

Outcome of Tunnelled Central Venous Haemodialysis Catheters Inserted by Radiologists

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Abstract

Radiologists have only recently been involved in the percutaneous placement of tunnelled central venous haemodialysis catheters. We report our initial experience with our first 60 catheters. All catheters were successfully inserted. Immediate complications encountered included puncture site haemorrhage in 3 patients (5%) and puncture of the left brachiocephalic vein in 1 patient (1.7%). These were managed conservatively without any clinical sequelae. About 80% of the catheters were uncomplicated and removed electively. Slightly more than 80% of the catheters were in place for more than 30 days.

Infection and blocked catheters were the most common short-term complications. Ten catheters (17%) were infected resulting in premature removal of 9. There was 1 death from presumed line sepsis. Mean duration before the onset of infection was 53 days; the rate of infection was 0.28 episodes per 100 catheter days. Five catheters (8%) were blocked or had poor flow. The mean duration before the onset of blockage was 39 days and the rate of blockage was 0.14 episodes per 100 catheter days. A higher proportion of catheters inserted from the left encountered complications.

In conclusion, percutaneous insertion of tunnelled haemodialysis catheters by radiologists is safe and effective. The right internal jugular vein should be the preferred access site. Precautions should be taken to avoid infectious complications given the high rate of catheter removal amongst infected catheters.

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Introduction

In end-stage renal failure patients, maintaining adequate vascular access continues to be an ongoing challenge. Native arteriovenous fistulas or synthetic arteriovenous grafts are satisfactory long-term options. These, however, are often not instantly available for use. It may take 6 to 8 weeks for an arteriovenous fistula to mature. During this time, a central venous catheter provides temporary access and allows haemodialysis to continue. Similarly, a patient with peritoneal dialysis who presents with peritonitis or obstructed Tenckhoff catheter also requires temporary catheter haemodialysis.

Central venous haemodialysis catheters can be either tunnelled through the subcutaneous tissue over the anterior chest wall or be inserted "directly" into the vein. The former technique using a cuffed catheter has been

shown to be safe and reliable with longer catheter survival than a standard, non-tunnelled, non-cuffed subclavian haemodialysis catheter.^{1,2} Tunnelled haemodialysis catheters have traditionally been inserted by surgeons with either percutaneous or surgical cut-down techniques. Only recently have radiologists been involved in the percutaneous placement of tunnelled central venous catheters.^{3,4} The purposes of this study were to report our preliminary experience and evaluate the technical success, complications and outcome of percutaneously inserted tunnelled haemodialysis catheters placed by our interventional radiology service.

Materials and Methods

All patients who had a Vascath (Bard, Utah, USA) double-lumen tunnelled haemodialysis catheter inserted

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between June 1997 and December 1997 were included in the study. The medical records of all patients were retrospectively reviewed. Telephone interviews were conducted with patients and dialysis centres where appropriate. Patients' particulars, indications for catheter haemodialysis, relevant co-morbid conditions, detailed information relating to catheter access site, dates of insertion, complications and eventual outcomes were recorded.

Catheter Insertion

The Vascath haemodialysis catheter is a 12.5 F double-lumen polyurethane catheter which has a pre-formed curve and a short tissue cuff. This cuff serves a dual function in anchoring the catheter in position and also in protecting against infections related to vascular access. Catheters inserted from the right internal jugular vein are 19 cm long. The catheters inserted from the left are 4 cm longer.

All catheters were inserted in the interventional suites of the radiology department by the attending consultant or by a supervised registrar. Informed consent was obtained from each patient prior to the procedure. A coagulation screen consisting of a recent (within 48 hours) platelet count, prothrombin time and activated partial thromboplastin time was performed prior to the procedure. A platelet count of $100,000 \times 10^3/l$ was considered acceptable. In patients with coagulopathy or thrombocytopenia, the procedure was performed with fresh frozen plasma or platelet cover, respectively. Prophylactic antibiotics were not routinely given.

