HEMODIALYSIS CATHETER INFECTION PROTOCOLS

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INTRODUCTION

- Hemodialysis patients with a catheter have a 2- to 3-fold increased risk of hospitalization for infection and death compared with patients with an arteriovenous fistula or graft.
- Catheter-related bloodstream infections (CRBSIs), exit-site infections, and tunnel infections are common complications related to hemodialysis central venous catheter use.

INTRODUCTION

- Catheter-related bloodstream infections (BSIs) alone have a reported incidence of 1.1 to 5.5 episodes per 1000 catheter days and are associated with increased morbidity, hospitalization, and death.

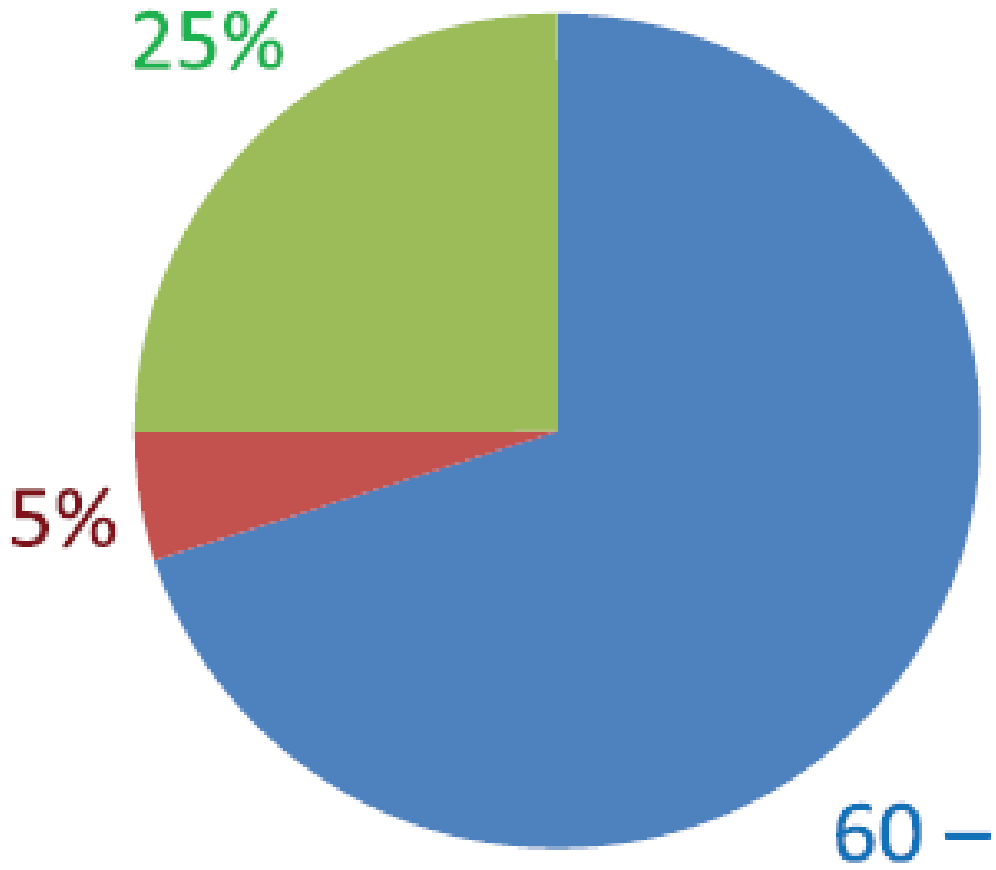
INTRODUCTION

- The most common causative pathogens are gram positive bacteria, with Staphylococcus aureus and coagulase-negative staphylococci accounting for 40% to 80% of CRBSIs.
- Gram-negative organisms cause 20% to 40% CRBSIs, whereas polymicrobial infections (10%-20%) and fungal infections (<5%) are less common.

INTRODUCTION

- Metastatic infectious complications of CRBSIs include endocarditis, osteomyelitis, spinal epidural abscess, septic arthritis, brain abscess, and septic pulmonary emboli

