Nephrol Dial Transplant (1999) 14: 1710–1714

Nephrology
Dialysis
Transplantation

*Original Article*

# Outcome and complications of temporary haemodialysis catheters

Lukas K. Kairaitis[1] and Thomas Gottlieb[2]

[1]Department of Renal Medicine and [2]Department of Infectious Diseases and Microbiology, Concord Repatriation General Hospital, Concord, NSW, Sydney, Australia

**Abstract**

**Background.** The use of temporary haemodialysis catheters is often complicated by mechanical or infectious complications. Risk factors for these complications and optimal management to reduce their incidence are largely unknown.

**Methods.** We conducted a prospective study of 105 haemodialysis catheters (79 subclavian, 26 jugular) inserted in 52 patients in order to identify patient outcomes and to analyse the effect of patient and catheter factors on the incidence of infectious complications by multivariate analysis.

**Results.** Fifty-nine per cent of catheters were removed for a suspected complication. Catheter-related bacteraemia (CRB) was diagnosed in 17 catheters (16%), giving a bacteraemia rate of 6.5 episodes per 1000 catheter days. Subgroup analysis revealed a higher risk of CRB with the use of the internal jugular compared with the subclavian site (hazard ratio 3.97, $P=0.02$). Age, diabetes or catheter exchange over a guidewire did not alter the risk of CRB. The cumulative risk of developing CRB increased in a linear fashion as the period of catheterization increased. Exit-site infection was the cause for removal in eight catheters (8%). Although the number of exit-site infections was small, the risk of exit-site infection was increased in diabetic patients (hazard ratio 10, $P=0.03$) and the jugular position (hazard ratio 6.5, $P=0.01$) but not by age or catheter exchange over a guidewire. *Staphylococcus aureus* and coagulase-negative staphylococcus accounted for all proven episodes of CRB. Exit-site infection was associated with a mixture of Gram-positive and Gram-negative organisms.

**Conclusions.** Temporary haemodialysis catheters have a high failure rate associated with a significant rate of complications. Use of the internal jugular site is associated with a significantly higher risk of infectious complications and methods to reduce this risk should be considered if this site is used.

**Key words:** catheter; complication; haemodialysis; infection; jugular; subclavian

*Correspondence and offprint requests to*: Dr Lukas Kairaitis, 15 Scott Street, Five Dock, NSW 2046, Sydney, Australia.

## Introduction

The use of temporary or semi-permanent haemodialysis catheters for haemodialysis remains an essential component of dialysis practice, both for the management of acute renal failure and as temporary 'bridging access' for patients whose other dialysis access is unavailable for use. Unfortunately the use of these catheters is often complicated by mechanical or infectious complications which may result in patient morbidity or premature catheter removal. Recent evidence linking the subclavian site with a 10–35% risk of subclavian vein stenosis [1,2] has led to a recommendation to avoid this site [1,3] with the aim of preserving the prospects for fistula formation in the ipsilateral arm.

Catheter-related bacteraemia (CRB) is the most significant infectious complication of haemodialysis catheters, occurring in 5–18% of catheters or in 3.9–8.6 episodes/1000 catheter days [4–7], a rate higher than for all other forms of central venous access [8]. Exit-site infection also occurs, usually leading to premature catheter removal. The high rate of infection and associated patient morbidity necessitates the establishment of optimal practice to reduce the risk of this complication.

We conducted a prospective study of jugular and subclavian haemodialysis catheters in order to identify patient outcomes and to analyse the effect of patient and catheter factors on the incidence of infectious complications by multivariate analysis.

## Subjects and methods

### *Study design*

Prospective data were collected on all temporary haemodialysis catheters inserted by the renal unit personnel of a University teaching hospital renal unit for the time period between January to August 1997 inclusive. The study population was predominantly composed of ambulatory patients with end-stage renal failure (48 of 52 patients). Femoral catheters and patients who died with a haemodialysis catheter *in situ* were excluded from analysis. Microbiological results

were not available for two uncomplicated catheters that were excluded from analysis.

