

Prospective study of peripheral arterial catheter infection and comparison with concurrently sited central venous catheters*

David Boon Chai Koh, BN(Hons), GradCert(CritCareNurs);

John R. Gowardman, MBChB, FRACP, FJFICM; Claire M. Rickard, RN, PhD; Iain K. Robertson, MMedSci;

Andrew Brown, GradDip(CritCare), MClinNurs

LEARNING OBJECTIVES

On completion of this article, the reader should be able to:

1. Explain the implications of arterial catheter line colonization.
2. Compare the incidence of arterial catheter line infections with central venous catheter infections.
3. Use this information in a clinical setting.

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Objective: Peripheral arterial catheters are perceived as having low infective potential compared with other catheters and may be overlooked as a cause of catheter-related bloodstream infection. We aimed to measure colonization and rates of catheter-related bloodstream infection in arterial catheters, to investigate risk factors for arterial catheter colonization, and to compare arterial catheter infection rates with those in concurrently sited and managed central venous catheters.

Design: Prospective 24-month cohort study.

Setting: Eight-bed combined general intensive care and high-dependency unit of a 350-bed Australian teaching hospital.

Patients: Three hundred twenty-one arterial catheters in 252 adult and pediatric patients were observed for 1,082 catheter days, and 618 central venous catheters in 410 patients were observed for 4,040 catheter days. All catheters were inserted in, or presented to, the intensive care unit. Both arterial catheters and central venous catheters were inserted by trained personnel under aseptic conditions, and management was standardized.

Interventions: None.

Measurements and Main Results: The incidence per 1,000 (95% confidence interval) catheter days of colonization (≥ 15 colonies) and catheter-related bloodstream infection was 15.7 (9.5–25.9) and 0.92

(0.13–6.44) for arterial catheters and 16.8 (13.3–21.3) and 2.23 (1.12–4.44) for central venous catheters. Arterial catheter colonization was not significantly different than that in central venous catheters (hazard ratio, 1.17; 95% confidence interval, 0.41–3.36; $p = .77$). Arterial catheter colonization increased with dwell time and was similar to central venous catheters over time. Femoral arterial catheters were colonized more often than radial arterial catheters (hazard ratio, 5.08; 95% confidence interval, 0.85, 30.3; $p = .075$), and colonization was significantly higher when the catheter was inserted in the operating theater or emergency department (hazard ratio, 4.45; 95% confidence interval, 1.42–13.9; $p = .01$) compared with the intensive care unit.

Conclusions: The incidence of catheter-related bloodstream infection from arterial catheters was low. However, both arterial catheter colonization and rates of catheter-related bloodstream infection were similar to those in concurrently sited and identically managed central venous catheters. By inference, the arterial catheter should be accorded the same degree of importance as the central venous catheter as a potential source of sepsis. (Crit Care Med 2008; 36:397–402)

KEY WORDS: peripheral arterial catheterization; arterial catheters; catheterization, central venous; intensive care; sepsis

*See also p. 620.

Registered Critical Care Nurse, Launceston General Hospital, Tasmania, Australia (DBCK); Senior Specialist, Intensive Care Medicine, Royal Brisbane and Women's Hospital, Herston, Senior Lecturer, University of Queensland, Queensland, Associate Professor, Griffith University, Nathan, Australia (JRG); Professor of Nursing, Griffith University, Research Centre for Clinical and Community Practice Innovation, Queensland, Australia (CMR); Senior Research Fellow, School of Human Life Sciences, University of Tasmania, Launceston TAS, Australia (IKR); Nurse Educator, Intensive/Coronary Care Unit, Launceston General Hospital, Launceston TAS, Australia (AB).

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For information regarding this article, E-mail: john_gowardman@health.qld.gov.au

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Peripheral arterial catheters (ACs) are indispensable tools for continuously monitoring blood pressure, and they provide convenient access for repeated blood sampling in the critically ill (1–6). While the essential benefits of ACs and other intravascular devices are undisputed, catheter-related bloodstream infection (CR-BSI) has remained the leading cause of nosocomial bloodstream infection in intensive care units (ICU) (7–9). Such infections have contributed to longer hospitalization, increased hospital costs, and significant patient mortality (10–13).