CLINICAL FEATURES

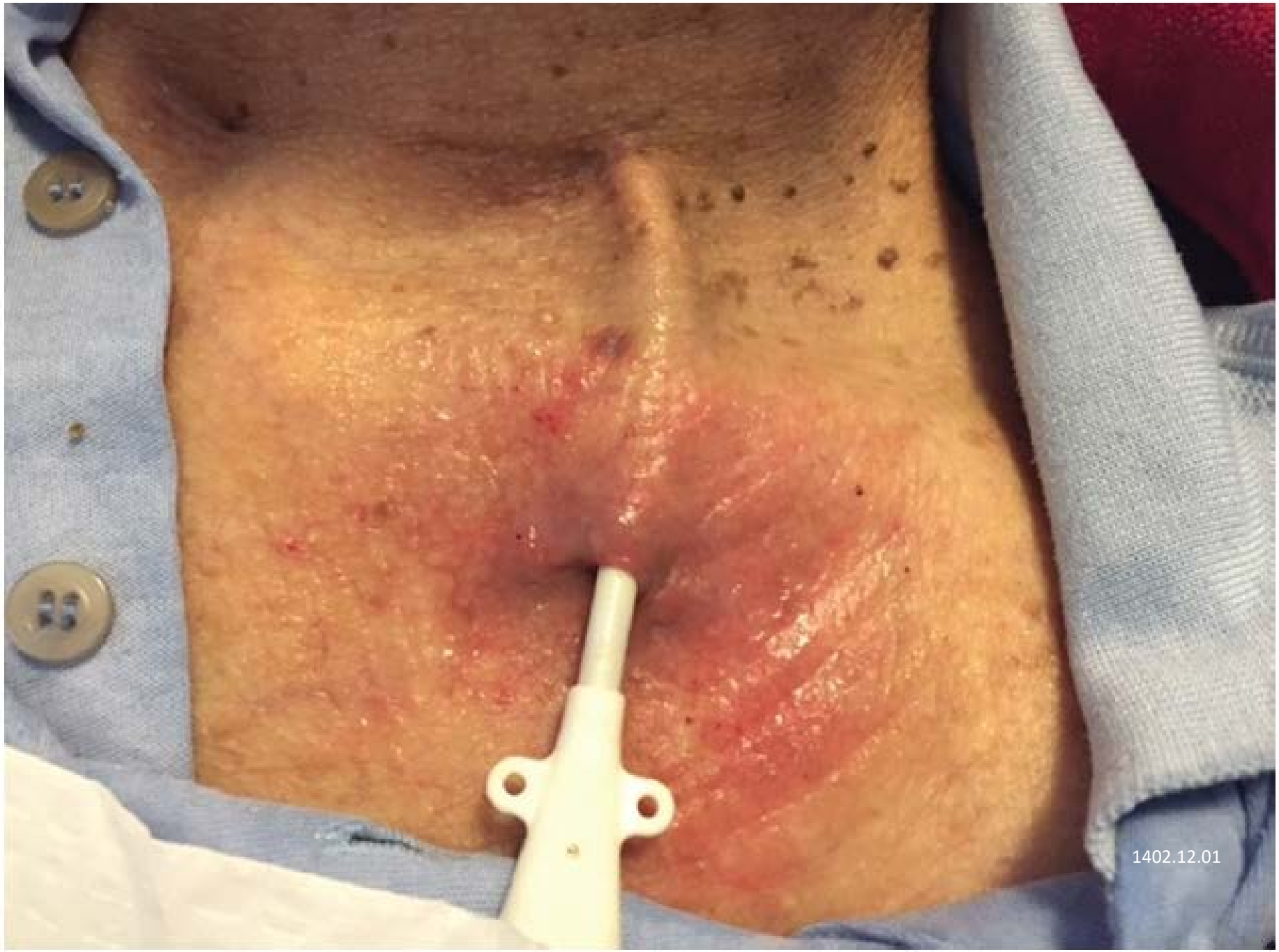


- Fever/Chills
- Exit Site/Tunnel Infection
- Other
  - Hemodynamic instability
  - Altered mental status
  - Catheter dysfunction
  - Hypothermia
  - Nausea/vomiting
  - Generalized malaise

Exit-site infection (Figure 2).

IDSA—Hyperemia, induration, and/or tenderness ≤2 cm from catheter exit site. May be associated with fever and purulent drainage from the exit site. It may or may not be associated with bacteremia. If there is purulent drainage, it should be collected and sent for Gram staining and culture.

CDC—Erythema or induration within 2 cm of the catheter exit site, in the absence of concomitant BSI and without concomitant purulence.



Tunnel infection (Figure 3).

IDSA—Tenderness, hyperemia, and/or induration that extends >2 cm from the exit site and along the subcutaneous tunnel. It may or may not be associated with bacteremia. If there is purulent drainage, it should be collected and sent for Gram staining and culture.

CDC—Tenderness, erythema, or site induration >2 cm from the catheter site along the subcutaneous tract of a tunneled catheter, in the absence of concomitant BSI.

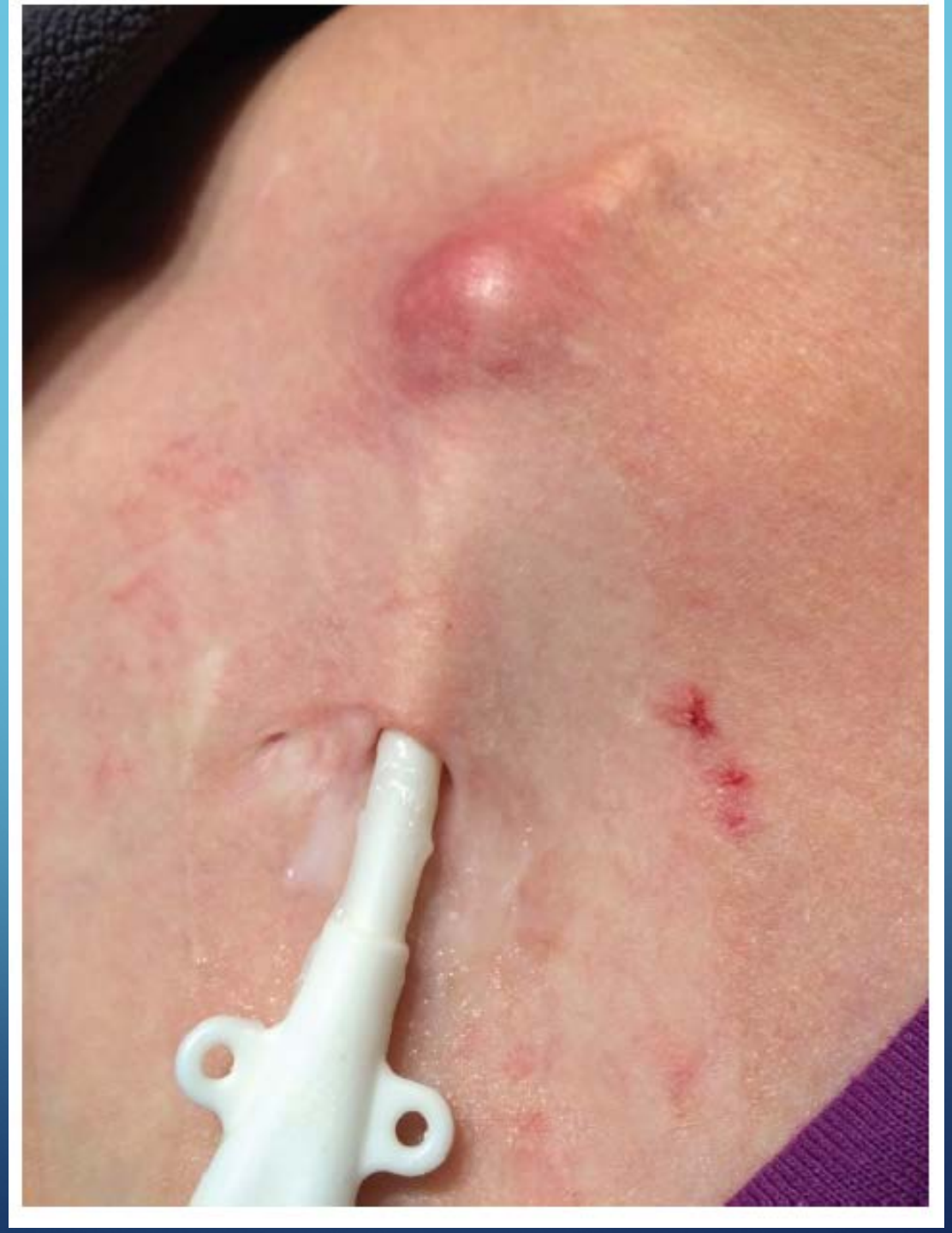


Table 2. CRBSI *Clinical* Definitions.