The procedure was done with the patient supine. No peri-procedural sedation was used. Both internal jugular veins were studied with ultrasound (7.5 MHz probe, GE Medical Systems, WI, USA) prior to preparing and draping the patient. The right internal jugular vein was the preferred site. The left side was used only if the right internal jugular vein was deemed unsuitable. Puncture of the internal jugular vein was done with an 18G puncture needle under real-time ultrasound guidance, at a site just above the sterno-clavicular joint.

An exit site was created on the anterior chest wall and a subcutaneous tunnel established between the puncture site and the chest wall exit. The catheter was then threaded through the subcutaneous tunnel with the help of a tunnelling device. The puncture site was dilated and a 13F peel away sheath inserted into the internal jugular vein. Through this sheath, the catheter was placed such that its tip was positioned in the lower superior vena cava as it entered the right atrium. Heparinised saline was introduced into each lumen of the catheter prior to securing its position with 2 anchoring non-resorbable sutures at the exit site. The skin was also closed at the puncture site with sutures. The stitches were removed at the end of 2 weeks, during which time a firm scar would

have formed around the Dacron cuff.

An erect chest radiograph was done at the end of the procedure to verify the position of the catheter and to exclude any complications (Fig. 1). The above procedure typically took about 30 to 45 minutes to complete.

Complications

Technical failures were classified as immediate and early failures. Immediate failures were defined as the unsuccessful insertion of a catheter at any one sitting. The number of puncture attempts was recorded. Early technical failures included all catheters that were malfunctioning within 7 days of insertion and had to be removed, whether as a result of persistent poor flow during dialysis, catheter dislodgement or early infection. It is probable that these early complications are related to technical factors arising from insertion of the catheter rather than catheter failures.

Immediate complications such as pneumothorax, inadvertent arterial puncture, puncture site haematoma or haemorrhage were also noted. Haemorrhage was defined as a prolonged ooze within 4 hours of the procedure necessitating a single change of dressing during this time interval. Manual compression or occlusive dressing was usually adequate to secure haemostasis.

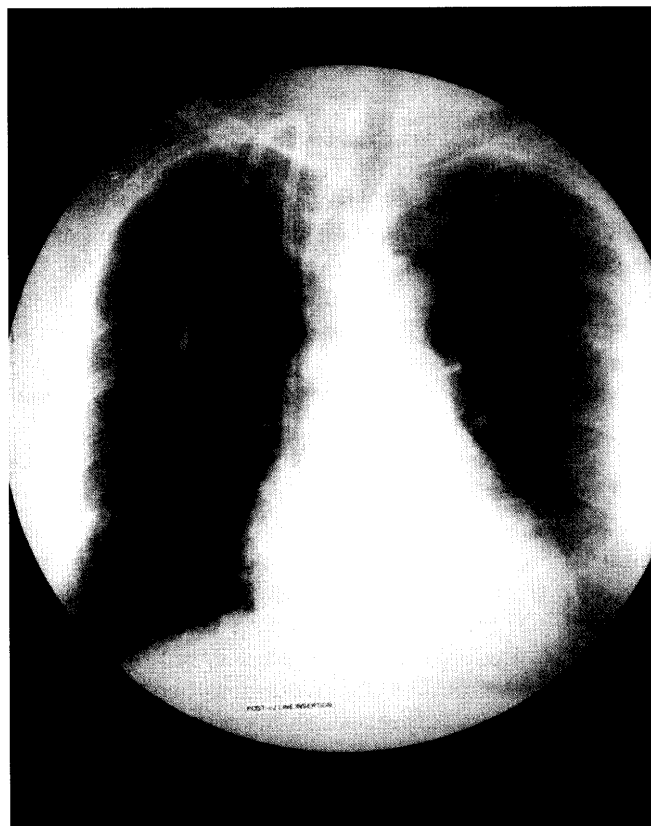


Fig. 1. Chest radiograph done after successful insertion of a right tunnelled haemodialysis catheter. The catheter follows a smooth curve across the right anterior chest wall and its tip lies within the right atrium. No pneumothorax is present.

