstream infections and major errors. We introduced several measures to improve initial clinical management of suspected bloodstream infection (box 2). This included introducing a modified sepsis recognition tool from the Surviving Sepsis Campaign. We also adapted the Surviving Sepsis Campaign sepsis bundles (www.ihi.org/IHI/Topics/CriticalCare/Sepsis) to develop guidelines for the management of suspected severe sepsis on general wards, adding more detailed instructions on fluid resuscitation and antibiotic recommendations according to the likely site of infection (see figure on bmj.com). We omitted ventilation guidelines and other recommendations more relevant to a critical care setting. Both the guidelines and the recognition tool were introduced at educational sessions using problem cases as illustrations. The guidelines and recognition tool were made available on the trust website. We also set up a bacteraemia service —members of the infection team reviewed patients with bloodstream infections as soon as possible after a positive blood culture result to check on prescription and administration of antibiotics and to make further recommendations as appropriate.[6] We provided constructive feedback in those cases where management had given cause for concern.

Because of relocation and staff changes between the time that we first analysed the data and developed our improvement strategy, we repeated our survey before the intervention to determine the new baseline error rate. All episodes of clinically significant bacteraemia from the medical wards were therefore studied for 15 consecutive weeks (five weeks before and 10 weeks after introduction of measures).



Major errors in diagnosis and management of episodes of bloodstream infection in medical wards in the initial survey (phase 1) and the intervention study (phase 2)

Effects of change

The improvement measures were associated with a reduction in major error rate from 11 of 37 (30%) to 6 of 79 (8%) (table 3). The figure compares major error rates before and after intervention. After the intervention, no delays in diagnosis occurred and fewer cases of delay before starting appropriate antibiotics and not acting on blood culture results were seen. The initial guidelines promoted helpful discussion and development of an improved protocol for use throughout the Leeds hospitals.

Lessons learnt and next steps

Our study suggests that providing education and guidelines can greatly improve the early management of bloodstream infection, a common medical emergency with high morbidity and mortality. Rather than concentrating just on medical staff, we could also have targeted nursing and pharmacy colleagues. Measures to minimise the high numbers of bloodstream infections acquired in hospital should be in place. The bacteraemia service responds to positive blood cultures but misses cases where blood cultures are not taken. The service required close liaison between laboratory and clinical infection teams that were based at different sites to ensure consistent advice. Other specialties could possibly become "de-skilled" by such a service, but we found that ward visits gave us opportunities to provide informal education. The results of our study need to be reproduced in other settings to demonstrate their widespread applicability,

Table 2 | Characteristics of cases of bloodstream infection according to errors in diagnosis and management. Values are numbers of patients unless stated otherwise

Variable	Major error	No major error
Total number	46	111
Male	28	70
Female	18	41
Male:female ratio	1.5	1.7
Mean (SE) age	69.6 (2.7)	47.0 (2.7)
Hospital acquired infection (%)	25 (54)	55 (50)
Mean (SE) modified early warning score	4.5 (0.3)	3.6 (0.3)
Modified early warning score ≥5	25/43 (58)	24/78 (31)
Mean (SE) white blood cell count ($\times 10^9$/l)	15.9 (1.5)	11.4 (1.0)
Mean (SE) C reactive protein (mg/l)	180.0 (17.7)	112.4 (10.3)
Deaths (%)	12 (26)	13 (12)
Mean (SE) length of stay (days)	30.3 (8.6)	20.2 (4.0)
Specialty areas		
Medicine	23	32
Surgery	12	24
Oncology	4	34
Others	3	18

Table 3 | Characteristics of cases of bloodstream infection in medical wards. Values are numbers of patients unless stated otherwise

Variable	Before intervention	After intervention
Major error		
Total number	37	79
Male	19	43
Female	18	36
Male:female ratio	1.0	1.2
Mean (SE) age	68.3 (6.3)	71.2 (2.0)
Hospital acquired infection	8	12
Mean (SE) white blood cell count ($\times 10^9$/l)	15.3 (3.2)	17.0 (1.4)
Mean (SE) C reactive protein (mg/l)	186 (25)	186 (14)
Mean (SE) medical early warning score	3.9 (0.5)	3.8 (0.3)
Medical early warning score ≥5	14	27
Mean (SE) length of stay (days)	24.4 (5.8)	28.2 (3.5)
Deaths (%)	10 (27)	17 (22)
Any major error (%)	11* (30)	6† (8)
Delayed diagnosis	2	0
Delayed antibiotics	5	4
Blood culture result not acted on	7	3

*More than 1 type of error in 3 cases.
†More than 1 type of error in 1 case.

sustainability, effect on morbidity and mortality, and cost effectiveness. It is also important to validate any changes to routine clinical practice to confirm that expected advantages are realised and crucially that the risks of unintended adverse effects are minimised. Thus, audit of practice changes should include assessment of potential adverse events, such as selection of antimicrobial resistance and infectionwith *Clostridium difficile*, as a consequence of altering antibiotic prescribing practice.

We understand from discussions with colleagues in infection specialties in other hospitals that the problem of the poor quality of early management of bloodstream infection is widespread. In addition, a similar survey conducted in another hospital found a major error rate of 25% for all clinical areas (P Stanley, personal communication, 2006). Again, the underlying factors included failure to recognise patients with serious infection, lack of understanding of empirical antimicrobial selection, and administrative delays. This clinical problem is common, affects most clinical specialties, and is associated with a high mortality rate, yet it receives relatively little attention. We propose that all acute hospitals, supported by their infection and intensive care specialists, should introduce a programme to monitor and if necessary improve the management of severe sepsis including bloodstream infections. Further information and support may be obtained from the Surviving Sepsis Campaign.

Box 2 Strategy for improving early management of bloodstream infections

The guidelines on both the recognition and management of severe sepsis were introduced at educational sessions and were made available on the trust website

Guidelines for recognition of severe sepsis

A recognition tool based on history, examination, and basic laboratory tests

Guidelines for management of severe sepsis

Recommendations on prescription of empirical antibiotics

Advice on fluid resuscitation

Advice on monitoring patients

Reminders to request senior or specialist review

Bacteraemia service

Provides checks on antibiotic prescribing and administration

Provides recommendations for further investigation and length of treatment

Provides feedback on initial management

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Contributors: JM planned and coordinated the project, collected data, decided whether a case was a major error or not, and coordinated writing the paper. JC liaised with the microbiology department and helped write the paper. JS collected data and helped write the paper. HMcG collected data, contributed to the bacteraemia service and helped write the paper. MW planned the original study and intervention measures and helped write the paper. JM is guarantor.

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