KDOQI[12]	CDC[13]	IDSA[14]	Public Health Agency of Canada[15]
Definite: Same organism from a semiquantitative culture of the catheter tip (>15 CFU/catheter segment) *and* from a BC in a symptomatic patient with no other apparent source of infection. **Probable:** Defervescence of symptoms after antibiotic therapy with or without removal of the catheter, in the setting in which BC confirms infection, but catheter tip does not (or catheter tip does, but blood does not) in a symptomatic patient with no other apparent source of infection. **Possible:** Defervescence of symptoms after antibiotic treatment or after removal of catheter in the absence of laboratory confirmation of BSI in a symptomatic patient with no other apparent source of infection.	Clinical manifestations and at least 1 positive BC from a peripheral vein and no other apparent source, with either positive semiquantitative (>15 CFU/catheter segment) or quantitative (>10^3 CFU/catheter segment) culture, whereby the same organism (species and antibiogram) is isolated from the catheter segment and a peripheral blood sample; Simultaneous quantitative cultures of blood samples with a ratio of ≥3:1 (catheter vs peripheral); Differential period of catheter culture versus peripheral BC positivity of 2 h; **OR** Isolation of the same organism from semiquantitative or quantitative culture segment and from blood (preferably from a peripheral vein) of a patient with accompanying symptoms of BSI and no other apparent source of infection.	Bacteremia/fungemia in a patient with an intravascular catheter with at least 1 positive BC and with clinical manifestations of infections (ie, fever, chills, and/or hypotension) and no apparent source for the BSI except the catheter **AND** One of the following should be present: A positive semiquantitative (>15 CFU/catheter segment) or quantitative (>10^3 CFU/catheter segment) culture whereby the same organism (species and antibiogram) is isolated from the catheter segment and peripheral blood. Simultaneous quantitative BC with a >5:1 ratio catheter versus peripheral. Differential time period of catheter culture versus peripheral BC positivity of >2 h.	**Definite:** Single positive BC and positive culture result of catheter segment with identical organism or ≥10-fold colony count difference in BC drawn from device and peripheral blood **OR** Single positive BC and positive culture from discharge from exit site or tunnel with identical organism. **Probable:** ≥2 positive BC results with no evidence for source other than the device or single positive BC for *S aureus* or *Candida* species with no evidence for source other than the device **OR** Single positive BC for coagulase-negative staphylococci, *Bacillus, Corynebacterium jeikeium, Enterococcus, Trichophyton*, or *Malassezia* species in immunocompromised or neutropenic host or patient receiving total parenteral nutrition with no evidence for source other than a centrally placed device. **Possible:** Single positive BC result with no evidence for source except a centrally placed device, and patient or organism does not fit criteria for probable infection.

Table 23.1. Definitions of CVC-Related Blood Stream Infections

KDOQI-2019	KDOQI-2006[13]	CDC[297]	IDSA[319]
Clinical manifestations and at least **1 positive BC** from a peripheral source (**dialysis circuit** or vein) **and** no other apparent source, **with** either positive semiquantitative (>15 CFU/catheter segment, hub or tip) or quantitative (>10^2 CFU/catheter segment, eg, hub or tip) culture, whereby the same organism (species and antibiogram) is isolated from the catheter segment (eg, hub or tip) and a peripheral source (dialysis circuit or vein) blood sample. If available, the following would be supportive: Simultaneous quantitative cultures of blood samples with a ratio of ≥3:1 (catheter hub/tip vs peripheral [dialysis circuit/vein]); differential period of catheter culture versus peripheral BC positivity of 2 hours.	**Definite:** Same organism from a semiquantitative culture of the catheter tip (>15 CFU/catheter segment) *and* from a BC in a symptomatic patient with no other apparent source of infection. **Probable:** Defervescence of symptoms after antibiotic therapy with or without removal of the catheter, in the setting in which BC confirms infection, but catheter tip does not (or catheter tip does, but blood does not) in a symptomatic patient with no other apparent source of infection. **Possible:** Defervescence of symptoms after antibiotic treatment or after removal of catheter in the absence of laboratory confirmation of BSI in a symptomatic patient with no other apparent source of infection.	Clinical manifestations and at least 1 positive BC from a peripheral vein and no other apparent source, with either positive semiquantitative (>15 CFU/catheter segment) or quantitative (>10^2 CFU/catheter segment) culture, whereby the same organism (species and antibiogram) is isolated from the catheter segment and a peripheral blood sample. Simultaneous quantitative cultures of blood samples with a ratio of ≥3:1 (catheter vs peripheral) Differential period of catheter culture versus peripheral BC positivity of 2 hours **OR** Isolation of the same organism from semiquantitative or quantitative culture segment and from blood (preferably from a peripheral vein) of a patient with accompanying symptoms of BSI and no other apparent source of infection.	Bacteremia/fungemia in a patient with an intravascular catheter with at least 1 positive BC and with clinical manifestations of infections (ie, fever, chills, and/or hypotension) and no apparent source for the BSI except the catheter **AND** One of the following should be present: A positive semiquantitative (>15 CFU/catheter segment) or quantitative (>10^2 CFU/catheter segment) culture whereby the same organism (species and antibiogram) is isolated from the catheter segment and peripheral blood. Simultaneous quantitative BC with a >5:1 ratio catheter versus peripheral. Differential time period of catheter culture versus peripheral BC positivity of >2 hours.

Abbreviations: BC, blood culture; BSI, bloodstream infection; CDC, Centers for Disease Control and Prevention; CFU, colony-forming unit; KDOQI, Kidney Disease Outcomes Quality Initiative; IDSA, Infectious Diseases Society of America.

Table 5. Core Interventions for Dialysis BSI Prevention.

Surveillance and feedback	• Conduct monthly surveillance for BSIs and other dialysis events using CDC's NHSN. • Calculate facility rates and compare with rates in other NHSN facilities. • Actively share results with front-line clinical staff.
Hand hygiene observations	• Perform observations of hand hygiene opportunities monthly • Share results with clinical staff.
Catheter/vascular access care observations	• Perform observations of vascular access care and catheter accessing quarterly. • Assess staff adherence to aseptic technique when connecting and disconnecting catheters and during dressing changes. • Share results with clinical staff.
Staff education and competency	• Train staff on infection control topics, including access care and aseptic technique. • Perform competency evaluation for skills such as catheter care and accessing every 6 to 12 mo and upon hire.
Patient education/ engagement	• Provide standardized education to all patients on infection prevention topics including vascular access care, hand hygiene, risks related to catheter use, recognizing signs of infection, and instructions for access management when away from the dialysis unit.
Catheter reduction	• Incorporate efforts (eg, through patient education, vascular access coordinator) to reduce catheters by identifying and addressing barriers to permanent vascular access placement and catheter removal.
Chlorhexidine for skin antisepsis	• Use an alcohol-based chlorhexidine (>0.5%) solution as the first-line skin antiseptic agent for central line insertion and during dressing changes.
Catheter hub disinfection	• Scrub catheter hubs with an appropriate antiseptic after cap is removed and before accessing. Perform every time catheter is accessed or disconnected.
Antimicrobial ointment	• Apply antibiotic ointment or povidone-iodine ointment to catheter exit sites during dressing change.

Statement: Surveillance of CVC Colonization and Preemptive CRBSI Management

24.2 There is inadequate evidence for KDOQI to support routine CVC surveillance cultures for colonization and subsequent pre-emptive antibiotic lock installation if culture is positive.