Short-term complications point towards catheter failure and include catheter fracture, migration and obstruction. The latter often manifests as poor flow rates during dialysis. In these instances, thrombolysis was usually attempted. This was achieved by instilling a 1 ml bolus of 6000 units of urokinase (Green Cross Corporation, Osaka, Japan) into each limb of the catheter. After a dwell time of 20 minutes, aspiration of blood was attempted. This process was repeated once if blood still could not be readily aspirated. Occasionally, mechanical unblocking, including fibrin sheath stripping was performed. Only when these measures failed, was the catheter removed and a new catheter inserted into the contra-lateral internal jugular vein or exchanged over a guide wire, preserving the existing venotomy but creating a fresh tunnel.

A local infection was diagnosed if there was erythema, swelling or pus at the exit site or along the subcutaneous tunnel. Gram stain and culture of any drainage material was performed. This was treated with antibiotics and daily dressing change with gauze soaked in povidone-iodine. Systemic bacteraemia was diagnosed when blood cultures were positive in a febrile patient who had no other source of sepsis. Two sets of aerobic and anaerobic blood cultures were obtained from both the central venous catheter and a peripheral vein. All patients with bacteraemia were treated empirically. The catheter was removed if the fever did not show a decreasing trend within 24 hours.

Catheter End Points

The end point of a catheter was defined by its removal from the patient. A catheter exchange over a guide wire was considered a new procedure. Catheters were removed from patients when they were no longer required, when they failed or when patients died. The reasons for elective removal included successful use of an arteriovenous fistula or graft, resolution of acute renal failure, conversion to peritoneal dialysis or conservative (non-dialysis) management of end-stage renal failure.

Data Analysis

Values are expressed as mean $\pm$ standard deviation (SD). Cumulative probabilities of catheter patency and freedom from infection including the 95% confidence interval (CI) were calculated using the Kaplan-Meier method. Catheters that were electively removed or still *in situ* when the patient died were classified as censored events when computing probability of catheter survival. In assessing freedom of catheter from infection, the first day of symptoms was deemed the start of infection.

Results

During the study period, 62 catheters were inserted in

60 patients, with 2 patients having 2 catheters inserted on separate occasions. Our cohort comprised of 25 men and 35 women, whose ages ranged from 25 to 84 years (mean 50.8 ± 14.2 years). Two patients were non-residents and left the country soon after the catheters were inserted and were therefore lost to follow up. These 2 patients were excluded from analysis. The indications for catheter haemodialysis are shown in Table I. All but 5 patients (91.4%) were either newly diagnosed end-stage renal failure patients or dialysis patients who had non-functioning arteriovenous fistulas or peritoneal dialysis catheters. Only 2 patients had catheters inserted for acute renal failure. Fifteen patients (25.9%) were diabetic.

Insertions were technically possible in all 60 procedures. Forty-nine catheters (81%) were inserted via the right internal jugular vein. Ten catheters (17%) were placed via the left internal vein and 1 catheter (2%) was inserted via the left subclavian vein because of bilateral occluded internal jugular veins. Of the 10 catheters inserted into the left internal jugular vein, there was only one occasion where puncture of the right side was attempted by the radiologist and failed. The reasons for left-sided puncture in the remaining 9 instances were aneurysm of the right common carotid artery (2), infected right central lines (2), swollen right upper limb (1), failed attempts by the clinicians on the right with resultant haematoma compressing the right internal jugular vein (1) and operator preference (3).

Amongst the 60 catheters, there was 1 early technical failure (1.7%) in our series. Four days after insertion, poor outflow was experienced despite satisfactory inflow. The catheter was removed after 2 unsuccessful attempts were made to adjust the catheter under fluoroscopy. This was a case early in our experience. On review, we realised that the internal jugular venous puncture had been performed too high in the neck, resulting in proximal migration of the catheter tip. We subsequently made it a point of puncturing the vein as close to the base of the patient's neck as possible.

