# Title: A prospective study of peripheral arterial catheter (AC) infection and comparison with concurrently sited central venous catheters (CVCs)

# **Authors:**

David Koh<sup>1,2,3</sup>
John Gowardman<sup>4,5</sup>
Claire M Rickard<sup>6</sup>,
Andrew Brown<sup>3</sup>,
Iain Robertson<sup>2</sup>

# Institutions where work was performed:

Launceston General Hospital, University of Tasmania, Clifford Craig Medical Research Trust

# Address for correspondence:

Dr John Gowardman, Senior Specialist, Department of Intensive Care Medicine Level 3, Ned Hanlon Building Royal Brisbane and Woman's Hospital, Herston, Brisbane, QLD 4029 Email: john\_gowardman@health.qld.gov.au

# Reprints will not be ordered

# **Financial Support:**

David Koh is supported by the Clifford Craig Medical Research Trust at UTas PhD Scholarship

# **Key Words (MeSH)**:

Peripheral Arterial Catheterization Arterial Lines Catheterization, Central Venous Intensive Care Sepsis

<sup>&</sup>lt;sup>1</sup> University of Tasmania

<sup>&</sup>lt;sup>2</sup> Clifford Craig Medical Research Trust

<sup>&</sup>lt;sup>3</sup> Launceston General Hospital

<sup>&</sup>lt;sup>4</sup>Royal Brisbane and Woman's Hospital

<sup>&</sup>lt;sup>5</sup> University of Queensland

<sup>&</sup>lt;sup>6</sup> Griffith University

2

A prospective study of peripheral arterial catheter (AC) infection and comparison

with concurrently sited central venous catheters (CVCs)

ABSTRACT

**Objective:** Peripheral arterial catheters (ACs) are perceived as having low infective

potential compared to other catheters, and may be overlooked as a cause of catheter-

related bloodstream infection (CRBSI). We aimed to measure colonization and CR-BSI

rates in ACs; to investigate risk factors for AC colonization; and to compare AC

colonization rates and risk factors with those in concurrently sited and managed central

venous catheters (CVCs).

**Design:** Prospective, 24 month, cohort study.

**Setting:** 8-bed combined general intensive care and high dependency unit of a 350-bed

Australian teaching hospital.

Patients: 321 ACs in 252 adult and paediatric patients were observed for 1,082

catheter days, and 618 CVCs in 410 patients were observed for 4,040 catheter days. All

catheters were inserted in, or presented to the ICU. Both ACs and CVCs were inserted

by trained personnel under aseptic conditions and management was standardised.

Interventions: Nil

Measurements and Main Results: The incidence per 1,000 (Cl95%) catheter days of colonization (≥15 colonies) and CRBSI was 15.7 (9.5, 25.9) and 0.92 (0.13, 6.44) for ACs, and 16.8 (13.3, 21.3) and 2.23 (1.12, 4.44) for CVCs. AC colonization was not significantly different to that in CVCs (HR 1.17, Cl95% 0.41, 3.36, p=0.77). AC colonization increased with dwell-time (p<0.001) and was similar to CVCs over time. Femorally sited ACs were colonized more often than radial ACs (HR 5.08; Cl95% 0.85, 30.3; p=0.075), and colonization was significantly higher when inserted in the operating theatre or emergency department (HR 4.45, Cl95% 1.42, 13.9, p=0.01) compared to the ICU.

**Conclusions:** The incidence of CRBSI from ACs was indeed low. However, both AC colonization and CRBSI rates were similar to those in concurrently sited and identically managed CVCs. By inference, the AC should be accorded the same degree of importance as the CVC as a potential source of sepsis.

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#### Introduction

Peripheral arterial catheters (ACs) are indispensable tools for continuously monitoring blood pressure, and 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 (CRBSI) 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. Potential explanations for the limited focus on AC are 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 Centres 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 CRBSI directly attributable to the AC (3,19). An extensive literature search of the databases Pubmed, Medline, Proquest, and CINAHL yielded a total of twenty-five articles which made direct references to AC between 1979 to 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, lack of standardised terminology, and statistical presentation of results (4,5,8,15,19,20). Most importantly, there is rarely direct comparative data on AC and CVC infection rates within the same population so as to test for similarities and differences between these lines with control of the many potential confounders.