### *Catheter management*

Dual-lumen polyurethane non-cuffed haemodialysis catheters ('Quinton', Wisconsin, USA, 'Arrow', Pennsylvania, USA) were inserted under strict asepsis and sutured to the skin. The decision as to catheter site was left to the operator at the time of insertion, and was dependent on both operator preference and clinical factors which contraindicated the use of alternative sites. The position of the catheter tip was verified radiologically prior to use. A semi-occlusive double-layer transparent dressing ('Opsite', Smith Nephew, UK) was applied. Dressings were inspected with each dialysis treatment and changed if required. Catheter lumens were 'locked' with a volume of unfractionated heparin (1000 units/ml) equivalent to the internal volume of the lumen. The catheters were not used for intravenous access other than for haemodialysis.

Catheters were removed when no longer required or when a suspected complication developed. If a purulent exudate or cellulitis was noted around the insertion site the catheter was removed, and swabs taken from the exit site. The catheter tip was sent for semi-quantitative culture as described by Maki *et al.* [9], and reported as positive if greater than 15 colony-forming units were isolated. Patients who developed a significant fever (greater than 38.5°C) with a haemodialysis catheter *in situ* had their catheter removed if a source of fever was not apparent after clinical examination and baseline investigations to find an alternative source of infection. Cultures of blood were taken and correlated with semi-quantitative cultures of the catheter tip.

### *Outcome assessment*

Catheter complications were determined in the following manner. A mechanical cause for removal was defined as poor flow or high blood pump pressures not resolved by other methods such as patient repositioning or catheter replacement over a guidewire. The incidence of subclavian venous stenosis was not studied. Catheter-related bacteraemia (CRB) was defined by the association of fever (38.5°C or greater) and the isolation of an identical micro-organism from cultures of blood and the catheter tip in the absence of an alternative source. Possible CRB was defined where fever developed in the absence of an alternative source where microbiological criteria were insufficient to diagnose CRB. Exit-site infection was defined as the development of cellulitis or purulent exudate at the site of insertion.

### *Statistical methods*

Each individual catheter episode was analysed separately in those patients who had more than one catheter during the time period of the study. Catheters exchanged over a wire because of mechanical complications were also treated as a single catheter episode. The effect of patient and catheter variables (including guidewire exchange) on the development of infectious complications (CRB and exit-site infections) was analysed using survival analysis and the proportional hazards model of Cox. The effect of duration of catheterization was analysed using a cumulative hazard model.

## Results

A total of 105 haemodialysis catheters were inserted in 52 patients (31 male, 21 female) and remained *in situ* for a cumulative total of 2613 catheter days. The subclavian position was used in 79 cases and 26 were inserted in the internal jugular vein. The maximum number of catheters in a single individual over the study period was seven in a patient with no alternative dialysis access during the period of the study. The age range of patients was 17–85 with a mean age of 65 years. Fifty haemodialysis catheters were inserted in 20 diabetic patients.

### *Catheter outcomes*

An uncomplicated course was found in 43 catheters (41%) which were removed electively. The remaining 62 catheters (59%) were removed because of either a suspected or subsequently proven complication (Figure 1), giving a median survival of 30 days. Eight catheters (8%) were removed because of exit-site infection and 10 (9%) were removed because of mechanical complications.

Forty-four catheters (41%) were removed because of fever and a clinical suspicion of catheter-related sepsis. Eight of these were associated with a proven alternative source of infection. Of the remaining 36 catheters, the criteria for CRB were met in 17 episodes (16%). The remaining 19 catheter episodes (18%) were classified as having possible CRB. From this last group, four had a positive culture of the catheter tip alone, eight were associated with positive blood cultures alone, and seven had no significant bacterial isolates from cultures of blood and catheter tips.

