

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Centers for Disease Control and Prevention

Draft Guideline for Prevention of Intravascular Device-Related Infections: Part 1. "Intravascular Device-Related Infections: An Overview" and Part 2. "Recommendations for Prevention of Intravascular Device-Related Infections; Notice of Comment Period"

AGENCY: Centers for Disease Control and Prevention (CDC), Public Health Service (PHS), Department of Health and Human Services (DHHS).

ACTION: Notice.

SUMMARY: This notice is a request for review and comment of the draft Guideline for Prevention of Intravascular Device-related Infections. The Guideline consists of two parts: Part 1. "Intravascular Device-related Infections: An Overview" and Part 2. "Recommendations for Prevention of Intravascular Device-related Infections," and was prepared by the Hospital Infection Control Practices Advisory Committee (HICPAC) and the National Center for Infectious Diseases (NCID), CDC.

DATES: Written comments on the draft document must be received on or before October 30, 1995.

ADDRESSES: Comments on this document should be submitted in writing to the CDC, Attention: IV Guideline Information Center, Mailstop E-69, 1600 Clifton Road, NE., Atlanta, Georgia 30333. To order copies of the Federal Register containing the document, contact the U.S. Government Printing Office, Order and Information Desk, Washington, DC 20402-9329, telephone (202) 512-1800. Specify the date of the issue requested and stock number 069-001-00089-1. See page II of the Federal Register for additional ordering and cost information. In addition, the Federal Register containing this draft document may be viewed and photocopied at most libraries designated as U.S. Government Depository Libraries and at many other public and academic libraries that receive the Federal Register throughout the country. The order-desk operator can tell you the location of the U.S. Government Depository Library nearest you.

FOR FURTHER INFORMATION CONTACT: The IV Guideline Information Center, telephone (404) 332-2569.

SUPPLEMENTARY INFORMATION: This 2-part document updates and replaces the

previously published CDC Guideline for Prevention of Intravascular Infections (Am J Infect Control 1983;11:183-199). Part 1, "Intravascular Device-related Infections: An Overview," reviews issues relevant to intravascular device-related infections and serves as the background for the consensus recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC) that are contained in Part 2, "Recommendations for Prevention of Intravascular Device-related Infection."

HICPAC was established in 1991 to provide advice and guidance to the Secretary and the Assistant Secretary for Health, DHHS; the Director, CDC; and the Director, NCID regarding the practice of hospital infection control and strategies for surveillance, prevention, and control of nosocomial infections in U.S. hospitals. The committee also advises CDC on periodic updating of guidelines and other policy statements regarding prevention of nosocomial infections.

The Guideline for Prevention of Intravascular Device-related Infections is the third in a series of CDC guidelines being revised by HICPAC and NCID, CDC.

Dated: September 14, 1995.

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Deputy Director, Centers for Disease Control and Prevention (CDC).

Guideline for Prevention of Intravascular Device-Related Infections Executive Summary

The revised guideline is designed to reduce the incidence of intravascular device-related infections and provides an overview of the evidence for recommendations considered prudent by consensus of HICPAC members. A working draft of the guideline was reviewed by experts in hospital infection control, internal medicine, pediatrics, and intravenous therapy; however, all recommendations contained in the guideline may not reflect the opinion of all reviewers.

This document focuses largely on the epidemiology, pathogenesis and diagnosis of, and preventive strategies for, infections associated with the intravascular devices most commonly used in health care settings and for which there is adequate scientific data on which to base recommendations for device use and care. Such devices include peripheral venous and arterial catheters, central venous and arterial catheters, peripherally inserted central venous catheters, and pressure monitoring systems. Newer devices (e.g., antimicrobial-impregnated

catheters, needleless infusion systems) are also discussed. However, intraaortic balloon pumps, cardiac catheters, pacemakers, and extracorporeal membrane oxygenators are not addressed in this document because there is insufficient scientific data on which to base recommendations for use and care.

The unique circumstances and special considerations related to intravascular device-related infections in pediatric patients and infections associated with parenteral nutrition and hemodialysis will be addressed in separate sections.

Introduction

Intravascular devices are indispensable in modern-day medical practice. However, the use of intravascular devices is frequently complicated by a variety of local and/or systemic infectious complications. Infections related to the use of intravascular devices, particularly catheter-related bloodstream infections, are associated with increased morbidity and mortality, prolonged hospitalization, and increased medical costs.

Part 1, "Intravascular Device-related Infections: An Overview" addresses many of the issues and controversies in intravascular-device use and maintenance. These issues include definitions and diagnosis of catheter-related infection, barrier precautions during catheter insertion, changes of catheters and administration sets, catheter-site care, and the use of prophylactic antimicrobials, flush solutions and anticoagulants. Part 2, "Recommendations for Prevention of Intravascular Device-related Infections" provides consensus recommendations of the HICPAC for the prevention and control of infections related to the use of intravascular devices.

The Guideline for Prevention of Intravascular Device-related Infections is intended for use by personnel who are responsible for surveillance and control of infections in the acute-care, hospital-based setting, but many of the recommendations may be adaptable for use in the outpatient or home-care setting.

Part 1. Intravascular Device-Related Infections: An Overview

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Table 1. Definitions for Catheter-related Infection

Table 2. Factors Associated with Infusion-related Phlebitis among Patients with Peripheral Venous Catheters

Figure 1. Potential Sources for Contamination of Intravascular Devices

I. Background

Intravascular devices are indispensable in modern-day medical practice. They are used to administer intravenous fluids, medications, blood products, and parenteral nutrition fluids, and to monitor the hemodynamic status of critically ill patients. However, the use of intravascular-devices is frequently complicated by a variety of local and/or systemic infectious complications (see definitions in Table 1), including septic thrombophlebitis, endocarditis, bloodstream infection (BSI), and metastatic infection (e.g., osteomyelitis, endophthalmitis, arthritis) resulting from hematogenous seeding of another body site by a colonized catheter. Catheter-related infections (CRIs), particularly catheter-related BSIs (CR-BSIs), are associated with increased morbidity; mortality of 10%–20%; prolonged hospitalization (mean of 7 days); and increased medical costs, in excess of \$6,000 (1988 dollars) per hospitalization.^{1–5}

II. Epidemiology

An estimated 200,000 nosocomial BSIs occur each year.⁶ During 1980–1989, significant increases were detected in the rates of nosocomial BSI reported from the National Nosocomial Infection Surveillance (NNIS) System hospitals where hospital-wide surveillance was conducted.⁷ Reported rates increased by 70%–279%, depending on hospital size and affiliation.

Most nosocomial BSIs are related to the use of an intravascular device, with BSI rates being substantially higher among patients with intravascular devices than among those without such devices.⁸ As with overall rates of nosocomial BSI, rates of device-related BSI vary considerably by hospital size, hospital unit/service, and type of device. During the years 1986–1990, NNIS hospitals conducting intensive care unit (ICU) surveillance reported rates of central catheter-related BSI ranging from 2.1 (respiratory ICU) to 30.2 (burn ICU) BSIs per 1,000 central catheter days. Rates of noncentral catheter-related BSI were substantially lower, ranging from 0 (coronary, medical, and medical/surgical ICU) to 2.0 (trauma ICU) BSIs per 1,000 noncentral catheter-days.⁸

The incidence of and potential risk factors for intravascular-device related infections may vary considerably with the type and intended use of the device, and these factors should be considered when selecting a device for use.

In general, intravascular devices can be divided into two broad categories,

those used for short-term, or temporary, vascular access and those used for long-term vascular access. Long-term (indwelling) vascular devices usually require surgical insertion, while short-term devices can be inserted percutaneously.

Devices Used for Short-Term Vascular Access

Peripheral venous catheters. Of all intravascular devices, the peripheral venous catheter is the most commonly used. Phlebitis, largely a physicochemical or mechanical rather than infectious phenomenon, remains the most important complication associated with the use of peripheral venous catheters. A number of factors, including type of infusate and catheter material and size, influence a patient's risk for developing phlebitis (Table 2); when phlebitis does occur, the risk of local CRI may be increased.^{9–13} However, peripheral venous catheters have rarely been associated with BSI;^{9 14–17} this may reflect the short duration of catheterization with these devices.

Peripheral arterial catheters. Peripheral arterial catheters are commonly used in acute-care settings to monitor the hemodynamic status of critically ill patients. Data suggest that peripheral arterial catheters may be associated with a substantially lower risk of local CRI and CR-BSI than are peripheral venous catheters left in place for a comparable length of time.¹⁸ Although the reasons for the differences in rates of CRI associated with these two types of catheters are not clear, arterial catheters may be less prone to colonization than are venous catheters because they are exposed to higher vascular pressures.¹⁹ Factors shown to predispose patients with peripheral arterial catheters to CRI are inflammation at the catheter insertion site, catheterization >4 days, or catheter insertion by cutdown.^{20 21} In contrast to peripheral venous catheters, peripheral arterial catheters inserted in the lower extremities, specifically the femoral area, do not clearly pose a greater risk of infection than do peripheral arterial catheters inserted in upper extremities or brachial areas.²²

In addition to monitoring hemodynamic status, arterial catheters may also be used to administer local intraarterial chemotherapy. Although this is a well-established method for treating metastatic or unresectable tumors, very little has been published on the infectious complications associated with this form of therapy. Maki et al. conducted an epidemiologic investigation of endarteritis associated

with intraarterial chemotherapy administration and identified several risk factors for infection: leukopenia, hypoalbuminemia, prior radiation therapy, difficult catheterization, and repeated manipulation of the catheter.²³

Midline catheters. Midline catheters are peripherally inserted (into antecubital veins), six-inch elastomer catheters that do not enter central veins, but have recently been used as an alternative to central venous catheterization. Presently, there is little published scientific data on which to assess the infectious risks posed by these newer devices.

Nontunneled central venous catheters (CVCs). CVCs account for an estimated 90% of all catheter-related bloodstream infections⁶ and nontunneled (percutaneously-inserted) CVCs are the most commonly used central catheters. Among the factors that influence the risk of infection associated with the use of CVCs are the number of catheter lumens and the site at which the catheter is inserted.

Multilumen CVCs are often preferred by clinicians, because they permit the concurrent administration of various fluids/medications and hemodynamic monitoring among critically ill patients. In nonrandomized trials, multilumen catheters have been associated with a higher risk of infection than have their single-lumen counterparts.²⁴⁻²⁶ In two of three randomized trials multilumen catheters were associated with an increased risk of infection.²⁷⁻²⁹ Multilumen catheter insertion sites may be particularly prone to infection because of increased trauma at the insertion site and/or because multiple ports increase the frequency of CVC manipulation.^{25, 26} Although patients with multilumen catheters tend to be more ill, the infection risk found with the use of these catheters may be independent of the patient's underlying disease severity.²⁸

In addition to the number of lumens, the site at which a CVC is inserted may play a major role in CVC-related infections. Five of six studies have shown a significantly higher colonization or infection rate with catheters inserted into the internal jugular vein compared with those inserted into the subclavian vein, with a risk ratio as high as 2.7.³⁰⁻³⁵ Other risk factors for CVC-related infections include repeated catheterization, presence of a septic focus elsewhere in the body, exposure of the catheter to bacteremia, absence of systemic antimicrobial therapy,³¹ duration of catheterization, and type of dressing.³³

Central arterial catheters. Pulmonary artery catheters (PACs) (i.e., Swan

Ganz¹ catheters) differ from CVCs in that they are inserted through a Teflon introducer and typically remain in place an average of only 3 days. However, they carry many of the same risks and have similar rates of BSI as do other central catheters. Risk factors reported for CRI in patients with PACs include duration of catheterization >3 days,³⁶ >5 days,³⁷ or >7 days;²¹ colonization of the skin insertion site;^{36, 38} and catheter insertion in the operating room using submaximal barrier precautions (i.e., gloves, small-fenestrated drape).³⁶ Site of insertion may also influence the risk of infection associated with PACs. Two studies suggest that PACs inserted into jugular veins have a higher rate of infection compared with those inserted into subclavian veins;^{36, 39} three other studies found no difference in infection rates associated with the two insertion sites.^{37, 38, 40}

Pressure monitoring systems. Pressure monitoring systems used in conjunction with arterial catheters have been associated with both epidemic and endemic nosocomial BSIs.^{41, 42} The first outbreak of infections due to contamination of pressure monitoring systems was reported in 1971;⁴³ subsequently, 26 such outbreaks have been reported.⁴⁴⁻⁴⁸ The final common pathway for microorganisms that enter the bloodstream of patients and cause bacteremia is the fluid column in the tubing between the patient's intravascular catheter and the pressure monitoring apparatus. Microorganisms in a fluid filled system may move from the pressure monitoring apparatus to the patient or from the patient to the pressure monitoring system.⁴²

The earliest outbreaks related to pressure monitoring were due to contaminated infusate⁴³ or failure to sterilize the fluid pathway in reusable transducers, particularly the chamber domes.^{49, 50} Because of the difficulties in sterilizing reusable transducers, sterile disposable plastic chamber domes were developed. These domes have a plastic membrane that makes contact with the sensor diaphragm on the head of the transducer and isolates the sterile fluid pathway from the transducer. However, systems containing these disposable domes have also been associated with outbreaks.^{45, 46, 51, 52} While reesterilization of disposable domes may damage the membrane and permit ingress of microorganisms into the sterile fluid pathway,⁵³ in most outbreaks the membranes in the disposable domes

remained intact.^{46, 51} A study in 1979 showed that fluid used to fill the space between the transducer head and the membrane of the disposable dome frequently contaminated the hands of the operator and that the system was inoculated by touch contamination during the subsequent assembly of the pressure monitoring system.⁵² This mode of contamination is most likely to occur when glucose solutions are used between the transducer head and the chamber dome membrane and when transducers are not effectively decontaminated between uses.⁵⁴ Most outbreaks that have occurred since the introduction of the disposable chamber dome have been due to this type of contamination.⁵⁴

Other mechanisms by which pressure monitoring systems have been contaminated include contamination of infusate,⁴¹ in-use contamination of the system by nonsterile calibrating devices,⁵⁵ contamination of the system by ice used to chill syringes,⁵⁶ introduction of microorganisms into the system by contaminated disinfectant⁴⁹ and in-use contamination of the system related to blind, stagnant columns of fluid between the transducer and infusion system.⁴² The importance of the latter mechanism in contamination was shown by a substantial drop in contamination of the system after introduction of a continuous flush device that eliminated the stagnant column of fluid.⁵⁷

To date, no outbreaks have been reported with the use of disposable pressure transducers. A prospective study of disposable transducers has shown a very low rate of associated infection (one case of bacteremia in 157 courses of pressure monitoring).⁵⁸ This study also showed that disposable transducers can be safely used for 4 days.⁵⁸ Disposable transducers were used as a control measure in one reported outbreak caused by contaminated reusable transducers.⁴⁵

Peripherally Inserted CVCs

Peripherally inserted CVCs (PICCs) are inserted into the right atrium by way of the cephalic and basilic veins of the antecubital space and provide an alternative to subclavian or jugular vein catheterization and, because they do not require surgical insertion, cost much less to insert than tunneled subclavian catheters or subcutaneous ports. PICCs have been used for a variety of purposes, including total parenteral nutrition (TPN) administration, and their use appears to be associated with a rate of infection similar to that reported with other percutaneously inserted CVCs.⁵⁹ Further studies are

¹ Use of trade names is for identification only and does not imply endorsement by the U.S. Public Health Service or the U.S. Department of Health and Human Services.

needed to adequately determine how long PICCs can safely be left in place^{59,60} and to determine the epidemiology and microbiology of associated infections.