In our ICU although we assumed our ACs had low infectivity we had substantial uncertainty due to the conflicting data presented in the literature, compounded by lack of locally applicable data. We therefore decided to design a study with the following aims:

- To prospectively measure AC colonization and CRBSI rates.
- To investigate risk factors associated with AC colonization
- To compare AC colonization rates and risk factors with those occurring in concurrently sited CVCs where patient management was uniform.

## **Materials & Methods**

The study was carried out over 24 months as a prospective, cohort study in an 8-bed combined general intensive care unit (ICU) and co-located high dependency unit (HDU) of a 350-bed regional Australian teaching hospital. The study was underpinned by a rigorous quality assurance project that had been previously set up to quantify infection rates in short term intravascular access devices (IADs). The ICU treated all forms of acute illnesses with the exception of post cardiothoracic surgical and acute neurosurgical cases. The case mix was predominantly adults with 5-10% of cases pediatric (complex pediatric cases being transferred). 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 centre and accepted major trauma with the exception of cranial. Institutional ethics committee approval was obtained for using the non-identified data.

All short term IADs (peripheral ACs and non-tunnelled 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 theatres (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) (2,6,19,21) 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 sterile drapes, and gloves, with chlorhexidine 0.5% in ethanol used as skin antisepsis (16,18,22,23). Sterile gowns were not routinely used for all AC insertions as maximal sterile barrier precautions have not been shown to adversely affect AC colonization (22). Although no specific site was mandated as preferred, punctuation at the radial artery was generally favoured 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 prior to the application of a transparent sterile dressing.

Administration sets, transducers, and infusate bags were replaced every 72 hours. All dressings and line 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 of 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, USA) 20G (3.81cm), *Arrow* "Quickflash"™ (Arrow International, PA, USA) 20G (3.81cm), *BD* Insyte™ (Becton Dickinson, UT, USA) 20G, (3.0cm), *Smiths/PVB*™ (Smiths Medical, Deutschland GmbH) 20G (8.0cm) and *Smiths/PVB*™ (Smiths Medical, Deutschland GmbH) 20G (20.0cm, 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 routine multidisciplinary ward round for any evidence of inflammation or purulence. AC removal was at the discretion of the medical staff either because it was no longer required, for mechanical failure, or on clinical suspicion of infection. The AC was not changed on a routine basis however those ACs inserted under emergency conditions in the DEM where sterility may not have been optimal were often changed as routine on arrival to the ICU.

Insertion of CVCs was similarly performed by experienced ICU personnel (consultant, registrar, senior resident). CVCs inserted in the OT or DEM were likewise inserted by trained operators. All CVCs were multi-lumen, polyurethane (Arrow™, Reading, PA) and inserted using a standard Seldinger approach (2,6,19,21), under strict aseptic technique with maximum sterile barrier precautions (sterile gloves, gown, large drapes, mask and cap) (22,23). Chlorhexidine 0.5% in ethanol was used as skin antisepsis (16,18). No specific anatomical insertion site was preferred; rather, 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 (24). All line 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 permitted in a limited number of cases but was not routinely performed. The CVC was not changed on a routine basis but removed for suspicion of sepsis, mechanical failure, or when no longer required (24). All patients if possible, had

their CVC removed prior to discharge to the general wards and peripheral IV access inserted if intravenous therapy was still deemed necessary (25).

#### Data collection

For study entry, complete data was required on the IAD and the device must have been inserted within the hospital departments of DEM, OT or the ICU. IADs inserted in other hospitals were not included due to the uncertainty of insertion technique, incomplete details of insertion time, and operator level of experience. During the study, IADs were excluded if their removal, and subsequent microbiological sampling, was 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 which was connected to the catheter. For CVCs, the label was attached to an external lumen. Data collected for ACs included: insertion details (time, place, operator), AC type and manufacturer, insertion site (radial, femoral, brachial, dorsalis pedis), patient demographics (including APACHE II, SAPS II scores and APACHE II diagnostic codes), patient interdepartmental transfers and AC removal details (date, time). The reason for AC removal was also recorded. Similar data was acquired for all CVCs and in all cases was collected concurrently with that for the AC. These data were recorded by trained ICU nursing staff in a purpose designed worksheet and subsequently entered into a customised *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 AC the distal 3 to 5cm 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 utilising Maki's (26) semi-quantitative 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).
- CRBSI: Catheter tip culture ≥15 colony forming units plus a positive blood culture taken within 48 hours of IAD removal with the same micro-organism and antibiogram with no other obvious source of infection apparent (11,18,26).

