Translumbar central venous catheters for long-term haemodialysis

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Abstract

Background. Vascular access for haemodialysis is achieved by tunnelled central venous catheter (CVC) in at least 23% of prevalent patients in the UK, Canada and the USA. Use of CVCs is associated with an increased incidence of venous stenosis that can progressively limit fu-
ture vascular access routes. Lack of conventional venous access routes mandates the use of alternative strategies such as the translumbar approach.

**Methods.** We retrospectively analysed patients at our centre requiring translumbar inferior vena caval CVCs (Tesio-Cath) for haemodialysis in the period 1999–2008. Written and electronic records capturing dialysis adequacy and complications, hospital admissions and laboratory data were examined.

**Results.** Thirty-nine pairs of translumbar CVCs were inserted in 26 patients with 15 864 catheter days follow-up, mean patient age 61.9 ± 12.1 years, 31% diabetic, 15% with ischaemic heart disease. All insertions were successful. Insertion of one CVC was associated with a self-limiting retroperitoneal haematoma. No patients died of a catheter-related cause or through lack of vascular access. Cumulative assisted primary catheter site patency was 81% at 6 months and 73% at 1 year (median 18.5 months). Good dialysis adequacy was achieved throughout (mean single-pool Kt/V 1.5 ± 0.4). The incidence of access-related infection was 2.84/1000 catheter days (exit site infection rate 2.02/1000 catheter days; catheter-related bacteremia rate 0.82/1000 catheter days). Catheter dysfunction (need for thrombolytic infusion or catheter change) led to 0.88 admissions per 1000 catheter days.

**Conclusion.** Translumbar inferior vena cava CVCs can offer relatively safe and effective long-term haemodialysis access in patients with no other options.

**Keywords:** haemodialysis; inferior vena cava; tunneled venous catheter; vascular access

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**Introduction**

Long-term haemodialysis requires the formation and maintenance of effective vascular access. The use of arteriovenous fistulae (AVF) is widely advocated where possible based upon a lower rate of complications [1–3]. Despite this, a large proportion of haemodialysis patients start and continue haemodialysis with a central venous catheter (CVC). Twenty-three to seventy-three percent of the patients started haemodialysis with a CVC, and 23–41% of the established patients continued with a CVC in an analysis of the Dialysis Outcomes and Practice Patterns Study [4]. Several factors contribute to enduring CVC use including patient and clinician preference [5,6] and a lack of access options related to female gender [7,8], a history of prior venous catheterisation [4] and the presence of diabetes [8].

CVCs are associated with an increased risk of access-related infection compared to AVFs and prosthetic grafts [9]. Rates of catheter-related infection have, however, been decreasing over the past decade with the use of newer catheter technology and catheter care protocols [10–12]. Endoluminal thrombosis [13] and a risk of central venous stenosis [14,15] remain a concern for a proportion of patients. As the number of accessible venous routes diminishes, achieving effective venous access becomes more challenging. Elaborate vascular surgical procedures have evolved to bypass stenoses with the interposition of prosthetic graft material to create a patent arteriovenous circuit that supports haemodialysis [16,17]. Extensive surgery may not be acceptable or feasible, and concerns exist about poor long-term patency and infection rates. Unconventional approaches are possible when all surgical and endovascular options for arteriovenous access creation or maintenance are exhausted. One option is to insert a CVC via an unconventional approach into a central vein, and amongst others, transhepatic and transrenal routes into the inferior vena cava (IVC) have been described in the literature [18–20].

The translumbar approach to cannulation of the IVC was first described over 20 years ago [21]. Since then, there have been a number of reports of this approach for haemodialysis access in the paediatric and adult literature [22–25]. A series of 17 catheters was published demonstrating good safety with poor long-term access survival (17% patency at 1 year) [25]. We have favoured this unconventional approach and describe a large and comprehensive series with long follow-up of the translumbar route for long-term haemodialysis access.

