# Catheter-related bloodstream infection

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Catheter-related bloodstream infection (CRBSI, also called catheter-related sepsis) is defined as the presence of bacteraemia originating from an i.v. catheter. It is one of the most frequent, lethal and costly complications of central venous catheterization. It is also the most common cause of nosocomial bacteraemia. Although the use of central venous catheters (CVC) is increasing, there is evidence that the problem of CRBSI can be reduced.

This article will consider the use of CVCs in the acute medical setting; long-term vascular access devices will not be reviewed.

## Epidemiology

Overall, CRBSI occurs in ~3% of catheterizations, however, the incidence may be as high as 16%.[1 2] This represents 2–30 episodes per 1000 catheter days. CRBSI can originate from peripheral i.v. and intra-arterial cannulae, but this is extremely rare. Pulmonary artery catheters have a similar incidence of CRBSI to CVCs; dialysis catheters appear to have a much higher rate (29% in one series).

## Pathogenesis

Immediately after insertion, the surfaces of the CVC become coated with plasma proteins, particularly fibrin. Bacteria migrate from skin along the catheter track and/or from the catheter hubs down the lumen(s) and become embedded in this protein sheath. Certain organisms have specific binding sites for the proteins that constitute the sheath. This process is termed colonization; studies using electron microscopy have shown that this happens within hours of insertion. For many years, it was thought that only the exterior of the catheter was subject to colonization. However, newer methods of catheter culture demonstrated that endoluminal colonization is at least, if not more, important (Fig. 1).[1 3]

Certain organisms such as staphylococci and *Candida* secrete a biofilm layer or 'slime' that gives them protection against antimicrobial agents. It is possible that a lag time of 3–4 days exists after insertion during which the risk of CRBSI is low. It appears that bacteraemia is more likely once a threshold count of bacteria or fungi is reached; there is a relationship between the number of organisms isolated from the catheter surface and the occurrence of CRBSI. The presence of adherent thrombus (the incidence of which may exceed 30%), increases the risk of CRBSI. Furthermore, should the thrombus itself become infected (septic thrombophlebitis), then a more severe illness is likely which is more resistant to treatment. The relative frequencies of causative organisms are given in Table 1.

CRBSI triggers a systemic inflammatory response, ranging from fever and leucocytosis through to septic shock and multiple organ failure. The reported mortality rate varies from 3 to 25%.[2] Metastatic infection is possible; for example, septic thrombosis, endocarditis and septic arthritis. It is important to consider such deep-seated infection when faced with an apparently non-resolving CRBSI.

Exit site and catheter track infections also occur and necessitate catheter removal. It is generally accepted that such infections may coexist with CRBSI or may be a precursor to CRBSI.

## Diagnosis

Diagnosis of CRBSI is based on the following:

(i) The presence of a CVC;
(ii) signs of catheter insertion site infection
(iii) clinical symptoms and signs of bacteraemia;
(iv) resolution of the symptoms and signs of bacteraemia after removal of the suspect CVC;
(v) positive blood culture; and
(vi) growth of the same organism from the catheter.

In practice, a presumptive diagnosis of CRBSI is often made on the basis of one or two of these criteria. The 'gold standard' is the combination of a positive blood culture with the same organism isolated from the

**Key points**

Catheter-related bloodstream infection (CRBSI) is the commonest cause of nosocomial bacteraemia.

The incidence of CRBSI arising from central venous catheters may exceed 10%.

CRBSI has a mortality rate of up to 25% and significantly increases hospital length of stay and overall treatment costs.

National guidelines exist on the prevention of CRBSI.

The need for a central venous catheter must be reviewed daily.

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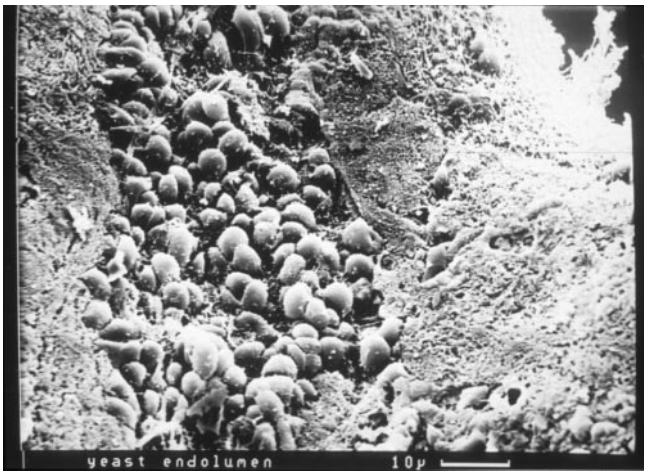


**Fig. 1** Electronmicrograph: Yeasts colonising the endolumen of a central venous catheter (Courtesy of Dr P Kite, Department of Medical Microbiology, Leeds Teaching Hospitals).

**Table 1** Organisms causing CRBSI (taken with permission from reference 1)

| Organism | Percentage of total |
|---|---|
| *S. aureus* | 22.0 |
| Coagulase-negative staphylococcus | 37.0 |
| Yeasts | 9.3 |
| Enteric Gram-negative bacilli | 12.4 |
| Enterococci and streptococci | 4.9 |
| Pseudomonas | 5.5 |
| Other | 8.9 |

catheter. However, a major diagnostic problem is that traditional methods of catheter culture necessitate removal of the CVC, whereby the line tip is either rolled on an agar plate or placed in a nutrient broth. These techniques detect bacteria that are merely colonizing the CVC as well as those causing a bacteraemia and therefore are sensitive but poorly specific for CRBSI.[4]

Although catheter removal in suspected CRBSI may be mandatory when faced with a deteriorating patient, 80% of catheters removed on the basis of fever and/or leucocytosis alone will be sterile. This places the patient at risk from the discomfort and mechanical complications of inserting another CVC and increases costs. There has been an impetus therefore to develop *in situ* methods of microbiological diagnosis. The following methods have been described:[3]

*Quantitative blood culture*. CRBSI is suggested when the number of microbes from a CVC sample of blood is five times that from a simultaneously collected peripheral sample. This is not widely available.