Devices Used for Long-Term Vascular Access

Tunneled central venous catheters. Surgically implanted right atrial catheters, including Hickmans, Broviacs, Groshongs, and Quintons, are commonly used to provide vascular access to patients requiring prolonged intravenous therapy (e.g., chemotherapy or home-infusion therapy, hemodialysis). In contrast to percutaneously inserted (nontunneled) CVCs, these catheters have a tunneled portion exiting the skin and a Dacron cuff just inside the exit site. The cuff inhibits migration of organisms into the catheter tract by stimulating growth of the surrounding tissue, thus sealing the catheter tract and providing a natural anchor for the catheter. In general, the rates of infections reported with the use of tunneled catheters have been significantly lower than those reported with the use of nontunneled CVCs;⁶¹⁻⁶⁹ however, two recent studies, one randomized, found no significant difference in the rates of infection among tunneled and nontunneled catheters.^{59,70}

Totally implantable intravascular devices (TIDs). TIDs are also tunneled beneath the skin, but have a subcutaneous port or reservoir with a self-sealing septum that is accessed by needle puncture through intact skin. TIDs offer the advantage of improved patient image and obviate the need for routine catheter-site care. Among devices used for long-term vascular access, TIDs have the lowest reported rates of catheter-related BSI,⁷¹⁻⁸¹ possibly because they are located beneath the skin with no orifice for ingress of microorganisms.

Recently, several investigators have attempted to compare the infectious morbidity associated with TIDs and other tunneled catheters. In one randomized study, TIDs and Hickman catheters had comparable rates of infection.⁷⁸ In another randomized study, TIDs had lower rates of infection compared with other tunneled catheters.⁷⁹ Groeger et al. conducted one of the largest comparisons of the infectious complications associated with long-term vascular access devices to date. In this prospective examination of 1431 devices in patients with cancer, TIDs (0.21 infections per 1,000 device-days) had a significantly lower rate of infectious complications compared with other tunneled catheters (2.77 infections

per 1,000 device days, $p < 0.001$).⁸⁰ However, the devices in Groeger's study were not randomly assigned, thus the differences observed may be due to factors other than those inherent to the devices. Existing data suggest that either of the indwelling devices can be safely used with a low risk of infection. The selection of a given device depends on the intended use, patient population, and patient/practitioner preference.

III. Microbiology

Over the past two decades, there has been a marked change in the distribution of pathogens reported to cause nosocomial BSIs.^{7,82,83} Since the mid-1980's, an increasing proportion of nosocomial BSIs reported to NNIS have been due to gram-positive, rather than gram-negative, species. Moreover, a major portion of the overall increase in nosocomial BSIs reported to NNIS during the past decade was due to significant increases in four pathogens: coagulase-negative staphylococci (CoNS), *Candida spp.*, enterococci, and *Staphylococcus aureus*. The distribution of these pathogens varied by hospital size and affiliation (i.e., teaching, nonteaching).⁷

CoNS, particularly *S. epidermidis*, have become the most frequently isolated pathogens in CRIs and accounted for an estimated 28% of all nosocomial BSIs reported to NNIS during 1986-89.^{7,84} The emergence of CoNS as the primary pathogen causing CRIs can be attributed to several factors: (1) increased use of prosthetic/indwelling devices (e.g., intravascular catheters);⁸⁵ (2) improved survival of low birthweight neonates and increased use of intralipids in these patients;⁸⁶ and (3) recognition of CoNS as true nosocomial pathogens rather than harmless commensals.⁷ The prevalence of these pathogens also shows that the hands of healthcare workers (HCWs) and the flora of patients' skin are likely the predominant sources of pathogens for most CRIs.

Prior to 1986, *S. aureus* was the most frequently reported pathogen causing nosocomial BSIs.⁸⁴ Now, *S. aureus* accounts for an estimated 16% of reported nosocomial BSIs.⁸⁷ *S. aureus* BSIs may be complicated by metastatic foci of infection (e.g., vertebral osteomyelitis) and endocarditis.⁸⁸⁻⁹⁰

Enterococci, another emerging nosocomial bloodstream pathogen, accounted for 8% of nosocomial BSIs reported to NNIS during 1986-1989.⁸⁴ More alarming, has been the emergence of vancomycin-resistant enterococci (VRE). During 1989-1993, 3.8% of the blood isolates from BSIs reported to NNIS were vancomycin resistant.

Although data were not available to adequately assess the attributable mortality of either the BSI or the antimicrobial resistance of the isolate, mortality was significantly higher among patients whose isolates were vancomycin resistant (36.6%) than among those whose isolates were vancomycin susceptible (16.4%).⁹¹ Risk factors associated with VRE BSIs include receipt of antimicrobials (including vancomycin), gastrointestinal colonization with VRE, underlying disease severity (e.g., in oncology or transplant patients), abdominal or cardiac surgical procedures, use of indwelling devices, and prolonged hospital stay.⁹²⁻⁹⁹ Although enterococcal BSIs may arise from the patients' endogenous flora, nosocomial transmission of VRE via the hands of HCWs,⁹³ patient-care equipment,¹⁰⁰ and contaminated environmental surfaces^{92,93} has also been suggested by the findings of recent outbreak investigations. The emergence of enterococci as significant nosocomial bloodstream pathogens is likely due, in part, to the increased use of invasive devices and the injudicious use of broad-spectrum antimicrobials for treatment and prophylaxis of infections.¹⁰¹⁻¹⁰⁵

Fungal pathogens represent an increasing proportion of nosocomial BSIs. During 1980-1990, NNIS hospitals reported a nearly fivefold increase in the rate of nosocomial fungal BSIs (1.0 to 4.9/10,000 discharges) and a nearly twofold increase in the proportion of BSIs due to fungal pathogens (5.4 to 9.9%).¹⁰⁶ Such increases were detected for hospitals of all sizes and affiliations and on all major hospital services. *Candida spp.*, particularly *C. albicans*, accounted for >75% of all nosocomial fungal infections reported to NNIS during this period. Candidemia has traditionally been thought to arise from the endogenous flora of colonized patients,¹⁰⁷⁻¹⁰⁹ but recent epidemiologic studies, assisted by the use of molecular typing, show that exogenous infection due to administration of contaminated fluids,^{110,111} use of contaminated equipment,¹¹² cross-infection,¹¹³⁻¹¹⁷ and the colonized hands of HCWs¹¹⁸⁻¹²² are also important contributors to candidemia among hospitalized patients.

Although less commonly implicated than either gram-positive bacterial or fungal species as a cause of BSI, gram-negative microorganisms account for the majority of CRIs associated with the use of arterial catheters. Moreover, it has been suggested that clusters of infections caused by certain gram-negative species, such as *Enterobacter*

spp., *Acinetobacter spp.*, *S. marcescens* or non-aeruginosa pseudomonads, should automatically raise suspicion of a common source, such as a contaminated pressure monitoring device. The predominance of gram-negative microorganisms in infections associated with pressure monitoring devices may be due to concomitant receipt of broad-spectrum antimicrobials by patients undergoing hemodynamic monitoring.

IV. Pathogenesis

The pathogenesis of CRIs is multifactorial and complex (Figure 1), but available scientific data show most CRIs appear to result from migration of skin organisms at the insertion site into the cutaneous catheter tract with eventual colonization of the catheter tip.¹²³⁻¹²⁶ However, there is a smaller, but growing, body of data to suggest that hub contamination can be an important contributor to intraluminal colonization of catheters, particularly long-term catheters.¹²⁷⁻¹³⁰

The relative importance of these two mechanisms of catheter contamination is the source of continuing debate. Recent findings suggest that duration of catheterization influences which of the two mechanisms predominates. Using electron microscopy, Raad demonstrated that hub contamination was the more likely mechanism of infection for long-term catheters (i.e., in place >30 days), while skin contamination was the more likely mechanism for short-term catheters (i.e., <10 days).¹³⁰ Although much less common than either of these two mechanisms, hematogenous seeding of the catheter tip from a distant focus of infection or administration of contaminated infusate may also cause CRIs.^{128 131-134}

Two other important pathogenic determinants of CRI are (1) the material of which the device is made, and (2) the intrinsic properties of the infecting organism. In vitro studies show that catheters made of polyvinyl chloride or polyethylene appear to be less resistant to the adherence of microorganisms than are newer catheters made of Teflon, silicone elastomer, or polyurethane.¹³⁵⁻¹³⁷ Some catheter materials also have surface irregularities that may further enhance the microbial adherence of certain species (e.g., CoNS, *Acinetobacter calcoaceticus*, and *Pseudomonas aeruginosa*).^{138 139} Thus, catheters made of certain materials may be more prone to microbial colonization and subsequent infection. Additionally, certain catheter materials are more thrombogenic than others, a characteristic that also may predispose

to catheter colonization and catheter-related infection.¹⁴⁰

The adherence properties of a given microorganism are also important in the pathogenesis of CRI. For example, *S. aureus* can adhere to host proteins (e.g., fibronectin) commonly present on catheters,^{141 142} and CoNS, the most frequent etiologic agents in CRIs, adhere to polymer surfaces more readily than do other common nosocomial pathogens such as *E. coli* or *S. aureus*.¹⁴³ Additionally, certain strains of CoNS produce an extracellular polysaccharide often referred to as "slime." In the presence of catheters, this slime potentiates the pathogenicity of CoNS by allowing them to withstand host defense mechanisms^{144 145} (e.g., acting as a barrier to engulfment and killing by polymorphonuclear leukocytes) or by making them less susceptible to antimicrobial agents¹⁴⁶ (e.g., forming a matrix that binds antimicrobials before their contact with the organism cell wall). More recent studies suggest that certain *Candida spp.*, in the presence of glucose-containing fluids, may produce "slime" similar to that of their bacterial counterparts, potentially explaining the increased proportion of BSIs due to fungal pathogens among patients receiving parenteral nutrition fluids.¹⁴⁷

V. Definitions and Diagnosis of Catheter-Related Infections

Establishing a clinical diagnosis of CRI, especially catheter-related BSI, is often difficult. Diagnosis is typically based on clinical and/or laboratory criteria, with each having significant diagnostic limitations. The introduction of semiquantitative methods for culturing catheters has greatly enhanced our ability to diagnose CRIs. Both semiquantitative and quantitative methods have greater specificity in identifying CRI than do traditional broth cultures, where a clinically insignificant inocula of microorganisms can result in a positive catheter culture.^{31 148}

However, interpretation of the results of these culture methods may vary depending on the type and location of the catheter and the culture methodology used. The use of varying definitions in studies of CRI have made it difficult to compare existing studies of these infections.

The predictive values of semiquantitative and quantitative methods may vary, depending on the source of catheter colonization.¹³⁰ For example, if the skin is the primary source of catheter colonization, methods that culture the external surface of the catheter may be preferable. Conversely, if hub contamination is the primary mechanism for catheter colonization,

methods that culture both the external and internal surfaces may have greater yield.¹³⁰ As the use of antimicrobial-coated catheters becomes more prevalent, existing definitions of catheter colonization and CRI may need to be modified.

Infections Associated with Short-Term Catheters

The most widely used laboratory technique for diagnosis of CRI is the roll-plate method described by Maki et al.¹⁴⁸ This method cultures a segment of the catheter after it has been removed from the patient by rolling the catheter segment across the surface of an agar plate and determining the number of bacterial colonies present after overnight incubation. Growth of ≥ 15 colony forming units (cfus) from a proximal or distal catheter segment by semiquantitative culture in the absence of accompanying signs of inflammation at the catheter site is considered indicative of catheter colonization. Growth of ≥ 15 cfus from a catheter by semiquantitative culture with accompanying signs of inflammation (e.g., erythema, warmth, swelling, or tenderness) at the device site is indicative of local CRI. In the absence of semiquantitative culture, CRI may be diagnosed when there is purulent drainage from the skin-catheter junction. Limitations of the roll plate method are that it requires removal of the catheter and overnight incubation before results become available.

