Radiological placement of the AshSplit haemodialysis catheter: a prospective analysis of outcome and complications

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Abstract

Background. The AshSplit catheter has recently been introduced as an alternative permanent tunnelled haemodialysis catheter, combining ease of insertion with good long-term patency and flow rates. Methods. Data were collected prospectively on all the long-term tunnelled haemodialysis (AshSplit) catheters inserted radiologically between January 1998 and March 1999. Information was obtained regarding the initial insertion, ongoing catheter function and re-intervention up to September 1999. Results. A total of 118 catheters were inserted in 88 patients (50 male), median (range) age 64 (20–86) years. Ultrasound guidance was used routinely and the right internal jugular vein was used in 80 (68%) cases. Initial complications occurred in 14 (11.9%) cases, which included local haemorrhage, carotid artery puncture, and air embolism. Infection occurred in 34% of catheters (2.4 × 10⁶ catheter days). Line thrombosis was documented in 20% (1.2 × 10⁶ catheter days). Satisfactory mean urea reduction ratio (URR) of 63 was obtained for all catheters. There were 47 re-interventions, mainly for fibrin sheath stripping (34) and/or thrombectomy (25). Total catheter duration was 21 600 days with a 1 month cumulative survival of 87% (Kaplan–Meier probability 85%). At the end of the study, 20 (17%) catheters were still functioning, 39 (33%) had been removed electively, and 22 (18%) patients had died with a functioning catheter in situ. Catheter infection was implicated in four deaths. Conclusions. Radiological insertion of the AshSplit catheter is well tolerated, providing reliable short- and long-term dialysis access. Radiology also has a role in maintaining patency. As with all tunnelled catheters, infection remains a problem.

Keywords: access; catheters; haemodialysis; long-term; split; tunnelled

Introduction

The arteriovenous (AV) fistula remains the reliable access route of choice for haemodialysis, but many patients require alternative access. This can be temporary while a fistula matures, or as alternative permanent access in patients in whom successful fistula surgery is not an option. Tunnelled haemodialysis catheters were traditionally placed in the operating theatre by surgeons. The advent of new catheters and interventional radiology techniques has seen a change in practice and radiological insertion has been shown to be safe and well tolerated [1,2]. There are many different types of permanent catheter available. Dual lumen single catheters have been used widely but performance can be affected by poor flow and high access recirculation rates [3]. More recently the twin single lumen catheter was introduced in an attempt to overcome these problems but the need for dual venous punctures and tunnels prolongs the procedure time and increases the risk of complications [4]. The AshSplit haemodialysis catheter (Medcomp, Harleysville, PA) combines the advantages of the single puncture insertion technique with the benefits of improved flow and reduced recirculation associated with two free-floating i.v. lumens [5]. The purpose of our study was to assess the radiological insertion and ongoing function of this new catheter. The Dialysis Outcomes and Quality Initiative (DOQI) guidelines [6], first published in 1997, were taken as the gold standard with which to compare performance.

Subjects and methods

It is renal unit policy to refer all patients for permanent catheter insertion to an interventional radiologist. All patients referred to the radiology department for insertion of an AshSplit haemodialysis catheter between January 1998 and March 1999 inclusive were included in the study. Follow-up data was collected until the end of September 1999 (21 months).

All insertions took place in the interventional angiography room under strict sterile conditions. Catheter insertion was...
performed by one of a team of five interventional radiologists (three consultants and two senior trainees). The timing of insertion was planned to be just before the next dialysis session and, unless patients were hospitalized for another reason, procedures were performed on a day-case basis. Conscious sedation (midazolam hydrochloride) was used in most patients, with continuous monitoring. Prophylactic i.v. antibiotics (cefuroxime 750 mg) were given routinely by four of the five operators (87.3%).

