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SURVIVAL OF TUNNELED HEMODIALYSIS CATHETERS FOR VASCULAR ACCESS: OUR EXPERIENCE FROM NORTH EAST INDIA

Nephrology

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ABSTRACT

Introduction: Despite being the least desirable method for vascular access, the demand for tunneled dialysis catheters (TDCs) is increasing. This study examined the overall catheter survival duration. **Materials and Methods:** This retrospective study was conducted over a period of 5 years in a tertiary care hospital in India. TDCs were inserted with or without fluoroscopic control (blind technique through the right internal jugular vein). The primary endpoint was the catheter survival duration. **Results:** Of 113 TDCs,69 had catheter-related outcomes. The mean age of patients was 54.00 ± 14.27 years. Diabetes mellitus was the most common cause of CKD. Absence of suitable veins and failure of arteriovenous access were the predominant reasons of TDC insertion. A total of 65 TDCs were inserted under fluoroscopic guidance and 48 by using the blind technique. The right internal jugular vein was the preferred site (87%) of insertion. Procedure-related complications were observed in 5(4.6%) cases. The mean catheter survival duration was 205.96 ± 200.93(range: 5–1045) days. Death with functioning catheter was the major cause of catheter discontinuation (66.7%). Catheter-related infection was noted in 16.8% of patients. The median catheter survival durations under fluoroscopic guidance and the blind technique were 137 (range:64.75–261.25) days and 185 (range:66–410) days, respectively. No significant difference in terms of catheter survival, infection, and complications was noted between the two techniques. **Conclusion:** TDCs have reasonably satisfactory survival. Catheter survival doesn't differ whether placed with or without fluoroscopic control.TDCs can be inserted through the right internal jugular vein by an expert with a limited fluoroscopy facility.

KEYWORDS

Hemodialysis, Tunneled Catheters, Survival, Vascular Access

INTRODUCTION:

Arteriovenous fistula (AVF) is the gold standard vascular access for hemodialysis. However, the majority of patients do not have AVF at the time of the initiation of hemodialysis. Temporary vascular catheters are often used for access during the initiation of hemodialysis. Many factors are responsible for the non-feasibility of successful AVF construction including inappropriate vascular conditions, thrombophlebitis caused by repeated cannulation and intravenous drug administration, comorbidities, peripheral vascular disease, aging, and lack of adequate expertise and patient education [1,2]. Few AVFs are not easily accessible due to anatomical consideration. Many AVFs do not even mature after construction, and a considerable number of AVFs eventually become nonfunctional even after maturation because of thrombosis and stenosis. Thus, the demand for tunneled hemodialysis catheters (TDCs) is increasing.

TDCs are usually inserted under ultrasonography and fluoroscopy guidance in the operation theatre. Until 2017, the facility for fluoroscopy was limited in our hospital, with only restricted access being available. Moreover, the cost of the procedure increases by three times with the use of fluoroscopy or the Cath lab, with most of our patients being unable to bear the high costs. Therefore, we initiated TDC insertion without fluoroscopy guidance. From 2018, we began performing TDC insertion under fluoroscopy guidance.
In the present study, we investigated the catheter survival duration and complications. In addition, we examined differences in the catheter survival duration and complications with or without the fluoroscopic-guided placement of TDCs.

MATERIALS AND METHODS:

Study population:

This retrospective study was performed at a tertiary care hospital from April 2016 to March 2021. Patients with end-stage kidney disease (ESKD) who received HD through TDCs placed in our center were included in the study. After the insertion of TDCs, patients continued receiving HD at our center or peripheral hospitals. Patients aged <12 years, those who previously received TDCs, and those with acute kidney injury were excluded from the study.

Data collection:

Patients were identified using the procedural register, and additional information was obtained from dialysis records, follow-up at clinic, hospital admissions, and telecommunication, particularly for peripheral centers and reporting by patients.

Types of permcath:

Two catheter designs were used: the staggered-tip (Mahurkar Maxid Covidien, Mansfield, MA) and the split-tip catheter (Hemosplit TM; Bard Access, Salt Lake City, United States).

Catheter insertion:

All TDCs were inserted by a single nephrologist on a daycare basis at the operation theatre through percutaneous access. Different catheter lengths were used based on the site: 19 cm (cuff to tip length) for the right internal jugular vein, 23 cm for the left internal jugular vein (IJV), and 23 cm or 55 cm for femoral veins. The subclavian vein was used only as the last option. The placement of TDCs at the left IJV, subclavian vein, and femoral vein (55cm) was performed under fluoroscopic guidance only. In critical care unit, TDCs were placed by blind technique due to lack of fluoroscopic facility.