Cooper et al. proposed direct gram-staining of catheters on removal as a rapid way to diagnose catheter infection and as a complement to semiquantitative culture.¹²⁶ However, this method appears to be considerably more time-consuming than semiquantitative culture and, thus, may be impractical for routine diagnostic use.

Acridine-orange staining of catheters has been proposed as a modification of the gram-staining technique.¹⁴⁹ Although similar to gram-staining, acridine-orange staining is a single-step procedure that uses a fluorescent dye to enhance detection of microorganisms in clinical specimens. This procedure avoids many of the technical shortcomings encountered with the direct gram-staining technique, but confirmatory studies documenting its quantitative test performance are needed before it can be recommended.

The most sensitive technique for diagnosis of CRI is quantitative culture. To culture a catheter quantitatively, the catheter segment is either flushed with and then immersed in broth¹⁵⁰ or placed in broth and sonicated,^{151 152} the

broth recovered from these procedures is cultured quantitatively. Sonication releases microorganisms from both the luminal and external surfaces of the catheter and thus may have greater sensitivity for diagnosing CRIs, especially those associated with central venous and arterial catheters, than do methods that only culture the external surface of the catheter.¹⁵²

All semiquantitative and quantitative catheter culture methods require removal of the implicated catheter, but the venous access site can be preserved by removing the catheter over a guidewire and inserting a new catheter over the guidewire. The proximal and distal segments of the catheter removed over the guidewire are cultured using the semiquantitative technique.¹⁵³ If a catheter is removed over a guidewire and has a negative culture, the catheter inserted over the guidewire may be left in place. If the catheter removed over a guidewire has a culture result suggesting colonization/infection, the second catheter should be removed, and a new catheter inserted at a new site.^{59 131 153}

Quantitative blood culturing techniques have been developed for diagnosis of CR-BSI in patients where catheter removal is undesirable because of limited vascular access. These techniques rely on quantitative culture of paired blood samples, one obtained through the central catheter and the other from a peripheral venipuncture site. In most studies, a colony count from the blood obtained from the catheter that is five to tenfold greater than the colony count from the blood obtained from a peripheral vein has been predictive of CR-BSI.¹⁵⁴⁻¹⁵⁶

Infections Associated With Long-Term Catheters

The use of these indwelling catheters may be complicated by a variety of local infectious complications: exit-site, tunnel, or pocket infections, as defined in Table 1.⁶⁹ However, clinical diagnosis of CRI involving the intravascular portion of indwelling catheters is particularly difficult; thus, laboratory diagnosis is important. The utility of the roll-plate method for diagnosis of infection associated with long-term vascular access devices has not been evaluated, but recovery of ≥ 15 cfus on semiquantitative culture of a catheter segment may be diagnostic of colonization of the intravascular segment. BSI resulting from a colonized intravascular segment may also be suspected if ≥ 10 -fold higher concentration of microorganisms on quantitative culture of blood obtained from the catheter compared with the

concentration of microorganisms in blood obtained from a peripheral venous site.¹⁵⁷⁻¹⁵⁹

Catheter-Related Bloodstream Infection

CR-BSI is most stringently defined as isolation of the same organism (i.e., identical species, antibiogram) from semiquantitative or quantitative cultures of both a catheter segment and the blood (preferably drawn from a peripheral vein) of a patient with accompanying clinical symptoms of BSI and no other apparent source of infection. In the absence of laboratory confirmation, defervescence after removal of an implicated catheter from a patient with BSI is also considered indirect evidence of CR-BSI.

Infusate-Related Bloodstream Infection

Since BSI may result from the administration of contaminated intravenous fluids, culturing intravenous fluids should be part of an investigation of potential sources of infection. Infusate-related BSI is usually defined as the isolation of the same organism from both infusate and separate percutaneous blood cultures, with no other identifiable source of infection.

VI. Strategies for Prevention of Catheter-Related Infections

Strict adherence to handwashing and aseptic technique remains the cornerstone of prevention of CRIs; however, other measures may confer additional protection and must be considered when formulating preventive strategies. These measures include the selection of an appropriate site of catheter insertion, selection of appropriate catheter material(s), use of barrier precautions during catheter insertion, change of catheters and administration sets at appropriate intervals, catheter-site care, and the use of filters, flush solutions, prophylactic antimicrobials, and newer intravascular devices (e.g., impregnated catheters, needleless infusion systems).

Site of Catheter Insertion

The site at which a catheter is placed may influence the subsequent risk of CRI. For peripheral venous catheters, lower extremity insertions pose a greater risk of phlebitis than do those inserted in the upper extremity, and upper extremity sites differ in their risk for phlebitis.¹⁶⁰⁻¹⁶⁴ Peripheral venous catheters inserted into hand veins have a lower risk of phlebitis than do those inserted in upper arm or wrist veins.⁶

Among CVCs, catheters inserted into subclavian veins have a lower risk for infection than do those inserted in

either jugular or femoral veins.^{31-36 39} Internal jugular insertion sites may pose a greater risk for infection because of their proximity to oropharyngeal secretions, and because catheters at internal jugular sites are difficult to immobilize. However, mechanical complications associated with insertion are less common with internal jugular vein insertion than with subclavian venous catheterization.

Type of Catheter Material

The relationship between catheter material and infectious morbidity has been largely examined by the study of peripheral venous catheters. The majority of peripheral venous catheters in the U.S. are made of Teflon or polyurethane, and these catheters appear to be associated with fewer infectious complications than are catheters made of polyvinyl chloride or polyethylene.^{17 135 165} In one large, randomized prospective study of Teflon and polyurethane catheters, the two types of catheters had comparable rates of local infection, 5.4% and 6.9%, respectively,¹⁷ but polyurethane catheters were associated with a nearly 30% lower risk of phlebitis when compared with Teflon catheters. In this trial, neither the Teflon nor polyurethane catheter was associated with BSI.¹⁷ By contrast, polyvinyl chloride or polyethylene catheters have been associated with BSI rates ranging from 0%-5%.^{166 167}

Steel needles, used as an alternative to synthetic catheters for peripheral venous access, have the same rate of infectious complications as do Teflon catheters.^{168 169}

However, the use of steel needles is frequently complicated by infiltration of intravenous fluids into the subcutaneous tissues, a potentially serious complication if the infused fluid is a vesicant.¹⁶⁹ In view of the low rates of BSI seen with newer Teflon and polyurethane catheters, the relative risks and benefits of using steel needles must be evaluated on an individual patient basis.

Catheter material seems to also be an important determinant in the risk of infection associated with CVCs. Most CVCs used in the U.S. are made of polyurethane, polyvinyl chloride, polyethylene, or silicone. In one small, prospective trial comparing silicone with polyvinyl TPN catheters, silicone catheters had a significantly lower rate of CR-BSI than did polyvinyl chloride catheters, 0.83 and 19 per 1,000 catheter days, respectively; however, the silicone catheters were tunneled, and the polyvinyl chloride catheters were largely nontunneled. The polyvinyl

chloride catheters also were associated with a higher risk of mechanical complications (i.e., breakage, blockage, displacement, and thrombosis).¹⁷⁰ Because of the potential confounding caused by the different types of catheters in this comparison (i.e., tunneled vs. nontunneled), appropriate conclusions about the contribution of catheter material to CVC-related infections can not be drawn.

Barrier Precautions During Catheter Insertion

It is generally accepted that good handwashing before and attention to aseptic technique during insertion of peripheral venous catheters provide adequate protection against infection. Central venous catheterization, however, carries a significantly greater risk of infection, and the level of barrier precautions needed to prevent infection during insertion of CVCs has been a source of debate.

Until recently, it was assumed that catheters inserted in the operating room posed a lower risk of infection than did those inserted on inpatient wards or other patient-care areas. However, data from two recent prospective studies suggest that the difference in risk of infection depends largely on the magnitude of barrier protection used during catheter insertion, rather than the sterility of the surrounding environment (i.e., ward vs. operating room)^{36 171}; CVCs or PACs inserted in the operating room using submaximal barrier precautions (i.e., gloves, small fenestrated drape) were more likely to become colonized and to be associated with subsequent BSI than were those inserted on the ward or in the ICU using maximal barrier precautions (i.e., gloves, gown, large drape, masks). These data suggest that if maximal barrier precautions are used during CVC insertion, catheter contamination and subsequent CVC-related infections can be minimized, irrespective of whether the catheter is inserted in the operating room or at the patient's bedside.^{171 172}

Changing Catheters and Administration Sets

Intravenous administration set changes. The optimal interval for routinely changing intravenous administration sets used for patient care has been examined in three well-controlled studies. Data from each of these studies show that changing administration sets ≥ 72 -hours after initiation of use is not only safe, but cost-beneficial.¹⁷³⁻¹⁷⁵ However, because certain fluids (i.e., blood, blood products, TPN, and lipid emulsions) are more likely than other parenteral fluids

to support microbial growth if contaminated,^{132 176-179} more frequent tubing changes may be required when such fluids are administered.

A common component of intravenous administration sets is the stopcock. Stopcocks are used for injection of medications, administration of intravenous infusions, or collection of blood samples and, thus, represent a potential portal of entry for microorganisms into vascular catheters or intravenous fluids. Although stopcock contamination is common, ranging between 45% and 50% in most series, the relative contribution of stopcock contamination to intravascular catheter or intravenous fluid contamination is unclear. Few studies have been able to demonstrate that the organism(s) colonizing stopcocks is the same one responsible for CRI.^{180 181} Data suggest that the use of a closed-needle sampling system can significantly reduce sampling-port and intravenous fluid contamination.^{182 183}

"Piggyback" systems may be used as an alternative to stopcocks. However, they also pose a risk for contamination of the intravascular fluid if the needle entering the rubber membrane of an injection port is partially exposed to air, or comes into direct contact with the tape used to fix the needle to the port. A recently described "piggyback" system appears to prevent contamination at these sites and reduces the incidence of CR-BSI sixfold compared with conventional stopcock and "piggyback" systems.¹⁸²

Intravenous catheter changes. Routine or scheduled change of intravascular catheters has been advocated as a method to reduce CRIs. Studies of peripheral venous catheters show that the incidences of thrombophlebitis and bacterial colonization of catheters seem to increase dramatically when catheters are left in place >72 hours.^{12 168} Both phlebitis and catheter colonization have been associated with an increased risk of CRI. Because of the increased risk of infection, as well as patient discomfort associated with phlebitis, peripheral catheter sites are commonly rotated at 48-72 hour intervals to reduce the risk of phlebitis.

In the maintenance of CVCs, decisions regarding the frequency of catheter change are substantially more complicated. Some investigators have shown duration of catheterization to be a risk factor for infection,^{33 35 184 185} and routine change of CVCs at specified intervals has been advocated as a measure to reduce infection. However, more recent data suggest that the daily risk of infection remains constant and show that routine changes of CVCs,

without a clinical indication, do not reduce the rate of catheter colonization or the rate of catheter-related BSI.^{186, 187}

The method of replacing CVCs has also been a topic of controversy and intensive study. CVCs can be changed by placing a new catheter over a guidewire at the existing site or by inserting the new catheter at another site. Catheter replacement over a guidewire has become an accepted technique for changing a malfunctioning catheter or exchanging a PAC for a CVC when invasive monitoring is no longer needed. Catheters inserted over a guidewire are associated with less discomfort and a significantly lower rate of mechanical complications than are those percutaneously inserted at a new site.^{131 186 188 189} Guidewire-assisted exchange may, however, be accompanied by complications, most notably bleeding at the site, hydrothorax, and subsequent infection of the newly placed catheter.^{131 189}

Studies examining the infectious risks associated with guidewire insertions have yielded conflicting results. Three prospective studies (two randomized) have shown no significant difference in infection rates between catheters inserted percutaneously and those inserted over a guidewire.^{153 187 190} One prospective randomized study has shown a significantly higher rate of BSIs associated with catheters changed over a guidewire compared with catheters inserted percutaneously.¹⁸⁶ Most investigators agree that if guidewire-assisted catheter change occurs in the setting of an CRI, the newly placed catheter should be removed (131, 153, 187, 188).

Catheter-Site Care

Cutaneous antiseptics and antimicrobial ointments. Skin cleansing/antiseptics of the insertion site is regarded as one of the most important measures for preventing CRI, but comparative studies of cutaneous antiseptics have largely examined its efficacy in eradicating bacterial flora from the hands of hospital personnel.^{191 192} However, in one trial, the effectiveness of 2% chlorhexidine, 10% povidone-iodine, and 70% alcohol¹⁹³ as cutaneous antiseptics were compared in preventing central venous and arterial CRIs. The rate of catheter-related BSI when chlorhexidine was used for catheter site preparation was 84% lower than the rates when the other two antiseptic regimens were used; however, the 2% chlorhexidine preparation used in this trial is not currently available in the U.S. More recently, a sustained-release chlorhexidine gluconate patch (250 mu/

mg dressing) has been introduced as a dressing for catheter insertion sites. In one randomized trial of epidural catheters, the use of these patches significantly reduced the incidence of catheter colonization.¹⁹⁴ However, the efficacy of the chlorhexidine patch in reducing intravascular device-related infection still needs to be determined.