# Statistical analysis:

Unadjusted observed rates per 1,000 catheter days of colonization and CRBSIs 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 is in-situ. However, colonization and CRBSIs are terminating events, either because they are recorded only at the time of catheter removal or because the CRBSI provokes the removal of the catheter. When comparing the incidence rate of colonization of alternative situations occurring over the same time periods, Cox proportional hazards regression was used: including 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. Cox proportional hazards regression is based on the variable time of occurrence of each terminating event, and was adjusted for confounding by age, gender, APACHEII and SAPSII scores (with box-cox transformations of these variables used to correct for skewed distributions). Hazard ratios were calculated with 95% confidence intervals and p-values to investigate the ratio of incidence rates in those remaining unaffected as time progressed in the comparator groups. Time-to-event graphs were drawn to illustrate the occurrence of these events over time.

Estimation of incidence rates between the earliest 3 days of catheter dwell-time and each subsequent 3-day periods was performed using Poisson regression. The mean duration of the AC dwell-time in each group was used as the nominal for the group duration. Non-linear regression using a third-order polynomial formula for the association between the rate of colonization was used to estimate coefficients, which were then used to calculate the incidence rates at 3 day, 7 day, 10 day, 14 day dwell-times and for the mean AC duration. Chi-squared for trend and logistic regression

(adjusted for age, gender, APACHE II and SAPS II scores) was used to assess whether duration of AC was associated with increasing colonization rates.

Statistical analyses were performed using *STATA*™ Statistics/Data Analysis

Version 9.2 (StataCorp, College Station, Texas USA). Non-linear regression was

performed using *Prism* 4™ for *Windows*™ (GraphPad Software, San Diego, CA USA).

P-values were adjusted for multiple comparisons were relevant by the Holm method.

## Results

# Patient Sample

Between 1<sup>st</sup> July 2004 and 30<sup>th</sup> June 2006, 321 arterial catheters (ACs) were sited for an average of 3.4 (± SD 3.5, median 2.1, IQR 1.0 to 4.2) days in 252 patients (144 (57.1%) males), whilst 618 CVCs were sited for an average of 6.5 (± SD 4.9, median 5.1, IQR 2.9 to 8.9) days in 410 patients. The mean age of patients with ACs was 62.5 ± SD 18.7 years; their mean APACHE II score was 19.3 ± 10.2. Seventy-four (29.4%) of the 252 patients with ACs died within 6 weeks of ICU admission. Only 4 (1.6%) patients were under 18 years. Admission diagnoses were: 31 (12.4%) sepsis or other major infection; 72 (28.8%) GI surgery; 33 (13.3%) multi-organ failure and multiple trauma; 18 (7.1%) non-septic respiratory failure; 6 (2.2%) non-surgical GI disease; 20 (8.0%) neurological disease; 16 (6.2%) cardiac failure or instability; 26 (10.2%) non-surgical malignancy; 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 4,040 catheter days. Proportions of colonized catheters were 5.3% of ACs and 11% of CVCs. Colonization and CRBSI rates per 1,000 catheter-days were 15.7 (CI95% 9.5 to 25.9) and 0.92 (CI95% 0.13 to 6.44) in ACs, and 16.8 (CI95% 13.3 to 21.3) and 2.23 (CI95% 1.12 to 4.44) in CVCs (see Table 1). The incidence rate of AC colonization was not different to that of CVCs (Hazard Ratio (HR) 1.17; CI95% 0.41 to 3.36; p=0.773) compared using Cox proportional hazards regression. See Figure 1. There was one instance of AC-related CRBSI.