Intraluminal Strategies

24.3 **KDOQI suggests that the selective use of specific prophylactic antibiotic locks can be considered in patients in need of long-term CVC who are at high risk of CRSBI (eg, multiple prior CRSBI), especially in facilities with high rates of CRBSI (eg, >3.5/1,000 days). (*Conditional Recommendation, Low-Moderate Level of Evidence*).**

Note: Under these circumstances and given the current data, KDOQI considers it reasonable for prophylactic use of specific antibiotics: cefotaxime, gentamicin or cotrimoxazole (TMP-SMX). KDOQI cannot support the routine prophylactic use of antibiotic locks with very low supporting evidence (Table 24.1).

24.4 **KDOQI suggests that the selective use of specific prophylactic antimicrobial locks can be considered in patients in need of long-term CVC who are at high risk of CRSBI, especially in facilities with high rates of CRBSI (eg, >3.5/1,000 days). (Conditional Recommendation, Low-Moderate Quality of Evidence)**

Note: Under these circumstances and given the current data, KDOQI can support the prophylactic use of methylene blue. KDOQI cannot support the routine prophylactic use of antimicrobial locks with very low supporting evidence (Table 24.1).

24.5 KDOQI suggests that the selective use of once weekly prophylactic CVC locking with thrombolytic agent (recombinant TPA) can be considered in patients in need of long-term CVC who are at high risk of CRSBI, especially in facilities with high rate of CRBSI (eg, >3.5/1,000 days). (Conditional Recommendation, Moderate Quality of Evidence)

Note: Under these circumstances and given the current data, KDOQI can support the prophylactic use of recombinant TPA.

Note: High-risk patients refers to those with prior multiple CRSBI, S aureus nasal carriers.

TREATMENT OF CATHETER-RELATEDINFECTION

EXIT-SITE INFECTION

- Obtain cultures of any drainage from the exit site before administration of antibiotics.
- Treat empirically withantibiotics to cover gram-positive organisms.
- Modify the antibiotic regimen once culture and sensitivity results are available.
- Exit-site infections are typically treated for 7 to 14 days, depending on the microorganism isolated and local practice.

TUNNEL INFECTION

- Obtain cultures of any drainage from the exit site and send blood cultures from the catheter.
- The catheter should always be removed, without exchange over a wire.
- A new catheter should be inserted at a separate site.

TUNNEL INFECTION

- Start empiric broad-spectrum antibiotics to cover both gram-positive and gramnegative organisms.
- Modify antibiotic regimen when culture and sensitivity results are available.
- Tunnel infections, in the absence of a concurrent CRBSI, are typically treated for 10 to 14 days, depending on the microorganism isolated and local practice.

CATHETER-RELATED BLOODSTREAM INFECTION

EMPIRIC MANAGEMENT

- Blood cultures should be sent from the catheter, dialysis circuit, and peripheral sites if possible.
- Broad-spectrum antibiotics should be initiated to cover both gram-positive and gram-negative organisms.

EMPIRIC MANAGEMENT

- Antibiotics should generally cover methicillin-resistant S aureus (MRSA) and Pseudomonas but are also dictated by local infection rates, dialysis center policies, and center-specific antimicrobial resistance patterns.
- Following initiation of empiric antibiotic therapy, it is crucial that culture sensitivity data are followed up in a timely manner, so that the most appropriate antibiotics based on sensitivity results can be used.

DEFINITIVE MANAGEMENT

- Treatment can be categorized into 3 groups:

1. systemic antibiotics,
2. Antimicrobial locking (instillation) solutions,
3. catheter management.

SYSTEMIC ANTIBIOTICS

- All patients with a CRBSI should receive systemic antibiotics, which will typically be administered for 2 to 6 weeks depending on the microorganism, clinical presentation, and complications.
- Final decision on specific antibiotic agent(s) is dependent on final blood culture result and sensitivities, and whether or not patient has any allergies

SYSTEMIC ANTIBIOTICS

- If methicillin-sensitive S aureus (MSSA) infection is isolated, cefazolin is the preferred choice over vancomycin because it is associated with decreased hospitalization and death secondary to infection.

SYSTEMIC ANTIBIOTICS

- Ease of administration is also a factor, ideally choosing agents that can be given to patients 3 times weekly for patients receiving conventional thrice weekly dialysis.
- Drug dose and timing vary for those who are not on conventional thrice weekly dialysis (eg, short daily or nocturnal dialysis).

ANTIBIOTIC LOCKS

- May be used as adjunctive therapy to systemic antibiotics.
- A recent systematic review and meta-analysis of hemodialysis patients with tunneled dialysis catheters, with a CRBSI, compared 3 treatment protocols for CRBSIs: (1) systemic antibiotics alone, (2) systemic antibiotics plus antibiotic lock (catheter not removed), and (3) systemic antibiotics plus guidewire exchange.

ANTIBIOTIC LOCKS

- It included 28 retrospective and prospective studies, with a total of 1596 patients.
- Patients treated with systemic antibiotics and antibiotic lock had similar cure rates to those treated with systemic antibiotics and guidewire exchange, and both were superior to the rates obtained when antibiotics were used alone.

ANTIBIOTIC LOCKS

- Recurrence of infection with the same organism was not different between the systemic antibiotics plus antibiotic lock group and the systemic antibiotics plus guidewire exchange but was much higher in patients treated with systemic antibiotics alone, which further supports the practice to use an antibiotic lock or guidewire exchange in conjunction with systemic antibiotics.

ANTIBIOTIC LOCKS

- •Antibiotic locks should be used when immediate catheter removal is not possible and when catheter salvage attempted.

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Version March 2024

Antibiotic lock solution concentrations for adjunctive treatment of non-hemodialysis catheter-related bloodstream infection (CRBSI)

Antibiotic lock solution concentrations for adjunctive treatment of non-hemodialysis catheter-related bloodstream infection (CRBSI)

	Antibiotic agent	Antibiotic concentration	Heparin concentration	Maximum dwell time (duration of stability)*	References
Antibiotic agents with activity against gram-positive organisms	Vancomycin	2.5 mg/mL¶	2500 units/mL	72 hours	Krishnasami[1]
		5 mg/mLΔ	5000 units/mL	72 hours	Luther[2]
		5 mg/mL	none	72 hours	Luther[2]
	Cefazolin	5 mg/mL◇	2500 units/mL	72 hours	Krishnasami[1]
		5 mg/mL§	none	48 hours	Vercaigne[3]
		10 mg/mL	5000 units/mL	72 hours	Vercaigne[3]
	Daptomycin	5 mg/mL¥	5000 units/mL	72 hours	LaPlante[4]
		5 mg/mL	none	72 hours	LaPlante[4]
	Nafcillin	100 mg/mL	none	12 hours	Nafcillin[5]
	Ampicillin	10 mg/mL‡	none	8 hours	Ampicillin[6]
Antibiotic agents with activity against gram-negative organisms	Gentamicin	1 mg/mL†	2500 units/mL	72 hours	Krishnasami[1]
		5 mg/mL**	5000 units/mL	72 hours	Vercaigne[3]
		5 mg/mL	none	72 hours	Vercaigne[3]
	Ceftazidime	10 mg/mL¶¶	5000 units/mL	48 hours	Vercaigne[3]