Tincture of iodine also has been widely used in hospitals for skin antisepsis before catheter insertion, but its efficacy in reducing catheter colonization and infection have not been thoroughly evaluated. Data derived from examining its use as an antiseptic prior to blood culturing suggest that it, like 70% alcohol and 10% povidone iodine, may be an effective cutaneous antiseptic for preparation of the skin prior to insertion of intravascular catheters.¹⁹⁵ However, tincture of iodine may cause skin irritation.¹⁹⁵

The application of antimicrobial ointments to the catheter site at the time of catheter insertion and/or during routine dressing changes has also been used to reduce microbial contamination of catheter-insertion sites. Studies of the efficacy of this practice in preventing CRIs have yielded contradictory findings.^{30 196-200} Moreover, the use of polyantibiotic ointments that are not fungicidal may significantly increase the rate of colonization of the catheter by *Candida* spp.^{198 200 201}

Recently, topical mupirocin, a nonsystemic anti-staphylococcal antimicrobial with documented efficacy in reducing nasal staphylococcal spp. carriage,²⁰² has been used for cutaneous antisepsis in conjunction with 2.5% tincture of iodine prior to catheter insertion. Used in this way, mupirocin was reported to reduce the incidence of internal jugular catheter colonization among cardiac surgery patients. However, the utility of mupirocin in reducing the rate of colonization of peripheral or arterial catheters has not been demonstrated²⁰³ and its use on catheter sites has not been approved. Moreover, mupirocin resistance has been reported (204-206). Controlled studies are needed to fully evaluate the effectiveness and potential adverse effects of mupirocin use for catheter-site maintenance.

Catheter-site dressing regimens.

Transparent, semipermeable, polyurethane dressings have become a popular means of dressing catheter-insertion sites. These transparent dressings reliably secure the device, permit continuous visual inspection of the catheter site, permit patients to bathe and shower without saturating the dressing, and require less frequent changes than do standard gauze and

tape dressings, thus saving personnel time. Nevertheless, the use of transparent dressings remains one of the most actively researched, and controversial, areas of catheter site care. Some studies suggest that their use increases both microbial colonization of the catheter site and the risk of subsequent CRI,^{15 207-210} while other studies have shown no difference in catheter colonization and infection rates between the use of transparent dressings and gauze and tape dressings.^{10 165 211} The potential risk of infection posed by transparent dressings appears to vary with the type of catheter (peripheral or central venous catheter) they are used to dress and, perhaps, with the season of the year.^{10 15 209}

In the largest controlled trial of dressing regimens to date, Maki et al. examined the infectious morbidity associated with the use of transparent dressings on >2,000 peripheral catheters.¹⁶⁵ Their findings suggest that the rate of catheter colonization among catheters dressed with transparent dressings (5.7%) is comparable to that of those dressed with gauze (4.6%) and that there are no clinically important differences in either the incidences of catheter-site colonization or phlebitis between the two groups. Further, these data suggest that transparent dressings can be safely left on peripheral venous catheters for the duration of catheter insertion without increasing the risk of thrombophlebitis.¹⁶⁵

Studies of the use of transparent dressings on CVCs have also yielded contradictory findings. Some investigators have found an increased risk of CRI among CVCs with a transparent dressing compared with those gauze;^{209 210} others have found the risk of infection posed by these two types of dressings to be comparable.^{211 212} Most of the data on the use of transparent dressings on CVCs are derived from studies of short-term nontunneled devices and little data have been published regarding the use of transparent dressings on long-term, tunneled CVCs.²¹³ In a metaanalysis of catheter dressing regimens, CVCs on which a transparent dressing was used had a significantly higher incidence of catheter tip colonization, but a nonsignificant increase in the incidence of CR-BSI.²¹⁴ Preliminary data suggest that newer transparent dressings that permit the escape of moisture from beneath the dressing may be associated with lower rates of skin colonization and CRI,^{213 215} but the length of time that a transparent dressing can be safely left on a CVC catheter site is unknown.

Collodion has also been evaluated for use as a potential dressing for catheter

sites. One small (n=34), retrospective study of its use on CVCs reported a low incidence of CRIs, despite catheters remaining in place an average of 16.5 days.²¹⁶ However, before collodion can be recommended for routine use as a catheter site dressing, randomized trials comparing collodion to existing dressings should be done.

In-Line Filters

In-line filters may reduce the incidence of infusion-related phlebitis (217-220), but there are no data to support their efficacy in preventing infections associated with intravascular devices and infusion systems. Proponents of the use of filters cite a number of potential benefits: (1) reducing the risk of infection from contaminated infusate or proximal contamination (i.e., introduced proximal to the filter); (2) reducing the risk of phlebitis in patients who require high doses of medication (e.g., antimicrobials) or in those in whom infusion-related phlebitis has already occurred; (3) removing particulate matter that may contaminate intravenous fluids;²²¹ and (4) filtering endotoxin produced by gram-negative organisms in contaminated infusates.²²² These theoretical advantages must be tempered by the knowledge that infusate-related BSI rarely occurs and that pre-use filtration in the pharmacy is a more practical, and less costly, way to remove particulates from infusates. Furthermore, in-line filters may become blocked, especially with certain solutions (dextran, lipids, mannitol), and consequently increase line manipulations and/or decrease the availability of administered drugs.²²³ Because of these potential untoward effects, the routine use of in-line filters may increase cost, personnel time, and possible infections.²²⁴

Silver-Chelated Collagen Cuffs

Since 1987, a silver-chelated, collagen cuff that is attachable to percutaneously inserted CVCs has been commercially available. Similar to the cuff used on Hickman and Broviac catheters, this cuff is designed to form a mechanical barrier to skin microorganisms migrating into the cutaneous catheter tract;^{201 225} the silver provides an additional antimicrobial barrier.^{201 225} Two randomized controlled trials examining the efficacy of silver-chelated collagen cuffs have been published. In the first trial, cuffed CVCs were associated with a threefold lower risk of catheter colonization and a nearly fourfold lower risk of CR-BSI compared with traditional noncuffed CVCs.²²⁵ In the second trial, a 78% reduction in

catheter colonization and a 100% reduction in CR-BSI were observed with these devices.²⁰¹ The relative contribution of the cuff versus the antimicrobial properties of the silver preventing CRI is uncertain. No controlled trials examining the efficacy of cuffs without antiseptic or antimicrobial coating have been published.

The protective effect of these cuffed CVCs appears to be immediate and exceeds that seen with the use of antimicrobial ointment alone.²⁰¹ However, cuffs appear to be most beneficial with catheters left in place for >4 days.²²⁵ Studies on the efficacy of these cuffs in preventing infection with longer-term CVCs (i.e., >20 days) have not been published.

Antimicrobial-Impregnated (Coated) Catheters

In animal models, antimicrobial or antiseptic impregnation of catheters appears to reduce bacterial adherence and biofilm formation,^{226 227} but the utility of these impregnated catheters in clinical settings has only recently been evaluated. Kamal et al. conducted a large, randomized, prospective trial among SICU patients to evaluate a CVC bonded with cefazolin for the entire length of its external and luminal surfaces.²²⁸ The authors found a sevenfold reduction in the incidence of catheter colonization (2% vs 14%), but no difference in catheter-site inflammation (i.e., culture-negative inflammation of the insertion site). No bacteremias occurred in either group. The authors suggest that antimicrobial coating of the luminal surfaces of catheters may be particularly beneficial in reducing the risk of infection resulting from hub contamination.

Data supporting the utility of antimicrobial coating for peripheral catheters are much less conclusive. Kamal et al. also studied a small number of peripheral arterial catheters as part of their evaluation of the cefazolin-impregnated catheter.²²⁸ Although impregnated peripheral arterial catheters had a fivefold lower incidence of CRI compared with noncoated catheters (3% vs 15%), this difference was not statistically significant. The lack of demonstrable efficacy of antimicrobial coating of peripheral arterial catheters in reducing CRI may be due, in part, to the inherently low incidence of CRI associated with the use of peripheral arterial catheters.

Of the studies reported to date, antimicrobial-coated catheters do not appear to pose any greater risk of adverse effects than do noncoated catheters, but additional controlled

trials need to be done to fully evaluate their efficacy, determine the appropriate situations for their use, and assess the risk of emergence of resistant bloodstream pathogens.

Intravenous Therapy Personnel

Because insertion and maintenance of intravascular catheters by inexperienced staff may increase the risk of catheter colonization¹⁵³ and CR-BSI, many institutions have established infusion therapy teams. Available data suggest that trained personnel designated with the responsibility for insertion and maintenance of intravascular devices provide a service that effectively reduces CRIs and overall costs.²²⁹⁻²³¹

Prophylactic Antimicrobials

Prophylactic administration of antimicrobials has been used to reduce the incidence of CR-BSIs, but scientific studies on the efficacy of this practice are inconclusive. Two published studies, one randomized²³² and one nonrandomized,²³³ suggest that antimicrobials administered systemically at the time of (or immediately after) insertion of a CVC may reduce the incidence of CR-BSI. Two randomized trials of systemically administered antibiotics demonstrated no benefit of such prophylaxis.^{234 235} One randomized controlled trial showed a significant protective effect of a heparin-vancomycin flush solution used daily in immunocompromised patients with tunneled CVCs.²³⁶ Two other randomized controlled trials have examined the effect of continuous low dose (25µg) vancomycin, added to TPN fluids, in reducing the incidence of CoNS BSI in low birthweight infants.^{237 238} In one of these trials, the incidence of CoNS BSI decreased from 34% to 1.4% (P<0.001) among neonates weighing <1500 gm.²³⁷ However, 4/71 (5.6%) treated neonates developed a BSI due to gram-positive cocci after vancomycin prophylaxis was completed. The other trial studied neonates weighing <1000 gm and found that the use of vancomycin was associated with a significantly lower incidence (0% vs 15%) of CoNS CR-BSI.²³⁸ Although prophylactic administration of vancomycin decreased the incidence of CoNS BSI, it did not decrease overall mortality among low birth weight infants in either study. Further studies are needed to assess the additional benefit afforded by prophylactic antimicrobials in reducing CRIs when standard infection control measures are adhered to and to assess the concern that such prophylaxis may select for resistant microorganisms,

particularly those resistant to vancomycin.

Flush Solutions, Anticoagulants, and Other Intravenous Additives

Flush solutions are designed to prevent thrombosis, rather than infection, but thrombi and fibrin deposits on catheters may serve as a nidus for microbial colonization of the intravascular devices. Furthermore, catheter thrombosis appears to be one of the most important factors associated with infection of long-term catheters.^{69 239} Thus, the use of anticoagulants (e.g., heparin) or thrombolytic agents may have a role in the prevention of CR-BSI. However, several recent studies suggest that 0.9% saline is as effective as heparin in maintaining catheter patency and reducing phlebitis among peripheral catheters.^{137 240 241} Furthermore, recent in vitro studies suggest that the growth of CoNS on catheters may be enhanced in the presence of heparin. In contrast, the growth of CoNS on catheters can be inhibited by edetic acid (EDTA),²⁴² suggesting that EDTA, rather than heparin, may decrease the incidence of CoNS CR-BSIs. Also, the routine use of heparin to maintain catheter patency, even at doses as low as 250-500 units/day, has been associated with thrombocytopenia and thromboembolic and hemorrhagic complications.²⁴³⁻²⁴⁶ Clinical trials are needed to further assess the relative efficacy, risks, and benefits of the routine use of various anticoagulants (e.g., EDTA) in preventing CRI.

The risk of phlebitis associated with the infusion of certain fluids (e.g., potassium chloride,²⁴⁷ lidocaine,^{247 248} antimicrobials,²⁴⁷ also may be reduced by the use of certain intravenous additives, such as hydrocortisone.²⁴⁷ Bassan et al. in a prospective, controlled trial of patients being evaluated for possible myocardial infarction found that heparin and/or hydrocortisone significantly reduced the incidence of phlebitis in veins infused with lidocaine.²⁴⁸ In other trials, topical application of venodialators such as glycerol trinitate,^{249 250} or anti-inflammatory agents such as cortisone near the catheter site,²⁵¹ has effectively reduced the incidence of infusion-related thrombophlebitis and increased the life span of the catheters.^{251 252} Larger, controlled trials are needed to assess the advisability of the routine use of these agents to reduce phlebitis.

Needleless Intravascular Devices

Attempts to reduce the incidence of sharps injuries and the resultant risk of transmission of bloodborne infections to

HCWs have led to the design and introduction of needleless intravenous systems. However, there are limited data by which to assess the potential risk of contamination of the catheter and infusate and subsequent CRI that may be associated with the use of these devices. In one trial where conventional and needleless heparin-lock systems were compared, the rates of infection were comparable.²⁵³ However, in another investigation, the combined use of a needleless infusion system and TPN was associated with an increased rate of BSIs among patients receiving home infusion therapy.²⁵⁴ As the use of these systems becomes more widespread, the potential infectious risks associated with their use can be more fully evaluated.