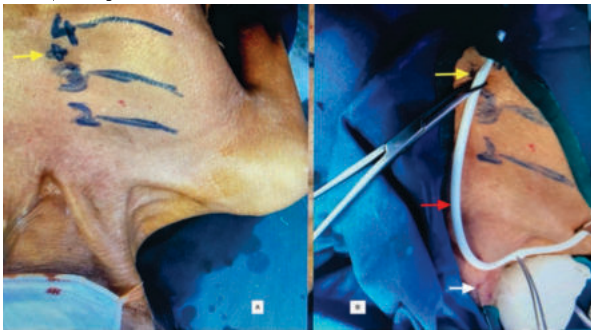
a) Cannulation of central veins (Seldinger method):

Cannulation was mostly performed using the blind technique. Ultrasonography with a vascular probe was used in case of abnormal anatomy or if the blind technique was not successful. We routinely used 2-mL syringe with a 24-G needle to locate the IJV before introducing the 18-G needle.

b) Insertion without fluoroscopic guidance (Blind technique through the right IJV without previous catheter insertion):

Skin surface marking was performed prior to the insertion of the catheter. Catheter length was assessed from the puncture point to 1-2 cm below the lower edge of the right third costal cartilage. Hsu et al [3] reported that the optimal skin surface landmark for the superior vena cava–right atrial junction is the lower edge of right third costal cartilage. Thus, we aimed the catheter tip position below the third costal cartilage. The cuff position and possible exit site were marked on the skin (Figure 1). Subsequently, the catheter tunnel was created using a tunneler. The catheter was inserted using the peel-away sheath after gradual dilatation. Chest X-ray was immediately performed to examine the position of the catheter tip and complications if any. If the tip was not present in the right atrium, the catheter was pulled or pushed accordingly to ensure proper position.

Figure1: Surface markings for catheter insertion by blind technique A. Numbering of right costal cartilages and marks for catheter tip position (yellow arrow); B. Catheter (red arrow) with the marks for tip position (yellow arrow), cuff & exit site position and puncture site (white arrow) with guidewire in situ.



c) Insertion under fluoroscopic guidance:
The insertion procedure was the same as above except the use of guidewires, and dilators were placed directly under a fluoroscopic view. The three T's were checked, namely the position of its tip, its top (curvature in the neck), and its tug (free aspiration of blood through a 10 cc syringe). Both the ports were then locked with 1,000 IU/mL of heparin in each port, and the catheter was sutured to the skin. Dialysis was immediately performed after insertion.

Catheter outcome measures [4]:
Catheter survival was defined as the period (in days) during which an HD catheter was functioning in situ. Catheters were removed from patients because of catheter failure or elective catheter removal. Catheter failure was defined as the inability to perform adequate HD due to poor flow rates, catheter dislodgement, catheter damage, or infection, necessitating catheter removal and new catheter insertion.

Elective catheter removal was defined as the removal of functioning catheters that were allowing adequate HD for various reasons such as the construction of an AVF, renal function recovery, renal transplantation, change to peritoneal dialysis, and patient death. Catheter-related bloodstream infections (CRBSIs) were defined according to the North American Vascular Access Consortium [5].

Statistical methods
All statistical analyses were performed using SPSS version 23. Continuous variables are presented as the mean and standard deviation or median with the 25th and 75th percentiles [interquartile range (IQR)], as appropriate. Categorial variables were evaluated using the chi-square test or Fisher's exact test. A P value of <0.05 was considered statistically significant.

RESULTS:
During the study period, 113 TDCs were inserted (99 at the operation theatre and 14 at the critical care unit) in 113 patients. Of the 113 TDCs, 32 catheters remained functional at the end of the study period. Follow-up data were not available for 12 catheters. Therefore, the outcomes of 69 catheters were analyzed. The most common reasons for TDC insertion were unsuitable veins (45%) and primary or secondary AVF failure (44%). The right internal jugular vein was the preferred site (87%) of insertion. Baseline characteristics of patients and results are shown in Table 1.