There was one instance of inadvertent puncture of the right common carotid artery. In this same patient, when insertion of the peel away sheath and introducer was

TABLE I: INDICATIONS FOR CATHETER HAEMODIALYSIS

	No. (%)
Newly diagnosed ESRF/awaiting AVF	35 (58.4)
AVF complications	17 (28.3)
Peritonitis with removal of Tenckhoff catheter	5 (8.3)
Acute renal failure	2 (3.3)
Infected haemodialysis catheter	1 (1.7)
Total	60 (100)

AVF: arteriovenous fistula; ESRF: end-stage renal failure

attempted from the left internal jugular vein, transgression of the left brachiocephalic vein was noted. This was because of a sharp right angle at the junction of the left internal jugular vein and the left brachiocephalic vein. The introducer and sheath were immediately withdrawn and re-positioned under fluoroscopy. A catheter was successfully inserted in this patient but its use was deferred for a day. The complication was managed conservatively with no adverse clinical sequelae. There were also 3 patients with a normal coagulation profile who experienced a prolonged ooze from the puncture site that required pressure bandages to secure haemostasis. No pneumothorax was encountered in our patients.

On follow up, 47 of the 59 catheters (79.7%) were electively removed as they were no longer required. This included 2 catheters that were still functioning in patients who died from unrelated causes. There were 12 catheters (20.3%) that failed and were removed prematurely. Nine catheters (15.2%) were infected and the remaining three (5.1%) had poor flow or were completely blocked. The catheters were in place for 7 to 233 days (mean 61 days) and the total number of catheter days was 3602 days. Amongst these catheters, 48 (81.4%) were *in situ* for more than 30 days. Even if only failed catheters were considered, 75% survived for more than 30 days. In the sub-group of catheters that lasted less than 30 days, only 3 out of 11 (27%) were removed because of catheter complications. The remainder were electively removed (Table II). The overall cumulative probability of catheter survival was 0.93 at 1 month (95% CI 0.86–0.99) and 0.82 at 2 months (95% CI 0.71–0.93) (Fig. 2). The median survival of catheters was not reached for the duration of follow up.

There was a total of 10 infectious complications involving 10 patients (16.9%). One patient had local exit site cellulitis which was only noticed during removal of the catheter upon maturation of his arteriovenous fistula. Another 8 patients had septicaemia with positive cultures from both the central and peripheral blood specimens and/or tip of catheter. One of these 8 patients also had concomitant stitch site abscess. There was 1 death in a patient with prior underlying MRSA pneumo-

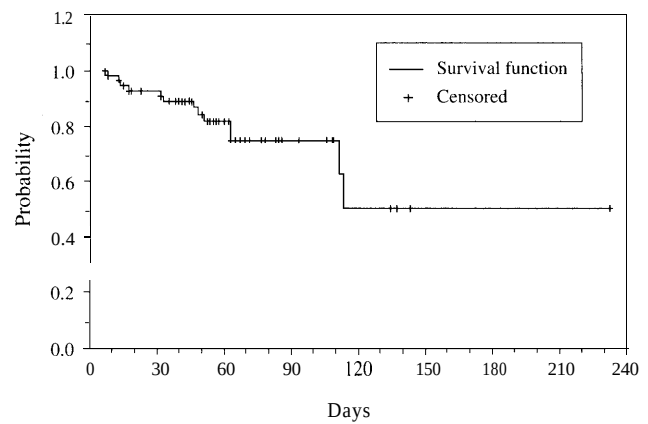


Fig. 2. Life table curve plotting probability of catheter survival over time.

nia and presumed line sepsis. No blood specimens were available for culture in this patient as he collapsed soon after admission. Mean duration catheters were indwelling before the onset of infection was 53 days. Overall, the rate of infection was 0.28 episodes per 100 catheter days. Life table analysis showed the probability of freedom from infection to be 0.94 at 1 month (95% CI 0.88–1.0) and 0.80 at 2 months (95% CI 0.68–0.93). There was only one instance of infection among the 15 diabetics in our study. The remaining 9 infections occurred in non-diabetics. The infection rates amongst diabetics and non-diabetics were 0.09 and 0.35 per 100 catheter days, respectively.