Using aseptic techniques, preferably the right internal jugular vein (IJV) was accessed with direct ultrasound guidance in all cases. A low, central approach to the vein, between the heads of sternocleido-mastoid, was chosen. The IJV was punctured with an 18-gauge cannula, and a 0.035 in guide-wire was then passed through the cannula and fluoroscopically guided through the right atrium to the inferior vena cava. At this stage the subcutaneous tunnel was fashioned over the anterior chest wall. The skin along the proposed site of the tunnel was infiltrated with local anaesthetic and the tunnelling device provided, with the tip of the catheter attached, was advanced from chest wall to vein puncture incision, so that the Dacron cuff was at least 2 cm within the tunnel. The vein puncture was then sequentially dilated up to 16 French and the peel-away sheath from the catheter kit inserted into the SVC. The two lumens of the catheter were then split proximally to the mark between the heads of sternocleido-mastoid, was chosen. The catheter tips were then positioned in the right atrium with repeat fluoroscopic confirmation or kinking. Two catheter lengths are available, 28 and 32 cm, and the choice was based on side of insertion and body habitus of the patient. The catheter tips were positioned at the proposed site of the tunnel was infiltrated with local anaesthetic and the tunnelling device provided, with the tip of the catheter attached, was advanced from chest wall to vein puncture incision, so that the Dacron cuff was at least 2 cm within the tunnel. The vein puncture was then sequentially dilated up to 16 French and the peel-away sheath from the catheter kit inserted into the SVC. The two lumens of the catheter were then split proximally to the mark on the catheter before they were advanced into the IJV through the peel-away sheath, which was pinched by the operator’s assistant to reduce the risk of air embolism. Good alignment of the two lumens was ensured to avoid compression or kinking. Two catheter lengths are available, 28 and 32 cm, and the choice was based on side of insertion and body habitus of the patient. The catheter tips were positioned in the right atrium with repeat fluoroscopic guidance. Both lumens were then locked with the exact placement (midazolam hydrochloride) was used in most patients, with continuous monitoring. Prophylactic i.v. antibiotics (cefuroxime 750 mg) were given routinely by four of the five operators (87.3%).

Awaiting referral for CAPD 1 (1.1%)
Short-term haemodialysis anticipated 10 (11.4%)

Table 1. Reason for referral for catheter placement

<table>
<thead>
<tr>
<th>Reason for Referral for Catheter Placement</th>
<th>No other venous access possible</th>
<th>Awaiting fistula creation</th>
<th>Short-term haemodialysis anticipated</th>
<th>Awaiting referral for CAPD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37 (42%)</td>
<td>40 (45.5%)</td>
<td>10 (11.4%)</td>
<td>1 (1.1%)</td>
</tr>
</tbody>
</table>

Between January 1998 and March 1999 inclusive, 88 patients were referred to the radiology department for insertion of 118 tunnelled permanent haemodialysis (AshSplit) catheters, giving a total catheter duration of 21 600 days. Over the study period, 68 (77%) patients had one catheter inserted, 14 (16%) patients had two catheters inserted, five (7%) patients required three catheters, and one patient had five catheters inserted. The patient cohort comprised of 50 (57%) males and 38 females with a median (range) age of 64 (20–86) years. The reasons for referral for catheter placement are detailed in Table 1.

The right IJV was used in 80 (68%) cases. One hundred and four insertions (88%) were uncomplicated. Table 2 details complications occurring at the time of insertion. The two cases (1.7%) of air embolism were the only complications listed in the DOQI...
guidelines that occurred, neither of which required any active management. The four carotid artery punctures were all detected at time of initial needle insertion, and only required pressure haemostasis.

All catheters functioned adequately for the first haemodialysis session giving a primary placement success rate of 100%. Eighty-eight catheters (74.6%) were still functioning at 3 months and 56 catheters (47.5%) at 6 months after insertion. The mean duration of all catheters was 190 days (range 5–587). By the end of September 1999, 20 (17%) catheters were still functioning with a mean duration of 334 days (range 9–310). Seventy-six (64%) catheters were no longer in situ, either because of elective removal (mean 195 days; range 69–473) or catheter failure (mean 133 days; range 9–380). Twenty-two (25%) patients had died with a catheter in place (mean 145 days; range 5–487). The reasons for catheter removal are listed in Table 3.

Of the 22 patients who died with a functioning catheter, four deaths were thought to be related to catheter complication: staphylococcal sepsis in three cases, and bacterial endocarditis in one. Overall mortality related to catheter complications was, therefore, 4.5% of patients.

Forty-seven re-intervention episodes were required in 24 (20.3%) catheters in the 21-month follow-up period, involving 18 (15.3%) patients. These occurred a mean of 159 days (range 5–476) following insertion. The most common reason was because of poor function due to fibrin sheath and/or catheter thrombus. Ten catheters required more than one re-intervention procedure during the lifespan of the catheter (five required two interventions, one required three, and four required more than three). The maximum number recorded was six in two different patients and catheters. This spanned a period of 11 and 8 months, respectively, and at the end of the study period the latter catheter was still functioning with duration of 372 days. The other catheter was eventually replaced because of persistent problems with thrombus after catheter duration of 380 days.