Multidose Parenteral Medication Vials (MDVs)

Parenteral medications are commonly dispensed in MDVs that may be used for prolonged periods for one or more patients. Although the overall risk of extrinsic contamination of MDVs appears to be small, an estimated 0.5 per 1,000 vials,²⁵⁵ the consequences of contamination may be serious. Contamination of MDVs due to breaks in aseptic technique have resulted in several nosocomial outbreaks. The implicated vehicles in these outbreaks have been lipids infused intravenously from multidose containers¹⁷⁷ and medications used for intra-articular injections.^{256 257} However, when bacteria or yeasts were inoculated into some commonly used medications, such as heparin, potassium chloride, procainamide, methohexital, succinylcholine chloride, and sodium thiopental, and left at room temperature, no microorganisms could be cultured from these medications after 96 hours, with rare exceptions, irrespective of whether they contained a preservative.²⁵⁸ Microorganisms could proliferate in lidocaine and insulin only if the inocula were prepared in peptone water (with one exception), which allowed for transfer of nutrients to the vials. Even under these conditions, when vials were kept at 4°C (the recommended storage temperature), microorganisms did not proliferate in the insulin. There is one report of hepatitis B virus transmission related to the use of a contaminated vial of bupivacaine in a hemodialysis unit.²⁵⁹

VII. Intravascular Device-Related Infections Associated With Total Parenteral Nutrition

Catheter-related BSI remains one of the most important complications of TPN therapy and reported rates of

infection during TPN vary widely depending on the population studied and the definitions used. Because TPN solutions commonly contain dextrose, amino acids, and/or lipid emulsions, they are more likely than conventional intravenous fluids to support microbial growth if contaminated.^{177 179 260-263} Lipid emulsions are particularly suited for the growth of specific bacteria and yeasts,^{176 177} with microbial growth occurring as early as 6 hours after inoculation of a lipid emulsion and reaching clinically significant levels (>10⁶ CFU/ml) within 24 hours.¹⁷⁸ Newer combined TPN solutions (e.g., 3-in-1 system) which use glucose, amino acids, lipid emulsion, and additives in one multiliter administration bag, may increase the risk of infection associated with TPN, but data on which to assess this risk are not available.

Although TPN solutions are particularly suited for microbial growth, most infections that occur during the administration of TPN result from contamination of the catheter. TPN-related CRI result much less commonly from infusion of contaminated fluids or from hematogenous seeding of the catheter.

The microbiology of TPN-related CR-BSIs is similar to that of other CR-BSIs, with gram-positive species, particularly CoNS or *S. aureus*, being the predominant pathogens. However, the proportion of BSIs due to fungal pathogens, particularly *Candida* spp., are significantly greater in patients receiving TPN.¹⁰⁶

Risk Factors

A number of factors have been associated with the development of CRI during TPN therapy, including catheter-site colonization,^{123 125 155} method and site of catheter insertion, the experience of the personnel inserting the catheter,¹⁵³ the use of the TPN line for purposes other than administration of parenteral nutrition fluids,²⁶⁴ breaks in the protocol for aseptic maintenance of the infusion systems,^{167 223 264 265} and the use of triple-lumen catheters.^{24 25 27 28}

Surveillance and Diagnosis

Surveillance for CRI during TPN administration should be the same as during the administration of other types of infusion therapy. Although culturing the skin adjacent to the catheter insertion site may help predict BSI in patients who are receiving TPN,^{123 125 155} routine microbiologic surveillance can not be advocated. As with other suspected CRIs, semiquantitative and quantitative catheter cultures may also be useful for the diagnosis of TPN-related CRIs. Vanhuynegem et al.

evaluated the efficacy of semiquantitative cultures of blood drawn through in place TPN catheters in febrile patients for diagnosing CR-BSI.²⁶⁶ Comparing their methodology to the semiquantitative culture technique of Maki, they found that such cultures had a positive predictive value of 60%, and a negative predictive value of 100%. Moreover, using this technique, they were able to prevent unnecessary removal of 87% of the catheters in which infection was suspected.

Strategies for Prevention

The strategies previously outlined for the prevention of CRIs are also effective in reducing the risk of infections associated with TPN, and rigorous aseptic nursing care has been shown to greatly reduce the incidence for TPN-related infection.^{265 267 268} Nevertheless, a number of supplemental preventive measures that have been proposed to reduce the risk for TPN-related CRIs bear discussion, including special precautions for infusate preparation, cutaneous antisepsis, and catheter selection and care.

Infusate preparation. Since TPN solutions are prone to microbial growth if contaminated, strict attention must be given to asepsis during the compounding of TPN solutions. Although controlled trials have not been done, centralized preparation of TPN solutions in hospital pharmacies, using a laminar flow hood, has generally been regarded as the safest method of preparation.

Cutaneous antisepsis. Findings on the efficacy of various antiseptic skin preparations on decreasing the incidence of CRI during TPN suggest that tincture of iodine and chlorhexidine in ethyl alcohol are superior to povidone-iodine as a skin antiseptic during TPN catheter care.²⁶⁹ Furthermore, in one prospective randomized study, the application of povidone-iodine ointment to the insertion sites of subclavian catheters used for TPN was not associated with a decrease in CRIs when compared with catheters on which povidone-iodine was not used.²⁶⁸

The application of organic solvents, such as acetone or ether, to "defat" (remove skin lipids) the skin prior to catheter insertion and during routine dressing changes has been a standard component of many hyperalimentation protocols. However, these agents appear neither to confer additional protection against skin colonization nor significantly decrease the incidence of CRI. Moreover, their use can greatly increase local inflammation and patient discomfort.²⁷⁰

Selection of catheter. Tunnelling of TPN catheters has been proposed for three reasons: (1) to prevent dislodgement of the catheter; (2) to reduce the incidence of CR-BSI by increasing the distance between the sites where the catheter exits the skin and where it enters the subclavian vein; and (3) to protect the catheter from potentially contaminated sites such as tracheostomies. However, few prospective randomized studies have been done to evaluate the efficacy of this practice. When Koehane et al. assessed the risk of BSI among patients with short-term, noncuffed, tunneled and nontunneled TPN catheters, they demonstrated a reduction in the incidence of CR-BSI among tunneled catheters as compared with nontunneled catheters.²⁶⁷ However, this reduction was greatest when a designated nutrition nurse was used to maintain the catheter; after improved adherence to the infection control protocol, short-term, noncuffed, tunneled and nontunneled catheters were associated with a similar rate of BSI. The only other controlled trial of short-term, noncuffed, tunneled and nontunneled catheters similarly failed to demonstrate a beneficial effect of tunnelling after rigorous attention to infection control,¹²⁷ suggesting that if strict infection control practices are adhered to, short-term, noncuffed, tunneled and nontunneled TPN catheters have a similar risk of infection.

Catheter-site dressings. The use of occlusive dressings on catheters used for TPN has been a continuing source of debate. Two controlled studies suggest that, with adherence to strict infection control protocols, semipermeable, transparent dressings are a safe, cost-effective alternative to gauze and tape for dressing TPN catheter-insertion sites.^{212 268} Moreover, data suggest that transparent dressings used on TPN catheter sites can be safely changed at 7-day intervals.^{212 268 271}

Catheter changes. Prospective, randomized trials examining the frequency of TPN catheter changes have not been published. However, data from a study in 1974 suggest that the rate of infection (6.2%) for TPN catheters in place for >30 days is similar to the rate of infection (7%) for all catheters.²⁶⁵

Specialized personnel. Many institutions have protocols and a nutritional support team for insertion and maintenance of catheters used for TPN. As with vascular devices used for other purposes, the use of specially trained personnel to insert and maintain the catheters appears to reduce the rate of infection in patients receiving TPN.^{230, 231, 267}

VIII. Intravascular Device-Related Infections Associated With Hemodialysis Catheters

Epidemiology

Each year approximately 150,000 patients undergo maintenance hemodialysis for chronic renal failure. Since 1979, when the Uldall subclavian catheter was introduced, CVCs have gained popularity as a convenient, rapid way of establishing temporary vascular hemodialysis access until placement or maturation of a permanent arteriovenous fistula or permanent access for patients without alternative vascular access.²⁷² In 1990, an estimated 73% of centers participating in the National Surveillance System for Hemodialysis Associated Diseases had ≥ 1 patients in whom CVCs were used for permanent vascular access.²⁷³ However, only a limited number of controlled trials examining the infectious risk associated with the use of CVCs for hemodialysis have been published; most data are derived from small studies at individual institutions.

Subclavian hemodialysis catheters have been associated with a rate of BSI that exceeds that reported for virtually all other subclavian catheters²⁷⁴⁻²⁸³ or for alternative forms of hemodialysis vascular access^{275 284} and their use may be complicated by bacterial endocarditis, septic pulmonary emboli,^{274 275 282 284} and/or thrombosis (e.g., venous thrombosis, catheter occlusion). The factors contributing to the increased rate of infection experienced with CVCs used for hemodialysis have not been fully elucidated,^{277 278} but manipulations and dressing changes of dialysis catheters by inadequately trained personnel,²⁸⁵ duration of catheterization and mean number of hemodialysis runs,²⁷⁷ and cutdown insertion of the catheter²⁸⁶ may increase the risk of CRI among hemodialysis patients.

More recently, jugular vein catheters have been used for hemodialysis access because descriptive studies indicate that they are associated with fewer mechanical complications than subclavian catheters, including subclavian thrombosis, stenosis, and perforation.²⁸⁷⁻²⁹⁴ These double-lumen, Dacron-cuffed, silicone CVCs have been used for exclusive, or prolonged, vascular access in chronic hemodialysis patients^{286 295} and appear to have a longer median use-life and fewer insertion complications than do either of their single-lumened Teflon or polyurethane counterparts.^{280 295 296} Moss et al. recently reviewed the 4-year experience with double-lumen, cuffed, silicone catheters at their institution. All

catheters (n=168) had been placed for long-term use (≥ 1 month) and were the sole vascular access for hemodialysis.²⁸⁶ The median life span for these catheters was 18.5 months, with 12- and 24-month catheter survival being 65% and 30%, respectively. As with subclavian hemodialysis catheters, thrombosis (catheter and vein) and infection were the most frequent catheter complications. BSI occurred in 16/131 (12%) patients and exit-site infections in 28/131 (21%); diabetics (33%) were significantly more likely to develop exit-site infections than were nondiabetics (11%). Based on the duration of catheterization, the authors determined the following rates of CRIs associated with the use of double-lumen CVCs: 0.25 BSIs per patient-year, 0.36 exit-site infections per patient-year (nondiabetics), and 0.87 exit-site infections per patient-year (diabetics). The BSI rates reported in this review were comparable to those reported for more conventional forms of hemodialysis vascular access (0.09-0.20 BSIs per patient-year).^{284 297-299}

Two studies have examined the potential impact of tunneled hemodialysis catheters on the risk of subsequent CRI. In a nonrandomized study, Hickman catheters used for prolonged hemodialysis access was associated with a significantly lower rate of BSI (0.08 BSIs per 100 catheter-days) than were nontunneled hemodialysis catheter.³⁰⁰ Schwab et al. prospectively examined the use of cuffed, tunneled, double-lumen jugular venous catheters for prolonged hemodialysis access. Compared with percutaneously inserted, noncuffed subclavian dialysis catheters, double-lumen jugular venous catheters had a longer live span, a lower (1.3% vs 3.6%) incidence of associated BSIs, but a significantly higher incidence of exit-site infection (29% vs 9%).²⁹⁵

Hemodialysis catheters may become contaminated by a variety of proposed mechanisms: (1) penetration of organisms from the skin due to the pulsatile action of the dialysis pump; (2) manipulation of catheter connections by medical personnel with contaminated hands; (3) leakage of contaminated hemodialysis fluid into the blood compartment; or (4) administration of contaminated blood or other solutions through the catheter during the dialysis session.

Microbiology

CR-BSIs in hemodialysis patients, as in other patient populations, are most frequently caused by *S. epidermidis*.^{274-276 281-283 285} However, because of their high rates of

colonization with *S. aureus*,³⁰¹ hemodialysis patients have a greater proportion of CR-BSIs due to *S. aureus*²⁸⁴ than among other patient populations.

Strategies for Prevention of Hemodialysis Catheter-Related Infections

Strategies for the prevention of infections associated with the use of hemodialysis catheters have not been as rigorously examined as those proposed for the prevention of infections associated with CVCs used for other purposes. Although there are limited data on infectious complications in hemodialysis settings associated with various types of catheters, frequency of catheter change, cutaneous antiseptics, and prophylactic administration of antimicrobials, no studies examining catheter-site dressing regimens, or the utility of newer devices, such as antimicrobial-impregnated hemodialysis catheters have been published.

Cutaneous antiseptics. In some series, as many as 50 to 62% of hemodialysis patients have been found to be carriers of *S. aureus*.³⁰¹⁻³⁰⁴ Therefore, skin antiseptics is a crucial component for the prevention of hemodialysis catheter-associated infections. In one randomized, controlled study of 129 subclavian dialysis catheters, the routine application of povidone-iodine ointment to catheter-insertion sites was more effective than plain gauze in reducing the incidence of exit-site infections (5% vs 18%), catheter-tip colonization (17% vs 36%), and BSIs (2% vs 17%);³⁰⁴ duration of catheterization was comparable for treated (mean, 38.6 days) and nontreated (mean, 36.2 days) catheters, each ranging from 2-210 days. The beneficial effect of povidone-iodine ointment was most evident among patients with *S. aureus* nasal carriage where its use reduced the incidences of BSI and exit-site infection by 100% and catheter-tip colonization by 71%. No adverse effects were detected with the routine application of povidone-iodine ointment to subclavian dialysis catheter-insertion sites.

Catheter changes. Since attainment and preservation of vascular access in patients with chronic renal failure are often difficult, the frequency of catheter change and the role of guidewire catheter exchange are of utmost importance. However, to date, there are limited data on which to base recommendations for either of these issues in hemodialysis patients. One prospective, randomized trial of subclavian dialysis catheters using guidewire exchange suggested that the

rate of BSIs was comparable when catheters were changed weekly or when clinically indicated.³⁰⁵ One recent study examined the role of guidewire exchange in the treatment of infected jugular vein hemodialysis catheters. In this study, a 92% one-year catheter survival was observed with the combined use of guidewire exchange and administration of antimicrobials 48 hours before and 2 weeks after guidewire exchange, when frank pus was not present at the exit site.³⁰⁶ These findings, however, are contrary to a large body of data suggesting that guidewire exchange should not be done in the setting of documented CRI.^{59 131 153 307 308}

Prophylactic antimicrobials. Hemodialysis patients receiving antistaphylococcal antimicrobials at the time of catheter placement have been shown to have a lower incidence of CRI.^{274 276 277 309} However, the role of prophylactic antimicrobials has not been directly studied.

