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What is This?
The Future of Vascular Access: Will the Benefits Be Worth the Risk?

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The introduction of the central venous catheter (CVC) has had a significant role in shaping modern medicine as we know it today. Complex medical and surgical interventions, such as parenteral nutrition, cancer therapies, hemodynamic monitoring, hemodialysis, bone-marrow and organ transplantations, and abdominal, cardiothoracic, and trauma surgery, would not be possible without the use of CVCs. Intravascular catheterization is the most common invasive procedure performed today. More than 150 million intravascular catheters, 5 million of which are CVCs and pulmonary artery catheters, are purchased annually in the United States. Continued increase in the use of these devices is reflected in the American market for intravascular catheters, which is currently at $840 million and estimated to reach $1.4 billion by 2003.

Unfortunately, these devices are not without significant risk of morbidity and mortality among all patient populations and age groups. Despite almost 50 years of experience with vascular catheters, practitioners continue to struggle with methods to prevent, diagnose, and treat complications associated with these devices. In a recent article, Collin et al listed 38 potential complications of CVCs, and more could be added. Catheter-related infection, thrombosis, and catheter malposition are interrelated common events that often precipitate additional complications. Arnow et al found that catheter-related bloodstream infection (CRBSI) was accompanied by other major complications such as septic shock, suppurative phlebitis, metastatic infection, endocarditis, or arteritis in 32% of 102 reported cases.

Infection and thrombophlebitis were recognized as major complications of venous catheterization from the earliest reports in the 1950s. However, surveillance of nosocomial infections in the United States did not begin until the 1970s. The scope of this problem was realized when reports from the Centers for Disease Control and Prevention (CDC), from 1980 to 1989, indicated that the overall bloodstream infection (BSI) rate in the United States increased by 70% at large, teaching hospitals and by 27% at small, nonteaching hospitals, of which 90% were associated with intravascular devices in intensive care units (ICUs). The increased incidence of BSIs was concomitant with the dramatic increase in the use of short- and long-term CVCs over this time period.

Currently, the CDC estimates that 200,000 hospital patients contract BSIs each year in the United States, with CVCs now accounting for about 90% of these BSIs. On average, CRBSIs prolong hospital stays by 6.5 days in ICU at a cost of $29,000 per infection. National Nosocomial Infection Surveillance (NNIS) data collected from January 1990 to April 1995 indicated that CRBSI rates (per 1000 catheter days) at hospital ICUs range from 4.9 in medical–surgical ICUs to 15.6 in burn ICUs. In the most recent report, NNIS data from 1992 to 1998 indicated the range to be from 4.5 in medical–surgical ICUs to 12.8 in burn ICUs. Although it is difficult to evaluate overlapping data, this comparison suggests that the incidence of CRBSI in adult, pediatric, and neonatal ICUs has slightly improved or at least remained relatively stable, albeit high, over the last 8 years.

Few data regarding nosocomial BSI rates exist in developing countries; however, European and US studies indicate that the risk of nosocomial BSIs is increased significantly in patients with CVCs (odds ratio, 4.6; 95% confidence interval [CI] range, 3.1–6.8). The global increase in the use of CVCs has not only increased the incidence of BSIs but has dramatically influenced pathogen prevalence throughout the world. Until the 1970s, reports of coagulase-negative staphylococci (CNS) BSIs in the United States were very low, because they were almost exclusively regarded as skin contaminants. According to NNIS data, between 1980 and 1989 a 754% increase in the incidence of bacteremia that was due to CNS and staphylococcus aureus (176%) was noted at large, academic, medical centers in the
United States.\(^6\) *Candida albicans* BSIs increased as much as 487% over the same time period. The coexistence of a pathogen population with an ever-increasing resistance to many antibiotics, a patient population characterized by increasingly complex clinical problems, and the concomitant increase in the use of CVCs contributed to the increase in gram-positive bacteremias and fungemias.\(^7\) CNSs now represent 32.2% of all primary BSIs in ICUs and are associated with 30% to 60% of CRBSIs.\(^8\) Among the nosocomial bacteremias caused by *Candida* and *Staphylococcus aureus*, the rate of death is dependent on the infecting organism. Mortality rates associated with (1) *Candida* bloodstream infection vary between 4.9% and 28%;\(^9\) (2) *S. aureus*, 16% to 43%;\(^10\) and (3) *Candida* bloodstream infection vary between 4.9% and 28%;\(^9\) (2) *S. aureus*, 16% to 43%;\(^10\) and (3) *Candida*, 50% to 80%, with attributable mortality as high as 38%.\(^11\)