**Subjects and methods**

This retrospective study identified all patients who had a translumbar inferior vena caval CVC of a single type, the Bio-Flex™ Tesio® Cath (MedComp, Harleysville, PA, USA) inserted from 1st January 1999 to 16th June 2008 at our centre. The West London Renal and Transplant Centre provides renal services to a population of over 2 million people, caring for a total of 1200 maintenance haemodialysis patients who receive their treatment with the same protocol for care applied across nine satellite dialysis units. All aspects of haemodialysis care are subject to a centralized consultant-led audit on a monthly basis including dialysis adequacy, access type and infection, water quality and anaemia management. Paper and electronic records relating to inpatient episodes were examined, and laboratory, radiological and dialysis data were analysed.

**Dialysis access**

All patients were considered for formation of an AVF, and this was encouraged when suitable vessels existed. CVCs were inserted when there was a lack of suitable vessels for first or subsequent access formation determined by clinical examination and independent surgical review if doubt existed. Some patients chose to have a CVC from the outset through a perception of ease-of-use, despite advocating the advantages of AVF. Translumbar inferior vena caval CVCs were inserted when other AVF and CVC approaches had been exhausted in the superior vena cava circulation. Screening for central venous occlusion was conducted using conventional central venography and/or computed tomographic (CT) angiography. Bilateral brachiocephalic venous and/or superior vena cava occlusion and the absence of large, accessible thoracic collateral veins for CVC placement were indications for the translumbar approach. Patency of the IVC was confirmed by conventional venography via the transfemoral route.

**Translumbar CVC insertion**

All translumbar CVCs were inserted by one experienced interventional radiologist (MH). Two 75 cm, 10 Fr single lumen Bio-Flex™ Tesio® Cath lines were inserted under fluoroscopic guidance into the IVC. All patients received local anaesthesia and moderate sedation. An angiographic 0.035-inch guidewire was inserted into the IVC to act as a marker using a 4-French (Fr) sheath via a common femoral venous approach under ultrasound and fluoroscopic guidance. The patient was then placed in the prone position with 25° elevation of the right side. The puncture site was chosen approximately one hand-breadth (8–10 cm) from the midline on the right side of the patient as determined by palpation of the lumbar spinous processes and the lower level of L3 vertebra (a point just cephalad to the right iliac
serves) to avoid puncturing the renal vein. A micropuncture was made with a 21-gauge (G) Acustick(TM) II Introducer System (Boston Scientific, Natick, MA, USA) into the IVC under fluoroscopic guidance with an angle of approach towards the anterior aspect of the L3 vertebra and the guidewire target. In the case of br-i-liae venous occlusion, the IVC was punctured directly below level of the renal veins under CT guidance obviating the need for a guidewire target. Upon aspiration of venous blood, position of the needle tip was confirmed with contrast. A 0.018-in wire was subsequently inserted into the IVC, and a 5-Fr dilating sheath was introduced over this into the IVC. Then an Amplatz stift 0.035-in wire (Boston Scientific, Natick, MA, USA) was inserted via the sheath, and over this, a peel-away 8-Fr dilating sheath (Cook Inc, Bloomington, IN, USA) was introduced. A second Amplatz stift 0.035-in wire was inserted next to the first one through the original 8-Fr sheath and IVC puncture site, and two peel-away 11-Fr dilating sheaths were inserted over both wires. The CVC lines were then inserted over the wires and individually advanced with the tips confirmed to be in the right atrium or right atrial/inferior vena cava junction by fluoroscopic imaging. The lines and cuffs were then tunnelled by creating two discrete tracts using the tunnelling devices from the venous entry site to the right flank with the skin exit points aimed at the anterior axillary line and above the level of the belt. Each catheter was then filled with 5000 U/ml unfractionated heparin to the volume of the catheter lumen.

CVC care
All CVCs were handled by trained staff using aseptic technique. The exit site was cleaned at the start of each dialysis session with 4% chlorhexidine gluconate solution (Hibiscrub®, Molnlycke Healthcare, Manchester, UK) for 1 min before being allowed to dry in air and a new bio-occlusive dressing was applied. Two percent mupirocin (Bactroban® Nasal Ointment, GlaxoSmithKline UK, Uxbridge, UK) was applied routinely to the exit site for 1 min before being allowed to dry in air and a new bio-occlusive dressing was applied with the tips confirmed to be in the right atrium or right atrial/inferior vena cava junction by fluoroscopic imaging. The lines and cuffs were then tunnelled by creating two discrete tracts using the tunnelling devices from the venous entry site to the right flank with the skin exit points aimed at the anterior axillary line and above the level of the belt. Each catheter was then filled with 5000 U/ml unfractionated heparin to the volume of the catheter lumen.