### *Catheter-related bacteraemia*

Seventeen of the inserted catheters were complicated by CRB (Table 1), equivalent to an infection rate of

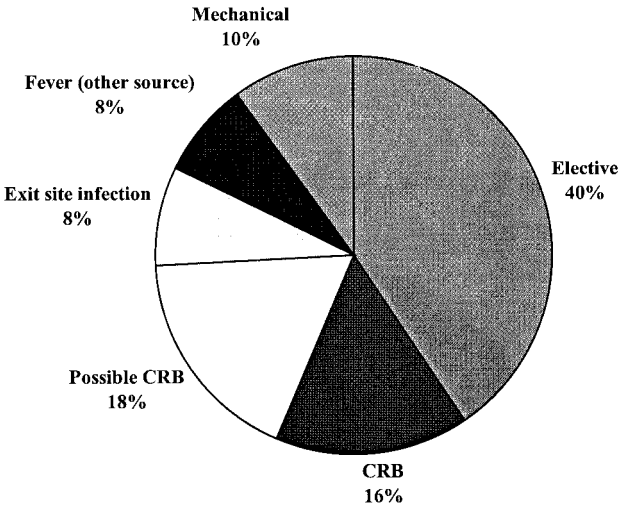


**Fig. 1.** Reasons for catheter removal.

**Table 1.** Characteristics of proven catheter-related bacteraemia episodes

| Catheter no. | Diabetic | Site | Duration *in situ* (days) | Micro-organism isolated |
|---|---|---|---|---|
| 1 | Y | jugular | 10 | *S. aureus* |
| 2 | Y | jugular | 56 | MRSA |
| 3 | Y | jugular | 7 | *S. aureus* |
| 4 | Y | jugular | 5 | MRSA |
| 5 | N | jugular | 26 | Coagulase-negative staphylococcus |
| 6 | N | jugular | 47 | Coagulase-negative staphylococcus |
| 7 | Y | subclavian | 39 | Coagulase-negative staphylococcus |
| 8 | Y | subclavian | 19 | *S. aureus* |
| 9 | Y | subclavian | 35 | *S. aureus* |
| 10 | Y | subclavian | 72 | *S. aureus* |
| 11 | Y | subclavian | 24 | Coagulase-negative staphylococcus |
| 12 | Y | subclavian | 61 | MRSA |
| 13 | N | subclavian | 18 | Coagulase-negative staphylococcus |
| 14 | N | subclavian | 5 | *S. aureus* |
| 15 | N | subclavian | 24 | Coagulase-negative staphylococcus |
| 16 | N | subclavian | 44 | Coagulase-negative staphylococcus |
| 17 | N | subclavian | 22 | MRSA |

Gram-positive organisms account for all proven episodes. Diabetic patients have a greater proportion of *S. aureus* as a cause of CRB.

16%, or 6.5 episodes/1000 catheter days. Survival analysis indicated that 50% of catheters not removed for other reasons develop CRB by 72 days. Analysis of the cumulative hazard of developing CRB (Figure 2) revealed a roughly linear increase in cumulative hazard, suggesting that the risk of developing CRB at a specified point in time was constant over the period of catheterization. In all cases of CRB the isolated organism was a Gram-positive species (methicillin-sensitive *S. aureus* in 6, methicillin-resistant *S. aureus* in 4, and coagulase-negative staphylococcus (CoNS) in 7). Diabetic patients had a significantly higher proportion of *S. aureus* when compared with non-diabetic patients ($\chi^2 = 7.137$, $P < 0.01$).

Multivariate analysis indicated that catheters inserted in the jugular vein were associated with a significantly higher risk of CRB (hazard ratio 3.57, $P = 0.02$). No relationship was found for the presence of diabetes (hazard ratio 1.9, $P = 0.21$), age (hazard ratio 1, $P = 0.974$) or exchange of the catheter over a guidewire (hazard ratio 0.9, $P = 0.9$).

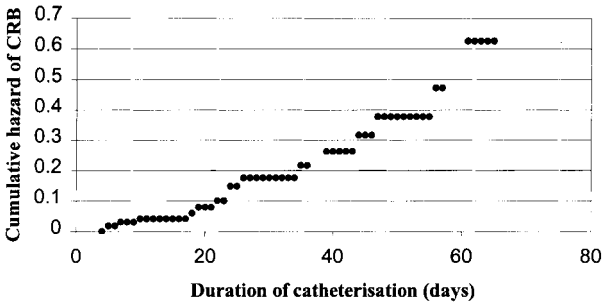


**Fig. 2.** Cumulative hazard (risk) of developing CRB with an increasing duration of catheterization. Linear appearance suggests that the risk of CRB is constant over time.