Data reported by the NNIS system measure nosocomial infection rates in ICUs only. As many as 500,000 tunneled and implanted catheters are used per year in the United States on an inpatient and outpatient basis, primarily for cancer therapies and parenteral nutrition.\(^12\) No national database currently exists to document catheter-related infection rates in long-term patients. Most recent studies report a mean infection rate of approximately 2.0 per 1000 catheter days,\(^13\) a much lower rate than that for the short-term catheters used in ICU patients. This suggests a lower risk with the use of long-term catheters. However, a review of four recent studies of adult cancer patients with tunneled and implant catheters indicated that between 19% and 42% of catheters were removed because of a complication.\(^14\) The percentage of catheters removed because of CRBSIs ranged from 13% to 33%, and from 19% to 27% because of local infection. Interestingly, the percentage of catheters removed because of thrombotic events was of a similar range: 1% to 34% removed because of catheter occlusion and from 3% to 25% removed because of catheter-related thrombosis.\(^15\)

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Tolar and Gould examined the timing and sequence of complications in 356 tunneled Groshong catheters.\(^26\) Overall, 397 complications were identified in 62% of catheters, and 31% of those experienced two or more sequential complications. “Ball-valve effect,” defined as continued inability to aspirate blood after urokinase instillation, was the most frequently identified complication (30% of events) and occurred the earliest and most repeatedly in the life of the catheter. Catheter-related sepsis and catheter-related venous thrombosis (CRVT) were the second and third most common complications, at 19.4% and 16.6%, respectively. CRVT was the most frequent secondary complication and was followed by catheter sepsis. This study and others have established a causal relationship between catheter-related infection and thrombosis.\(^23-29\)

CRVT and thrombotic intraluminal occlusions compose 25% to 40% of all catheter-related complications.\(^30\) The rate of thrombotic events is reported to be as high as 1.5 per 1000 catheter days.\(^31\) Approximately 57% of persistent access failures are related to thrombus in or around the catheter tip.\(^32\) Symptomatic CRVT occurs in only about 6% to 10% of patients.\(^33-35\) When asymptomatic patients were studied by venogram, CRVT was found in 66% of patients with both short- and long-term catheters.\(^33-35\) Andrew et al found a 75% incidence of CRVT in a cross-sectional study of pediatric home TPN patients.\(^36\)

Complications of upper extremity CRVT are similar to those of lower extremity deep vein thrombosis (DVT): pulmonary embolism (PE), postthrombotic syndrome, and venous gangrene (rare).\(^37\) The rate of PE has been reported to be as high as 36% in patients with CVC\(^38\) and 59% in pulmonary artery catheters.\(^39\) Hingorani et al found that after 6 months of follow-up, patients with upper extremity DVT had a much higher rate of PE than did patients with lower extremity DVT (17% vs 8%, respectively).\(^40\) Another surprising finding was that pulmonary embolisms that were due to upper extremity DVT conferred a higher rate of death than those that were due to lower extremity DVT (48% vs 13%, respectively). Compared with catheter-related infections, the morbidity and mortality associated with catheter-related thrombotic events have not been well appreciated, even though they occur with greater frequency.