LOS ANGELES COUNTY DEPARTMENT OF HEALTH SERVICES
HARBOR-UCLA MEDICAL CENTER

SUBJECT: GUIDELINES FOR ANTIBIOTIC LOCK AND ETHANOL LOCK THERAPY

POLICY NO. 325R

CATEGORY: Provision of Care	**EFFECTIVE DATE:** 7/18
POLICY CONTACT: Jennie Ung, PharmD	**UPDATE/REVISION DATE:** 2/22
REVIEWED BY COMMITTEE(S): Pharmacy and Therapeutics	

PURPOSE:
To provide guidelines for appropriate use of antibiotic lock therapy (ALT) and ethanol lock therapy (ELT) in the treatment of Central Line-associated Bloodstream Infection (CLABSI) in adult and pediatric patients whose line cannot easily be removed and/or replaced because of ongoing necessity for central access and lack of alternative access (e.g., peripheral IV or placing new line at the new site).

POLICY:
Providers at Harbor-UCLA Medical Center may consider using ALT or ELT for patients who have CLABSI with no signs of exit site or tunnel infection and who require salvage of current intravascular catheter secondary to limited alternative intravascular access. The use of ALT and ELT must be approved by an Infectious Disease specialist.

PROCEDURE:

1. ALT solutions containing the desired antimicrobial concentration (Appendix A) are mixed with heparin or normal saline in a sufficient volume to fill the catheter lumen.
2. Ports to be used and the volume of solution instilled should be specified by the physician. Volume varies depending on the volume of lumen and hub of the particular size line being treated (Appendix C).
3. Dwell time for antibiotic lock fluid should be specified by the physician (range of 6-48 hours). Dwell time depends on clinical circumstances and availability of port but should not exceed 48 hours. If it is anticipated that the dwell time will be less than 6 hours, lock therapy should not be used.
4. Flush the catheter with normal saline and instill indicated volume of lock solution.
5. The caps of the catheter hubs then are secured tightly to "lock" the antibiotic or ethanol into the lumen of the catheter. Use labels to indicate the locked lumen so that medication is not flushed through the catheter.
6. Lock therapy should not be removed until the minimum dwell time has elapsed (e.g., no infusion or flushes) unless a life-threatening situation requires early removal of lock solution.
7. At the conclusion of the lock period, aspirate the lock solution volume completely from the catheter

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REVISED: 3/19
REVIEWED: 7/18, 3/19, 2/22

APPROVED BY: _____ _____

Anish Mahajan, MD
Chief Executive Officer

Griselda Gutierrez, MD
Associate Chief Medical Officer

before administering the next dose.

8. ALT precautions:
   a. Do not prepare ALT using heparin for patients with Heparin-Induced Thrombocytopenia (HIT).
   b. Review allergy history thoroughly to prevent an allergic reaction to requested antibiotics.
9. ELT is **NOT** to be used in the following patients:
   a. Those with polyurethane catheters (See appendix D for catheter material)
   b. Those who received isoniazid within 24 hours, metronidazole within 48 hours, disulfiram within 7 days
   c. Those less than 6 months of age or weighing less than 6kg
   d. Those with a history of ethanol allergy
10. Refer to Appendix D for Physician Ordering Procedure.
11. Refer to Appendix E for Pharmacy Preparation and Dispensing Procedure.

Reviewed and approved by:
Medical Executive Committee on date 02/2022

Appendix A: Lock Solutions

Antibiotic Locks with Heparin
ceFAZolin 5mg/mL- heparin 2500unit/ mL
cefTAZidime 10mg/mL- heparin 2500unit/mL
gentamicin 2.5mg/mL- heparin 2500unit/mL
vancomycin 5mg/mL- gentamicin 2.5mg/mL- heparin 2500unit/mL
vancomycin 5mg/mL - heparin 2500unit/mL
Anticoagulant-Free Antibiotic Locks
ceFAZolin 5mg/mL
cefTAZidime 10mg/mL
gentamicin 2.5mg/mL
vancomycin 5mg/mL
Ethanol 70%

How to cite:
Tresso KA, Santos BN, Braga FT, Margatho AS, Mendes KD, Silveira RC. Lock therapy in prevention and treatment of catheter-associated bloodstream infection: integrative review. Acta Paul Enferm. 2023;36:eAPE01221.

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Keywords
Central venous catheters; Catheters, indwelling; Vascular access device; Catheter-related infecions; Nursing care; Anti-bacterial agents; Anti-infective agents; Lock therapy; Ethanol

Descritores
Cateteres venosos centrais; Cateteres de demora; Dispositivos de acesso vascular; Infecções relacionadas ao cateter; Cuidados de enfermagem; Antibacterianos; Anti-Infecciosos; Lock terapia; Etanol

Abstract

Objective: To synthesize knowledge on the use of lock therapy for prevention and treatment of long-term central vascular access devices-associated bloodstream infection in hospitalized adult and elderly patients.

Methods: Integrative review conducted in CINAHL, Cochrane Central, Embase, LILACS, PubMed, Scopus, and Web of Science databases, from January 1st, 2010 to September 28th, 2021, without language restrictions. Data were analyzed descriptively.

Results: Sixteen studies were identified, six (37.5%) on the use of lock therapy for prevention of bloodstream infection associated with central vascular access devices, and ten (62.5%) on treatment. The articles on prevention reported the use of non-antibiotic solutions. Nine of the ten studies that addressed lock therapy as treatment used antibiotic solutions. Two studies assessed the effectiveness of lock therapy in a short duration (three to four days), seven in a longer duration (between 10 and 14 days), and one did not specify the length of time. Each study described an intervention technique and the length of stay of the intraluminal solution. Regarding the risk of bias, five randomized clinical trials, two non-randomized clinical trials, and eight observational studies were rated as low risk. Only one observational study was classified as moderate risk.

Conclusion: The use of non-antibiotic solutions such as ethanol was identified for prevention of bloodstream infection. For treatment, intravenous daptomycin was used. While the studies included in this review on prevention did not show statistical evidence, the ten studies on treatment demonstrated that lock therapy is an effective complement to systemic treatment, showing good catheter salvage rates.