Discussions of nosocomial bloodstream infection in the critically ill have tended to focus on central venous catheters (CVCs) rather than ACs. A potential explanation for the limited focus on ACs is the relatively short duration that they are *in situ*, giving rise to the assumption and somewhat accepted notion that ACs have a low infection risk (14–17). The latter ideology is the position of the Centers for Disease Control and Prevention (CDC), whose 2002 guidelines classify ACs as having “low infection rates—rarely associated with bloodstream infection” (18).

There is, however, a paucity of data addressing the potential risk of CR-BSI directly attributable to the AC (3, 19). An extensive literature search of the databases PubMed, MEDLINE, Proquest, and CINAHL yielded a total of 25 articles that made direct reference to ACs between the years 1979 and 2006. However, it is difficult to compare the findings of existing studies due to differences in study designs, patient populations, dwell times, techniques for microbial analyses, terminology, and statistical presentation of results (4, 5, 8, 15, 19, 20). Most important, there is rarely direct comparative data on AC and CVC infection rates within the same population to test for similarities or differences between these catheters while controlling for the many potential confounders.

In our ICU we assumed that our ACs had low infectivity, although this was uncertain due to the conflicting data presented in the literature, compounded by lack of locally applicable data. We therefore designed a study with the following aims: 1) to prospectively measure AC colonization and CR-BSI rates; 2) to investigate risk factors associated with AC colonization; and 3) to compare AC colonization rates with those occurring in concurrently sited CVCs where patient management was uniform.

MATERIALS AND METHODS

The study was during a 24-month period as a prospective, cohort study in an eight-bed combined general intensive care unit (ICU) and co-located high-dependency unit of a 350-bed regional Australian teaching hospital. The ICU treated all forms of acute illnesses with the exception of postcardiothoracic surgical and acute neurosurgical cases. The case mix of the ICU was predominantly adults, with 5% to 10% of cases pediatric. Admission and treatment rights in the ICU were limited to intensivists, and the unit was staffed by critical care registered nurses. The hospital was a major gastrointestinal surgery referral center and accepted major trauma with the exception of cranial. Institutional ethics committee approval was obtained for using the nonidentified data.

All short-term intravascular access devices (IAD) (peripheral ACs and nontunneled short-term CVCs) that presented to, or were inserted in, the ICU were screened for the study. This included IADs inserted in the ICU as well as those inserted in either the department of emergency medicine (DEM) or operating theaters (OT), which were *in situ* when the patient was admitted to ICU. Both adult and pediatric patients were included.

IAD Management. In the ICU, insertion of all ACs (whether by the Seldinger technique or cannula) (2, 6, 17, 19) was by trained operators (consultant, registrar, senior resident) and performed under strict asepsis. Insertion in DEM and OT was ideally under identical aseptic conditions, although emergent insertions may not have achieved this standard. Sterile barrier precautions employed during AC insertion included the use of large sterile drapes, sterile gloves, and chlorhexidine 0.5% in ethanol for skin antisepsis (16, 18, 21, 22). Sterile gowns were not routinely used for all AC insertions as maximal sterile barrier precautions have not been shown to adversely affect AC colonization (21). Although no specific site was mandated as preferred, punctuation at the radial artery was generally favored with femoral, brachial, and dorsal pedis sites also acceptable dependent on patient variables. The AC was taped or sutured to the skin and the site cleaned before the application of a transparent sterile dressing. Administration sets, transducers, and infusate bags were replaced every 72 hrs. All dressings and catheter care were as per the CDC guidelines (18).

Within the ICU, the AC was routinely used for blood sampling, including arterial blood gas analyses and continuous intra-arterial pressure monitoring. Accessing the AC was performed only by nursing staff specifically trained in the procedure. Several types of AC were used in this study: Arrow (Arrow International, PA) 20G (3.81 cm), Arrow Quickflash (Arrow International) 20G (3.81 cm), BD Insyte (Becton Dickinson, UT) 20G, (3.0 cm), Smiths/PVB 20G (8.0 cm), and Smiths/PVB

20G (20.0 cm, use confined to the femoral artery). Choice was at the discretion of the clinician performing the procedure. The AC site was inspected daily as part of the multidisciplinary ward round for evidence of inflammation or purulence. The AC was not changed on a routine basis. AC removal at the discretion of the medical staff occurred because it was no longer required, for mechanical failure, or on clinical suspicion of infection.