The issue of risk in the use of CVCs changes perspective when combining the risks of catheter-related infection with catheter-related thrombosis. However, there is an even greater evolving crisis to consider. In the past 15 years, practitioners have seen the emergence of gram-positive microorganisms, not only as major nosocomial pathogens but with a corresponding increase in their antibiotic resistance. Approximately 25% of the *S. aureus* bloodstream isolates in the United States today are resistant to methicillin (MRSA).\(^41\) The incidence of methicillin resistance among CNS has also dramatically increased. Methicillin resistance among clin-
cal isolates of CNS (MRCNS) increased from 20% to 60% between 1980 and 1989. In a 1995–1996 SCOPE survey, 79% of CNS strains were found to be resistant to methicillin.\textsuperscript{41} The majority of MRSA and MRCNS strains are cross-resistant to all beta lactams, macrolides, lincosamides, tetracyclines, aminoglycosides, and now quinolones.\textsuperscript{12}

Vancomycin has effectively treated infections caused by gram-positive resistant organisms since the early 1980s. During the last two years, S. aureus strains with reduced susceptibility to vancomycin have been recovered from patients in Japan and in three patients in the United States.\textsuperscript{42} Five cases of reduced or complete resistance of S. epidermidis to vancomycin, one from the United Kingdom and four from the Slovak Republic, have been reported over the last several years. The case in the United Kingdom involved peritonitis associated with a peritoneal dialysis catheter. In the other four patients, CVCs, neutropenia, prophylaxis with ofloxacin, and prior vancomycin therapy were common antecedents.\textsuperscript{42} The first case of BSI associated with an S. epidermidis strain with decreased susceptibility to vancomycin has now been reported in the United States. Prolonged exposure to vancomycin and the presence of a Groshong CVC were predisposing factors in this patient.\textsuperscript{13}

Over the last 10 years, many new compounds with activity against drug-resistant, gram-positive bacteria have been investigated. The most promising of these drugs appear to be the parenteral streptogramins, quinupristin/dalfopristin (Synercid, Rhône-Poulène-Rorer, Collegeville, PA), the oxazolidinone linezolid, and a new topical antibiotic, MBI 226.\textsuperscript{5,43} In phase III clinical trials, Synercid has been comparable in efficacy with vancomycin for catheter-related bacteremia caused by S. aureus and S. epidermidis.\textsuperscript{44} On the basis of its activity \textit{in vitro} and clinically, Synercid has been submitted to the Food and Drug Administration for approval.\textsuperscript{45} Synergics's parent compound, pristinamycin, has been used in Europe for several years with no significant increase in resistance over time;\textsuperscript{46} however, recent reports of resistance to streptogramins of \textit{Enterococcus faecium} and \textit{staphylococci} are of concern.\textsuperscript{45} Even chlorhexidine, an antiseptic shown to be superior in prevention of catheter-related infections, has demonstrated low-level, plasma-mediated resistance in antibiotic-resistant strains of \textit{S. aureus} and \textit{S. epidermidis}; however, the clinical relevance of this is in question.\textsuperscript{47–50}

Increases in the rate of antimicrobial resistance will continue to result in the use of much more expensive drugs, more prolonged hospitalizations, higher death rates, and larger increases in health care costs. Yearly expenditures incurred from drug resistance in the United States are estimated to approach $4 billion and are rising.\textsuperscript{51} The emergence of \textit{S. aureus} and \textit{S. epidermidis} vancomycin-resistant strains is a considerable threat to patients with CVCs. The prospect of developing an untreatable staphylococcal infection could adversely tilt the risk-to-benefit ratio for many moderate- to high-risk therapies that have become routine standards of care.\textsuperscript{12}

The pathogenesis of catheter-related infection and thrombosis is a highly complex, multifactorial, physiologic response to the presence of a foreign body in biologic tissue. The future of VADs lies in the understanding of these complex physiologic events, the modification of catheter surfaces to interrupt the processes of the host–biomaterial response, and the ability to outwit the antibiotic-resistant capacity of both bloodborne and biofilm embedded bacteria. The time from development of new drugs to market takes, on average, 8 to 10 years. The new science of biomaterial surface modification holds much promise but is evolving slowly. Antibiotic- and antiseptic-coated catheters have already demonstrated the ability to significantly decrease the risk of catheter-related infections in short-term catheters.\textsuperscript{52,53} This capacity may be greatly enhanced by the development of antithrombogenic surfaces in the future.