Microbiological screening
Quarterly screening of all patients for nasal and exit site carriage of methicillin-resistant Staphylococcus aureus was adopted as routine practice at our centre in 2007. All patients returning to their satellite dialysis unit after an inpatient admission were screened with additional swabs of their throat, axilla and groin. Patients with positive nasal or exit site swabs were treated four times daily for a 5-day course with topical 2% mupirocin ointment nasally and to the exit site.

Dialysis adequacy
Patients were dialysed three times weekly using low-flux synthetic AM-BIO-1000Wet haemodialysers (Asahi Kasei Medical Europe GmbH, Frankfurt, Germany) with Gambro AK-100 or AK-200 (Gambro AB, Stockholm, Sweden) dialysis machines during 1999–2005 and Braun Dial machines (B. Braun Medical Inc, Bethlehem, PA, USA) from 2005. Dialysis session length ranged from 2.5 to 5 h. Dialysis adequacy was measured by single-pool Kt/V (spKt/V) on a monthly basis using the Daugirdas method [26]. Dialysis prescription was tailored to achieve a spKt/V of ≥1.6. In patients failing to achieve this target, haemodialysers were replaced. Blood flow was increased, blood flows were increased to ≥350 ml/min, dialysate flow rates were adjusted to ≥500 ml/min and access recirculation was assessed by a urea-based method and if necessary access was changed.

Systemic sepsis
Pyrexia was defined as a tympanic temperature of ≥38°C, and all patients with pyrexia with or without a systemic inflammatory response were investigated with exit-site swabs, multiple blood cultures drawn from the catheter itself and from peripheral veins and urine and sputum culture where appropriate to circumstances. Samples were obtained prior to starting antibiotics. Sepsis was presumed to be catheter-related if there was no clinical or microbiological evidence of another source. Antibiotic starts were pre-empted microbiological confirmation of infection and followed a defined protocol. Subsequent therapy was tailored to antibiotic sensitivities, and proven or suspected CVC infections were treated for a minimum duration of 2 weeks. Catheter-related bacteremia (CRB) was defined as per established standards [27]. Catheter salvage was attempted where clinically appropriate. Catheter-related sepsis was defined as the clinical presence of sepsis with growth of organisms in the blood and/or the catheter tip (where catheter removal occurred) with no evidence of alternative source of infection and similar to established reporting standards [27]. Catheter-related infection resulting in hypotension requiring inotrope support, persistent bacteremia despite antibiotics and tunnel infection lasting more than 3 days despite targeted intravenous antibiotic therapy were indications for catheter removal.

CVC infection—exit-site infection
Exit-site swabs were taken if there was exudate with or without pain, crusting, erythema or induration at the exit site. Infection limited to the exit site and in the absence of pyrexia was treated with oral agents according to determined antibiotic sensitivities for a minimum of 2 weeks. Febrile patients were treated as for systemic sepsis described above.

CVC infection—tunnel infection
Tunnel infections were defined by pain, redness or induration along the subcutaneous course of the line, with or without exudates at the exit site and were treated from the outset with intravenous vancomycin and oral ciprofloxacin. These antibiotics were adjusted when culture results were available with the addition of a second appropriate oral antibiotic for a minimum of 6 weeks. Persisting infection was an indication for CVC removal as detailed above.

CVC dysfunction
The target blood flow for CVCs was ≥350 ml/min. CVC dysfunction was identified by consistently suboptimal blood flow of <250 ml/min and/or declining dialysis adequacy. Three consecutive falls in monthly spKt/V, irrespective of magnitude, defined declining dialysis adequacy. Catheter displacement or kinking was excluded by plain X-ray. Subsequently, 5000 units of urokinase was instilled into each lumen for 2 h as a locking solution, and dialysis was re-attempted on an outpatient basis. If this failed, patients were admitted to the ward for a 12-h intraluminal infusion of 12 500 units urokinase as previously described [28]. Failure of thrombolytic strategies mandated catheter replacement. Oral antiplatelet or anticoagulant agents were not used with intent to improve blood flow rate.