The incidence rate of AC colonization increased the longer the catheters remained in situ with a significant increasing trend across this time period (Chi² test for trend 4.12; p<0.001). When the rate of colonization was estimated in AC catheters removed in successive 3 day periods (Table 2), there was a more than doubling of the rate across the 5 periods to day 15 (only 4 ACs remained for longer than 15 days). The estimated time-adjusted incidence rate of AC colonization at the mean duration of 3.13 days was 13.4 per 1,000 catheter days, with 3-day, 7-day and 10-day rates of 13.2, 19.0 and 23.4 per 1,000 catheter days respectively. See Figure 2.

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; Cl95% 1.42 to 13.9; p=0.010) compared to the ICU (Figure 3). There was a trend towards higher colonization of ACs when inserted by registrars or RMOs (HR 3.61; Cl95% 0.62

to 21.1; p=0.078) compared to 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; Cl95% 0.85 to 30.3; p=0.075) than other sites, and *Arrow*™ (n=157) or *Insyte*™ (n=70) catheters were more likely to be colonized (HR 6.50; Cl95% 0.93 to 45.7; p=0.060) than other catheters (n=106). See Figure 4. ACs showed a trend to increased colonization following GI surgery or neurological injuries and diseases compared to any other cause of admission (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 serious CRBSI in our ICU. The CVC CRBSI rate was likewise comparatively low. We attribute the low rates of CRBSI to our ICU's stringent infection control policies, particularly insertion asepsis, and 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 susceptibility to CRBSI, then the AC should still be regarded as a significant potential source of CRBSI. The evidence supporting AC tip colonization as surrogate end point for AC-related bloodstream infection has been well validated with

good correlation between the incidence of colonization and CRBSI having been established (27,28). Our results showed that the colonization rates of ACs over duration of time when compared to colonization rates of CVCs over duration of time were similar in a system where management was consistent. This contradicts the prevailing view that AC infection risk is much lower 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 of ACs. In particular, when systemic sepsis is suspected in a critically ill patient the AC should probably be treated no differently to the CVC.

A number of factors were found to 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 CRBSI incidence for ACs sited at the femoral position to be higher when compared to radial (1,29). Other studies have found little differences in AC colonization rates between sites (5,15,20,30,31). Our work suggests it is reasonable to attempt siting ACs at the radial in the first instance with the femoral site as an alternative when radial access is not possible. Other variables affecting colonization included hospital department in which the AC was originally sited with ACs inserted in DEM being significantly more colonized than those inserted in OT and ICU. Additionally colonization of ACs was higher when inserted by registrars or resident medical officers when compared to specialists,

although high variability in this estimate makes interpretation uncertain. It would seem logical that ACs inserted in 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. Our results suggest it would be reasonable to replace ACs inserted in DEM shortly after the patients' admission into ICU, to minimise the risk of AC CRBSI. However, further studies with larger sample sizes would be valuable in further investigating this association.

Coagulase-negative Staphylococci emerged as the dominant micro-organism colonized at the ACs in our study, in keeping with the findings of others (7,10,19,21,32-35). Other colony-forming micro-organisms found included Staphylococcus Aureus, Corynebacterium species and Enterococcus Faecalis. Although other studies have also demonstrated similar micro-organisms, colonization rates have varied (1,7,11,17,79,20,24,32-34,36,37). Coagulase-negative Staphylococci, are normally micro-organisms 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 (32). The biofilm may also bind with antibiotics before they can target the micro-organism (32). The mortality rate attributed to Coagulase-negative Staphylococcal CRBSI is significantly lower when compared to other pathogens, whereas Staphylococcus Aureus

CRBSI accounted for a higher mortality rate as documented by a previous metaanalysis of 2573 CRBSIs (38). The numbers of CRBSI in our study for both CVCs and ACs were too low to allow a mortality analysis.