*Acridine orange staining of blood taken from the CVC*. This is not widely available.

*Endoluminal brush sampling.* A tiny brush is passed down the catheter lumen and is examined microbiologically by culture. This test has a high sensitivity and specificity but is not widely available. In addition, there are concerns about the generation of a bacteraemia caused by dislodgement of organisms.

*Differential time to positivity*. CRBSI is suggested when blood from the CVC demonstrates microbial growth at least 2 h earlier than growth is detected in blood collected simultaneously from a peripheral vein. Most currently used automated blood culture systems can readily provide this information and it is likely that this will become a standard diagnostic test.

## Associated factors

Immunosuppression, either relative (seen in the critically ill) or absolute (e.g. haematological malignancy), places the patient at increased risk of CRBSI. The microbiological environment also influences the rate of CRBSI with higher rates in the intensive care unit *vs* the outpatient setting. Frequent accessing of the catheter and poor aseptic technique are risk factors for CRBSI, as is the administration of TPN.[1] Subclavian CVCs have the lowest infection rate followed by internal jugular and femoral catheters. However, when considering the site of insertion, infective risks must be balanced against mechanical complications (e.g. pneumothorax with subclavian cannulation).[5]

CRBSI is unlikely in the first 3–4 days of catheterization; thereafter it is likely that the risk incidence (risk per catheter per day) is constant, although the cumulative incidence increases over time.

## Treatment

In general, the catheter should be removed if CRBSI is suspected. When the line is 'precious' and/or other access impossible, it may be justifiable to leave the catheter in place and treat medically. Some clinicians practice guidewire exchange of such 'precious' catheters; if the removed catheter is proven on microbiological examination to be the source of sepsis then the exchanged catheter is removed and another site selected.[5]

Antibiotic therapy should be based on culture reports. However, the optimal duration of such therapy is uncertain and treatment should be in consultation with microbiologists. One week's treatment may be appropriate where the catheter has been removed, 2 weeks if the infection is caused by *Staphylococcus aureus* or fungi. Where deep-seated infection is suspected (because of treatment failure), further imaging and prolonged antibiotic therapy may be required. Treatment in such cases may also include surgery. Where microbiological data are not available or treatment is indicated before cultures are complete, blind antibiotic therapy should target the likely pathogens (including resistant Gram-negative organisms and methicillin-resistant *S. aureus*).[5]

## Prevention

Removal of the CVC is the only certain way to prevent infection; therefore, the continued need for a CVC must be reviewed critically at least daily. National guidelines exist on the prevention of CRBSI and, although based on imperfect evidence, they should

**Table 2** Summary of guidelines for preventing infections associated with the insertion and maintenance of CVCs. (Taken from reference 6. Copyright 2001 with permission from the Hospital Infection Society)

| |
|---|
| Selection of catheter type |
| Use a single-lumen catheter unless multiple ports are essential |
| For total parenteral nutrition, a dedicated CVC or lumen should be used exclusively |
| Use an implantable or tunnelled catheter for long term (>30 days) use |
| Consider the use of an antimicrobial impregnated catheter for patients at high risk of CRBSI |
| Selection of catheter insertion site |
| Balance risks of infection against mechanical risks of insertion |
| Use the subclavian route unless contraindicated |
| Consider the use of peripherally inserted catheters as an alternative to CVCs |
| Aseptic technique during insertion |
| Use optimum insertion technique including sterile gown, gloves and drapes |
| Clean the insertion site with alcoholic chlorhexidene gluconate solution (or alcoholic povidone iodine) and allow to dry |
| Catheter and catheter site care |
| Before accessing the CVC, disinfect the external surfaces of the catheter hub and connection ports with an aqueous solution of chlorhexidene gluconate or povidone iodine (unless against manufacturer's recommendations) |
| Use sterile gauze or transparent dressing over the insertion site |
| Catheter flush solutions should contain anticoagulant |
| Replacement strategies |
| Do not routinely replace non-tunnelled CVCs as a method of CRBSI infection |
| Guidewire exchange is acceptable for malfunctioning catheters if there is no evidence of infection |

form the basis for local practice. The guidelines are summarized in Table 2.

The place of antimicrobial impregnated CVCs is uncertain. The chlorhexidene/silver sulphadiazine-coated and minocycline/rifampin-coated catheters are widely available and are the most extensively studied. They are effective in reducing colonization and CRBSI and may be cost effective but concerns persist about the induction of bacterial resistance and immunological reactions to the catheter coatings. In addition, benefit may only be seen in placement over one week. Current guidance suggests that such catheters be considered in 'high risk' patients, but no systems currently exist that allow risk assessment of CRBSI.[6]

Newer devices to prevent catheter infection and CRBSI (such as silver iontophoretic catheters) await further evaluation. When evaluating trials comparing different CVCs, it is important to note that the low event rate of CRBSI mandates extremely large study groups (probably over 200 patients in both the control and trial cohorts). Unfortunately, few published trials have this necessary power.

## Conclusion

CRBSI is an iatrogenic problem that causes significant morbidity, mortality, excess length of stay and excess costs. Local protocols to minimize CRBSI should be in place, most important of which should be the requirement for daily review of the need for the CVC and an aggressive approach to removal.

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**See multiple choice questions 37–39.**