Original Article

Dialysis Vascular Access: Where do Tunneled Catheters Stand? – A Single-Center Experience

Abstract

Introduction: Tunneled cuffed catheters (TCC) provides a short and intermediate-term access solution for dialysis patients who fail to get an arteriovenous fistula (AVF). They are associated with high morbidity and mortality along with high rates of infectious complications. **Methods:** We present a single-center prospective cohort of 159 TCCs inserted over one year. Patients were dialyzed in-hospital and in various peripheral dialysis units attached to the institute. The primary endpoint was catheter drop-out. **Results:** The mean age of patients was 41.8 ± 16.9 years. The right internal jugular vein was the commonest site of TCC insertion (66%). The absence of suitable veins was the predominant reason for TCC insertion. The mean time to catheter drop-out was 134.4 ± 83.3 days (5–399 days). Death with a working catheter was the most common cause of catheter drop-out (22.6%). About 25% of catheters were lost to catheter-related bloodstream infections (CRBSI), either alone or as overlap with poor flow. CRBSI rates were 3.74 episodes per 1000 catheter-days. No difference in survival between the staggered tip and split-tip catheters was found. **Conclusions:** With the advent of the "hub and spoke" model for dialysis in the public sector healthcare, TCCs are suboptimal with regards to patient and catheter survival, with high infection rates. It must be regarded as a temporary solution and AVF creation should be prioritized.

Keywords: *Catheter-related bloodstream infection, hub and spoke model of dialysis, Tunneled cuffed catheters*

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Introduction

Renal replacement therapy (RRT) initiatives are desperately trying to keep pace with the chronic kidney disease (CKD) epidemic. Hemodialysis is the first choice of RRT modality in India.[1] Vascular access remains the Achilles' heel of hemodialysis. An arteriovenous fistula (AVF) is the ideal access solution, a fact emphasized by various guidelines. The barriers to successful AVF creation are the insidious nature of the illness, late referral to nephrologists, lack of acceptability of dialysis, absence of a clear vascular access plan in hospitals, etc.[2] Thus, dialysis catheters have an undeniable role in the management of incident patients or even those on long-term dialysis.[3] There has been a conscious shift towards tunneled cuffed catheter (TCC) use in recent years.[4] Previous studies have mostly been confined to single centers.[5] In the present study, we examined the outcomes of TCCs in a single, low-cost public sector referral institute in western India running a "hub and spoke" model of care.

Methods

Patients undergoing TCC insertion in our institute from September 2017 to September 2018 were prospectively followed. Two different catheter designs, the staggered-tip (MAHURKAR® Maxid™ Covidien, Mansfield, MA) and the split-tip catheters (Hemosplit® and Equistream®; Bard Peripheral Vascular, Tempe, AZ) were used. Different catheter lengths were used based on site: 19 cm (cuff to tip length) for the right internal jugular, 23 cm for the left internal jugular and 27 cm or 36 cm for femoral veins. Femoral catheters were used only when patients provided negative consent for peritoneal dialysis. Subclavian catheters were avoided due to the high risk of central venous stenosis associated with their use. TCCs were inserted under local anesthesia, in a procedure room by nephrologists. The Seldinger technique was used under ultrasound guidance. No pockets were created. The femoral tunnel was kept

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oblique, and the exit site-directed laterally. The catheter was inserted using a peel-away sheath but Equistream® catheters were inserted over the guidewire whenever possible. Catheter lock was done with heparin (5000 U/ml) and an X-ray was done to confirm the tip position. The 3 T's (Tip, Top, and Tug) were documented. Dialysis was allowed immediately after insertion.

Dialysis was carried out in various peripheral centers within the state (Gujarat, India) linked to our institute. Some patients were dialyzed in-house. Patients were seen on a 1–3 monthly basis. The patients were instructed to report back in case of poor blood flow, fever, or complications. Catheter lock solution was heparin alone. Most catheter removals, when needed, were done in the same procedure room. Some of the missing details were retrospectively collected. Catheter drop-out was used as the primary end point and was defined as death of a patient on a TCC or TCCs removed for any cause.

Catheter-related bloodstream infections (CRBSI) were defined as per North American Vascular Access Consortium as:[6]

1. "Definite": same organism grown from at least one percutaneous blood culture and the catheter hub
2. "Probable": with positive blood cultures obtained from a catheter and/or a peripheral vein in a symptomatic patient after excluding alternative sources of infection
3. "Possible": when patients failed to get a culture or received empirical antibiotics before negative blood culture but no alternate explanation of a persistent febrile illness that was temporally related to TCC use.