Whether hemodialysis catheters can be treated in the same way as CVCs used for other purposes is unclear. Prospective, controlled trials of hemodialysis catheters are needed to determine the epidemiology of CRIs associated with their use and to evaluate the role of preventive role of different types of catheter materials, appropriate insertion sites, intervals for catheter change, guidewire exchange, catheter-site dressing regimens, and the use of newer modalities (e.g., such as antimicrobial-impregnated hemodialysis catheters).

IX. Intravascular Device-Related Infections in Pediatric Patients

This section addresses some of the specific issues relevant to intravascular access and intravascular device-related infections among the pediatric population. However, the epidemiology of intravascular-device related infections in pediatric patients is less well-described than that in adults, and there are limitations to the existing data. First, few controlled trials of intravascular devices in children have been reported; most published data are derived from uncontrolled retrospective or prospective studies. Second, pediatric data that are available were derived, largely, from studies in neonatal (NICU) or pediatric intensive care units (PICU) where rates of infection are usually higher than on general pediatric wards. Finally, semiquantitative culture methods have, in large part, not been used in the studies of CRIs in children because such cultures require catheter removal.

Microbiology

As in adults, most CR-BSIs in children are caused by staphylococcal spp., with *S. epidermidis* being the predominant species.^{310 311} Other species of gram-positive cocci and fungi are the next most frequently isolated pathogens, with *Malassezia furfur* being an especially common pathogen in neonates receiving intravenous intralipids.³¹¹⁻³¹⁹

Bertone et al. performed quantitative skin cultures on 50 neonates to determine the microbial flora present at commonly used catheter-insertion sites.³²⁰ Only 33 neonates had an intravascular device in place at the time of culturing; 25 had peripheral venous catheters and eight had CVCs. The highest mean colony counts were found at jugular sites (2.7×10^4 cfus/10cm²) and the lowest at subclavian sites (5.2×10^3 cfus/10-cm²). However, femoral and jugular sites had similar mean colony counts as did subclavian and umbilical sites. Although CoNS was the pathogen most frequently cultured from all body sites, other microbial species (e.g., aerobic gram-negative bacilli, yeast, and *Enterococcus* spp.) were more commonly cultured from umbilical and femoral sites.³²⁰

Epidemiology

The majority of nosocomial BSIs in children are also related to the use of an intravascular device. During 1985-1990, children's hospitals participating in NNIS and conducting ICU surveillance reported significantly higher rates of BSI among PICU patients with CVCs (11.4 BSIs per 1,000 central-catheter days) compared with those without CVCs (0.4 BSIs per 1,000 noncentral-catheter days).⁸ Participating Level III NICUs reported a median of 5.1 BSIs per 1,000 umbilical or central-catheter days for the $\geq 1,500$ gram birthweight group and 14.6 BSIs per 1,000 umbilical or central-catheter days for the $< 1,500$ gram birthweight group over the same period.³²¹ Birthweight and device utilization were important determinants of a NICU infant's risk for acquiring BSI.³²¹ Others have shown receipt of intravenous lipids to also be an important risk factor for the acquisition of CR-BSI, particularly CoNS BSIs, among neonates.⁸⁶

Cronin studied 376 catheters, of varying types, to determine the incidence of catheter colonization and CR-BSI among NICU patients.³²² The incidence of catheter colonization varied by type of catheter, site of insertion, and duration of catheterization. Consistent with the findings of other investigators, the rate

of catheter colonization was significantly lower among patients receiving systemic antimicrobials, having birthweight ≥ 1500 gm, and not receiving parenteral nutrition. In general, the colonization rates detected in this study were higher than those previously reported for catheters in adults and children.^{17 148 311 312} However, the authors could not conclusively determine the relationship of catheter colonization to BSI.

Peripheral venous catheters. As in adults, the use of peripheral venous catheters in pediatric patients may be complicated by phlebitis, extravasation, and catheter colonization. Garland et al. prospectively studied 654 peripheral Teflon catheters in PICU patients to determine the incidence of and risk factors for each of these complications.³¹¹ Of the 654 catheters studied, 83 (13%) were associated with phlebitis. Catheter location, infusion of hyperalimentation fluids with continuous intravenous lipid emulsions, and length of ICU stay before catheter insertion were all factors that increased a patient's risk for phlebitis. However, contrary to the studies among adults, the risk of phlebitis did not increase with the duration of cannulation. The overall incidence of phlebitis in this ICU population (13%) was comparable to that reported in general pediatric patients (10%); for children >10 years of age the incidence of phlebitis (21%) was comparable to that reported for adults¹⁶⁹ and older children.³²³

Of 459 peripheral venous catheters cultured by Garland, 54 (11.8%) were colonized. However, only one (1.9%) of these colonized catheters was associated with CR-BSI. In an earlier study, comparable rates of catheter colonization (10.4%) were found for Teflon peripheral catheters (n=115) used in patients on general pediatric wards.³¹² Time in place was the single most important predictor of subsequent catheter colonization, with the incidence of colonization increasing threefold after catheters remained in place >144 hours.³¹¹ Between 48 and 144 hours, the catheter colonization rate was stable at 11%. Other factors significantly but less strongly associated with catheter colonization were patient age and receipt of lipid emulsions. Catheters inserted emergently were no more prone to colonization than were those inserted electively.³¹¹

Extravasation, the most frequent complication, occurred with 28% of catheters. Several risk factors for extravasation were identified, including patient age (≤ 1 year), receipt of anticonvulsant, and duration of catheterization (≤ 72 hours); the risk of

extravasation decreased significantly after the catheter was in place for ≥ 72 hours.³¹¹

There are limited data examining the relationship of catheter material to the risk of infection among pediatric patients. In one study of premature infants, Teflon catheters and steel needles used in scalp veins had a comparable risk of infection. However, Teflon catheters had a significantly longer survival than did steel needles.³¹³

Peripheral arterial catheters. In a prospective study using semiquantitative culture of 340 peripheral arterial catheters, Furfaro identified two risk factors for CRI: (1) use of an arterial system of a certain design, and (2) duration of catheterization.³¹⁴ The implicated arterial system (system A) contained a stopcock and a 120-cm pressure tubing through which blood was drawn back to clear the line of heparin before taking a sample. The alternate system (system B), with a significantly lower risk of infection, contained a one-way valve that did not permit blood backflow into the tubing. The authors noted that the implicated arterial system (A) was the design most widely used in U.S. hospitals.³¹⁴

Although there was a correlation between duration of catheterization and risk of catheter colonization, the risk remained constant for 2–20 days at 6.2%. Catheters in place ≤ 48 hours had a zero risk of colonization.³¹⁴

Umbilical catheters (UCs). Although the umbilical stump becomes heavily colonized soon after birth, umbilical vessel catheterization is often used for vascular access in newborn infants because umbilical vessels are easily cannulated, allow for delivery of intravenous fluids/medications, permit easy collection of blood samples, and permit measurement of hemodynamic status. Studies of the infectious complications associated with UCs indicate that the incidences of catheter colonization and BSI appear to be similar for umbilical vein catheters (UVC) and umbilical artery catheters (UAC). The incidences of colonization reported among UACs have ranged from 40 to 55%;^{324 325} those among UVCs have varied between 22% and 59%.^{324–326} The incidences of BSI detected for the two types of catheters are also similar, 5% for UACs and 3%–8% for UVCs.^{324 326} However, the risk factors for infection appear to differ for the two types of catheters.

Landers et al. found that neonates with very low birthweight and prolonged receipt of antimicrobials were at increased risk for UAC-related BSIs. In contrast, those with higher

birthweight and receipt of parenteral nutrition fluids were at increased risk for UVC-related BSI; duration of catheterization was not an independent risk factor for infection either type of umbilical catheter.³²⁴

In addition to the risk of endemic infection, umbilical vessel catheterization has been associated with epidemics among critically ill NICU infants. Solomon et al. reported an outbreak of *C. parapsilosis* fungemia among NICU infants⁴¹ in which duration of umbilical artery catheterization, prolonged receipt of parenteral nutrition, and low gestational age were risk factors for fungemia.⁴¹

Several investigators have reported lower rates of UC colonization among infants or neonates receiving systemic antimicrobials during umbilical catheterization.^{315 325 326} However, the one prospective study of prophylactic antimicrobials in patients with chronic UACs found no clear benefit to this therapy.³²⁷

Central venous catheters. The use of indwelling catheters (e.g., Hickmans and Broviacs, TIDs) in children has become increasingly important over the past decade for the treatment of children with chronic medical conditions, especially malignancies. The Broviac, rather than the Hickman, catheter is preferentially used in children because of its smaller diameter; TIDs may be particularly advantageous in younger pediatric patients (<2 years) where external catheter segments may be contiguous with the diaper area and thus easily contaminated.^{73 328 329}

Although data from the Children's Cancer Study Group suggest that as many as 18% of all chronic venous access devices in children are removed due to infection,³³⁰ the use of these devices in children have generally been associated with low rates of infections.^{64 66 71 73 77 331 332} Several factors have been associated with an increased risk of infection among children with indwelling CVCs, including younger age (<2 years), underlying malabsorption syndrome, and receipt of TPN.³³³ Although Indwelling CVCs are largely used in immunocompromised patients for the administration of chemotherapy, neutropenia has not, in children, been shown to increase the risk of infection associated with these devices.³³⁴

As with adults, the relative merits and risk associated with the use of long-term vascular access devices in children have been the source of considerable investigation. In most studies, TIDs had longer survival and fewer infectious complications than other tunneled catheters. In one study in which the

potentially confounding variables of patient age, underlying diagnosis, and therapy were controlled for in a matched analysis, Hickmans and TIDs were associated with comparable rates of infection. Broviacs still had a higher rate of infection than TIDs, but this difference was only significant after 400 days of catheterization.³³⁵

Because of the limited vascular sites, the required frequency of catheter change in children is particularly important. Stenzel examined the frequency of catheter change in PICU patients by using survival analysis techniques. In that study of 395 CVCs, catheters remained free of infection for a median of 23.7 days. More importantly, there was no relationship between duration of catheterization and the daily probability of infection ($r=0.21$, $p>0.1$), suggesting that routine catheter replacement would not be expected to reduce the incidence of CRI.³³⁶

Results of prospective randomized trials examining the effect dressing

regimens, frequency of catheter and administration sets changes, or use of newer antimicrobial-coated catheters in reducing the incidence of CRI among pediatric patients have not been published.

Table 1

Definitions for Catheter-Related Infection

Colonized catheter: growth of >15 colony forming units from a proximal or distal catheter segment in the absence of accompanying clinical symptoms.

Exit-site infection: erythema, tenderness, induration, and/or purulence within 2cm of the skin at the exit site of the catheter.

Pocket infection: erythema and necrosis of the skin over the reservoir of a totally implantable device and/or purulent exudate in the subcutaneous pocket containing the reservoir.

Tunnel infection: erythema, tenderness, and induration in the tissues overlying the catheter and >2cm from the exit site.

Catheter-related bloodstream infection (CR-BSI): isolation of the same organism (i.e., identical species, antibiogram) from a semiquantitative or quantitative culture of a catheter segment and from the blood (preferably drawn from a peripheral vein)

of a patient with accompanying clinical symptoms of BSI and no other apparent source of infection. In the absence of laboratory confirmation, defervescence after removal of an implicated catheter from a patient with BSI may be considered indirect evidence of CR-BSI.

Infusate-related bloodstream infection:

isolation of the same organism from infusate and from separate percutaneous blood cultures, with no other identifiable source of infection.

