Role of culturing from the tip and the tunneled segment of the catheters in tunneled catheter infection

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PURPOSE
Both the tip and the tunneled segment of removed tunneled jugular catheters were cultured to determine whether there is a difference between both cultures in diagnosis of the catheter infections. The role of interventional radiology in prevention, diagnosis, and management of the tunneled catheter infections is also discussed.

MATERIALS AND METHODS
In this prospective study, 22 tunneled jugular catheters were removed due to infection in a single center between January 2006 and January 2007. The clinical indications for catheter removal secondary to infection were repetitive positive catheter cultures, persistent fever with no other known etiology, tunnel infections, and sepsis most likely attributed to the catheter.

RESULTS
Mean duration of catheter placement was 110.7 days; 13 patients (59%) whose catheters were removed had negative catheter cultures. Cultures from 9 catheters were positive from the tip and/or tunneled segment. Among those, 7 patients had catheter-related bloodstream infections and 2 had local tunnel infections.

CONCLUSION
Despite the limited number of patients, our study demonstrated that catheter tip cultures are sensitive indicators of catheter-related bloodstream infections, while tunneled part cultures are sensitive in cases of local infections. Obtaining additional cultures from the tunneled segment may not only increase the sensitivity and specificity of the diagnosis of catheter infection, but may also show antibiotic sensitivity in cases of negative tip culture.

Key words: • jugular catheters • interventional radiology • infection

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Central venous catheters (CVC) are frequently used for venous access and are an important part of medical treatment. There are different types of CVCs, including temporary (non-tunneled), permanent (tunneled) CVCs, and subcutaneous venous ports, which are chosen regarding anticipated function and duration of use. Tunneled catheters pass through approximately 10 cm subcutaneous tunnel before entering a vein, leading to a lower rate of infection than temporary catheters; they are preferred for long-term use.

Two groups of patients often require tunneled catheters: (1) patients who are expected to receive prolonged courses of chemotherapy, parenteral nutrition, blood products, and antibiotics; and (2) patients undergoing chronic hemodialysis (1–4).

The most important complication is infection. Catheter-related infections (CRI) increase morbidity and mortality, length of hospitalization, and health care costs; thus the prevention, recognition, and management of this complication are as important as placement of these catheters (4–7).

We cultured different parts of the catheters to determine if infection was more frequently associated with the tip (distal portion) or the tunneled segment (proximal portion) of the catheter; our aim was to determine whether we should culture the tip, the proximal portion, or both when a patient demonstrates clinical indicators of infection.

Materials and methods

Between January 2006 and January 2007, 22 patients were studied. All patients were referred for removal of tunneled jugular catheters because of suspected CRI; all patients had local or systemic signs of infection. The mean patient age was 33.4 years (range, 6 to 70 years). All patients had received their catheters at the same angiography unit, using standard radiological technique (3, 8). For each patient, the decision to remove the catheter represented a consensus of infectious disease physicians, ward physicians, and interventional radiologists. Of 22 patients, 8 were from the oncology service, 10 from the hemodialysis service, 3 from the hematology service, and 1 had ulcerative colitis (Table 1).

A total of 155 tunneled catheters were inserted in 140 patients during the study period. Catheters removed for reasons other than infection were not included in this analysis. Eleven hemodialysis catheters and 11 infusion catheters were explanted in 22 patients.

Diagnosis of catheter-related infections

According to the Society of Interventional Radiology (SIR) reporting standards, early complications are those that occur within 30 days of catheter insertion, and late complications are those that occur more

than 30 days after the procedure (8). Infection within 7 days of insertion is considered a procedure-related complication in which aseptic procedural technique has failed.

