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Colonization of Bacteria on Polyvinyl Chloride and Teflon Intravascular Catheters in Hospitalized Patients

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During an 8-month period all intravascular catheters were removed by sterile technique upon completion of use and submitted to the hospital microbiology laboratory. All catheters were routinely cultured by the semiquantitative culture technique, with ≥15 colonies being defined as a positive result. Of the 687 Teflon catheters cultured, 6.9% were positive by culture, compared with 24.6% of 77 polyvinyl chloride catheters ($P < 0.001$). Also, colonization of coagulase-negative staphylococci on polyvinyl chloride was more than on Teflon. These data suggest that polyvinyl chloride catheters are colonized more frequently with organisms than are Teflon catheters; additionally, there is an increased affinity of coagulase-negative staphylococci for polyvinyl chloride as compared with Teflon, substantiating our previous observations with an in vitro system. We conclude that the type of catheter material may be important in determining the incidence of catheter-related infections and in selective colonization by coagulase-negative staphylococci.

Infections associated with intravascular devices represent a serious but potentially preventable source of morbidity and mortality in hospitalized patients (2). Nonsterile insertion techniques, prolonged use of intravascular (IV) catheters, administration of irritating infusates, and other similar factors may predispose patients to catheter infections, although the exact mechanisms that initiate infection are poorly understood.

Bacterial colonization of IV catheters appears to be a key step in this process and likely precedes the development of clinical catheter infection. Why certain bacteria tend to cause these infections whereas other organisms are less frequently encountered in this setting is unclear. In an earlier in vitro study, we demonstrated that coagulase-negative staphylococci, but not *Escherichia coli*, had a significantly greater affinity for polyvinyl chloride (PVC) than for Teflon (TEF) catheters, as evidenced by quantitative bacterial cultures and scanning electron microscopy (10). The present study was designed to analyze differences in rates of bacterial colonization of PVC and TEF catheters during clinical use and to compare the bacterial species involved.

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MATERIALS AND METHODS

Catheter data. Infection control policy in our hospital requires that all IV catheters except hyperalimentation lines be removed within 3 days by sterile technique and be submitted to the microbiology laboratory for semiquantitative cultures. During the period of 1 January to 31 August 1982, all IV catheter samples thus received were identified by patient name, date, type of catheter, and catheter material.

Microbiological processing. The distal tips (4- to 6-cm lengths) of submitted catheters were processed by the blood agar roll technique for semiquantitative culture by the method of Maki et al. (7). Blood agar plates were incubated for 18 h at 36°C and examined visually for colonies. A colony count of ≥15 colonies per roll culture plate was defined as a positive result. All bacteria were then identified by standard microbiological techniques (4), including use of the API 20E system (Analytab Products, Plainview, N.Y.).

Data analysis. At the conclusion of the study, data on 787 catheter specimens were stratified by catheter type, composition, and culture results. There were 687 TEF catheters, of which 201 were 24-in. (ca. 61-cm) long-line catheters used for measuring central venous pressure. All 77 PVC catheters were long lines used for pulmonary arterial pressure monitoring. No hyperalimentation catheters were included. Twenty-three catheters were excluded from the study because they were of different materials. The chi-square test was used for comparisons of statistical significance.

To determine whether the duration of catheter use was similar for PVC and TEF catheters, the charts of 53 patients with IV lines were selected at random and

TABLE 1. Comparison of culture-positive PVC and TEF catheters by the semiquantitative blood agar roll technique

Catheter type	No. (%)			
	Total	Positive (≥15 colonies per plate)	With 1 to 14 colonies per plate	With growth
PVC	77	19 (24.6)[a]	4 (5.2)[b]	23 (29.9)[a]
TEF	687	48 (6.9)[a]	37 (5.3)[b]	85 (12.3)[a]

[a] $P < 0.001$.
[b] Not significant.

reviewed. A total of 38 of these patients had long lines; 23 were TEF and 15 were PVC catheters. The average duration of long-line TEF catheter use was 4.2 days, and that of PVC catheter use was 3.8 days. All patients in the intensive care units were seriously ill with diverse medical and surgical diagnoses.