Table 2

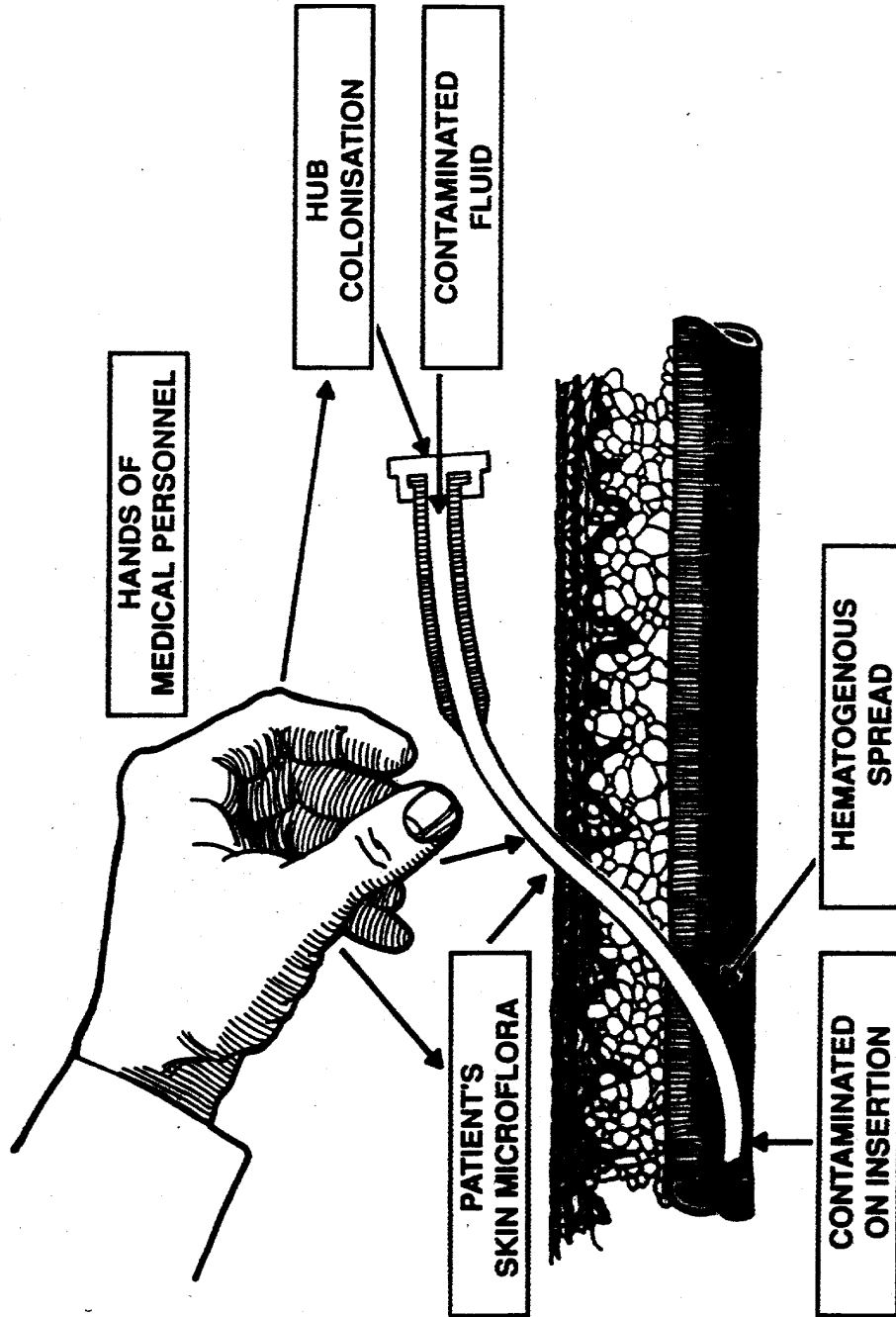
Factors Associated With Infusion-Related Phlebitis Among Patients With Peripheral Venous Catheters

Catheter material
Catheter size
Site of catheter insertion
Experience of personnel inserting catheter
Duration of catheterization
Composition of infusate
Frequency of dressing change
Catheter-related infection
Skin prep
Host factors
Emergency room insertion

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EXECUTIVE CORRESPONDENCE

Figure 1. Potential Sources for Contamination of Intravascular Devices



Part 2. Recommendations for the Prevention of Nosocomial Intravascular Device-Related Infections

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Appendix. Summary of Recommended

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Intravascular Catheters, Administration Sets and Parenteral Fluids

References

I. Introduction

This guideline presents general recommendations for intravascular-device use in all patients, device-specific recommendations, and recommendations for special circumstances, i.e., intravascular-device use in pediatric patients, and central venous catheter use for parenteral nutrition administration and hemodialysis access.

As in previous CDC guidelines, each recommendation is categorized on the basis of existing scientific data, theoretical rationale, applicability, and economic impact. However, the previous CDC system for categorizing recommendations has been modified as follows:

Category IA. Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies.

Category IB. Strongly recommended for all hospitals and viewed as effective by experts in the field and a consensus of HICPAC based on strong rationale and suggestive evidence, even though definitive scientific studies may not have been done.

Category II. Suggested for implementation in many hospitals. Recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretical rationale, or definitive studies applicable to some, but not all, hospitals.

No Recommendation; Unresolved Issue. Practices for which insufficient evidence or consensus regarding efficacy exists.

II. General Recommendations for Intravascular-Device Use

A. Health Care Worker Education and Training

Conduct ongoing education and training of health care workers regarding indications for the use of and procedures for the insertion and maintenance of intravascular devices, and appropriate infection control measures to prevent intravascular device-related infections.^{285 337 338}

Category IA

B. Surveillance

1. Conduct surveillance for intravascular device-related infections to determine device-specific infection rates, monitor trends in those rates, and assist in identifying lapses in infection control practices within one's own institution. Express data as the number of catheter-related infections or catheter-related bloodstream infections per 1000 catheter-days to facilitate comparisons with national trends.^{7 339-341}

Category II

2. Palpate the catheter insertion site for tenderness daily through the intact dressing.

Category IB

3. Visually inspect the catheter site if the patient develops tenderness at the insertion site, fever without obvious source, or symptoms of local or bloodstream infection.

Category IB

4. In patients who have large, bulky dressings that prevent palpation or direct visualization of the catheter-insertion site, remove the dressing and visually inspect the catheter site at least daily and apply a new dressing.

Category II

5. Record the date and time of catheter insertion in a obvious location near the catheter-insertion site (e.g., on the dressing or on the bed).

Category IB

6. Do not routinely perform surveillance cultures of patients or of devices used for intravascular access.

Category IB

C. Handwashing

Wash hands using an antiseptic-containing product before palpating, inserting, changing, or dressing any intravascular device.

Category II

D. Barrier Precautions During Catheter Insertion and Care

1. Wear vinyl or latex gloves when inserting an intravascular catheter as required by the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens Standard.³⁴²

Category IB

2. Wear vinyl or latex gloves when changing the dressings on intravascular catheters.³⁴²

Category IB

3. NO RECOMMENDATION for the use of sterile versus nonsterile gloves during dressing changes.

Unresolved Issue

E. Catheter-Site Care

1. Cutaneous Antiseptics and Antimicrobial Ointments

Cleanse the skin site with an appropriate antiseptic including 70% alcohol, 10% povidone-iodine, or 2% tincture of iodine before catheter insertion.²⁶⁹ (EXCEPTION: see umbilical catheter section)

Category IA

2. Catheter-Site Dressing Regimens

a. Use either a sterile gauze or transparent dressing to cover the catheter site.^{10 165 211 268}

Category IA

b. Leave dressings in place until the catheter is removed, or changed, or the dressing becomes damp, loosened, or soiled. Change dressings more frequently in diaphoretic patients.¹⁶⁵

Category IB

F. Changing Intravenous Catheters and Administration Sets

1. Remove an intravascular device as soon as its use is no longer clinically indicated.

Category IA

2. Change intravenous tubing, including "piggyback" tubing no more frequently than at 72-hour intervals, unless clinically indicated.¹⁷³⁻¹⁷⁵ (Exception: See F3 Below)

Category IA

3. No Recommendation for intravenous tubing changes beyond 72-hour intervals.

Unresolved Issue

4. Change tubing used to administer blood, blood products, or lipid emulsions within 24 hours of completing the infusion.^{178 179}

Category IB

G. Preparation and Quality Control of Intravenous Admixtures

1. Admix all parenteral fluids in the pharmacy in a laminar-flow hood using aseptic technique.

Category II

2. Check all containers of parenteral fluid for visible turbidity, leaks, cracks, particulate matter, and the manufacturer's expiration date before use.

Category IA

3. Use single-dose vials for parenteral additives or medications whenever possible.^{256 257 259}

Category II

4. If Multidose Vials are Used:

a. Refrigerate multidose vials after they are opened unless otherwise specified by the manufacturer.²⁵⁸

Category II

b. Cleanse the rubber diaphragm of multidose vials with alcohol before inserting needle into the vial.³⁴³

Category IA

c. Use a sterile needle and syringe each time a multidose vial is accessed and avoid touch contamination of the needle prior to penetrating the rubber diaphragm.^{259 344-346}

Category IA

d. Discard multidose-vials when empty, when suspected or visible contamination occurs, or when the manufacturer's stated expiration date is reached.²⁵⁶⁻²⁵⁹

Category IA

H. "Hang Time" for Parenteral Fluids

1. Do not leave parenteral nutrition fluids hanging for longer than 24 hours.^{347 348}

Category IA

2. No Recommendation for the "hang time" of intravenous fluids other than parenteral nutrition fluids.

Unresolved Issue

I. In-Line Filters

Do not routinely use filters for infection control purposes.^{220 222-224}

Category IA

J. Intravenous Therapy Personnel

Designate trained personnel for the insertion and maintenance of intravascular devices.²²⁹⁻²³¹

Category IB

K. Needleless Intravascular Devices

No Recommendation for use, maintenance, or frequency of change of needleless intravenous devices.

Unresolved Issue

L. Prophylactic Antimicrobials

Do not routinely administer antimicrobials for prophylaxis of catheter colonization or bloodstream infection before insertion or during use of an intravascular device.^{69 234 235}

Category IB

III. Peripheral Venous Catheters

A. Selection of Catheter

1. Select catheters based on the intended purpose and duration of use, known complications (e.g., phlebitis and infiltration), and experience at the institution. Use a Teflon catheter, a polyurethane catheter, or a steel needle.^{12 17 165 168 169}

Category IB

2. Avoid the use of steel needles for the administration of fluids/medications that may cause tissue necrosis if extravasation occurs.¹⁶⁹

Category IA

3. No Recommendation for the use of antimicrobial-impregnated peripheral venous catheters.

Unresolved Issue

B. Selection of Catheter-Insertion Site

1. *In adults*, use an upper extremity site in preference to one on a lower extremity for catheter insertion. Transfer a catheter inserted in a lower extremity site to an upper extremity site as soon as the latter is available.¹⁶⁰⁻¹⁶⁴

Category IA

2. *In pediatric patients*, insert catheters into a scalp, hand, or foot site in preference to a leg, arm, or antecubital fossa site.³¹¹

Category II

C. Catheter Changes

1. *In adults*, change peripheral venous catheters and rotate peripheral venous sites every 48-72 hours to minimize the risk of phlebitis.^{12 165 168}

Category IB

2. *In adults*, remove catheters inserted under emergency conditions, where breaks in aseptic technique are likely to have occurred. Insert a new catheter at a different site within 24 hours.

Category IB

3. *In pediatric patients*, No Recommendation for the frequency of change of peripheral venous catheters.

Unresolved Issue

4. *In pediatric patients*, No Recommendation for removal of catheters inserted under emergency conditions, where breaks in aseptic technique are likely to have occurred.

Unresolved Issue

5. No Recommendation for the frequency of change of midline catheters.

Unresolved Issue

6. Remove peripheral venous catheters when the patient develops signs of phlebitis (i.e., warmth, tenderness, erythema, palpable venous cord) at the insertion site.^{11 12 148}

Category IA

D. Catheter and Catheter-Site Care

1. Flush Solutions, Anticoagulants and Other Intravenous Additives

a. Routinely flush peripheral venous heparin locks with normal saline unless they are used for obtaining blood specimens in which case a dilute heparin (10 units per ml) flush solution should be used.^{241 349}

Category IB

b. No Recommendation for the routine application of topical nitrates near the insertion site of peripheral venous catheters.^{249 250 252}

Unresolved Issue**2. Cutaneous Antiseptics and Antimicrobial Ointments**

No Recommendation for the routine application of topical antimicrobial ointment to the insertion site of peripheral venous catheters.^{197 198 200}

Unresolved Issue**IV. Central Venous and Arterial Catheters****A. Selection of Catheter**

1. Use a single-lumen central venous catheter unless multiple ports are essential for the management of the patient.²⁶⁻²⁹

Category IB

2. Use tunneled catheters (e.g., Hickman or Broviac) or implantable vascular access devices (i.e., ports) for patients ≥ 4 years of age in whom long-term vascular access (>30 days) is anticipated.^{61-63, 68, 72, 73, 350} Use totally implantable access devices for younger pediatric patients (age <4) who require long-term vascular access.^{71, 73, 332, 351, 352}

Category IA

3. In adults, consider use of a silver-impregnated, collagen-cuffed or antimicrobial-impregnated central venous catheter if, after full adherence to other catheter infection control measures (e.g., maximal barrier precautions), there is still an unacceptably high rate of infection.^{201, 225, 228} Designate trained personnel to insert cuffed catheters to ensure maximal efficacy and prevent possible extrusion.^{201, 225}

Category II

4. In pediatric patients, No Recommendation for the use of antimicrobial/antiseptic-impregnated central venous catheters.

Unresolved Issue**B. Selection of Catheter-Insertion Site**

1. Use subclavian, rather than jugular or femoral, sites for central venous catheter placement unless medically contraindicated (e.g., coagulopathy).³¹⁻³⁵

Category IB

2. No Recommendation on preferred site for insertion of pulmonary artery (Swan-Ganz) catheters.³⁶⁻⁴⁰

Unresolved Issue**C. Barrier Precautions During Catheter Insertion**

Use sterile technique including a sterile gown and gloves, a mask, and a large sterile drape for the insertion of central venous catheters. Use these precautions even if the catheter is inserted in the operating room.^{36, 203}

Category IB**D. Catheter Changes**

1. No Recommendation for the frequency of routine changes of dressings used on central venous catheter sites.²⁶⁸

Unresolved Issue

2. No Recommendation for frequency of change of totally implantable devices (i.e., ports) or the needles used to access them.

Unresolved Issue

3. Change peripherally inserted central venous catheters at least every 6 weeks.⁵⁹

Category IB

4. No Recommendation for the frequency of change of peripherally inserted central venous catheters when the duration of therapy is expected to exceed 6 weeks.

Unresolved Issue

5. Change pulmonary artery catheters at least every 5 days.^{21 36 37}

Category IB

6. No Recommendation for the removal of central catheters inserted under emergency conditions, where breaks in aseptic technique are likely to have occurred.