Statistical methods

Mean (± standard deviation) or median and proportions were used to express quantitative and qualitative data, respectively. The Chi-square test was used to compare proportions. Kaplan–Meier survival curves were used to estimate the median catheter survival. A P value <0.05 was considered significant. Statistical analysis was performed with SPSS Statistics for Windows, version 20. (Armonk, NY: IBM Corp.)

Results

During study enrollment, 183 TCCs were used in 171 patients. Seven catheters were lost to early complications. With 17 patients having incomplete data or being lost to follow-up, only 159 TCCs were included in the final evaluation. The reasons for TCC insertion were poor veins, primary or secondary AVF failures, persistent AKI, and in patients awaiting transplant or AVF surgery. The right internal jugular vein was the preferred site. The baseline details are presented in Table 1.

Early causes of catheter drop out included improper tip position (n = 3), primary poor flow (n = 2, exclusively femoral catheters), complete heart block (n = 1, did not recover on catheter removal), and patient death (n = 1). Other complications included significant exit site oozing (n = 2, managed conservatively). The only fatal incident occurred during the placement of a left internal jugular catheter but no evidence of vascular injury, pleural, or pericardial collection could be documented. The possible reason could have been a cardiac arrhythmia.

The catheter survival data is shown in Table 2. Some causes of catheter drop-out (N = 44) were not directly linked to the catheter dysfunction per se. Thirty-nine catheters (24.5%) were functioning at the end of the study period. Further, follow-up was not done due to the small number of surviving catheters. There was no difference in overall catheter survival between in-house or peripheral dialysis centers (median survival 127.4 vs. 137.4 days, P = 0.92). Despite lower flow-related and infection-related complications in patients who were dialyzed in-house, this lack of difference in catheter survival can probably be explained by a non-significant trend towards early death in patients dialyzed in the Institute compared to those dialyzed in peripheral units (median time to catheter drop-out due to death 82 days vs. 109.5 days, P = 0.18).

We compared two commonly used tip designs (staggered tip and split-tip) for the difference

Table 1: Baseline characteristics of the study cohort

Parameter	Value
Total no.	159
Age	41.8±16.9 years
Males	88 (55.3%)
Cause of Renal Failure	
Diabetes	60 (37.7%)
CKD of Unknown Etiology	47 (29.6%)
Obstructive Uropathy	21 (13.2%)
Postpartum AKI (Persistent AKI)	10 (6.3%)
Posttransplant	8 (5%)
Others	13 (8.2%)
Site of TCC placement	
Right internal jugular vein	106 (66.7%)
Left internal jugular vein	30 (18.9%)
Left femoral vein	20 (12.6%)
Right femoral vein	3 (1.8%)
Reason for TCC Insertion	
Poor veins	76 (47.8%)
Previous primary AVF Failure	23 (14.5%)
Recent Secondary AVF Failure	13 (8.2%)
Prolonged AKI/Graft Failure	22 (13.7%)
Local Limb complications	12 (7.5%)
Awaiting AVF/Transplant	13 (8.2%)
Follow-up	5-437 days

CKD - Chronic kidney disease; AKI - Acute kidney injury, AVF - Arteriovenous fistula within overall survival, flow, and the propensity to infection. Catheter drop-outs at 30 days (4/66 vs. 5/93, P = 1.0), 90 days (10/62 vs. 21/88, P = 0.308), and 180 days (27/52 vs. 28/67, P = 0.352) were similar for both designs. The difference in CRBSI rates, flow-related malfunction, and requirement of salvage with fibrinolytic agents was statistically insignificant between the 2 catheter designs. All-cause catheter losses were also not significantly different (Log-rank: χ^2 = 2.804, P = 0.09) [Figure 1]. The apparent longer survival of the staggered tip design depicted is because of the different times of follow-up between the two designs.

CRBSI was seen in a significant proportion of patients. CRBSI rates were 3.74 episodes per 1000 catheter days. CRBSI rates were significantly higher in patients dialyzed in peripheral units (4.4 vs. 2.08 per 1000 catheter days). Up to 30 patients (25%) lost catheters predominantly due to CRBSI. However, several had a concomitant flow-related issue, leading to abbreviated dialysis sessions and the decision was taken to remove the catheters. Exit site infection was noted in 12 cases (0.5 cases per 1000 catheter days) and tunnel infection was noted in 2 cases (0.09 cases per 1000 catheter days). Exit site infections, being self or technician reported run the risk of being under-recognized in the study.