**Cumulative survival**

The Kaplan–Meier survival probability for all catheters, excluding elective removals and those functioning at the time of death, was 78% at 30 days, 54% at 90 days, and 30% at 180 days.

### Table 2. Complications occurring at time of catheter insertion

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number (% of all catheters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged bleeding at puncture site or tunnel</td>
<td>6 (5.1%)</td>
</tr>
<tr>
<td>Carotid artery puncture</td>
<td>4 (3.4%)</td>
</tr>
<tr>
<td>Symptomatic air embolism</td>
<td>2 (1.7%)</td>
</tr>
<tr>
<td>Pneumothorax (not requiring chest drain)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Catheter wall perforation</td>
<td>1 (0.8%)</td>
</tr>
</tbody>
</table>

*Four cases occurred with heparin lock of 5000 U/ml, two since heparin lock reduced to 1000 U/ml.
Only complication classified under DOQI guidelines.

### Table 3. Status of catheters at follow-up

<table>
<thead>
<tr>
<th>Catheter status</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functioning catheter</td>
<td>20 (16.9%)</td>
</tr>
<tr>
<td>Functioning catheter at death</td>
<td>22 (18.6%)</td>
</tr>
<tr>
<td>Elective removal (n = 39)</td>
<td></td>
</tr>
<tr>
<td>AV fistula</td>
<td>34 (28.8%)</td>
</tr>
<tr>
<td>Transplanted</td>
<td>3 (2.5%)</td>
</tr>
<tr>
<td>Recovered function</td>
<td>1 (0.85%)</td>
</tr>
<tr>
<td>Started CAPD</td>
<td>1 (0.85%)</td>
</tr>
<tr>
<td>Removed for malfunction (n = 37)</td>
<td></td>
</tr>
<tr>
<td>Catheter infection</td>
<td>18 (15.3%)</td>
</tr>
<tr>
<td>Thrombosis/poor flow</td>
<td>12 (10.2%)</td>
</tr>
<tr>
<td>Displaced catheter</td>
<td>6 (5.1%)</td>
</tr>
<tr>
<td>Catheter perforation</td>
<td>1 (0.85%)</td>
</tr>
</tbody>
</table>

### URR

Monthly URR data was obtained for 109 catheters for the duration of catheter function. Data from the remaining nine catheters was not available due to the short nature of the catheters’ functioning lifespan. An overall mean (SD) URR of 63.2 (7.3) was obtained for all catheters.

### Infection

There were 29 episodes of exit-site infection documented affecting 18 catheters, equivalent to 1.3 episodes per 1000 catheter days. I.v. antibiotics were given in 63 cases for suspected systemic catheter infection, usually because of pyrexia or systemic illness; subsequent positive blood cultures were documented in 51 cases, affecting 40 (34%) catheters. This corresponds to an overall systemic infection rate of 2.4 per 1000 catheter days. Twenty-two (18.6%) catheters became infected within the first 3 months and 18 (15.3%) documented infections occurred in catheters of greater than 3 months’ duration. *Staphylococcus aureus* was the most common organism isolated.

A subgroup of the catheter population (12 patients, 13.6%) was methicillin-resistant *S. aureus* (MRSA) positive, which included colonization of the catheter. MRSA was successfully treated in five of these patients following systemic antibiotic therapy with vancomycin. Of the remaining seven catheters, four continued to function despite being colonized and three were removed because of infection. Catheter removal because of persistent infection was required in 18 cases (15.3% or 0.83 per 1000 catheter days). Removal occurred a mean of 143.4 days (range 17–340 days) following insertion. Systemic infection requiring removal occurred within 3 months of insertion in eight catheters (6.8%).

### Catheter malfunction and thrombosis

Catheter thrombus was documented by contrast study on 25 occasions, affecting 24 catheters (1.16 per
Discussion

Adequate haemodialysis relies on secure and reliable venous access. The AV fistula remains the access route of choice and should be considered in all patients [6]. Some patients, however, are not suitable for fistula surgery because of poor venous anatomy or coexisting medical problems. As the average age of the dialysis population increases, this subgroup also increases in number. A separate problem is providing vascular access in the short to medium term for patients who are awaiting maturation of a fistula, renal transplantation or conversion to CAPD.