In order to conduct surveillance within a particular ICU, and to compare practices between different ICUs, methods of measurement of the rate of colonization need to be employed that are not sensitive to variable factors that are affected by extraneous influences. Such factors might include the nature and severity of the illnesses of the patients and the duration the ACs may remain in place. Raw percentages or incidence rates per 1,000 catheter days that are not adjusted for the effects of different distributions of AC durations may produce misleading comparisons between different time periods and different ICUs. For example, in our study, there was a doubling of the incidence rate in ACs removed at 14 days compared to those removed at 3 days. From our literature review, we have found that there is no standardised method in reporting the results of these other studies. Some studies have chosen to report colonization incidence rates in percentages (1,4,5,15,21,24,29,31,39), while others have presented their incidence rates as rate per 1000 catheter-days (19,20,22). Other factors such as the study designs, patient populations, catheter indwelling times, lack of standardised terminology used, and techniques for microbial analyses have also contributed to this lack of standardisation in reporting results, and hence make comparison of different studies complex (1,4,5,8,15,19-22,24,29,31,39). We have presented our colonization incidence rates in both methods of measurement so as to allow direct comparison with

other studies. Our AC colonization incidence rate was 15.71 per 1,000 catheter days or 5.3%, while our CVC colonization incidence rate was 16.83 per 1,000 catheter days or 11.0% as reported in Table 1. Our AC colonization incidence rate was higher than some other international studies (1,5,15,20,22,24,31,39) (AC colonization rates ranging from 0.09% - 3.3%) but lower than four other studies (4,17,19,29) (AC colonization rates ranging 7.7% -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 post-operative 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 towards obtaining a low incidence rate of AC colonization or AC CRBSI (14,15,31). The patient population sample in our study, which is reflective of many ICUs in regional Australia, included both post-operative surgical patients, undergoing various surgeries, as well as critically-ill medical patients (Table 3). The acuity of patients admitted is reflected by the relatively high APACHEII scores. The AC CRBSI incidence rate of 0.31% in our ICU was within the low range of AC CRBSI incidence rates of other studies (1,4,5,15,19,24,31,39) (0%-0.60%) Only two published studies have reported higher CRBSI incidence rates in ACs (4.5% and 5.6%) but both studies only had relatively low numbers of ACs in their studies (52 & 71 ACs respectively) (21,29). One limitation of our study was that not all patients were randomized or controlled to undergo routine blood cultures. Blood cultures which had

been taken were done for clinical reasons rather than specifically for the study. We envisaged that there may have been a higher number of bacteremias detected if we had done so.

Our study has also demonstrated that the colonization rate of AC is progressive over the duration of time the AC is left indwelling (Figure 4). 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 to incidence of AC colonization (3,5,6,15,16,33). We found there was an incidence rate of 26.5 per 1000 catheter days of the ACs that were positively colonized if they had remained in-situ for 14 days or more however this was the exception with our mean overall in situ duration of only 3.13 days equating to a colonization rate of 13.4 per 1000 catheter days. We conclude that there is a definite association between colonization in ACs and the duration of time the AC is left in-situ, as shown in our study and other studies (18,21,24,27). Current CDC guidelines recommend that peripheral ACs need not be routinely replaced to prevent catheterrelated infection (18). This guideline was based on two previous studies conducted on ACs (21,24). However, these studies seem to contradict each other. Eyer et al's. randomized study of three methods of long-term catheter maintenance advocated that ACs should be left in-situ and not be changed unless indicated (24). Raad et al's. study on the other hand advocated that ACs should be routinely changed every 4 days (21). The authors justified this recommendation as most appropriate for their study's patient population, which comprised mainly of immuno-compromised patients (21). The

question however remains: Should ACs remain in situ without routinely changing as advocated by the CDC guidelines (18)? We feel that this question remains unanswered based on a number of factors. Firstly, the lack of standardisation in the reporting of results in the published data has made comparison of AC colonization and CRBSI rates difficult. Secondly, there is no general consensus among the proponents of infection control to agree at what level of colonization of micro-organisms is deemed to be acceptable, before it triggers CRBSI. Thirdly, there needs to be more studies investigating how the different variants of micro-organisms colonizing AC sites interact or increase their virulence over time, particularly when in interaction with different patients and their immune systems.