Five catheters were blocked or experienced poor flow (8.5%). One of these occurred in a patient with hypercoagulopathy who was non-compliant with warfarin. The catheter blocked soon after she stopped her medication. Another patient's catheter occluded after he defaulted haemodialysis. In 1 patient, while the outflow from the catheter was satisfactorily, poor inflow was encountered during aspiration. Catheter contrast studies in this patient confirmed the presence of a fibrin sheath enveloping the tip of the catheter. This was stripped away using a goose snare with temporary relief. The mean duration catheters were *in situ* before impairment of flow was 39 days. Rate of catheter blockage was 0.14 per 100 catheter days. Thrombolysis with urokinase was attempted in 2 patients with success in only 1.

In our group of 15 catheters with short-term complications, there was a higher proportion of catheters inserted from the left compared to the group of catheters removed electively without complications (40% versus 9%). Three of the 5 catheters that had poor flow and 3 of the 10 infected catheters were inserted from the left. Our 1 case of early technical failure was also inserted from the left.

Discussion

Catheter haemodialysis is a valuable tool in providing

TABLE II: REASONS CATHETER REMOVED LESS THAN 30 DAYS AFTER INSERTION

	No.
Resolution of acute renal failure	2
Catheter complications	3
Died from unrelated cause	1
Successful use of peritoneal dialysis catheter	4
Voluntarily stopped haemodialysis	1
Total	11

continued access while awaiting maturation of a permanent access site. Results of our study demonstrate the feasibility and safety of tunnelled catheters inserted percutaneously by radiologists. Amongst the 60 catheters we inserted, there was only 1 early technical failure (1.7%). This occurred fairly early on in our experience with tunnelled catheters and may reflect a short but real learning curve involved in this technique. A 9% early technical failure rate has been reported with tunnelled dialysis catheters inserted via surgical cut down.² Schnabel et al⁴ encountered a 4% early technical failure with tunnelled catheters inserted percutaneously.

The right internal jugular vein is the preferred site for insertion of a central venous catheter. Several investigators have suggested that internal jugular cannulation may be safer than the subclavian route for both short- and long-term vascular access.⁵⁻⁷ The internal jugular venous approach was also preferable because of greater risk of subsequent venous stenosis associated with subclavian catheters.^{6,8,9} Furthermore, the right internal jugular vein offers a straight access to the superior vena cava. A catheter inserted from the left, on the other hand, passes through an obliquely running left brachiocephalic vein before joining its counterpart on the right to form the superior vena cava. Occasionally, as in 1 of our patients, the left brachiocephalic vein may be orientated more horizontally which creates abrupt acute angles at junctions. In these cases, insertions of the peel away sheath and relatively stiff introducer may be problematic. Complications can, however, be avoided with careful fluoroscopy during insertions. In our series, of all the catheters inserted from the left, only 1 was due to a failed attempt on the right by the radiologist. As the procedures were performed by both consultant interventional radiologists and registrars in the team, our early complications are more representative of that seen in a busy service-oriented department.

Infection and blocked catheters were the most common short-term complications encountered in our patients, similar to the experience of other investigators.^{3,10,11} There were 10 catheters that were infected, resulting in the premature removal of 9, including 1 patient who died from presumed line sepsis. Although there was a patient with concomitant stitch site abscess amongst our 9 patients with septicaemia, only 1 had isolated exit site cellulitis. Other investigators have, however, reported a greater proportion of exit site infections compared with bacteraemia.^{2,10} It is possible that the high humidity in our environment encourages the rapid progression from local exit site infections to systemic bacteraemia, resulting in very few instances of isolated exit site infection.