*Exit-site infection*

Eight catheters were complicated by exit-site infection (Table 2). Culture results revealed a mixture of Gram-positive and Gram-negative isolates. Subgroup analysis indicated that both the presence of diabetes (hazard ratio 10, $P = 0.03$) and use of the jugular site (hazards ratio 6.5, $P = 0.01$) were associated with a higher risk of removal for exit-site infection; this effect persisted with multivariate analysis. No relationship was found for age (hazards ratio 1, $P = 0.8$) or exchange of the catheter over a guidewire (hazard ratio 0.9, $P = 0.9$).

## Discussion

Despite their crucial role in dialysis practice, haemodialysis catheters have a high 'failure' rate and a high rate of infectious complications. The internal jugular site is associated with a significantly increased risk of catheter related bacteraemia. Although exit-site infection lacks a precise diagnosis and the number of exit-site infections was small, we found a significantly higher rate of removal for suspected exit-site infection in diabetic patients and with the use of the internal jugular position.

The high rate of CRB in our study is in keeping with previous published series of similar haemodialysis catheters [4–7], and may even still be an underestimate of the true rate of catheter related sepsis. The strict definition of CRB requires the isolation from cultures of blood and the catheter tip of the same organism. The likelihood of positive cultures may be influenced by delays in diagnosis of CRB, the timing of collection of blood cultures in relation to antibiotic therapy as well as the absolute level of bacteraemia. In our series 16% of catheters were removed because of 'possible'

**Table 2.** Defining characteristics of catheters removed because of exit-site infections showing the disproportionate number of diabetic patients

| Catheter no. | Diabetic | Site | Duration *in situ* (days) | Micro-organism(s) and site |
|---|---|---|---|---|
| 1 | Y | subclavian | 19 | Coagulase-negative staphylococcus (tip + swab) |
| 2 | Y | jugular | 17 | *Klebsiella oxytoca* (tip + swab) |
| 3 | Y | subclavian | 8 | *S. aureus* (tip + swab) |
| 4 | Y | subclavian | 6 | *S. aureus* (tip + swab) |
| 5 | Y | jugular | 14 | *Pseudomonas aeruginosa* (tip + swab) |
| 6 | Y | jugular | 15 | *Pseudomonas aeruginosa* (tip + swab) |
| 7 | Y | jugular | 10 | *Proteus mirabilis* (tip + swab) |
| 8 | N | jugular | 31 | *S. aureus* (tip + swab) |

A mixture of Gram-positive and Gram-negative organisms was isolated.

CRB. In all of these cases, no alternative source of fever was identified and the results of microbiological cultures were insufficient to confirm the diagnosis of CRB. Given the confounding possibility of false-positive culture results, it is likely that catheter-related sepsis was the cause of fever in some of these patients. The reasons for the higher rates of CRB associated with haemodialysis catheters have not been clearly defined. Haemodialysis patients have been reported to have a high rate of colonization (50–60%) with *S. aureus* [10–12], and this is reflected in the disproportionate numbers of *S. aureus*-associated CRB in previous series [4–5,13] as well as our own. The greater proportion of *S. aureus* bacteraemia in diabetic patients in our study may be related to the even higher rates of *S. aureus* colonization reported in diabetic dialysis patients [14].