Insertion of CVCs was performed by experienced ICU personnel (consultant, registrar, senior resident). CVCs inserted in the OT or DEM were likewise inserted by trained operators. The predominant type of CVCs used in the study were multilumen (triple/quad) polyurethane (Arrow, Reading, PA) catheters. No antibiotic CVCs were used. All CVCs were inserted using a Seldinger approach (2, 6, 19, 17) under strict aseptic technique with maximum sterile barrier precautions (sterile gloves, gown, large drapes, mask, and cap) (21, 22). Chlorhexidine 0.5% in ethanol was used as skin antisepsis (16, 18). All CVCs were nontunneled and for short-term access only. No long-term devices (e.g., Hickmans) or pulmonary artery catheters were included. No specific anatomical insertion site was mandated: Insertion into the internal jugular, subclavian, or femoral veins was based on patient variables and operator experience. The CVC site was inspected daily as part of the multidisciplinary ICU ward round for signs of redness, induration, or purulence (23). All catheter manipulations, including pressure transducers, giving sets, and site dressings, were performed by trained ICU nursing staff using a set protocol. CVCs were not used for blood sampling. Guide-wire exchange was not routinely performed. The CVC was not changed on a routine basis but removed because of suspicion of sepsis, mechanical failure, or when no longer required (23). All patients had their CVC removed before discharge to the general wards if possible, and peripheral intravenous access was inserted if intravenous therapy was still deemed necessary (24).

Data Collection. For study entry, complete data were required on the IAD, and the device must have been inserted within the hospital departments of DEM, OT, or ICU. IADs inserted in other hospitals were not included due to the uncertainty of insertion technique, insertion time, and operator level of experience. During the study, IADs were excluded if their removal and subsequent microbiological sampling were not according to the study protocol.

On admission to the ICU, IADs were identified with a unique identifier label. In the case of the AC this was attached to the J-loop extension device that was connected to the catheter. For CVCs, the label was attached to an external lumen. Data collected for ACs included insertion details (time, place, and operator); AC type and manufacturer; insertion site (radial, femoral, brachial, dorsalis pedis);

patient demographics, including Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score II, and APACHE II diagnostic codes; patient interdepartmental transfers; and AC removal details (date, time). APACHE II and Simplified Acute Physiology Score II were used as indicators of clinical status of the patients, whereas systematic recording of comorbidities was not undertaken. The reason for AC removal was also recorded. Similar data were acquired for all CVCs and in all cases were collected concurrently with those for the AC. Specific details regarding site of CVC insertion and number of lumens were not used for this study. These data were recorded by trained ICU nursing staff in a purpose-designed worksheet and subsequently entered into a customized Microsoft Access database by a research assistant.

Microbiological Sampling. IADs were removed by the bedside ICU nurse using a sterile technique. For both CVCs and ACS, the distal 3- to 5-cm end of the IAD tip was removed using a sterile dressing pack, which included sterile forceps and scissors, taking care not to contaminate the tip on removal. The tip was then immediately transferred to a sterile container and transported to the microbiology department for analysis using Maki and colleagues' (25) semiquantitative method of tip culture. Microbiological details, including all tip culture and relevant patient blood culture results (not a mandatory procedural requirement of this study), were then entered into the central database.

Microbiological Definitions. The following definitions of IAD infection were applied: colonization: tip culture ≥ 15 colony forming units (11–18); CR-BSI: catheter tip culture ≥ 15 colony forming units plus a positive blood culture taken within 48 hrs of IAD removal with the same microorganism and antibiogram with no other obvious source of infection apparent (11, 18, 25).

Statistical Analysis. Unadjusted rates per 1,000 catheter days of colonization and CR-BSI were estimated using Poisson regression to provide comparability to rates reported in other publications. Poisson regression and simpler comparable methods for calculation of incidence rates assume that these events were occurring at random throughout the period each catheter was *in situ*. However, identification of colonization and identification of CR-BSI are terminating events, either because they are recorded only at the time of catheter removal or because the CR-BSI provokes the removal of the catheter. Cox proportional hazards regression is used when comparing the hazard rates of terminating events occurring at variable times. In this study it was used for the comparison of AC and CVC colonization, AC colonization at different insertion sites (radial or femoral), insertion in different locations (ICU, OT, or DEM), and the use of different catheter types. Estimates of hazard ratios (HRs) with 95% confidence intervals

Table 1. Colonization and catheter-related bloodstream infection (CR-BSI) associated with arterial and central venous catheters