"Definite," "Probable," and "Possible" CRBSI was seen in 36, 24, and 20 episodes, respectively. The most common infections were *Staphylococcus aureus*, Coagulase-negative Staphylococci, *Escherichia coli*, *Klebsiella* sp. and *Pseudomonas aeruginosa* [Table 3].

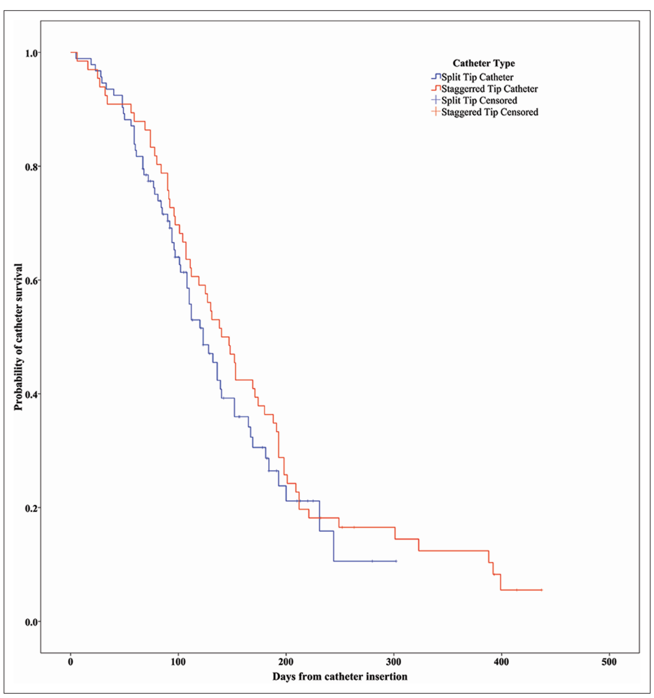

Figure 1: Survival of catheters by tip design (staggered vs. split-tip)

Discussion and Conclusions

Under 25% of patients with ESRD in India begin dialysis with an AV Fistula and non-tunneled hemodialysis catheters (NTHC) are the overwhelming first option.[7] Several factors contribute to the high incidence of bacteremia associated with dialysis catheters, including lack of hygiene, hot and humid climate, poor catheter care, recurrent intradialytic handling due to poor flow, etc., TCCs can address some of these concerns. TCCs, which

Table 2: Trends of catheter survival

Parameter	Value
Mean (S.D.) Catheter survival (days)	134.4 (83.4)
Range of Catheter Survival (days)	5-399
Mean Catheter survival by catheter site (days)	
Right internal jugular vein	139±86.2
Left internal jugular vein	134±73.6
Femoral	113±81.7
Catheters working at end of the study period	39 (24.5%)
Catheter drop-out (days)	
≤30	12 (7.5%)
>30 but ≤90	48 (30.2%)
>90 but ≤180	96 (60.4%)
>180 but ≤365	117 (73.6%)
Total catheter drop-outs	120 (75.5%)
Causes of catheter dropout	
Death with a working catheter	35 (29.2%)
AV Fistula available	27 (22.5%)
Transplant	9 (7.5%)
CRBSI	30 (25%)
Inadequate flow	22 (18.3%)
Recovery from RRT needs	6 (5%)
Others	6 (5%)

CRBSI - Catheter-related blood stream infection

Table 3: Bacterial etiology of catheter-related bloodstream infection (CRBSI)

	Number (percent)
Gram-Positive organisms	
Staphylococcus aureus	16 (26.7)
Coagulase-negative staphylococcus	12 (20)
Enterococcus faecium	1 (1.7)
Gram-Negative organisms	
Escherichia coli	11 (18.3)
Klebsiella spp.	7 (11.7)
Pseudomonas aeruginosa	5 (8.3)
Acinetobacter baumannii	3 (5)
Enterobacter spp	2 (3.3)
Birkholderia cepacia	2 (3.3)
Aeromonas	1 (1.7)

are relatively easy to place, allows multiple sites to be used, require minimal infrastructure, provide immediate availability for use, and allow better flow and longevity than NTHC and are an attractive option in patients without a functional AVF.[8] Guidelines have preferred TCCs over NTHCs for long-term use (>1–3 weeks).[4]

Preferential use of the right internal jugular vein is recommended by several guidelines.[2,9] We used local anesthesia for catheter placement. Previous authors have reported using sedation, in selected patients.[5] While we did all the procedures under ultrasound, others have proposed fluoroscopic guidance in the placement of TCCs. Non-fluoroscopy-guided catheter placement is safe and cost-effective.[10,11] Nevertheless, early catheter losses, especially related to improper tip position and primary poor blood flow could be avoided if fluoroscope guidance is used.