In this study, use of the internal jugular position was associated with an increase in CRB, a finding in contrast to a previous smaller haemodialysis catheter series [5]. Catheter site was not randomized in this study; however, a randomized study may be impractical due to clinical factors which contraindicate the use of a particular site (such as the presence of a fistula, difficult cannulation, or the presence of localized infection over the insertion site). In addition, the difference in this study persisted using multivariate analysis for all measured potential risk factors, making ascertainment bias unlikely. The results of this study are also supported by large studies of central venous catheters which document higher rates of bacterial colonization of jugular catheters compared with subclavian catheters [15–17], a factor thought to be an important step in the pathogenesis of infectious complications. The reasons for these higher colonization rates are unclear but possibilities include the shorter subcutaneous tunnel of the internal jugular site, closer proximity to the nasal microflora, and difficulty in maintaining a dry insertion site. The increased risk of CRB with jugular catheters has relevance to clinical practice, particularly as concerns about the development of subclavian vein stenosis and thrombosis have led to a recommendation for the use of the jugular site in preference to the subclavian position.

Exit-site infection was more common in this study with jugular catheters and in diabetic patients; however, the number of exit-site infections was small and the possibility of a type two error is possible. Of interest is the finding that all catheters removed for this reason were colonized, and may well have gone on to develop CRB had they remained *in situ*. In addition, exit-site infection and CRB are likely to have a similar pathogenesis, and the higher rate of CRB observed with jugular catheters lends strength to the argument that exit-site infection is likely to be similarly increased. Exit-site infection remains difficult to reproducibly define, hence the use in this study of a relatively broad definition in combination with a strict policy of removal when exit-site infection was clinically suspected.

The relationship between infectious complications and the duration of catheterization has previously been the subject of debate. Our analysis of the cumulative hazard of developing CRB suggests that the instantaneous risk of developing CRB at any point in time is relatively constant, as demonstrated by the roughly linear increase in cumulative hazard over time (Figure 2). This result is similar to data published by Almirall *et al.* using a similar survival analysis [5] and has previously been demonstrated in central venous catheters [18]. These data suggests that catheter colonization and subsequent infection is a random event and that a 'threshold' duration at which the probability of CRB sharply increases does not exist. The implication for clinical practice is that a policy of routine catheter change after a predetermined length of time may not alter the probability of an individual patient developing CRB, as the ultimate determinant of an individual patients' risk of CRB is the total duration of catheterization for all sequential catheters. This observation is supported by studies in both haemodialysis catheters [19] and central venous catheters [20,21] demonstrating no reduction in the risk of CRB with routine catheter change. In addition, we found that catheter exchange over a guidewire was not associated with an altered risk of infectious complications. Dahlberg *et al.* reported a similar lack of significant difference in rates of CRB with catheters replaced over a guidewire [6], and routine catheter exchange on a weekly basis in a study by Uldall *et al.* [22] did not

reduce bacteraemia rates, presumably due to the reasons discussed above.

In summary, this prospective study shows that temporary haemodialysis catheters are associated with a high 'failure' rate and a high rate of infectious complications. The risk of CRB increases linearly with time and is more common with the use of the internal jugular position. Diabetic patients appear to be at greater risk of exit-site infections and have a greater proportion of *S. aureus* infections as a cause of CRB. The increased rate of infection associated with the use of the internal jugular position should be balanced against the perhaps greater risk of central venous stenosis with subclavian cannulation. Effective planning of dialysis access is thus essential in pre-dialysis patients to minimize the use of these catheters. When temporary haemodialysis access is necessary the duration of catheterization should be minimized; however, routine catheter change after a defined period may not reduce an individual patient's risk of CRB. Alternative forms of dialysis access such as the cuffed haemodialysis catheter should be considered where prolonged periods of catheterization are anticipated, such as whilst awaiting maturation of an arteriovenous fistula. Further larger studies are needed to establish the optimal management of haemodialysis catheters to reduce the risk of infectious complications.

*Acknowledgements.* The authors would like to thank Dr Karen Byth of the Division of Medicine, Westmead Hospital, Sydney for help with statistical analysis of this study.