# Conclusion

In conclusion, ACs have been thought of as having low infection rates; rarely associated with CRBSI. We confirm that the rate of BSI from AC is indeed low, however, 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 commend that the same degree of care is accorded to the AC as to the CVC. Although AC colonization increases substantially with time our results do not allow us to draw conclusions as to acceptable in situ times without change.

# Acknowledgements

We are grateful to Janet Lehner for data entry, and the nurses and physicians of the ICU in the Launceston General Hospital, for their dedication and invaluable assistance throughout the study.

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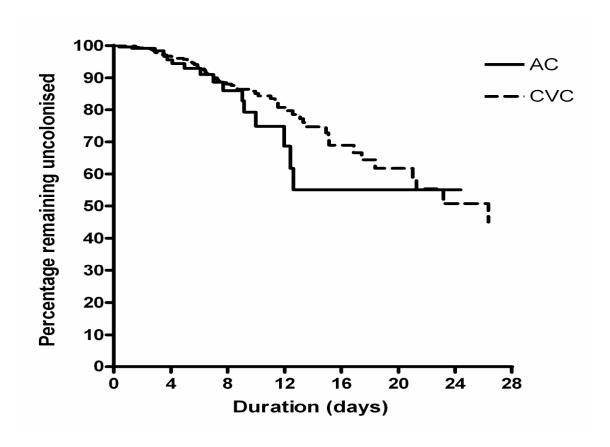
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Figure 1. Survival from colonization of arterial and central venous catheters



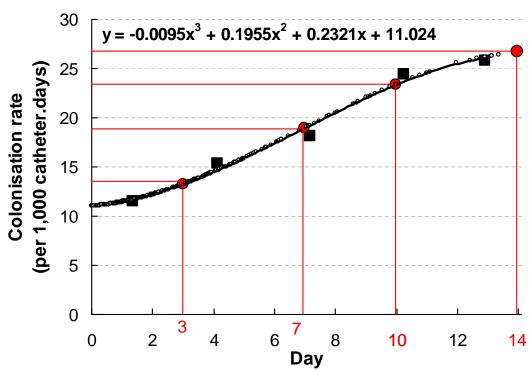


Figure 2. The increase in AC colonization rates over the first 14 days of insertion

- Observed rate in successive 3-day periods plotted at group mean
- Predicted rate at time of removal of AC in each individual

Figure 3. Survival of arterial catheters from colonization by insertion setting

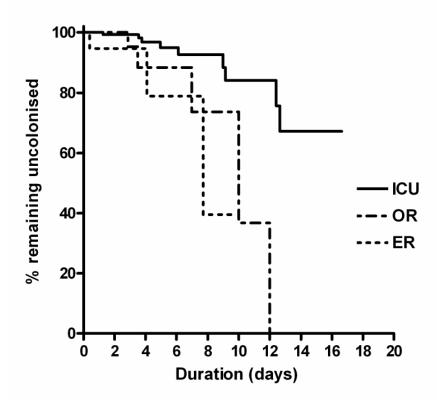


Figure 4. Survival of arterial catheters from colonization by insertion site

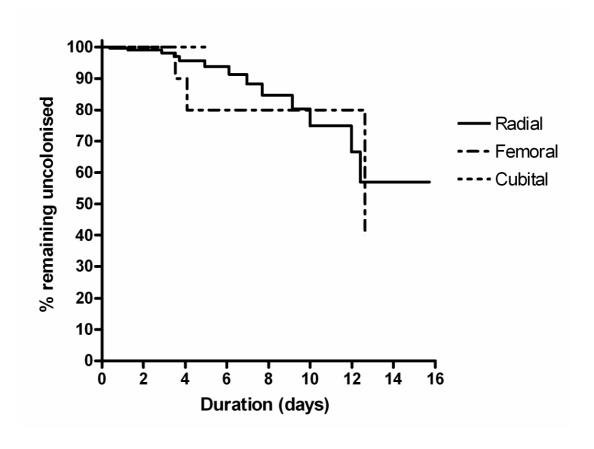


Table 1. Colonization and CRBSI associated with arterial and central venous catheters

