Controlling intravascular catheter infections

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SYNOPSIS

Sepsis related to intravenous catheters is the commonest cause of bloodstream infections in Australia. The risk of infection is highest with percutaneous central venous catheters, somewhat lower with tunnelled or subcutaneous catheters, and lowest with peripheral intravenous catheters. The best prevention is removal of intravenous lines when they are no longer necessary. Optimal insertion techniques and line maintenance are also important. Once infection occurs, the line should generally be removed. Antibiotic therapy is directed against suspected micro-organisms (usually staphylococci) and modified with the results of cultures. If septic shock occurs general supportive measures including intravenous fluids, inotropic drugs and observation in an intensive care unit will also be necessary.

Index words: sepsis, bacteraemia, bloodstream.

Introduction

Intravenous catheters are indispensable in modern medicine and are no longer restricted to hospital inpatients. There is a growing number of patients on 'home' intravenous therapy, predominantly for total parenteral nutrition or cancer chemotherapy. However, these devices are increasingly associated with sepsis and are now the commonest cause of all bloodstream infections. These infections cause significant morbidity and mortality.

Rates of intravascular catheter-associated bloodstream infections

In Australia, there are at least 3500 cases of intravenous catheter-associated bloodstream infections annually. These are associated with a case fatality rate of 24%, and the mortality rate directly attributable to intravenous catheter sepsis is 12%. This equates to 1.5 bloodstream infections per 1000 admissions.[1]

Percutaneous central venous catheters are associated with 23 bloodstream infections per 1000 catheters. In contrast, catheters in peripheral veins are associated with only 0.36 bloodstream infections per 1000 catheters.[2] Peripheral vein catheters remain *in situ* an average of 1.5 days, while central venous catheters remain *in situ* about four times longer (an average of 5.5 days). The daily infection risk with central venous catheters is about 20 times that of peripheral catheters. Tunnelled or surgically implanted catheters (Hickmans, Portacath) and peripherally inserted central venous catheters appear to have a quarter the daily risk of percutaneous central venous catheters, but they still pose a much higher risk than peripheral catheters.

Why there is such a disproportionate infection rate of central venous catheters is unclear. It may reflect the poorer health of patients requiring this type of therapy as well as the longer duration of intravenous access in this group. The infusion of total parenteral nutrition, the use of triple lumen (versus single lumen) catheters, and some catheter insertion sites (jugular and femoral sites in particular) are independent risk factors. However, all these factors only partially account for the marked differences in daily infection risk rates.

Of concern, is the observation that a large number of intravenous catheters (including central venous catheters) in hospitalised patients are not in active use for prolonged periods of time but remain *in situ* 'just in case'. Also, some catheters are being used for interventions that are not necessary (for example, total parenteral nutrition when nasogastric feeding is possible).

Pathogenesis

There are several modes of colonisation with pathogens.[3] At the skin entry site, the outer surface of the catheter can become colonised with organisms originating from the skin. These bacteria can then migrate proximally along the catheter's surface to reach the bloodstream. Alternatively, the catheter's inner surface may become colonised by introduction of organisms through the catheter hub (e.g. from the hands of hospital staff). Rarely, micro-organisms may be introduced by contaminated infusate (especially total parenteral nutrition). The point at which colonisation changes to invasive infection is unclear, but it is thought to be related to the number of organisms present on the catheter, and is time dependent (infection is rare within the first 48 hours of catheter placement).

The role of biofilms (collections of bacteria adherent to the catheter surface and organised within an extensive glycocalyx) is important. Although micro-organisms in biofilms are visible on microscopy, they are often unculturable, and are protected from the effects of antibiotics. If biofilms are present, cure is usually only possible by removing the catheter.

Table 1	
Major pathogens with approximate frequencies[2]	
Pathogens	*Frequency*
Coagulase-negative staphylococci	35%
Staphylococcus aureus	25%
Yeasts (especially candida species)	10%
Enterococci and streptococci	10%
Pseudomonas species	5%
Enteric Gram negative bacilli (e.g. Klebsiella)	15%
Other	5%

Microbiology

Skin-associated micro-organisms are the predominant isolated pathogens (see Table 1). Coagulase-negative staphylococci (e.g. *Staphylococcus epidermidis*) are the commonest, possibly because they appear to have the best adherence to inert surfaces. *Staphylococcus aureus* infections are second in frequency, with the infection risk being highest in patients with neutrophil defects or venous thrombophlebitis. Enteric mucosal micro-organisms such as enterococci, *Enterobacteriaceae*, pseudomonas, and candida species may colonise the catheter either by colonising the skin, by colonising the infusate (especially total parenteral nutrition) or by haematogenous seeding from mucosal breaches.