Unresolved Issue

7. Do not routinely change percutaneously inserted central venous catheters by any means as a method to prevent catheter-related infections.^{186 187 357}

Category IA

8. Use guidewire-assisted catheter exchange to replace a malfunctioning catheter or to convert an existing catheter if there is no evidence of infection at the catheter site.^{131 153 186-190}

Category IB

9. If catheter-related infection is suspected, but there is no evidence of local catheter-related infection (e.g., purulent drainage, erythema, tenderness), change the catheter over a guidewire. Send the removed catheter for semiquantitative or quantitative

culture. Leave the newly inserted catheter in place if the catheter culture is negative. If the catheter culture indicates colonization/infection, remove the newly inserted catheter and insert a new catheter at a different site.^{131 153 187 188}

Category IB

10. Do not use guidewire-assisted catheter exchange whenever catheter-related infection is documented. If the patient requires continued vascular access, remove the implicated catheter and replace it with another catheter at a different insertion site.^{131, 153, 187, 188}

Category IA**E. Catheter and Catheter-Site Care****1. General Measures**

a. Do not use parenteral nutrition catheters for purposes other than hyperalimentation (e.g., administration of fluids, blood/blood products).^{167 224 264 265}

Category IA

b. No Recommendation for obtaining blood samples for culture through central venous or central arterial catheters.³⁵³⁻³⁵⁶

Unresolved Issue**2. Flush Solutions, Anticoagulants, and other Intravenous Additives**

Flush indwelling central venous catheters (e.g., Hickman and Broviac) routinely with an anticoagulant. Groshongs do not require routine flushing with an anticoagulant.^{62 64-66 69}

Category IB**3. Cutaneous Antiseptics and Antimicrobial Ointments**

a. Do not routinely apply antimicrobial ointment to central venous catheter-insertion sites.^{30 200}

Category IB

b. Do not apply organic solvents (e.g., acetone or ether) to the skin before insertion of parenteral nutrition catheters.²⁷⁰

Category IA**4. Catheter-Site Dressing Regimens**

Change catheter-site dressings when they become damp, soiled, or loose or if inspection of the site or catheter change is necessary.

Category IA**V. Additional Recommendations for Central Venous Hemodialysis Catheters****A. Selection of Catheter**

Use cuffed central venous catheters for hemodialysis if the period of

temporary access is anticipated to be ≥ 1 month.^{286 295}

Category IB

B. Selection of Catheter-Insertion Site

No Recommendation for the site of insertion of central venous hemodialysis catheters.

Unresolved Issue

C. Catheter Changes

1. No Recommendation for the frequency of routine changes of dressings used on hemodialysis catheter sites.

Unresolved Issue

2. No Recommendation for the removal of hemodialysis catheters when a patient develops fever without an obvious source.

Unresolved Issue

D. Catheter and Catheter-Site Care

1. General Measures

a. Do not use hemodialysis catheters for purposes other than hemodialysis (e.g., administration of fluids, blood/blood products, or parenteral nutrition).

Category II

b. Restrict manipulations of the hemodialysis catheter, including dressing changes, to trained dialysis personnel.²⁸⁵

Category IB

2. Cutaneous Antiseptics and Antimicrobial Ointments

Apply povidone-iodine ointment to the catheter insertion site before and after hemodialysis.³⁰⁴

Category IB

VI. Peripheral Arterial Catheters and Pressure-Monitoring Devices

A. Selection of Pressure-Monitoring System

Use disposable, rather than reusable, transducer assemblies when possible.^{45 47 58}

Category IA

B. Catheter and Pressure-Monitoring System Changes

1. In adults, change peripheral arterial catheters and rotate catheter-insertion sites every 4 days.^{20 21}

Category IB

2. In pediatric patients, No Recommendation for the frequency of change of peripheral arterial catheters.

Unresolved Issue

3. Replace disposable or reusable transducers at 96-hour intervals. Replace other components of the system, including the tubing, continuous-flush device, and flush solution at the time the transducer is changed.^{47 58}

Category IB

4. Replace the arterial catheter and the entire monitoring system if the patient develops a bacteremia while the catheter is in place, irrespective of the source of bacteremia. The catheter and monitoring system should be replaced 24 to 48 hours after antimicrobial therapy has been started.^{42 47}

Category IB

C. Care of Pressure-Monitoring Systems

1. General Measures

a. Keep sterile all devices and fluids that come into contact with the fluid of the pressure-monitoring circuit (e.g., calibration devices, heparinized saline).^{43 49 55 56}

Category IA

b. Minimize the number of manipulations and entries into the pressure-monitoring system. Use a closed-flush system (i.e., continuous flush), rather than an open system (i.e., one that requires a syringe and stopcock), to maintain the patency of the pressure-monitoring catheters. If stopcocks are used, treat them as a sterile field and cover them with a cap or syringe when not in use.^{47 57}

Category IA

c. When the pressure monitoring system is accessed through a rubber diaphragm rather than a stopcock, wipe the diaphragm with an appropriate antiseptic before and after accessing the system.¹⁸³

Category IA

d. Do not administer dextrose-containing solutions or parenteral nutrition fluids through the pressure-monitoring circuit. Use only heparinized normal saline.⁴⁷

Category IA

e. Do not routinely use pressure-monitoring devices to obtain blood cultures.⁴⁷

Category IB

2. Sterilization or Disinfection of Pressure-Monitoring Systems

a. Clean reusable transducers first with soap and water and then sterilize with ethylene oxide or subject to high-level disinfection when: (1) The transducer is used between patients, (2) the transducer is reused on a single patient who requires prolonged pressure monitoring, or (3) the monitoring circuit (including chamber-dome and continuous flow device) is replaced.^{47 54} Because transducers differ in design, consult the manufacturers' instructions for detailed reprocessing recommendations.

Category IA

b. Sterilize and disinfect transducers in a central processing area. Reprocess and disinfect reusable transducers in patient care areas only in emergency situations.⁴⁷

Category IB

VII. Additional Recommendations for Umbilical Catheters

A. Catheter Changes

1. No Recommendation for the frequency of change of umbilical catheters.

Unresolved Issue

2. No Recommendation for the removal or exchange of umbilical vein catheters when the patient develops a fever without an obvious source.

Unresolved Issue

B. Catheter-Site Care

1. Cleanse the umbilical insertion site with an appropriate antiseptic, including alcohol or 10% povidone-iodine before catheter insertion.^{322 324 325} Do not use tincture of iodine because of the potential effect on the neonatal thyroid.

Category IB

2. No Recommendation for the routine application of polymicrobial ointment to umbilical catheter insertion sites.

Unresolved Issue

APPENDIX.—SUMMARY OF RECOMMENDED PROCEDURES FOR MAINTENANCE OF INTRAVASCULAR CATHETERS, ADMINISTRATION SETS AND PARENTERAL FLUIDS

Frequency of catheter/device change	Frequency of dressing change	Frequency of administration set change	"Hang time" for parenteral fluids	Use of antimicrobial ointments
<p>Peripheral Venous Catheters:</p> <p>In adults, change catheter and rotate site every 48–72 hours. Replace catheters inserted under emergency conditions within 24 hours.</p> <p>In pediatric patients, NO RECOMMENDATION for the frequency of catheter change or for the removal of catheters inserted under emergency conditions.</p>	<p>Leave dressings in place until the catheter is removed, or changed, or the dressing becomes damp, loosened, or soiled.</p> <p>.....</p>	<p>Change intravenous tubing, including "piggy-back" tubing no more frequently than at 72-hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p> <p>Change tubing used to administer blood, blood products, or lipid emulsions within 24 hours of completing the infusion.</p>	<p>Do not leave parenteral nutrition fluids hanging >24 hours.</p> <p>NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.</p>	<p>NO RECOMMENDATION for the routine application of antimicrobial ointments to catheter site.</p>
<p>Peripheral Arterial Catheters and Pressure-monitoring Devices:</p> <p>In adults, change catheter and rotate insertion sites every 4 days.</p> <p>In pediatric patients, NO RECOMMENDATION for the frequency of catheter change.</p> <p>Replace disposable or reusable transducers at 96-hour intervals. Replace other components of the system, including the tubing, continuous-flush device and flush solution at the time the transducer is changed.</p>	<p>Leave dressing in place until the catheter is removed, or changed, or the dressing becomes damp, loosened, or soiled.</p> <p>.....</p>	<p>Change intravenous tubing, including "piggy-back" tubing no more frequently than at 72-hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p>	<p>Do not administer dextrose-containing solutions or parenteral nutrition fluids through the pressure monitoring circuit. Use only heparinized normal saline.</p> <p>NO RECOMMENDATION for the "hang time" of heparinized normal saline.</p>	<p>NO RECOMMENDATION for the routine application of antimicrobial ointments to catheter site.</p>
<p>Midline Catheters:</p> <p>NO RECOMMENDATION for the frequency of catheter change.</p>	<p>Leave dressing in place until the catheter is removed, or changed, or the dressing becomes damp, loosened, or soiled.</p>	<p>Change intravenous tubing, including "piggy-back" tubing no more frequently than at 72-hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p> <p>Change tubing used to administer blood, blood products, or lipid emulsions within 24 hours of completing the infusion.</p>	<p>Do not leave parenteral nutrition fluids hanging >24 hours.</p> <p>NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.</p>	<p>NO RECOMMENDATION for the routine application of antimicrobial ointments to catheter site.</p>

APPENDIX.—SUMMARY OF RECOMMENDED PROCEDURES FOR MAINTENANCE OF INTRAVASCULAR CATHETERS,
ADMINISTRATION SETS AND PARENTERAL FLUIDS—Continued

Frequency of catheter/de-vice change	Frequency of dressing change	Frequency of administra-tion set change	"Hang time" for parenteral fluids	Use of antimicrobial oint-ments
<p>Central Venous Catheters (nontunneled catheters and tunneled catheters [Hickmans, Groshongs, Ports]:</p> <p>Do not routinely change percutaneously inserted (nontunneled) central venous catheters by either rotating insertion sites or by guidewire-as-sisted catheter ex-change.</p> <p>NO RECOMMENDA-TION for frequency of change of tun-neled catheters, to-tally implantable de-vices (i.e., ports), or the needles used to access them.</p>	<p>Leave dressing in place until the catheter is re-moved, or change, or the dressing becomes damp, loosened, or soiled.</p> <p>NO RECOMMENDATION for the frequency of rou-tine changes of dressing used on catheter site.</p>	<p>Change intraveneous tub-ing, including "piggy-back tubing" no more frequently than at 72-hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p> <p>Change tubing used to ad-minister blood, blood products, or lipid emul-sions within 24 hours of completing the infusion.</p>	<p>Do not leave parenteral nutrition fluids hanging >24 hours.</p> <p>NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.</p>	<p>Do not routinely apply antimicrobial ointment to catheter insertion site.</p>
<p>Peripherally Inserted Central Venous Cath-eters:</p> <p>Change at least every 6 weeks.</p> <p>NO RECOMMENDA-TION for frequency of change when the duration of therapy is expected to ex-ceed 6 weeks.</p>	<p>Leave dressing in place until the catheter is re-moved, or changed, or the dressing becomes damp, loosened, or soiled.</p> <p>NO RECOMMENDATION for the frequency of rou-tine changes of dressing used on catheter site.</p>	<p>Change intravenous tub-ing, including "piggy-back" tubing no more frequently than at 72 hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p> <p>Change tubing used to ad-minister blood, blood products, or lipid emul-sions within 24 hours of completing the infusion.</p>	<p>Do not leave parenteral nutrition fluids hanging >24 hours.</p> <p>NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.</p>	<p>Do not routinely apply antimicrobial ointment to catheter insertion site.</p>
<p>Central Arterial Catheters (pulmonary artery cath-eters):</p> <p>Change catheter at least every 5 days.</p>	<p>Leave dressing in place until the catheter is re-moved, or changed, or the dressing becomes damp, loosened, or soiled.</p> <p>NO RECOMMENDATION for the frequency of rou-tine changes of dressing used on catheter site.</p>	<p>Change intravenous tub-ing, including "piggy-back" tubing no more frequently than at 72 hour intervals.</p> <p>NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals.</p>	<p>NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.</p>	<p>Do not routinely apply antimicrobial ointment to catheter insertion site.</p>
<p>Central Hemodialysis Cath-eters:</p> <p>NO RECOMMENDA-TION for the fre-quency of catheter change.</p>	<p>Leave dressing in place until the catheter is re-moved, or changed, or the dressing becomes damp, loosened, or soiled.</p> <p>NO RECOMMENDATION for the frequency of dressing change.</p>	<p>NOT APPLICABLE (Do not use hemodialysis catheters for purposes other than hemodialysis [e.g., administration of fluids, blood/blood prod-ucts, or parenteral nutri-tion]).</p>	<p>NOT APPLICABLE (Do not use hemodialysis catheters for purposes other than hemodialysis [e.g., administration of fluids, blood/blood prod-ucts, or parenteral nutri-tion]).</p>	<p>Apply povidone-iodine ointment to the catheter insertion site before and after hemodialysis.</p>

APPENDIX.—SUMMARY OF RECOMMENDED PROCEDURES FOR MAINTENANCE OF INTRAVASCULAR CATHETERS, ADMINISTRATION SETS AND PARENTERAL FLUIDS—Continued

Frequency of catheter/device change	Frequency of dressing change	Frequency of administration set change	"Hang time" for parenteral fluids	Use of antimicrobial ointments
Umbilical Catheters: NO RECOMMENDATION for frequency of catheter change.	NOT APPLICABLE	Change intravenous tubing, including "piggy-back tubing" no more frequently than at 72-hour intervals. NO RECOMMENDATION for intravenous tubing changes beyond 72-hour intervals. Change tubing used to administer blood, blood products or lipid emulsions within 24 hours of completing the infusion.	Do not leave parenteral nutrition fluids hanging >24 hours. NO RECOMMENDATION for the "hang time" of intravenous fluids other than parenteral nutrition fluids.	NO RECOMMENDATION for the routine application of antimicrobial ointments to the catheter site.

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[FR Doc. 95-23550 Filed 9-26-95; 8:45 am]

BILLING CODE 4163-18-P