Resumo

Cureus

Open Access Review Article

DOI: 10.7759/cureus.45000

Corrected: A Systematic Review of the Impact of Antibiotic and Antimicrobial Catheter Locks on Catheter-Related Infections in Adult Patients Receiving Hemodialysis

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Corrected 11/21/2023

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ABSTRACT

- Central venous catheter (CVC)-based hemodialysis is a major contributor to bacteremia in immunocompromised hosts.
- Heparin-locking CVCs is a frequent therapeutic procedure. However, it has not been shown to reduce catheter-related bloodstream infections (CRBSIs).

ABSTRACT

- For this systematic review, we searched PubMed, PubMed Central, ResearchGate, Science Direct, and Multidisciplinary Digital Publishing Institute (MDPI) for multiple articles published between January 2018 and January 2023 to determine how antimicrobial locking solutions affect CRBSIs, which could ultimately lower the risk of morbidity, mortality, and hospitalization costs.

ABSTRACT

- Antilocking products, catheter-related bacteremia, central-line associated bloodstream infections, tunneled dialysis catheter, hemodialysis, antibiotic, and antimicrobial catheter locks, and the Medical Subject Heading (MeSH) method for PubMed were used as the main keywords for searching publications.

ABSTRACT

- A pool of 13 studies with 46,139 individuals showed that the therapy group had a lower incidence of CRBSIs than the heparin-treated control group.
- Furthermore, it was discovered that bacteria were resistant to gentamicin, and the use of antibiotics had no discernible impact on catheter malfunction.

ABSTRACT

- In conclusion, the most effective locking solution to date is an antilocking solution made up of an antibiotic or antimicrobial agent combined with low-dose heparin (500-2,500 U/mL).

CATHETER REMOVAL WITH REPLACEMENT IN NEW SITE

- One option is immediate catheter removal, followed by placement of a temporary catheter, then conversion back to tunneled catheter.

INDICATIONS FOR IMMEDIATE REMOVAL

- Severe sepsis
- Hemodynamic instability
- If fever or bacteremia persists 48 to 72 hours after initiation of antibiotics to which the organism is susceptible
- Metastatic infection
- Signs of tunnel infection
- Fungal organisms.

CATHETER REMOVAL WITH REPLACEMENT IN NEW SITE

- Consider catheter removal for patients with CRBSIs due to S aureus, Pseudomonas species, and fungus.
- A temporary non-tunneled catheter should be inserted into another anatomical site.

CATHETER REMOVAL WITH REPLACEMENT IN NEW SITE

- In some cases, patients may not have any alternative site available for catheter insertion, and in these patients, catheter exchange over a wire or catheter salvage might be considered instead of catheter removal, regardless of microorganism isolated.

CATHETER EXCHANGE OVER A GUIDEWIRE

- For CRBSIs due to other pathogens (eg, gram-negative bacilli other than Pseudomonas species or coagulase-negative staphylococci), empirical intravenous antibiotic therapy may be started without immediate catheter removal.

CATHETER EXCHANGE OVER A GUIDEWIRE

- If the symptoms that prompted initiation of antibiotic therapy (fever, chills, hemodynamic instability, or altered mental status) resolve within 2 to 3 days and there is no metastatic infection, then the infected catheter can be exchanged over a guidewire for a new tunneled catheter

INFECTION COMPLICATIONS

- Infection complications are thought to occur in ~15 - 40% of CRBSIs.6 These are most common for S aureus infections, with endocarditis being the most common.
- Other complications include vertebral osteomyelitis or discitis (2%-15%), and less commonly, spinal epidural abscess, septic arthritis, and septic pulmonary emboli.

INFECTION COMPLICATIONS

- Mortality rates are high: Reports in the literature vary between 6% and 34% in all cases of CRBSI.
- Mortality is highest with S aureus infection complicated by metastatic complications, associated with 30% to 50% of mortality in these patients

ENDOCARDITIS

- The most frequent and severe complication of CRBSIs.
- Most common with S aureus, reported in 25% to 35% of S aureus bacteremias in hemodialysis patients, significantly higher than in S aureus infection in the general population.

ENDOCARDITIS

- Next most common organisms are coagulase-negative staphylococci, enterococci, and viridans group streptococci.
- Consider transthoracic echocardiography in all patients with S aureus CRBSIs.
- Associated with mortality rates of 30% to 50%
- Requires minimum 6 weeks' intravenous antibiotic therapy.

VERTEBRAL OSTEOMYELITIS OR DISCITIS

- Most commonly caused by S aureus.
- Fever and back pain are the most common presenting symptoms.
- Plain film x-ray may be helpful to start, but diagnosis made primarily by computed tomography (CT) or magnetic resonance imaging (MRI).

VERTEBRAL OSTEOMYELITIS OR DISCITIS

- If blood cultures are nondiagnostic for the organism, then CT-guided percutaneous aspiration of the disk space should be undertaken.
- Requires minimum 6 weeks' antibiotic therapy, and may require up to 3 months of intravenous antibiotic treatment.

SPINAL EPIDURAL ABSCESS

- Uncommon.
- Most common symptoms are back pain, fever, and weakness.
- MRI is the best diagnostic modality.
- Requires minimum 6 weeks' antibiotic therapy, and all patients should have neurosurgical evaluation.

SEPTIC ARTHRITIS

- Usually presents as an acute inflammatory monoarthritis.
- Knee, hip, shoulder, and ankle are most commonly affected joints.
- Diagnosis should be made by joint aspiration, with fluid sent for cell count, Gram stain, cultures, and crystals.
- Requires joint irrigation and debridement and minimum 2 weeks' antibiotic therapy.

Aniort *et al. BMC Nephrology* (2019) 20:149
https://doi.org/10.1186/s12882-019-1338-6

BMC Nephrology

STUDY PROTOCOL Open Access

Evaluation of the efficacy of an interdialytic "ethanol 40% v/v - enoxaparin 1000 U/mL" lock solution to prevent tunnelled catheter infections in chronic hemodialysis patients: a multi-centre, randomized, single blind, parallel group study