Diagnosis

In the majority of bloodstream infections associated with central venous catheters, there will be little or no evidence of sepsis at the insertion site (in contrast to infections associated with peripheral vein catheters).

The diagnosis of catheter-associated bloodstream infection requires a positive culture of blood from a peripheral vein and clear evidence implicating the catheter as the source. The culture of 15 or more colonies of a pathogen from a catheter tip is diagnostic of catheter-associated bloodstream infections. Unfortunately, this method only has a positive predictive value of 16–31% because most catheter tip cultures are negative.[4]

Another approach to diagnosis (which conserves the catheter) is simultaneous culture of blood drawn peripherally and blood drawn from the catheter. As the density of organisms is greatest in the catheter specimen (if it is the source of sepsis), the catheter blood culture will usually become positive at least two hours earlier than the peripheral blood culture (using the Bactec system). This technique has been reported to have a sensitivity and specificity of greater than 90% and a positive predictive value of approximately 80%.

Treatment

Catheter removal is usually essential in all cases of catheter-associated bloodstream infections, with the exception being some cases associated with Hickmans or Portacath catheters. Even with these, catheter removal is still essential if *Staphylococcus aureus* or candidal septicaemia occurs and

strongly recommended if Gram negative bacilli (due to likelihood of treatment failure) are isolated from blood cultures.

If low virulence organisms such as coagulase-negative staphylococci are isolated, removal of the line itself may be sufficient to resolve the infection, but usually the patient is also treated with one week of intravenous antibiotics. If a Hickmans or Portacath is involved and is not removed, the patient is treated with two weeks of intravenous antibiotics. This may control the infection in 80% of cases, however, if the bacteraemia or fever persist despite appropriate antimicrobial therapy, the central venous catheter must be removed.

If bloodstream infection is suspected and the catheter is replaced, the new central venous catheter should not be passed over a guide-wire at the same venepuncture site. If it is, the new catheter will almost certainly be contaminated with the same organism (see Table 2 for further prevention issues).

While awaiting blood culture results, empiric therapy to cover staphylococci and Gram negative bacilli (i.e. vancomycin, or flucloxacillin in combination with an aminoglycoside) is the best initial treatment. The regimen may be modified once the pathogen is identified.

If *Staphylococcus aureus* is isolated, treat with antibiotics (e.g. flucloxacillin if sensitive) for a minimum of 14 days after catheter removal (4–6 weeks therapy if persistent fevers or a suspected distant focus of infection). If candida is isolated,

Table 2
Prevention of catheter-related infection
General measures
• Do not insert an intravenous catheter unless essential (would oral therapy suffice?)
• Adequate skin preparation and aseptic technique
• Full aseptic technique for central venous catheters (gowns, gloves and drapes)
• Cover site with sterile, semi-permeable dressing
• Disinfect access sites before use
• Scrupulous hand hygiene by staff
• Remove catheter when no longer clinically necessary
Type and site of catheter
• Use peripheral catheter rather than central catheter if possible
• Routinely replace peripheral catheters within 48–72 hours (no evidence for routine replacement of central venous catheters)
• Peripherally inserted venous catheter instead of subclavian/jugular/femoral central venous catheter if possible
• If central venous catheter used, the subclavian site has the lowest infection risk, whilst the jugular vein and femoral vein sites have the highest infection risks
• Use a peripherally inserted venous catheter or tunnelled central venous catheter or totally implantable device if more than 14 days access predicted
• Use central venous catheters with as few lumens as possible
• Catheters with surface irregularities, polyvinyl chloride or polyethylene are associated with higher infection risks
• Antibiotic or antiseptic impregnated catheters can reduce sepsis rates with central venous catheters especially if a unit has a high rate of catheter-associated sepsis

treatment is generally with a triazole (e.g. fluconazole) for at least 14 days after the last positive blood culture. The fungal isolate should be fully identified, as species other than *Candida albicans* are often resistant to triazoles.