Compared to the previous Indian paper cited, we had fewer patients (9, 7.5%) in whom TCCs were used as a bridge before transplant.[5] Some patients presenting late, develop significant limb edema from the disease process or multiple peripheral punctures necessitating TCC placement.[6,12]

A quarter of the catheters were functioning at the end of the study. Death with a working TCC was the most common cause of catheter drop-out, as reported previously.[9,13] About 31% of patients died during follow-up. Previous cohorts have reported 2-3 times increased deaths in patients on catheters. One study reported 59% death with a 6-month follow-up when patients could not get permanent vascular access.[14] As per USRDS data, 26% of patients who initiated dialysis with a catheter died within 12 months, compared to 11% of patients with an AVF.[15] Most deaths in our study were cardiovascular, volume overload, and infections. Some of these mortality data (those occurring in remote locations) were collected from medical records, death certificates, and via discussion with caregivers. Transfer to another form of renal replacement (renal transplant, $n = 9$; peritoneal dialysis $n = 1$), availability of permanent access (AV fistula, $n = 22$) and recovery of renal function ($n = 4$) were other significant causes of catheter drop-out. Forty-four (36.7%) catheter drop-outs were not attributable to the catheter dysfunction. Some catheters were lost to mechanical damage ($n = 1$), accidental removal ($n = 3$), and withdrawal from dialysis ($n = 1$).

The equivalence of flow rate, thrombosis, and overall survival by catheter tip design has been reported previously.[16] However, other studies have contradictory results in favor of either tip design.[17,18] A recent meta-analysis found no difference in flow rates, infections, or thrombosis between staggered and split-tip designs, but survival was better at 6 months (but not at 1 month or 12 months) for staggered tip catheters.

CRBSI contributes to catheter loss, morbidity, and high overall mortality. One systematic review reported a CRBSI rate of 4.8 per 1000 catheter days with NTHCs, compared with 2.8 per 1000 catheter days with other types of central venous catheters.[19] More recent studies have reported far lower CRBSI rates for TCCs.[3,8] Although we used a liberal definition of CRBSI, our study reports an alarming CRBSI rate according to modern standards (3.74 per 1000 catheter days) and a high rate of catheter loss attributable to infection as a significant cause. The catheter infection rates for NTHCs have been recently reported as 7.34 episodes per 1000 catheter days in a recent Indian study.[20] Possible reasons for high CRBSI as well as higher death rates in our study could be low socioeconomic status, suboptimal nutrition, no prophylactic antibiotic lock use and use of TCCs as a "last resort." Our study setting, where patients were dialyzed at peripheral centers with little to no direct supervision may be an important determinant in this regard. In cases labeled "possible" CRBSI, although such catheters do not meet standard CRBSI definitions, such troublesome catheters are not acceptable to patients, dialysis units, or nephrologists and ultimately contribute to catheter loss. It is important to understand that TCCs were offered to patients who did not have any other viable option. TCC insertion and hemodialysis being reimbursed under state and national health schemes make it financially more viable to most low-income-group patients than peritoneal dialysis. For most patients, the option against TCCs would have been to remain on NTHCs, which are associated with higher morbidity.

Our study presents a current "real world" look into the situation of dialysis in India. With the advent of the so-called "hub-and-spoke model" of dialysis, where a central public sector tertiary-care hospital is responsible for the oversight of peripherally located dialysis units, the time has come to rethink vascular access priorities. Appropriate experience or sensitization towards vascular access care may be lacking. There is a tendency to treat all episodes of fever or chills during dialysis as CRBSI and a cocktail of high antibiotics is often prescribed without any investigations.

The best method of reducing TCC related complication is eliminating their use. Non-tunneled and tunneled catheters should be offered as a temporary solution only. A multidisciplinary team with a dialysis and/or access coordinator, renal nutritionist, intervention radiologist or nephrologist, and a dedicated access team should be created.[21] Hand hygiene protocols and catheter care protocols should be reinforced and interim audits done. Topical exit site mupirocin application should be made routine and prophylactic antibiotic lock with a first-generation cephalosporin or an aminoglycoside should be strongly considered.[22,23]

To conclude, while TCCs are attractive and sometimes the only access option, they are less than ideal in most settings. AVF creation must be a top priority. Patients on catheters must be considered high risk and appropriate attention be directed towards permanent access creation. Continued surveillance for early identification of a failing AVF must be a part of CKD care. Catheter care protocols and stringent infection control measures must be established and reinforced.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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