CRI are classified into 2 groups: catheter-related bloodstream infection (CR-BSI) and local CRI (L-CRI). In this study, the definition of CR-BSI included symptoms of systemic infection at the time of catheter removal with positive (proximal and/or distal) catheter culture ($>10^3$ colony-forming units (CFU/mL). Clinically, all symptoms of infection were expected to resolve within 48 hours after catheter removal. L-CRI was defined as the presence of signs of infection around the tunnel or at the catheter insertion site with or without positive (proximal and/or distal) catheter culture ($>10^3$ CFU/mL). The definition of L-CRI excluded bacteremia and systemic signs of infection.

Although we did not include catheter colonization or contamination in this study, catheter colonization is defined as a quantitative catheter culture $>10^3$ CFU/mL with absence of any signs of local or systemic infection, and contamination is positive catheter culture with $<10^3$ CFU/mL and absence of signs of infection (9).

In our practice, catheter removal is performed for suspected CRI only in cases with 2 consecutive positive blood cultures and signs of infection, with persistent bacteremia or no clinical improvement despite adequate antimicrobial therapy for 5 to 7 days. Despite our best efforts, there is a possibility that we did classify some "true" contaminated/colonized catheters as CR-BSI caused by coagulase-negative staphylococci.

Ideally, cultures from catheters and peripheral blood samples should be obtained just before initiation of antibiotic therapy (10). However, since the patients are vulnerable to catheter infections, empiric antibiotic treatment is given immediately once the catheter infection is suspected by clinicians. This increases the possibility of having negative cultures from the removed catheters. We postulated that obtaining multiple cultures from different parts of the catheter in addition to peripheral blood would increase the sensitivity and specificity of the diagnostic tools for catheter-related infections.

Catheter removal

A full blood count and coagulation parameters were studied before the explantation procedure. Patients with an international normalized ratio (INR) higher than normal and platelet count $<25,000/mm^3$ received blood products before the procedure to correct deficiencies. Removals were performed under local anesthesia in adults. Patients were already receiving antibiotics for underlying infections (whether related to the catheter or not) during catheter removals.

All catheters were removed by using sterile technique and blunt dissection. Care was taken during removal to avoid contact of the catheter with the skin. While holding a gentle manual compression on the venotomy site and on the tunnel, the catheter was cut into pieces representing the tip (3–4 cm) and the tunneled portion distal to the cuff (3–4 cm) for cultures. Each catheter segment was sent to the microbiology laboratory in 2 different tubes.

Catheters

Catheters were 14.5 F Hemo-Cath double-lumen catheter (Medcomp, Harleysville, Pennsylvania, USA) in the hemodialysis group and 7 to 11 F Bio-Cath double-lumen catheters (Medcomp, Harleysville, Pennsylvania, USA) in the infusion group.

Results

Twenty-two catheters (14%) were removed due to suspected CRI. The mean duration of catheter (life span) at the time of removal was 110.7 days (range, 10–767 days).

Eighteen catheters were removed in the late period, and 4 catheters were removed in the early period. There was only one case of true local catheter infection among the catheters removed in the early period and one local infection at the late period; both were infusion catheters. Three catheters removed in the early period were negative for catheter and peripheral blood cultures. Early local infection was diagnosed in one neutropenic patient. In this patient, local symptoms of infection appeared >2 weeks after the procedure (a prolonged period for diagnosis of procedure-related infection). Severe immune suppression and poor hygienic catheter care might have contributed to tunnel infection in this patient.

There were 6 positive peripheral blood cultures. In 3 of these, proximal and distal cultures were both positive. In the remaining 3 patients with positive peripheral blood cultures, only 1 distal culture was positive, whereas 2 distal and 3 proximal cultures were negative.

Peripheral venous blood cultures were negative in 16 catheters. In 11 of these, cultures from both the proximal and the distal part of the catheters were negative as well. In the remaining 5 catheters, cultures from the proximal parts were all positive. In the 5 catheters with positive proximal cultures, only 2 had positive distal cultures, suggesting that catheter colonization started from the tunnel portion.