If the patient remains febrile after removal of the device, three sets of blood cultures should be obtained. Endocarditis or septic thrombophlebitis should be suspected if blood cultures remain positive for more than 48 hours after the device has been removed.

Conclusion

Catheter-related sepsis is a common complication of modern medical therapy. Reduction of this complication may be achieved by minimising intravenous access. If there is no absolute need for intravenous access, remove the intravenous line. Use peripheral access rather than central venous catheters wherever possible. When central venous catheter access is necessary, use peripherally inserted venous catheters or tunnelled/implanted lines if possible. If bloodstream infections occur, removal of the intravenous line is essential, with only a few exceptions (Hickmans- or Portacath-associated bloodstream infections with low virulence organisms such as coagulase-negative staphylococci).

REFERENCES

1. Collignon PJ. Intravascular catheter associated sepsis: a common problem. Med J Aust 1994;161:374-8.
2. Managing bloodstream infections associated with intravascular catheters. Drug Ther Bull 2001;39:75-80.
3. Crump JA, Collignon PJ. Intravascular catheter-associated infections. Eur J Clin Microbiol Infect Dis 2000;19:1-8.
4. Maki DG, Weise CE, Sarafin HW. A semiquantitative culture method for identifying intravenous-catheter-related infection. N Engl J Med 1977;296:1305-9.

FURTHER READING

Raad I. Intravascular-catheter-related infections. Lancet 1998;351:893-8.

Self-test questions

The following statements are either true or false (answers on page 47)

7. Removal of the catheter is necessary in patients with catheter-related bloodstream infections caused by *Staphylococcus aureus*.

8. Central venous catheters inserted at the subclavian site have a higher risk of infection than those inserted into the femoral vein.

Book review

Paediatric Pharmacopoeia

Melbourne: Women's and Children's Health, Royal Children's Hospital; 2002.

The book is available in three formats. (Prices include GST but not postage.)

- Paediatric Pharmacopoeia, 13th ed. $49.50
- Paediatric Pharmacopoeia – Pocket Prescriber, 1st ed. $9.90
- Paediatric Pharmacopoeia e-book. $99
- 3-set package, one copy of each. $143

Peter D. Jones, Associate Professor of Health, The University of Newcastle, Director, University Department of Rural Health, Northern NSW, Tamworth, and Chair of the Specialist Advisory Committee for General Paediatrics, Royal Australasian College of Physicians

The three versions of Paediatric Pharmacopoeia make up an excellent resource to help with the prescribing of drugs to children. They are published by the Pharmacy Department of the Royal Children's Hospital, Melbourne. In their current format they are very useful references for doctors treating children in hospital or emergency department settings.

The Pocket Prescriber appears to be a new publication. It offers an alternative to Frank Shann's Drug Doses[1], which is the current booklet used in hospitals throughout the country to help calculate doses in children. The Pocket Prescriber is a larger, heavier and more expensive booklet than Drug Doses (86 mm wide versus 72 mm wide, 100 g versus 50 g, $9.90 versus $6.50), but still fits into the top pocket of my standard business shirt. It is filled with excellent information and it is good to see the antibiotic guidelines in the booklet. It is well presented with a much sturdier red cover than Drug Doses and I think its slight increase in size and weight means that it will be less easy to lose on the wards. This booklet should be an essential piece of equipment for all doctors working with children in a hospital setting. Hospitals should ensure that staff who prescribe and administer drugs to children have a copy of this book and refer to it frequently because I am certain that it could lead to fewer prescribing errors in hospital care.

The Paediatric Pharmacopoeia, 13th edition, is another very useful little book that contains some extra information and specific warnings about each drug. The e-book is easy to navigate and has the most potential to be a useful resource for general practitioners and paediatricians who are prescribing for children in the community. It is easy to find the immunisation schedule, and with time the guidelines may start to have more relevance to community-based rather than hospital-based care. The e-book does contain information about the presentation options of particular drugs (i.e. tablet and mixture strength) and the different trade names available in Australia. I believe the e-book could be improved by including information regarding Pharmaceutical Benefits Scheme prescriptions to make this package of resources more applicable to doctors working outside the hospital setting.

REFERENCE

1. Shann F. Drug Doses. Parkville, Victoria: Royal Children's Hospital; 2001.