## References

1. Uldall PR. Subclavian cannulation is no longer necessary or justified in patients with end-stage renal failure. *Semin Dial* 1994; 7: 161–164
2. Vanherweghem JL. Thrombosis and stenosis of central venous access in hemodialysis. *Nephrologie* 1994; 15: 117–121
3. NKF-DOQI clinical practice guidelines for vascular access. *Am J Kidney Dis* 1997; 30 [Suppl 3]: S150–189
4. Vanholder R, Hoenich N, Ringoir S. Morbidity and mortality of central venous catheter haemodialysis: a review of 10 years experience. *Nephron* 1987; 47: 274–279
5. Almirall J, Gonzalez J, Rello J *et al*. Infection of hemodialysis catheters: incidence and mechanisms. *Am J Nephrol* 1989; 9: 454–459
6. Dahlberg PJ, Wilfrido R, Yutuc MD, Newcomer KL. Subclavian hemodialysis catheter infections. *Am J Kidney Dis* 1986; 5: 421–427
7. Sherertz RJ, Falk RJ, Huffman KA, Thomann CA, Mattern WD. Infections associated with subclavian Uldall catheters. *Arch Intern Med* 1983; 143: 52–56
8. Gosbell IB, Duggan D, Breust M, Mulholland K, Gottlieb T, Bradbury R. Infection associated with central venous catheters: a prospective survey. *Med J Aust* 1995; 162: 210–213
9. Maki DG, Jarrett F, Sarafim HW. A semi-quantitative culture method for identification of intravenous catheter related infection. *N Engl J Med* 1977; 296: 1305–1309
10. Yu VL, Goetz A, Wagener M *et al. Staphylococcus aureus* nasal carriage and infection in patients on hemodialysis. Efficacy of antibiotic prophylaxis. *N Engl J Med* 1986; 315: 91–96
11. Goldblum SE, Ulrich JA, Goldman RS, Reed WP. Nasal and cutaneous flora among hemodialysis patients and personnel: quantitative and qualitative characterization and patterns of staphylococcal carriage. *Am J Kidney Dis* 1982; 2: 281–286
12. Kirmani S, Tuazon CU, Murray HW, Parrish AE, Sheagran JN. *Staphylococcus aureus* carriage rate of patients receiving long-term hemodialysis. *Arch Intern Med* 1978; 138: 1657–1679
13. Kozeny GA, Venezio FR, Bansal VK, Vertuno LL, Hano JE. Incidence of subclavian dialysis catheter-related infections. *Arch Intern Med* 1984; 144: 1787–1789
14. Breen JD, Karchmer AW. *Staphylococcus aureus* infections in diabetic patients. *Infect Dis Clin North Am* 1995; 9: 11–24
15. Richet H, Hubert B, Nitemberg G *et al.* Prospective multi-center study of vascular catheter related complications and risk factors for positive central catheter cultures in intensive care patients. *J Clin Microbiol* 1990; 28: 2520–2525
16. Brun Buisson C, Abrouk F, Legrand P, Huet Y, Larabi S, Rapin M. Diagnosis of central venous catheter-related sepsis. Critical levels of quantitative tip cultures. *Arch Intern Med* 1987; 147: 873–877
17. Darouiche RO, Raad II, Heard S *et al.* A comparison of two antimicrobial-impregnated central venous catheters. *N Engl J Med* 1999; 340: 1–8
18. Wenzel R. *Prevention and Control of Nosocomial Infections.* 2 edn. Williams and Wilkins, Baltimore, Maryland, 1993; 562
19. Uldall PR. Subclavian cannulation for haemodialysis. *Int J Artif Organs* 1981; 4: 213–214
20. Cobb DK, High KP, Sawyer RG *et al.* A controlled trial of scheduled replacement of central venous and pulmonary artery catheters. *N Engl J Med* 1992; 327: 1062–1068
21. Eyer S, Brummitt C, Crossley K, Siegel R, Cerra F. Catheter-related sepsis—prospective, randomized study of 3 different methods of long term catheter maintenance. *Crit Care Med* 1990; 18: 1073–1079
22. Uldall PR, Merchant N, Woods F *et al.* Changing subclavian haemodialysis catheters to reduce infection. *Lancet* 1981; 2: 1373

*Received for publication: 9.9.98*
*Accepted in revised form: 15.2.99*