Thirteen patients (59%) whose catheters were removed had no positive catheter cultures (Table 2). Among these 13 patients, peripheral blood cultures were positive in 2 patients with negative catheter cultures at both

Table 1. Patient demographics

Age (years; mean, range)	33.4, 6–70
Number of males	10
Number of females	12
Number of catheters	22
Hemodialysis	11
Tunneled infusion	11
Catheter life span (days; mean, range)	110.7, 10–767

Table 2. Culture results from tunneled catheters and peripheral venous blood samples

	Peripheral venous blood culture	Both proximal and distal catheter cultures	Proximal catheter culture alone	Distal catheter culture alone
Positive	6	5	3	1
Negative	16	11	3	5

the tip and the tunneled segments, suggesting other sources of bacteremic infection.

There were a total of 9 positive catheter cultures at the tip and/or at the tunneled segment (3 hemodialysis catheters and 6 infusion catheters). Of the 9 patients with these catheters, 7 (3 with hemodialysis catheters and 4 with infusion catheters) actually developed CR-BSI. The remaining 2 patients (both with infusion catheters) had L-CRI. Only 4 of 9 patients with positive catheter cultures had consistent positive peripheral blood cultures at the time of catheter removal.

Eight tunneled segment cultures and 6 tip cultures were positive (both positive in 5 catheters). Three catheter cultures were positive only at the tunneled segment, and 1 catheter was only positive at the tip. Culture results are summarized in Table 2.

We were able to document the catheter as the source of infection in only 41% of the patients (9 of 22 patients) in this study. Interestingly, among 7 patients with CR-BSI, only 4 had positive simultaneous peripheral blood cultures. Since 3 patients with positive catheter cultures and negative peripheral blood cultures had symptoms of systemic infection, this may indicate a lack of sensitivity of blood cultures, most likely related to empiric antibiotic treatment.

In cases of local infections related to the catheters, cultures from the tunneled segment had significantly higher sensitivity than those from the tip, despite the limited number of proven local infections (n = 2). This can be explained by the fact that the catheter colonization almost always begins at the tunneled part since it is close to the exit site.

Discussion

CRI are the most important complications of CVCs; they can result in severe morbidity and mortality (11–13). Bloodstream infections caused by catheters account for 13% of all nosocomial infections and 23–66% of all bacteremic episodes; 10–20% mortality from nosocomial CR-BSI has been reported in the literature (14–18).

An accurate diagnosis of CRI usually involves removing the catheter for catheter tip culture; therefore, the diagnosis is almost always retrospective. Only 15–25% of CVCs removed due to infection have actually been demonstrated to be infected in various studies (19). In our series of patients, 41% (9 of 22) of the catheters were infected. In a study of cancer patients with fever and indwelling catheters, only 10% and 24% of all episodes of fever were related to bacteremia in neutropenic and non-neutropenic patients, respectively (20). Approximately 6% of inserted tunneled catheters are associated with CR-BSI (21). In our study, CR-BSI was diagnosed in 7 (4.5%) of 155 tunneled catheters. Therefore, a careful evaluation of doubtful CRI should be done since this is an important reason for catheter removal in all hospitals. Catheter removal is strongly suggested in complicated infections (with septic thrombosis, endocarditis, osteomyelitis) and infections caused by difficult-to-treat organisms (22, 23).

Catheter salvage is recommended for patients with uncomplicated infections. Antibiotic lock therapy may increase the chance of salvage (24). However, we do not use antibiotic lock therapy in our practice; in patients with 2 consecutive positive blood cultures and systemic signs of infection not responsive to adequate antimicrobial therapy, we routinely remove tunneled catheters.

Causes of infection related to CVC include contamination by skin organisms, contamination of the catheter hub, contaminated infusion systems, and, rarely, hematogenous seeding from a distant infection. Skin contamination is the most likely mechanism of etiology in infections in short-term catheters, whereas hub contamination is more frequent in long-term catheters (9). CRI originate from skin flora in 65% of the patients and from a contaminated hub in 30% of the patients (25–31). In skin contamination, microbial agents adhere to the surface of the catheter and migrate from the proximal to the distal part of the catheter, where microorganisms colonize. The production of the polysaccharides results in the formation of a microbial film around the catheter. Microbial growth in catheter cultures may represent persistence of the infection despite prolonged antibiotic therapy in cases with clinical infection (7).