Statistics
Parametric data were analysed using Student’s t-test, categorical variables were compared using chi-square or Fisher’s exact test as appropriate and timeline incidence data were analysed using a Poisson model. Kaplan–Meier survival analysis was made on an intention-to-treat basis for patient survival and CVC-assisted primary catheter site patency [29]. Statistical significance was defined by P < 0.05. STATISTICA 9.0 (StatSoft Inc, Tulsa, OK, USA) and StatsDirect 2.7.4 (StatsDirect, Altirincham, Cheshire, UK) were used to perform statistical analysis.

Results
Thirty-nine pairs of translumbar inferior vena cava CVCs were inserted in 26 patients, with experience of 15 864 catheter days total follow-up. The mean length of follow-up was 13.3 ± 15.5 months (range 0.2–81.6). Thirty-five percent of the patients were over 65 years old, with similar numbers of whites (n = 14) and non-whites (n = 12). Diabetes mellitus was the cause of end-stage renal disease for 3/26 patients.
Mean age at insertion for diabetics was 65.1 ± 11.1 vs 60.2 ± 12.5 years in non-diabetics (P = 0.3); both groups were of equivalent haemodialysis vintage, 4.7 ± 2.4 vs 6.2 ± 3.6 years, respectively (P = 0.3). Overall, patients were established on haemodialysis for a mean duration of 5.9 ± 3.2 years before they required a translumbar catheter (range 0–12.9 years) (Table 1). Twenty-one of twenty-six (81%) patients had at least one arteriovenous haemodialysis access (AVF or Arteriovenous graft, AVG) prior to receiving a translumbar CVC. Patients had a mean of 4.2 vascular accesses prior to requiring a translumbar CVC (mean 3.0 ± 1.3 CVCs, 1.0 ± 0.9 AVFs, 0.5 ± 0.7 AVGs). All patients had bilateral brachiocephalic venous occlusions, and 8/26 had concurrent superior vena caval occlusion.

### Catheter function and dialysis adequacy

All translumbar CVCs were placed successfully and functioned immediately after insertion with immediate blood flow rates that did not exceed 300 ml/min. Catheter tips rested in the right atrium in 18/37 cases and the right atrial/inferior vena cava junction in 20 cases reflecting patient habitus as well as upper venous anatomy. Subsequent mean monthly blood flow rate for all catheters was 300 ± 3 ml/min (range 100–450 ml/min; median 307 ml/min). The mean spKt/V was 1.5 ± 0.4 over the course of the study. There was a trend to a higher mean spKt/V (from 1.2 to 1.6) over time reflecting an increase in the target for minimum spKt/V at our unit from 1.4 to 1.6 (Figure 1). An spKt/V ≥ 1.2 was achieved in 87.2% of patients, and an spKt/V ≥ 1.4 was achieved in 71.8%.

### Patient survival

Cumulative patient survival was 81.5% at 1 year, 68.1% at 2 years and 51% at 3 years, censoring for change of dialysis modality, transplantation and transfer to another unit. No patients died as a result of lack of vascular access options or CVC related infection. Diabetic comorbidity did not significantly affect patient survival (logrank χ² = 0.593, P = 0.4).

By comparison, there was no significant difference in cumulative patient survival between the translumbar CVC cohort and a previously published cohort of 435 patients with jugular CVCs from our centre [30]—84.7% at 1 year, 71.4% at 2 years and 63.0% at 3 years (logrank χ² = 1.10, P = 0.3) (Figure 2). Of note, both cohorts were similar with respect to age and major comorbid conditions but different with respect to gender predominance (Table 2).

### Translumbar CVC patency

Cumulative assisted primary CVC site patency was 73.2% at 1 year, 33.4% at 2 years and 27.9% at 3 years, censoring...
for death with functioning CVC, change in dialysis modality, transplantation and transfer to another unit (Figure 3). The presence of diabetes did not significantly affect CVC patency (logrank $\chi^2 = 2.96, P = 0.09$). By comparison, the jugular CVC cohort from our centre [30] had an assisted primary CVC site patency of 77.8% at 1 year and 44.0% at 3 years. The difference between the two groups did not reach statistical significance (logrank $\chi^2 = 1.58, P = 0.2$) (Figure 4).