The prognosis of exit site infection and bacteraemia is different. Exit site infections resolve with antibiotics in 90% to 100% of cases and rarely leads to loss of cath-

eter.^{2,10,11} Conversely, only 25% of all patients with bacteraemias respond to antibiotics without catheter removal.¹⁰ In view of this, our finding of a preponderance of bacteraemia amongst infected catheters in our study has important implications. It highlights the need for careful attention to aseptic techniques whenever one handles these catheters.

There is no conclusive evidence that prophylactic antibiotics lead to improved catheter infection rates. This is borne out by the varied practice and different regimens of investigators when dealing with this issue. There is, however, an interesting report suggesting that local application of mupirocin ointment (a topical antibiotic with high *in vitro* anti-staphylococcal activity) at the exit site after catheter placement and at the end of each dialysis session reduces the risk of exit site infection and *Staphylococcus aureus* bacteraemia in haemodialysis patients.¹²

Infection rates of between 0.19 to 0.83 have been reported in the literature.^{3,4,11} Our total infection rate of 0.28 per 100 catheter days is comparable. Moss et al^{1,10} and Cappello et al¹³ had found an increased risk of exit site infection in diabetic patients. We, like Lund et al,³ failed to demonstrate this risk amongst our patients.

Our catheter blockage rate of 0.14 episodes per 100 catheter days compares favourably with other published series of 0.20 to 1.27 episodes per 100 catheter days.^{1,3,4,13} These investigators reported substantial success with thrombolysis. As many as 80% to 95% of clotting episodes were satisfactorily re-opened with instillation of urokinase.^{2,3,11} We tried thrombolysis in 2 patients and were successful in only 1. Three of our 5 blocked catheters had to be removed. It is possible that incorporation of a thrombolysis protocol may increase catheter salvage.

Interestingly, 3 of the 5 blocked catheters were inserted from the left, despite 6 times more catheters inserted on the right. Several reasons may account for this finding. Firstly, the left-sided catheters are 4 cm longer than those inserted from the right (23 cm compared with 19 cm). The risk of catheter failure may be related to the length of the catheter. Secondly, catheters inserted from the left have to negotiate several bends as it passes to the superior vena cava. There is a greater likelihood that a portion of the catheter is kinked or the tip of the catheter impinges upon the vessel wall.

The mean duration that catheters were in place was slightly more than 2 months with more than 80% of catheters lasting for more than 30 days. Even among the failed catheters, 75% of catheters lasted for more than 30 days. About 80% of the catheters were removed electively, providing the opportunity for native arteriovenous fis-

tulas to mature, for peritonitis to settle and for acute renal failure to resolve. A standard non-tunnelled double-lumen catheter inserted into the subclavian vein would typically have a use-life of 2 to 3 weeks.¹⁴ It would have required multiple insertions of these catheters to achieve duration of access similar to our tunnelled catheters. It would seem that the increased time and effort taken to tunnel a catheter across the anterior chest wall is justifiable. It, however, does not mean that all patients should have a tunnelled catheter inserted for haemodialysis. Schwab et al² suggested the use of tunnelled catheters only if temporary vascular access is required for duration longer than a month. Otherwise, a standard non-tunnelled catheter would suffice. We are currently analysing data from a prospective randomised trial between tunnelled catheters inserted by radiologists and non-tunnelled catheters placed by physicians in the ward. This study will certainly shed more light on the value of tunnelled catheters and better define the role of each type of catheter.

In conclusion, we found that percutaneous insertion of tunnelled haemodialysis catheters under image guidance to be safe and effective in providing temporary haemodialysis access. The right internal jugular vein should preferably be used. Precautions should, however, be taken to avoid infectious complications given the relative high rate of bacteraemia and catheter removal amongst infected catheters. Implementation of a thrombolysis protocol may improve the survival of these catheters.

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