Approximately 60% of CR-BSI are caused by *Staphylococcus epidermidis* and *Staphylococcus aureus*. Other common pathogens are *Enterococcus faecalis*, *Pseudomonas aeruginosa,* and *Candida albicans*. In hemodialysis patients, *S. aureus* is the leading cause of CR-BSI (10). Our culture results were consistent with this literature.

Teflon or polyurethane catheters and one-double lumen catheters are associated with fewer infections than polyvinyl chloride or polyethylene and triple-lumen catheters. For long-term catheters, the effect of tunneling on infection rates remains controversial. Because dialysis treatment requires more tubing connections, there is a high risk for the introduction of organisms through the hub (32, 33). Femoral venous access is associated with a significantly higher incidence of CRI than jugular and subclavian access; and temporary (short-term) subclavian vein access is associated with lower incidence of CRI than jugular access (4).

Fibrin sheath formation is a common thrombotic complication and is responsible for up to 50% of episodes of malfunction of long-term dialysis catheters (34). Frequent mechanical fibrin sheath stripping and thrombolysis may keep dialysis catheters free of infections.

Infection not only increases morbidity and mortality, it also has economic implications. Several methods have been proposed to decrease the spread of infection along the lumen of the catheters. These include impregnation and coating of catheters with antimicrobial or antiseptic agents, such as rifampicin, minocycline, or silver-platinum-carbon. They have been demonstrated to reduce infections, but increase the risks of patient sensitivity and the development of bacterial resistance (35, 36). We believe that there is still a need for long-term studies showing the benefits to justify a two- or three-fold increase in the cost of such catheters.

A multidisciplinary approach involving interventional radiologists, clinicians, and clinical nursing teams may help reduce infection rates in tunneled catheters. Aseptic placement technique, hygienic technique when handling catheters, ensuring patient understanding of self-care, and adequate training of all personnel involved in patient care may reduce the incidence of infection. Reports in the literature have concluded that

even with an accurate and reliable technique for catheter placement, sufficient follow-up nursing care is essential to long-term viability (37).

Suspected catheter infections lead to unnecessary catheter removals—in as many as 59% of patients in our center. The decision to remove a catheter for suspected infection should be made by a multidisciplinary team. Interventional radiologists tend to keep venous access as long as possible to prevent venous occlusions consequent to repeated catheterizations; and infectious disease physicians who care for patients with severe treatment resistant bacteremic infections often want to remove the catheter earlier rather than later.

The diagnosis of CR-BSI can be made accurately only if the removed catheter cultures and simultaneous peripheral blood cultures are positive for the same pathogen and if clinical signs of infection resolve after catheter removal and appropriate antibiotic treatment. In diagnosing L-CRI, peripheral blood cultures should be negative, with positive catheter cultures associated with signs of infection around the tunnel or exit site. In our study, we cultured proximal parts of the removed catheters in addition to the catheter tip and peripheral blood cultures. In this way, we tried to assess the value of these separate cultures in diagnosis of local versus systemic catheter-related infections. Although our population was small for statistical evaluation, the results of tandem catheter cultures appeared to be more sensitive than tip culture alone in the diagnosis of true CR-BSI and L-CRI. Therefore, we believe that if catheter infection is suspected, both proximal and distal portions of the catheter should be cultured at the time of removal.

Comparative studies with larger series of patients should be designed to justify the efficacy and cost-effectiveness of two separate catheter cultures. Obtaining tandem cultures from the removed catheters may not only increase the sensitivity and specificity of the retrospective diagnosis of catheter infection but may also show antibiotic sensitivity in cases of negative tip or tunneled segment culture.

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