Catheter Site	No. of Catheters	Total Catheter-Days	Colonization			CR-BSI		
			No.	Rate ^a	% ^b	No.	Rate ^a	% ^b
Arterial catheters	321	1082	17	15.71	5.3	1	0.92	0.31
Central venous catheters	618	4040	68	16.83	11.0	9	2.23	1.46

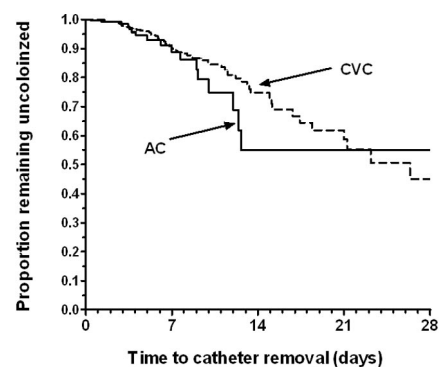
^aUnadjusted rate per 1000 catheter days; ^bpercentage of catheters.

(CIs) and *p* values were adjusted for confounding by age, gender, APACHE II, and Simplified Acute Physiology Score II (with box-cox transformations of these variables used to correct for skewed distributions). Time-to-event graphs were drawn to illustrate the occurrence of these events over time. The *p* values were adjusted for multiple comparisons were relevant by the Holm method. Statistical analyses were performed using STATA Statistics/Data Analysis version 9.2 (StataCorp, College Station, TX).

RESULTS

Patient Sample. Between July 1, 2004, and June 30, 2006, 321 ACs were sited for an average of 3.4 ($\pm$ SD 3.5; median, 2.1; interquartile range, 1.0–4.2) days in 252 patients (mean age, 62.5 $\pm$ 18.7 yrs; mean APACHE II score 19.3 $\pm$ 10.2). During the same period, 618 CVCs were sited for an average of 6.5 ($\pm$ SD 4.9; median, 5.1; interquartile range, 2.9–8.9) days in 410 patients (mean age, 61.5 $\pm$ 16.5 yrs; mean APACHE II score, 21.4 $\pm$ 17.9). Seventy-four (29.4%) of the 252 patients with ACs died within 6 wks of ICU admission. Only four (1.6%) patients were <18 yrs old. Admission diagnoses in 252 patients with ACs for whom principle diagnosis was recorded were 31 (12.4%) sepsis or other major infection, 72 (28.8%) gastrointestinal surgery, 33 (13.3%) multiorgan failure and multiple trauma, 18 (7.1%) nonseptic respiratory failure, six (2.2%) nonsurgical gastrointestinal disease, 20 (8.0%) neurologic disease, 16 (6.2%) cardiac failure or instability, 26 (10.2%) nonsurgical malignancy, and 30 (11.9%) other major surgery.

In total, the 321 ACs were observed for 1,082 catheter days and the 618 CVCs were observed for 4040 catheter-days. Proportions of colonized catheters were 5.3% of ACs and 11% of CVCs. Colonization and CR-BSI rates per 1,000 catheter days were 15.71 (95% CI, 9.5–25.9) and 0.92 (95% CI, 0.13–6.44) in ACs and 16.83 (95% CI, 13.3–21.3) and 2.23 (95% CI, 1.12–4.44) in CVCs (Table 1). The



Numbers of catheters remaining in situ on days								
0	4	8	12	16	20	24	28	
AC	321	87	30	10	3	2	2	1
CVC	618	379	183	74	34	23	10	8

Figure 1. Proportion of arterial (AC) and central venous catheters (CVC) remaining uncolonized on removal. The incidence rate of AC colonization was not different than that of CVCs (hazard ratio, 1.17; 95% confidence interval, 0.41–3.36; *p* = .773).

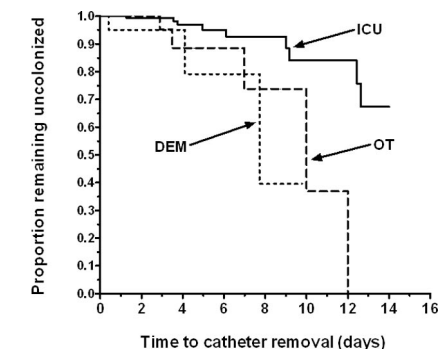
incidence rate of AC colonization was not different than that of CVCs (HR, 1.17, 95% CI, 0.41–3.36; *p* = .773) compared using Cox proportional hazards regression (Fig. 1). There was one instance of AC-related CR-BSI. The percentage of catheters colonized at the time of removal was noted to increase with time during successive 3-day periods (Table 2) (Fig. 1).