Sepsis

The incidence of catheter-related infection was 2.84/1000 catheter days (95% confidence interval, CI, 2.07–3.80) (Table 3). There were 32 episodes of exit-site infection (including one Pseudomonal tunnel infection). There were 13 episodes of CRB, a rate of 0.82/1000 catheter days. Bacteraemia was due to two organisms in 2/13 episodes. There were 19 hospital admissions for all-cause infection. Nine of nineteen (47%) were due to proven or presumed catheter-related sepsis (Table 3). The mean duration of admission due to catheter-related sepsis was 12.7 ± 10.9 days (range 2–34 days). Eleven of fifteen (73%) of pathogenic isolates were Gram-positive bacteria.

Catheter dysfunction

Four of thirty-nine (10.3%) catheters dislodged and required replacement. Catheter dysfunction requiring urokinase infusion occurred in 10 catheters, a rate of 0.63/1000 catheter days (95% CI, 0.30–1.16). Nine of thirty-nine (23.1%) catheters required replacement for persistent dysfunction (Table 3).

Bleeding complications

The insertion of one catheter was associated with a self-limiting retroperitoneal haematoma that was managed conservatively and no blood transfusion required. A second retroperitoneal bleed occurred following catheter displacement. There were no other complications.

Discussion

The number of patients receiving haemodialysis in the US is increasing on an annual basis, reaching nearly 320 000 by the end of 2006 [31]. Despite national and international guidelines and initiatives such as Fistula First [32] recommending the AVF as the vascular access of choice [1–3],
the number of haemodialysis patients using CVCs increased by 50% in the US 1998–2004 [33]. The problem posed by difficult vascular access in patients dependent on CVCs is likely to increase. There is a small number of studies to date reporting on translumbar catheters for haemodialysis [22,25,34].

Cumulative 1- and 2-year haemodialysis patient survival of 81.5 and 68.1% in this series is comparable to contemporary UK Renal Registry data of 80.9 and 69.0% [35] and to US Renal Data Service (USRDS) data of 79.2 and 65.4%, respectively [31]. However, patient survival is less than that of a contemporary cohort dialysing via internal jugular

Fig. 3. Cumulative translumbar CVC survival. Numbers at risk shown in black font.

Fig. 4. Cumulative CVC survival characterized by site of insertion. Translumbar CVCs, solid line; internal jugular CVCs, Duncan et al. [30], dashed line. Numbers at risk shown in bold—translumbar CVCs and italics—internal jugular CVCs. Differences in patient demographics described in Table 2.
Catheter-related bacteraemia 0.82 (0.44–1.40)
Exit-site infections 2.01 (1.38–2.85)
All-cause hospital admission 3.97 (2.05–5.08)
Access-related hospital admission due to CVCs 1.45 (0.92–2.16)
All infection-related hospital admission 1.19 (0.72–1.87)
Access infection-related hospital admission 0.57 (0.2–1.08)
Access dysfunction-related 0.88 (0.48–1.48)

Incidence rates as events/1000 catheter days with 95% confidence intervals.

CVCs at our centre [30]. Patients requiring translumbar access had a longer haemodialysis vintage and therefore very likely carried a higher burden of comorbidity including cardiovascular disease.

Mean assisted primary catheter site patency was much longer than that reported by Biswal et al. in a series of 10 translumbar CVCs [34] and exceeds that reported by Lund et al. (17% at 1 year) [25]. Patient demographics and comorbidities are not reported in detail in either paper and may have accounted for some of the differences seen. Catheter patency is lower than for the contemporary cohort with internal jugular access [30]. This is not unexpected as patients requiring translumbar access have a history of recurrent access dysfunction which likely compromises further access function.

We report good access flow rates for translumbar haemodialysis catheters. Lund et al. report in limited detail an achieved flow rate of between 200 and 300 ml/min in a series of 15 catheters that were inserted for haemodialysis and two for plasmapheresis [25]. The mean blood flow rate of 300 ml/min in our series is comparable to that reported in a series of 184 internal jugular TesioCaths (291 ml/min) [36]. Achieved blood flow rates will reflect the local target for dialysis adequacy. There is no comparative published data on dialysis adequacy with translumbar haemodialysis access. Translumbar CVCs in this study achieved desired increases in dialysis adequacy with a mean spKt/V exceeding the mean urea reduction ratio of 61% published by Wivell et al. [36] and equivalent to that for internal jugular TesioCaths at our centre [30].