Catheter	Catheter numbers	Total catheter days	Colonization			CRBSI		
site			n	Rate <sup>a</sup>	% <sup>b</sup>	n	Rate <sup>a</sup>	% <sup>b</sup>
Arterial								
catheters	321	1,082.1	17	15.71	5.3%	1	0.92	0.31%
Central venous catheters	618	4,040.4	68	16.83	11.0%	9	2.23	1.46%

<sup>&</sup>lt;sup>a</sup> unadjusted rate per 1,000 catheter days <sup>b</sup> % of catheters

Table 2. Catheter colonization by day of removal

Period <sup>a</sup>	No. catheters removed (colonized)	Mean AC duration	Mean rate <sup>b</sup>	Cl95% <sup>b</sup>	OR <sup>c</sup>	Cl95% <sup>c</sup>	$p^c$
		(days)					
Observed 6	estimates of incidence r	ates in cathete	ers removed during f	ixed periods after ins	sertion		
0-3 days	193 (3)	1.4	11.5	(3.7 to 35.3)	1.0		
3-6 days	79 (5)	4.1	15.4	(3.7 to 63.0)	4.0	(0.9 to 17.9)	0.070
6-9 days	23 (3)	7.2	18.2	(3.9 to 85.5)	6.9	(1.0 to 47.5)	0.097
9-12 days	16 (4)	10.2	24.4	(5.9 to 100.4)	18.3	(3.05 to 109.8)	0.004
12-15	4 (2)			,		,	
days	, ,	12.9	25.9	(5.2 to 129.2)	34.7	(4.31 to 278.6)	0.003
Calculated	point estimates of incid	lence rates at s	specified time points	d			
3.13 days	-						
е			13.4	(4.8 to 39.1)			
0 days			11.0	(3.8 to 29.2)			
3 days			13.2	(4.7 to 38.8)			
7 days			19.0	(7.2 to 49.4)			
10 days			23.4	(8.2 to 67.4)			
14 days			26.5	(5.5 to 122.0)			

Each catheter is assigned exclusively to the period designating the day on which the catheter is removed

Observed incidence rate per 1,000 catheter days estimated by Poisson regression, adjusted for age, gender, APACHEII and SAPS scores

Odds ratio estimated by logistic regression adjusted for age, gender, APACHEII and SAPS scores, in each case compared to the rate during the period 0-3 days; p-values corrected for multiple comparisons by the Holm method: Chi-squared test for trend 4.18 p<0.001

d Calculated from the best-fit third order polynomial expression applied to the observed mean colonization rates:

Calculated rate =  $(-0.0095*day^3) + (-0.1955*day^2) + (0.2321*day) + 11.024$  Where the constants are derived from non-linear regression of the observed mean incidence rates

<sup>&</sup>lt;sup>e</sup> Mean duration in-situ in study group where AC was removed before 15<sup>th</sup> day

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

	$N^a$	$N^a$	Rate	CI95%	$RR^b$	CI95%	p- value
Cardiovascular							
shock	0	14	0.00	(0.00 to 0.00)	0.00	(0.00 to 0.00)	0.000
Sepsis	2	28	10.94	(2.35 to 50.9)	0.55	(0.10 to 2.91)	0.482
GI surgery	5	65	23.08	(7.06 to 75.5)	3.49	(0.85 to 14.4)	0.084
Major surgery	1	27	14.71	(1.92 to 112.9)	1.01	(0.07 to 14.1)	0.991
Cancer	1	23	6.68	(0.79 to 56.9)	0.42	(0.04 to 4.18)	0.456
Respiratory disease	1	16	10.04	(1.76 to 57.2)	0.41	(0.04 to 3.86)	0.439
Organ failure	3	30	29.19	(7.95 to 107.2)	2.27	(0.50 to 10.33)	0.288
GI disease	0	5	0.00	(0.00 to 0.00)	0.00	,	
Neurological				,			
disease	1	18	20.14	(2.61 to 155.6)	5.18	(0.84 to 31.8)	0.076

Number of colonizations (n) in patients (N) with the condition
Hazard ratio (relative rate) calculated by Cox proportional hazards regression, adjusted for age, gender, APACHE II and SAPS scores: each disease is compared with the rates in all the remaining patients.