The rates of colonization were affected by a number of identifiable factors. Colonization of ACs was higher when inserted in the OT and DEM (HR 4.45, 95% CI, 1.42–13.9; *p* = .010) compared with the ICU (Fig. 2). There was a trend toward higher colonization of ACs when inserted by registrars or resident medical officers (HR 3.61; 95% CI, 0.62–21.1; *p* = .078) compared with specialists. When the site of insertion and type of catheter were examined simultaneously in a multivariate model, there was a trend for the femoral site to have been more heavily colonized (HR 5.08; 95% CI, 0.85–30.3; *p* = 0.075) than other sites (Fig. 3). Arrow (*n* = 157) and Insyte (*n* = 70) catheters were more likely to be

Table 2. Arterial catheter (AC) colonization when catheters were removed at different time periods

No. of Days	No. of Catheters Removed ^a	No. of Catheters Colonized	%	Mean AC Duration, Days
0–3	193	3	1.6	1.4
3–6	79	5	6.3	4.1
6–9	23	3	13	7.2
9–12	16	4	25	10.2
12–15	4	2	50	12.9

^aIn six catheters, removal time was not documented.



Number of catheters remaining in situ on days	0	4	8	12	16
ICU —	202	68	24	10	3
OT - - -	99	13	5	0	0
DEM . . .	20	6	1	0	0

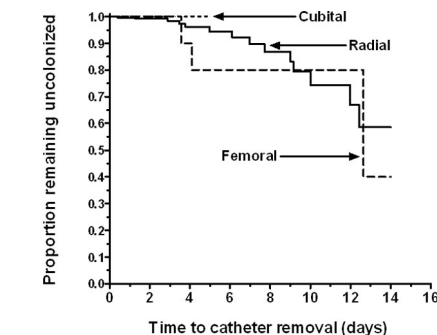
Figure 2. Proportion of arterial catheters (ACs) remaining uncolonized on removal in relation to insertion in the intensive care unit (ICU), operating theater (OT), or department of emergency medicine (DEM). Colonization of ACs was higher when inserted in the OT and DEM (hazard ratio, 4.45; 95% confidence interval, 1.42–13.9; $p = .010$) compared with the ICU.

colonized (HR 6.50; 95% CI, 0.93–45.7; $p = .060$) than other catheters ($n = 106$). ACs showed a trend to increased colonization following gastrointestinal surgery (Table 3).

The microorganisms responsible for AC colonization were coagulase-negative staphylococci (78.9%), *Staphylococcus aureus* (10.5%), *Corynebacterium* species (5.3%), and *Enterococcus faecalis* (5.3%).

DISCUSSION

We have shown that the AC is not a major source of CR-BSI in our ICU. The CVC CR-BSI rate was likewise comparatively low. We attribute the low rates of CR-BSI to our ICU's stringent infection control policies, particularly insertion asepsis, the early removal of IADs when no longer required, and the fact that the majority of our IADs were *in situ* for short periods of time. Despite this, if rates of colonization are indicative of increased



Number of catheters remaining in situ on days	0	4	8	12	16
Radial —	265	68	22	7	1
Cubital - - -	15	2	0	0	0
Femoral . . .	21	9	3	2	1

Figure 3. Proportion of arterial catheters (ACs) remaining uncolonized on removal in relation to anatomical insertion site. The femoral site was more heavily colonized (hazard ratio, 5.08; 95% confidence interval, 0.85–30.3; $p = .075$) than other sites. (In 20 catheters, the site was not recorded.)

susceptibility to CR-BSI, then the AC should still be regarded as a significant potential source of CR-BSI. The evidence supporting catheter tip colonization as surrogate end point for vascular access device-related bloodstream infection has been well validated, with good correlation between the incidence of colonization and CR-BSI having been established (26, 27). Our results showed that the colonization rates of ACs over duration of time when compared with colonization rates of CVCs over duration of time were similar in a system where management was consistent. This contradicts the prevailing view that infection risk is much lower in ACs than in CVCs (11, 18, 20). The major implication from our study is that as healthcare practitioners, we should accord the same degree of importance to ACs as we do to CVCs when accessing or handling ACs. In particular, when systemic sepsis is suspected in a critically ill patient, the AC should probably be treated no differently than the CVC.