Although we are awaiting scientific developments, implementation of aggressive prevention and treatment strategies must be our priority. Two evidence-based documents are now available to assist clinicians in the prevention and management of catheter-related infection and thrombosis: the CDCs “Guideline for Prevention of Intravascular Device-Related Infections”\textsuperscript{54} and the American Pharmaceutical Association’s “Using Drug Treatment Protocols to Aid in Managing Patients With Venous Access Devices,” which includes three protocols for managing patients with CVC-related thrombotic events, venous thrombosis, and infection.\textsuperscript{55–57} Simply acquiring or reading these state-of-the-art documents will not be enough, however. The complexity and enormity of the problem require the establishment of a dedicated, multidisciplinary, quality-improvement team that is responsible for the implementation of these recommendations, individualized to their patient population.\textsuperscript{54,58–60}

The vascular access team should involve members who are knowledgeable in the area of vascular access; this might include a medical director, team coordinator (nurse), certified IV nurse or certified nutrition support nurse, vascular access nurses, surgeon, interventional radiologist, home care nurse, pharmacist, staff nurse, infection control, and a risk-management representative. The role and responsibilities of this group should include a process for early assessment of patients for appropriate device selection, insertion and management of devices, implementation of policies and procedures, selection of VADs and associated products, ongoing education of physicians and nurses, quality-improvement program, patient education program, outpatient follow-up, and clinical research.\textsuperscript{59–65} This special issue of \textit{NCP} provides a comprehensive review of topics that are critical to the development.
of strategies for the institution of vascular access programs in inpatient and outpatient settings.

The escalating trend of antimicrobial resistance among the most common pathogens that are responsible for catheter-related infections has produced a dangerous situation on both a national and international scale. With the existing threat of the loss of efficacy of vancomycin against staphylococcal infections in the absence of therapeutic alternatives, an increase in morbidity and mortality attributable to nosocomial bloodstream infections is certain to occur.12,66 This, along with the high rate of thrombotic complications associated with the use of vascular catheters, may threaten the benefit of these devices in the future unless practitioners become proactive and meet the challenge to implement aggressive prevention and treatment strategies before it is too late.

References


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Calculated risks are knowing all the possible outcomes and preparing accordingly. Expect the best but be prepared for the worst. All others are unnecessary risks. The feedback you provide will help us show you more relevant content in the future.

If you are taking a calculated risk you would know the worst-case scenario and you will stay prepared for that. But the great thing is that you can have amazing benefits as well that you might never get without taking the risk. Other than this, you get a thrill as well with risk that makes your life exciting. So take calculated risk and enjoy life. As high-profile cases have shown, causes, coincidences and effects mean that balancing risks and benefits is not always a straightforward task. But we can work out roughly the risks without immunisation by tracking the course of a disease like measles over the decades. In England and Wales in 1940, just over a decade before I was born, there were 409,000 measles cases, of which 857 died – a case fatality rate of 0.2%, which is also that quoted by the Centers for Disease Control and Prevention (CDC) in the US. In other words, the 1 in 500 chance of death I mentioned earlier.

Presentation on theme: "The benefits of Community Pharmacy delivering Vascular Risk Assessments." Presentation transcript: The benefits of Community Pharmacy delivering Vascular Risk Assessments. Use of POCT equipment allows immediate calculation of risk in one appointment reducing lost to follow up scenarios. Robust systems will be put in place to guarantee the appropriate use of and the QA of all POCT equipment. Summary: Community pharmacy can help X PCT deliver VRA - increasing access and choice. Engaging a different part of the population from general practice. Engaging hard to access groups. Helping to minimise health inequalities. Questions & discussion.