Table 1: Baseline characteristics of patients and catheter outcomes

All Parameters	Mean ± SD/Frequency (%)
Age (Years)	54.00 ± 14.27 (Range 16.00 - 84.00)
Gender	
Male	74 (65.5%)
Female	39 (34.5%)
Coronary artery disease (Yes)	15 (13.3%)
Hypertension (Yes)	100 (88.5%)
Native Kidney Disease	
Diabetic kidney disease	62 (54.9%)
Unknown	20 (17.7%)
Chronic tubulo- interstitial nephritis	18 (15.9%)
Hypertension	7 (6.2%)
IgA Nephropathy	2 (1.8%)
Polycystic kidney disease	1 (0.9%)
Chronic glomerulonephritis	1 (0.9%)
Renal calculous disease	1 (0.9%)
Lupus Nephritis	1 (0.9%)
Indication	
Unsuitable Veins	40 (45.5%)
Failed AVF	39 (44.3%)
HD Initiation	9 (10.2%)
Venous Access	
Internal Jugular Vein	108 (95.6%)
Femoral Vein	4 (3.5%)
Subclavian Vein	1 (0.9%)
IJV Side	
Right	95 (87.6%)
Left	13 (12.4%)
Type of Catheter tip	
Staggered-tip	58 (51.3%)
Split-tip	55 (48.7%)
Technique Of Insertion	
Fluoroscopy guided	65 (57.5%)
Blind	48 (42.5%)
Early Complication	
None	108 (95.6%)
Arterial Puncture	4 (3.5%)
Hematoma	1 (0.9%)
HD Center	
Peripheral centers	66 (58.4%)
Our centre	47 (41.6%)
Catheter outcome	
Catheter failure Expired	55 (79.7%
Blockage	4 (5.8%)
Spontaneous Expulsion	2 (2.9%)
Catheter damage Elective removal	1 (1.4%) 7 (8.7%)
Catheter survival (days)	205.96 ± 200.93 (Range 5.00 - 1045.00)
Place Of Death	
Home	38 (69.1%)
Hospital	17 (30.9%)
Death With Working Catheter (Yes)	46 (83.6%)
Reason Of Elective Removal	
AVF-Maturation	3 (50.0%)
Transplant	2 (33.3%)
Conversion to Peritoneal Dialysis	1 (16.7%)
Infection	19 (16.8%)

The median catheter survival duration with interquartile range (IQR) was 150 (62–310) days. All the catheters satisfactorily functioned after insertion, and none demonstrated kinking or twisting. The median survival durations for catheters placed under fluoroscopic guidance and by using the blind technique were 137 (IQR 64.75–261.25) days and 185 (IQR 66–410) days, respectively. The catheter survival between the two techniques was not significantly different (P = 0.334). The results are shown in Table 2. Complications related to catheter insertion, infections, and catheter failure did not differ between the two techniques (Table 2).

Table 2:Association between Technique of Insertion and Parameters

Parameters	Technique Of Insertion		p value
	Fluoroscopy guided (n = 65)	Blind (n = 48)	
Age (Years)	53.40 ± 15.24	54.81 ± 12.96	0.5961
Gender			
Male	43 (66.2%)	31 (64.6%)	
Female	22 (33.8%)	17 (35.4%)	
Diabetes Mellitus	32 (49.2%)	31 (64.6%)	0.1043
Type of Catheter			0.0973

Staggered-tip	29 (44.6%)	29 (60.4%)	
Split-tip	36 (55.4%)	19 (39.6%)	
Early Complications			0.7892
None	61 (93.8%)	47 (97.9%)	
Arterial Puncture	3 (4.6%)	1 (2.1%)	
Hematoma	1 (1.5%)	0 (0.0%)	
HD Center			0.6893
Peripheral centre	39 (60.0%)	27 (56.2%)	
Our centre	26 (40.0%)	21 (43.8%)	
Catheter Status			0.3673
Continuing	23 (35.4%)	21 (43.8%)	
Not Continuing	42 (64.6%)	27 (56.2%)	
Reason of catheter removal			0.0842
Expired	36 (85.7%)	19 (70.4%)	
Elective Removal	1 (2.4%)	6(18.5%)	
Blockage	3 (7.1%)	1 (3.7%)	
Spontaneous Expulsion	1 (2.4%)	1 (3.7%)	
Fracture Catheter	1 (2.4%)	0 (0.0%)	
Catheter survival (days)	170.69 ± 140.76	260.81 ± 263.09	0.3344
Death With Working Catheter	32 (88.9%)	14 (73.7%)	0.2492
Infection	9 (13.8%)	10 (20.8%)	0.3263

We did not observe any severe early complications such as air embolism, pneumothorax, haemothorax, and severe bleeding. The staggered tip catheter had higher mean survival than did the split-tip catheter (236.60 ± 216.82 vs 163.69 ± 171.42 days); however, this difference was not statistically significant (P = 0.189). Catheter damage in the form of catheter port fracture was observed in 4 (3.5%) patients who received staggered tip catheters. The catheter was removed in only one patient, whereas the port was replaced with that of non-tunnelled catheters in the other three patients. Spontaneous expulsion was noted in 2 (2.8%) patients who received split-tip catheters. CRBSIs were observed in a significant proportion of patients (16.8%). The CRBSI rate was 1.36 per 1000 catheter days. Three deaths related to catheter infections were noted. Klebsiella pneumoniae was the organism isolated in the three cases.