CRB occurred at a rate of 0.82/1000 catheter days in this series, lower than reported by Lund et al., 1.4/1000 catheter days [25]. Only one episode of CRB required CVC removal. There is no data on infection in the study by Biswal et al. [34]. Our rate is similar to the rate of 0.81/1000 catheter days reported in a large single-centre UK study of all CVC types [12] and lower when compared with other studies of internal jugular TesioCaths, 2.3/1000 catheter days [36] and 1.4/1000 catheter days [37]. It is however higher than the rate of 0.34/1000 catheter days in a cohort of 759 CVCs followed up over 9.5 years at our centre 1999–2008 (unpublished data). This relatively higher rate of CRB associated with the translumbar approach is probably a result of the anatomical site of insertion where the patient lies on the exit site and it is subject to more mechanical stress.

Catheter thrombosis requiring an infusion of thrombolytic occurred at a much lower rate than 3.3/1000 catheter days in the study by Lund et al. [25]. This difference may be because they report thrombosis in single double-lumen catheters versus our twin single-lumen catheters, two of their catheters were used for plasmapheresis, and they do not state whether they used a catheter locking solution. Furthermore, the CVCs used in that study reflect older technology with step-tip configuration which may also have been contributory.

All-cause mechanical catheter dysfunction requiring thrombolytic infusion or catheter replacement occurred at a rate comparable to the rate of 0.8/1000 catheter days in the series of 303 internal jugular by Wang et al. [37]. This is higher than the rate of 0.33/1000 catheter days reported by Duncan et al. [30]. It could be anticipated that translumbar catheters are more prone to mechanical dislodgement because of the site of insertion. The phenotype of patients requiring translumbar CVCs may differ, they may have endothelial dysfunction or procoagulant states that predisposed them to increased rates of access loss and this warrants further study. The possible effects of variation in patient demographics, co-morbidities, dialytic protocols and administered therapies (e.g. anticoagulants) cannot be excluded when comparing different cohorts and may account for some of the differences seen.

The rate of complications associated with translumbar CVC insertion was low in this series in keeping with previous studies. Retroperitoneal haematoma is a recognized rare complication of this procedure, occurring in one patient in both the published series by Biswal et al. [34] and Markowitz et al. [38].

The transhepatic route can be used in cases of infrarenal caval occlusion, but is complicated by a high rate of catheter thrombosis (24/1000 catheter days) [19] and displacement (14–16%) [19,20]. The transfemoral route would appear to be a useful first option where there is preserved lower body venous patency as it is associated with fewer periprocedural complications than either the translumbar or transhepatic routes [39,40]. We do not opt for this approach at our centre; assisted primary CVC site patency is lower for this approach (mean of 85 days [40] versus a mean of 250 days [34] and 406 days in this study) with an associated higher rate of infection, 5.2/1000 catheter days [40]. In addition, there is a high rate of ipsilateral deep venous thrombosis reaching 25% in one series [39].

We report in detail on the translumbar route for maintenance haemodialysis access and demonstrate high-adequacy dialysis with low rates of catheter-related infection. Outcomes reported may have been influenced by recruitment bias and reflect practice at a single centre. The catheter care protocols used, a policy of clinically appropriate catheter salvage with empirical broad-spectrum antibiotics and prior experience with translumbar catheters may also have influenced outcome. Abnormally high proportions of CVCs result from basic problems in the choice, creation and maintenance of arteriovenous accesses, and this series serves to highlight an extreme on the spectrum of the complications of enduring catheter use for haemodialysis. As such, it reinforces the primacy of arteriovenous access as the vascular access form of choice in haemodialysis.
where this is possible. However, the translumbar route can be a useful option in patients with exhausted upper body venous access requiring CVVs for haemodialysis and can offer better patency and infection rates than the transmoral route.

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Conflict of interest statement. We have no conflicts of interest to declare. The results of this paper have not been published previously in whole or in part, except in abstract format. We have had no involvements that might raise the question of bias in the work reported or in the conclusions, implications or opinions stated.

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