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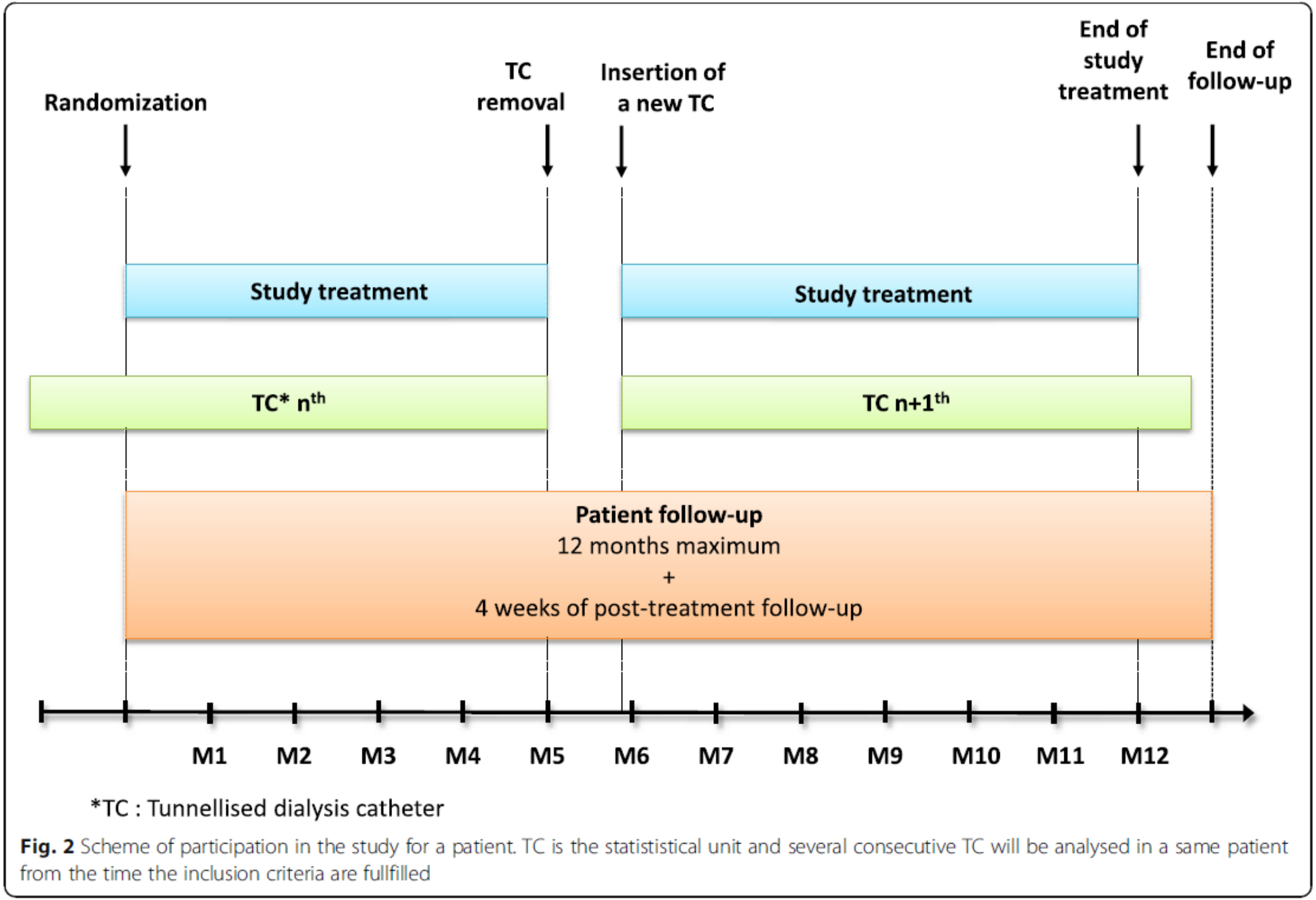

Fig. 2 Scheme of participation in the study for a patient. TC is the statistical unit and several consecutive TC will be analysed in a same patient from the time the inclusion criteria are fullfilled

Original research article

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High success rate in salvage of catheter-related bloodstream infections due to *Staphylococcus aureus*, on behalf of project group of Italian society of nephrology

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Abstract

Background: Catheter-related bloodstream infections caused by *Staphylococcus aureus* represent one of the most fearful infections in chronic haemodialysis patients with tunnelled central venous catheters. Current guidelines suggest prompt catheter removal in patients with positive blood cultures for *S. aureus*. This manoeuvre requires inserting a new catheter into the same vein or another one and is not without its risks.

Methods: A protocol based on early, prompt diagnosis and treatment has been utilized in our renal unit since 2012 in an attempt to salvage infected tunnelled central venous catheters. We prospectively observed 247 tunnelled central venous catheters in 173 haemodialysis patients involving 167,511 catheter days.

Results: We identified 113 catheter-related bloodstream infections (0.67 episodes per 1000 days/tunnelled central venous catheter). Forty were caused by *S. aureus*, including 19 by methicillin-resistant *S. aureus* (79% saved) and 21 by methicillin-sensitive *S. aureus* (90% saved), of which 34 (85%) were treated successfully. Eight recurrences occurred and six (75%) were successfully treated. A greater than 12 h time to blood culture positivity for *S. aureus* was a good prognostic index for successful therapy and tunnelled central venous catheter rescue.

Conclusion: Our data lead us to believe that it is possible to successfully treat catheter-related bloodstream infection caused by *S. aureus* and to avoid removing the tunnelled central venous catheter in many more cases than what has been reported in the literature. On the third day, it is mandatory to decide whether to replace the tunnelled central venous catheter or to carry on with antibiotic therapy. Apyrexia and amelioration of laboratory parameters suggest continuing systemic and antibiotic lock therapy for no less than 4 weeks, otherwise, tunnelled central venous catheter removal is recommended.

Managing CRBSI

Suspected clinical signs for CRBSI

- Chills and fever occurred during or at the end of dialysis
- Redness and / or secretion from the exit-site
- Previous CRBSI
- Exclusions of other diseases (respiratory system diseases, urinary tract infection)

Behavior by nurses

- Blood sampling (blood count with formula, CRP, PCT)
- Cultures of blood drawn simultaneously from central venous catheter and peripheral site
- Nasal swab and tampon exit site (if secretion)

Empiric therapy approach

First episode	Recurrence	New episode
Cephazoline 2 g IV plus Ceftazidime 1 g IV + Lock therapy with cephazoline	Antibiotic therapy based on previous antibiogram, perhaps changing the drug + Lock therapy based on previous antibiogram	Antibiotic therapy based on clinical history + Lock therapy based on clinical hystory

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- As soon as the lab reported the growth of MRSA or methicillin-resistant Staphylococcus epidermidis (MRSE), therapy with systemic vancomycin (loading dose 25–30 mg/kg/dry body weight) and lock therapy with vancomycin were immediately started.
- Ceftazidime was discontinued and therapeutic serum concentrations (15–20 mg/L) of vancomycin were achieved within the next few days.

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- In case of MSSA or methicillin-sensitive Staphylococcus epidermidis (MSSE),we continued administering systemic and alanine aminotransferase (ALT) cefazolin and discontinued ceftazidime.
- Patients whose antibiograms were ready after 24–48 h were shifted from vancomycin to daptomycin (6 mg/kg/ day) when higher MIC levels of vancomycin (1.5–2 mcg/ mL) were observed among MRSA isolates.

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- Over the following 48–72 h, the patient was always hospitalized and monitored by clinical and laboratory parameters including C-reactive protein (CRP) and procalcitonin (PCT) .