The pathogenesis underlying the relatively high colonization of ACs remains

unresolved and warrants further study. There are clear differences between ACs and CVCs that may modulate colonization. These include differences in circulatory characteristics (pressure, flow, and distribution), structure and function of the biofilm, and frequency of accessing the catheter. ACs were mainly used for regular, often multiple blood samples, thereby predisposing to hub/port contamination, and CVCs were mainly used for infusion and monitoring. Our study found that a number of factors affect the colonization rates of ACs. Using multivariate analysis, we found that ACs inserted at the femoral site showed a trend toward a higher incidence of colonization than ACs inserted at the radial site or cubital site. Two previously published, prospective studies had showed that CR-BSI incidence for ACs was higher when sited in the femoral artery compared with the radial artery (1, 28). Other studies have found little differences in AC colonization rates between sites (5, 15, 20, 29, 30). Our work suggests that it is reasonable to attempt siting ACs at the radial site in the first instance, using the femoral site as an alternative when radial access is not possible. Colonization of ACs was also higher when they were inserted in the DEM instead of the OT and ICU, and colonization of ACs may have been higher when inserted by registrars or resident medical officers when compared with specialists. It would seem logical that ACs inserted in the DEM would be more prone to an increased incidence of colonization due to the frequent emergent nature of these insertions. While areas outside of the ICU attempt to adhere to aseptic techniques and sterile barrier precautions during IAD insertions, the urgency of having these IADs inserted may sometimes allow for a compromise in implementing sterility. It might be reasonable to replace ACs inserted in the DEM earlier after the patients' admission into ICU, to minimize the risk of AC CR-BSI. However, randomized controlled trials would be required to test this hypothesis.

Coagulase-negative staphylococci emerged as the dominant microorganism colonized at the ACs in our study, in keeping with the findings of others (7, 10, 19, 21, 31–34). Other colony-forming microorganisms found included *S. aureus*, *Corynebacterium* species, and *E. faecalis*. Although other studies have also demonstrated similar microorganisms, colonization rates have varied (1, 7, 11, 17, 19, 20, 24, 31–33, 35, 36). Coagulase-nega-

Table 3. Absolute and relative rates of arterial catheter (AC) colonization in patients with different reasons for admission

Disease	n ^a	N ^a	Rate	95% CI	RR ^b	95% CI	p
Cardiovascular shock	0	17	0.00	0.00–0.00	0.00		
Sepsis	2	38	10.94	2.35–50.9	0.55	0.10–2.91	.482
GI surgery	5	88	23.08	7.06–75.5	3.49	0.85–14.4	.084
Major surgery	1	30	14.71	1.92–112.9	1.01	0.07–14.1	.991
Cancer	1	35	6.68	0.79–56.9	0.42	0.04–4.18	.456
Respiratory disease	1	22	10.04	1.76–57.2	0.41	0.04–3.86	.439
Organ failure	3	34	29.19	7.95–107.2	2.27	0.50–10.33	.288
GI disease	0	8	0.00	0.00–0.00	0.00		
Neurological disease	1	27	20.14	2.61–155.6	1.21	0.15–9.66	.855

GI, gastrointestinal; CI, confidence interval; RR, relative rate.

^aNumber of colonizations (n) in patients (N). Missing diagnosis data for 22 catheters (including three colonized); ^bhazard ratio (relative rate) calculated by Cox proportional hazards regression, adjusted for age, gender, Acute Physiology and Chronic Health Evaluation II, and Simplified Acute Physiology Score. Each disease is compared with the rates in all the remaining patients.

tive staphylococci are normally microorganisms of low virulence. However, certain strains of coagulase-negative staphylococci can produce an extracellular polysaccharide that forms a biofilm on the catheter surface, which acts as a barrier to granulocyte-killing of bacteria (31). The biofilm may also bind with antibiotics before they can target the microorganism (31). The mortality rate attributed to coagulase-negative staphylococcal CR-BSI is significantly lower compared with other pathogens, whereas *S. aureus* CR-BSI accounted for a higher mortality rate as documented by a previous meta-analysis of 2,573 CR-BSIs (37). The numbers of CR-BSI in our study for both CVCs and ACs were too low to allow a mortality analysis.