The advent of the tunnelled haemodialysis catheter has produced an alternative access route that finds a role in providing reliable venous access for both the medium and long term and use of these catheters has become integrated into the modern nephrology service [3]. Traditionally these catheters were placed surgically in the operating theatre, but recent advances in interventional radiology techniques have seen a trend towards non-surgical insertion [1,2]. This has many advantages for the patient, as the procedure is performed on a day-case basis without the need for a general anaesthetic. The final position of the catheter is crucial in providing good flow and the use of ultrasound and fluoroscopy are advantageous in securing good placement. An integrated renal and radiological service is able to provide ongoing support in the investigation and management of malfunctioning catheters [8]. Initial concerns that radiological insertion would result in increased infection rates have proved unfounded [1,2].

The patient population in this study is relatively elderly (median age 64 years), consistent with the dialysis population in Britain [9]. Alternative vascular access is a problem in this population and this is reflected by the requirement of a permanent catheter in 42% of our group. At any point in time approximately 40% of our haemodialysis population are dialysing via a catheter. In half of these the catheter is providing short-term access, giving a permanent catheter dialysis population of approximately 20%.

Twenty-two patients died during the study period with a functioning catheter in situ. This relatively high mortality rate reflects not only the reduced life expectancy associated with end-stage renal disease, but also the fact that many of our patients had multiple coexistent medical problems. Our catheter mortality rate of 4.5%, although higher than some of the American studies [1,2], is comparable with another British study [3], which reported a catheter mortality rate of 3.9% and may be explained by differences in patient demographics and infection rates.

Reports of the risks of venous stenosis in patients with subclavian catheters have seen a change in practice away from subclavian catheterization to internal jugular placement [10]. Our figures show that the IJV was used for the placement of over 90% of catheters in accordance with the DOQI guidelines [6].

Immediate complications occurred in 12% of insertions. The majority of these related to bleeding at the puncture site, or the tunnel, which was self-limiting and did not require evacuation or further treatment. Local bleeding is relatively common in dialysis patients because of platelet dysfunction and other authors have concluded that it should not be considered as an immediate complication [1]. It is worthy of note that four cases of prolonged bleeding occurred in our cohort in the first 3 months when a heparin lock of 5000 iU/ml was used. The decision was made to reduce this concentration to 1000 iU/ml for the initial lock, and only two cases occurred in the next 12 months. From the list of complications cited by DOQI, we only had two cases of symptomatic air embolism, not requiring treatment. Both occurred in technically difficult cases, resulting in an immediate complication rate of less than 2%. These complication rates compare favourably with other studies of radiological insertion [1,2] and are better than rates of approximately 6% quoted for surgical insertion [11,12].

Prophylactic antibiotics were used in the majority (87%) of procedures. There is debate within the literature as to the need for antibiotics at the time of insertion and many centres do not give antibiotics routinely [1,2]. Antibiotics were given routinely by four out of five of the radiologists, with no obvious variation in infection rates.

We experienced no initial catheter failures, giving a primary function rate of 100%. This is better than previous studies, which report primary failure rates of between 1.7 [9] and 6% [13]. This success can be related to a combination of ultrasound and fluoroscopy, which guides initial puncture and final placement of the catheter. The Seldinger technique is also less traumatic to the vein than direct surgical cut-down [14].

Catheter performance was audited from the time of insertion to the time of removal or the end of the follow-up period. Therefore, the minimum length of follow-up was 6 months and less than 1 year for many of the functioning catheters. One-month patency figures of 87% and survival probability (as estimated by the Kaplan–Meier method) of 85% compare very
favourably with data from other studies. Trerotola et al. reported a 1-month survival of 81% with the Quinton catheter [1].

Overall patency and survival rates are important but the adequacy of haemodialysis delivered by the catheter is probably the most useful assessment of long-term function. The AshSplit catheter is capable of higher flow rates in a clinical setting than conventional catheters [5]. The monthly assessment of haemodialysis adequacy provides an indication of flow delivered by the catheter and, in turn, this can be used to identify problems with lumen patency and position. Analysis of available data for the catheters in our study gives a mean URR of 63.2. These figures are just below the local recommended limits for all haemodialysis patients of 66, indicating that the AshSplit catheter provides reliable vascular access over the life span of the catheter. Analysis of the mean monthly figures shows a trend towards higher URR, i.e. better performance with longer catheter duration. One explanation for this is that over the long term, failing catheters have been removed or exchanged to reveal a subset of catheters that provide consistently good blood flow and performance.