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- On the third day, we decided whether to continue antibiotic therapy or to remove the catheter on the basis of the patient's clinical status (fever), hemodynamic parameters (blood pressure), laboratory parameters (white blood cells (WBCs), CRP and PCT) and transthoracic echocardiogram
- A transoesophageal echocardiogram was performed only when endocarditis was suspected.

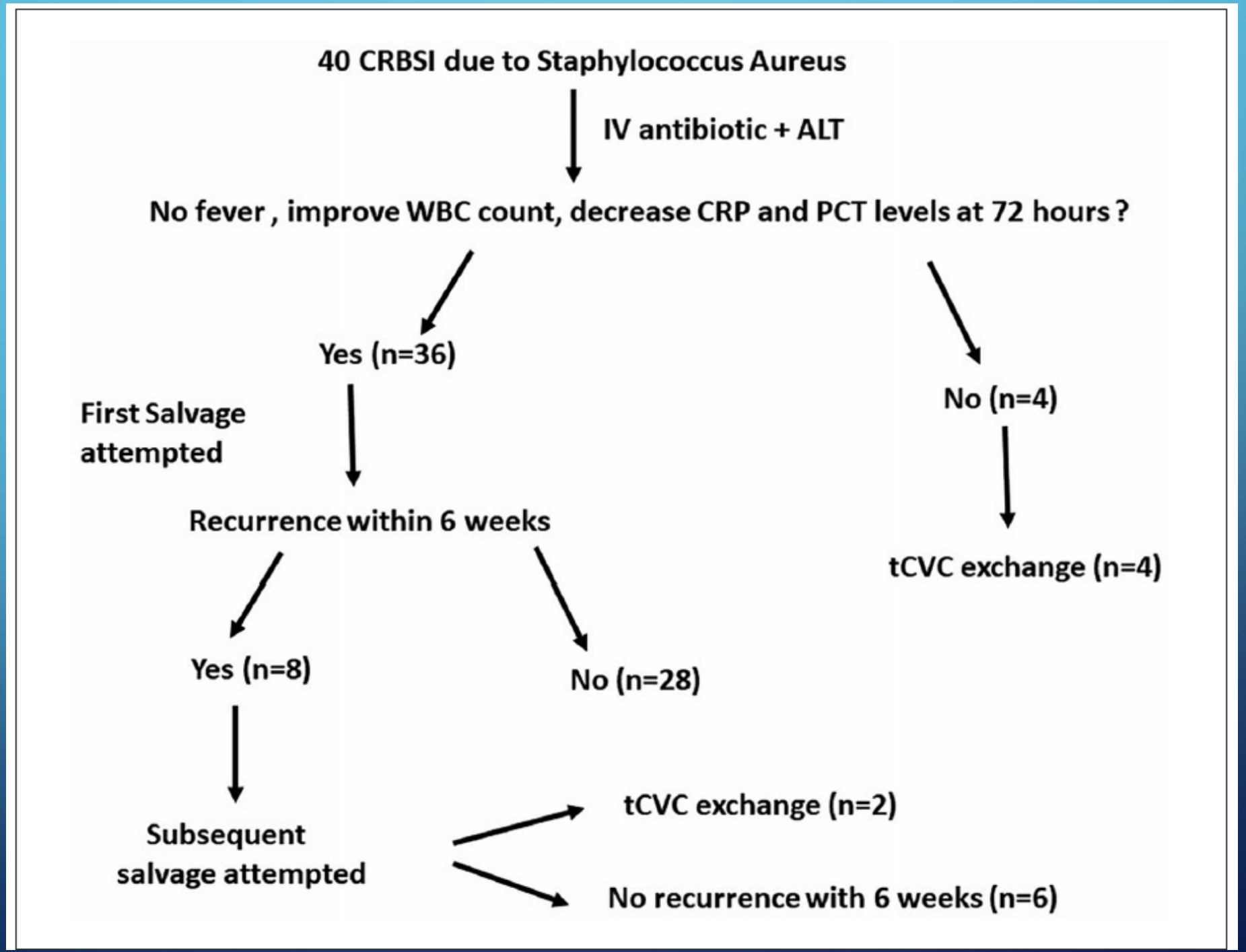
40 CRBSI due to Staphylococcus Aureus
IV antibiotic + ALT
No fever , improve WBC count, decrease CRP and PCT levels at 72 hours ?
Yes (n=36)
No (n=4)
First Salvage attempted
tCVC exchange (n=4)
Recurrence within 6 weeks
Yes (n=8)
No (n=28)
Subsequent salvage attempted
tCVC exchange (n=2)
No recurrence with 6 weeks (n=6)

Table 1. Clinical and laboratory parameters at baseline and at the third day.

Baseline	Normal range	tCVC saved (N = 34)	tCVC replaced (N = G)	p value
Fever > 38° (%)	36.1–37.2°C	100%	100%	
White blood cell	5000–10,000/mL	11,200 ± 2400	12,700 ± 1800	0.08
C-reactive protein	0–10 mg/L	73.7 ± 18.8	85.8 ± 17.4	0.07
Procalcitonin	<0.15 µg/L	5.5 ± 1.7	6.7 ± 1.2	0.06
Time to positivity (TIP)	0 h	16.7 ± 2.8	9.2 ± 3.4	<0.000
Third day	**tCVC saved (N = 34)**	**tCVC replaced (N = G)**		**p value**
Fever > 38° (%)	0%	63%		<0.000
White blood cell	9100 ± 1400	12,300 ± 1400		<0.000
C-reactive protein	18.7 ± 4.4	64.2 ± 21		<0.000
Procalcitonin	2.6 ± 0.8	5.8 ± 1.2		<0.000

tCVC: tunnelled central venous catheters.

On the basis of our data, we believe that a higher percentage of CVC removals can be avoided in *S. aureus* CRBSI cases (especially MSSA) than previously reported if early diagnosis is made and treatment is started within 6 h. Nonetheless, within the third day, the decision concerning either the removal of the tCVC or the continuation with antibiotic therapy must be carefully evaluated. Persistent bacteraemia after 72 h of antimicrobial therapy to which the pathogen is susceptible, severe sepsis, haemodynamic instability, recurrences, endocarditis, polymicrobial flora, or CRBSI associated with dysfunction are all circumstances for which tCVC removal is recommended.

Finally, we suggest an update of the current guidelines, which should always distinguish between MRSA and MSSA, to avoid administering vancomycin as empirical therapy. This is needed to prevent the development of *S. aureus* vancomycin resistance. Moreover, in cases of MRSA positivity, monitoring serum concentrations of vancomycin appears to be fundamental. Several factors remain to be defined; for instance, we suggest recording time of positivity, reporting when the first symptoms are observed, and the lag time before starting empirical therapy.