RESULTS

The results obtained from semiquantitative roll cultures of catheter specimens are shown in Table 1. Of the 77 PVC catheters submitted, 19 (24.6%) were positive, and an additional 4 (5.2%) had growth of 1 to 14 colonies per plate. Of the 687 TEF samples, 48 (6.9%) were positive by the criteria listed. Additionally, 37 TEF catheters (5.3%) had growth of 1 to 14 colonies per roll plate culture. When comparing the frequency of positive cultures on PVC versus TEF catheters, the difference was statistically significant ($P < 0.001$).

Table 2 lists the organisms isolated from roll cultures of PVC and TEF catheters. A total of 20 isolates were obtained from the 19 culture-positive PVC catheters, of which 17 (85%) were coagulase-negative staphylococci. A total of 63 isolates were obtained from 48 positive TEF catheters, of which 39 (61.9%) were coagulase-negative staphylococci. Data from PVC and TEF long-line catheters (Table 2) revealed that 24.6% of the PVC catheters were colonized as compared with 12.9% of the TEF catheters ($P < 0.02$). An increased percentage of PVC catheters was found to be colonized with coagulase-negative staphylococci as compared with TEF catheters (85 versus 54%, $P < 0.05$).

DISCUSSION

The results from our survey of clinical catheter colonization indicate that PVC catheters were colonized more frequently with bacteria than were TEF catheters and that colonization of PVC catheters was more likely to be due to coagulase-negative staphylococci, whereas TEF catheters were colonized with a wider variety of microorganisms. In a previous report (10), we described an in vitro system for comparing quantitative adherence of bacteria to different catheter materials. Coagulase-negative staphylococci were demonstrated to have a significantly greater affinity for PVC than for TEF catheters. In addition, the number of coagulase-negative staphylococci adherent to PVC catheters was significantly greater than the number of *E. coli*.

Christensen et al. recently reported a nosocomial outbreak of coagulase-negative staphylococcal septicemia related to the use of IV catheters (2). Interestingly, a retrospective determination of catheter types in use at the time of the outbreak indicated that all were PVC catheters (personal communication).

The reasons why coagulase-negative staphylococci appear to have greater in vitro and in vivo affinity for PVC than for TEF are not clear. The interaction of bacteria with other surfaces may depend on multiple factors, including intrinsic catheter surface features such as hydrophobicity (9), presence of trace materials (1), surface charge differences, microbial traits such as glycocalyx or pilus production (3, 5, 8), or as yet unknown factors. The presence of fibrin, plasma products, and other materials circulating in the host may also participate in this interplay (11). Several studies have demonstrated some of the morphological features of bacterial adherence to catheter surfaces (3, 6, 8). Whether survival and growth of coagulase-negative staphylococci on

TABLE 2. Comparison of organisms isolated from culture-positive PVC and TEF catheters

Catheter type	No. positive/ total no.	% Positive	No. of organisms[a]					
			Total	CNS	GNB	*Staphylococcus aureus*	Yeasts	Miscellaneous
PVC	19/77[b,c]	24.6	20	17 (85%)[d,e]	2 (10%)	0	1	0
All TEF	48/687[b]	6.9	63	39 (61.9%)[d]	10 (15.8%)	3	6	5
Long-line TEF	26/201[c]	12.9	35	19 (54.3%)[e]	6 (17%)	1	6	3

[a] CNS, Coagulase-negative staphylococci; GNB, gram-negative bacilli.
[b] $P < 0.001$.
[c] $P < 0.02$.
[d] $0.005 < P < 0.10$.
[e] $P < 0.05$.

catheter tips in vitro and in vivo are by similar mechanisms is also not clear. Based on studies using scanning electron microscopy, Peters et al. (8) have suggested that the catheter surface is eroded by bacteria, especially coagulase-negative staphylococci, with microcolony formation on catheters. This could be a common factor for the in vitro and in vivo adherence phenomenon. Regardless of the mechanisms involved, there appears to be an affinity of coagulase-negative staphylococci for PVC catheters, both in vitro and in vivo.

Further efforts to investigate these interactions may help to clarify the pathogenesis of catheter-associated infections and suggest a possible means for interrupting or preventing colonization of synthetic IV catheters. Such studies may result in a reduction in the number of clinical infections related to these catheters.

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