From our literature review, we have found that no standardized method was used in reporting the results of other studies. Some chose to report colonization incidence rates in percentages (1, 4, 5, 15, 17, 23, 28, 30, 38), while others presented their incidence rates per 1,000 catheter days (19, 20, 21). Raw percentages or incidence rates per 1,000 catheter days, however, do not take into account varying AC durations and therefore may produce misleading comparisons. Other differences, such as study designs, patient populations, catheter indwelling times, terminology, and techniques for microbial analyses, also contributed to this lack of standardization in reporting results and hence complicate comparison of different studies (1, 4, 5, 8, 15, 17, 19–21, 23, 28, 30, 39). Surveillance within a particular ICU and comparisons between different ICUs require calculation methods for rates of colonization that are insensitive to the mix of diseases and their se-

verity and to the duration the ACs remain in place. Cox proportional hazards regression as used in our study uses colonization at catheter removal as a proxy for the accumulating prevalence of colonization over time after insertion. The time of onset of colonization cannot be measured *in vivo* in any practical way, and thus the use of this proxy measure and statistical methodology would seem reasonable although not ideal. We have presented our colonization incidence rates as both percentages and rates per 1,000 catheter days to allow direct comparison with other studies. Our AC colonization incidence rate was 15.7 per 1,000 catheter days or 5.3%, while our CVC colonization incidence rate was 16.8 per 1,000 catheter days or 11.0%, as reported in Table 1. Our AC colonization incidence rate was higher than that reported in some other international studies (1, 5, 15, 20, 21, 23, 30, 38) (AC colonization rates ranging from 0.09% to 3.3%) but lower than that reported in four other studies (4, 17, 19, 28) (AC colonization rates ranging from 7.7% to 22.5%).

We postulated that the incidence rates of AC colonization in some of these studies may be lower than our study because of the patient population studied. Some studies have only included postoperative patients, which are not critically ill, and as such the AC would only be left *in situ* for 1–2 days. These patients are at a low risk of AC infection, and therefore there would be a bias toward obtaining a low incidence rate of AC colonization or AC CR-BSI (14, 15, 30). The patient population sample in our study included both postoperative surgical patients and critically ill medical patients (Table 3). The

acuity of patients is reflected by the relatively high APACHE II scores. The AC CR-BSI incidence rate of 0.31% in our ICU was within the low range of AC CR-BSI incidence rates (0% to 0.60%) of other studies (1, 4, 5, 15, 19, 23, 30, 38). Only two published studies have reported higher CR-BSI incidence rates in ACs (4.5% and 5.6%), but both studies had only relatively low numbers of ACs in their studies (52 and 71 ACS, respectively) (17, 28). One limitation of our study was that routine blood cultures were not performed by a frequent fixed protocol. Blood cultures that had been taken were done for clinical reasons rather than specifically for the study. We envisaged that a higher number of bacteremias may have been detected if we had done so.

Our study has also demonstrated that the percentage of catheters that were colonized at removal increased over the time. This reinforces findings from other studies, which also indicate that the longer the duration the AC is left *in situ*, the higher the cumulative risk of AC colonization (3, 5, 6, 15–18, 23, 26, 32). Current CDC guidelines recommend that peripheral ACs not be routinely replaced to prevent catheter-related infection (18). This guideline was based on two previous studies conducted on ACs (17, 23). However, these studies seem to contradict each other. Eyer et al. (23) conducted a randomized study of three methods of long-term catheter maintenance and advocated that ACs should be left *in situ* and not be changed unless indicated (23). Raad et al. (17), on the other hand, advocated that ACs should be routinely changed every 4 days. The authors justified this recommendation as most appropriate for their study's patient population, which comprised mainly immunocompromised patients (17). The question, however, remains: Should ACs remain *in situ* without being routinely changed, as advocated by the CDC guidelines (18)? Although our study was not designed to specifically address this issue, data from the CVC literature would suggest that scheduled replacement either *de novo* at 7 days or every 3 or 7 days has failed to find a benefit. Indeed morbidity, including risk of infection, is increased with scheduled change (23, 39). Although data on the pathogenesis of AC colonization are lacking, there is no reason to assume it differs markedly from that of CVCs. Thus, although colonization of both ACs and CVCs is cumulative over time, rou-

tine change of these devices to prevent infection is unjustified.

CONCLUSIONS

ACs have been thought of as having low infection rates and rarely associated with CR-BSI. We confirm that while the rate of bloodstream infection from ACs is low, the AC still needs to be taken seriously as a potential source of sepsis, as colonization rates approach those of concurrently managed CVCs. We therefore recommend that the same degree of care is accorded to the AC as to the CVC.

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