Radiological re-intervention has been shown to have a valuable role in the ongoing management of permanent catheters [7,15]. The formation of fibrin sheaths around the catheter lumens is a recurrent problem in a subset of patients and, at present, is difficult to prevent. Stripping using a goose-neck snare technique has proved valuable in restoring flow in such cases and this technique can be safely applied on more than one occasion as our results testify. Our figures for re-intervention suggest that recurrent problems with thrombosis and fibrin sheath formation are confined to a subset of problematic catheters and patients and prompt treatment can be successful in prolonging catheter function [7,8].

Catheter infection remains one of the major reasons for removal and failure. Many studies quote infection rates as a proportion of all catheters placed or patients involved, but this can be misleading as it ignores the influence of catheter duration. When this is included, the infection rate can be quoted as number of events per 1000 catheter days, and this is probably the most accurate assessment [1,3]. Our rate (2.4) compares favourably with that quoted of between 1.6 and 3.36 infections per 1000 catheter days in recent series [1–4].

In our series, of the 51 positive blood cultures identified, many resolved after a single dose of i.v. antibiotic therapy and further cultures were sterile. For the purposes of this study all such cases were included as systemic infection regardless of the number of positive cultures. Neilson et al. have shown that positive line cultures are not a good indicator of sepsicaemia and peripheral cultures are more reliable [16]. It is standard practice in our unit to check both peripheral and catheter blood when infection is suspected. Despite scrupulous sterile technique bacterial colonization of indwelling catheters is inevitable. Dittmer et al. with a prospective study, showed a mean time to colonization of 27 days and all catheters were colonized by 16 weeks [17].

Our 3-month infection rate of 18.6% exceeds the 10% figure quoted by the DOQI guidelines [6], but only just over one-third of infected catheters required removal for persistent infection. This is comparable with the rate quoted by Gibson et al. of 28% [3]. A recent survey of dialysis practice in the UK has shown a poor awareness of the problems associated with catheter infection, with as many as 76% of units surveyed admitting that catheter infection rates are not audited [9]. The need for continual assessment with revision of local practices is important and regular monitoring of catheter patients (including surveillance cultures) could be valuable in reducing the infection rates, particularly in at-risk groups such as those infected with MRSA [16,17]. The use of antibiotics during insertion is debatable and often follows long-held hospital practices dating from surgical insertion. Despite the variable policy of antibiotic cover at the time of insertion of our catheters, there is no evidence that any catheter infection was directly related to the insertion procedure.

After infection, thrombosis is the other main cause of secondary catheter failure. Direct comparisons can be difficult because of the various figures quoted and definitions used. For the purpose of our study, we only included those with contrast study-proven catheter thrombus and not simply those where poor flow was documented during dialysis, as there are alternative explanations for this, other than thrombus. Thrombosis rates of between 16 and 42% are quoted (current series 20%) [1–4,18]. Removal rates due to thrombosis are less prone to variation and our rates are lower than other large series (10 vs 13–28%) [1,2].

The use of urokinase locks in our renal unit was found to be ad hoc, with approximately 30% of patients receiving regular urokinase. This practice of ‘prophylactic’ urokinase is not well founded in the literature and has significant budgetary implications. Instillation of a thrombolytic at the onset of catheter dysfunction is usually effective in restoring catheter patency [8].

Conclusions

The AshSplit catheter has become established as a credible alternative for vascular access in haemodialysis. Radiological insertion of the catheter is well tolerated by patients and associated with low complication rates. Satisfactory levels of haemodialysis adequacy have been demonstrated and the catheter has been shown to perform reliably both in patients requiring temporary and permanent vascular access. Patency rates are encouraging and radiology has a significant role to play in maintaining and prolonging catheter function. Catheter infection and thrombosis
are the major limiting factors with significant associated cost implications for re-intervention and hospitalization. More work is needed to reduce these problems to an acceptable level. Nevertheless, the AshSplit catheter provides a valuable means of permanent vascular access for a high proportion of patients and continued follow-up of this new catheter’s performance is needed to evaluate its role over the long term.

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