DISCUSSION

Despite being the least desirable method for vascular access, the demand for TDCs for HD is increasing [1,6]. In the present study, unsuitable veins for AVF creation and AVF failure were the most common indications for TDC insertion; this finding is consistent with that of a study conducted in western India [7]. In our region, few patients (15%–19%) undergo HD initiation with AVF [8] because of the presence of unsuitable veins resulting from venipunctures during multiple hospitalizations, the urgent initiation of dialysis with single-lumen catheters, and the lack of adequate expertise. Therefore, TDCs remain the only optimal choice.

The overall survival of TDCs is highly variable. Our study results revealed a mean catheter survival of 205 (200.93) days, which is consistent with that reported in other studies [4,9]. A prospective study [7] conducted in India indicated a mean catheter survival of 134.4 (83.4) (days). Cetinkaya et al [10] conducted a study in Turkey and found a median catheter survival duration of 289 (IQR 10–720) days. Variations in catheter survival depend on the definition used, location of the central vein, proper placement, and handling of catheters during dialysis. Develter et al [11] performed a study of 245 single-lumen cuffed catheters in Europe and observed that the mean survival time per catheter was 276 days. The mean survival of catheters was close to 2 years after adjustment for death and elective removal. In the present study, death with a functioning catheter (66.7%) was the most common cause of catheter discontinuation; this finding is consistent with those of other studies [7,10]. The survival of catheters would increase after adjustment for death and elective removal.

Placement of tunnelled catheters under ultrasound and fluoroscopic guidance in the operating theatre in a private hospital is expensive. The majority of our patients could not bear the high costs because they were already overburdened with the cost of dialysis. Beyond these, fluoroscopy facility is not commonly available in our critical care units and for emergency placements. The median catheter survival duration was non-significantly higher when placed using the blind technique (185 [IQR 66–410] days) than when placed under fluoroscopic guidance (137 [IQR 64–261] days); this can be attributable to the use of right-sided and staggered-tip catheters and the absence of past interventions. Catheter malposition (25%–40%) is the common problem encountered when using the blind technique [12].

However, we did not encounter this problem significantly. We used the optimal anatomical landmark of the right atrium below the right third costal cartilage that corroborated in most cases. Fluoroscopy guidance enables accurate catheter positioning [12] and allows direct imaging of wires and dilators, thus minimizing the potential for injury. Similarly, early complication and infection rates did not differ between the two techniques. Extensive data for catheter insertion without fluoroscopic guidance except in emergency situations are not available [13]. Therefore, a catheter can be placed without fluoroscopy when the facility is limited.

In this study, catheter damage in the form of fracture catheter port was observed in 3.5% of patients, and all catheters with damage were of the staggered-tip type. The reason for the damage may be the mishandling of catheters during dialysis sessions (e.g., using artery forceps to remove caps). External damage to catheters was reported in other studies [4] (3.1% for Ash-Split and 1.4% for Permcath catheters).

We observed the spontaneous expulsion of split-tip catheters in 2 (2.8%) patients. Cuff extrusion was observed in 2% of patients by Sampath Kumar et al [14]. The reason may be the improper positioning of cuff, malnourishment, inadequate fibrosis induced by dacron cuff, and mal-handing of catheters during dialysis (e.g., pulling the catheter while dressing).

The mean catheter survival duration did not differ between the split-tip and staggered-tip catheters; this finding is consistent with those of other studies [4,7]. A metanalysis [15] including 988 patients did not report a significant difference in the delivered blood flow rate among stepped-tip, split-tip, and asymmetrical-tip TDCs. Thus, catheters can be selected by considering factors such as cost, clinician's expertise, and patient's preference.

Procedure-related complications were observed in 4.6% of our study population; this result is comparable to those of other studies [4,10,13,16]. No significant difference in procedure-related complications was observed between the fluoroscopic guidance and blind technique. Complications depend upon the level of expertise and facility.

Wide variations were noted in catheter-related infections among different studies [4,7,14]. We observed catheter-related infections in 16.8% of patients; this finding is consistent with those of other studies [16,17]. For tunnelled-cuffed catheters, the infection rate was approximately 0.5–5.5 events per 1000 catheter-days [18]. In our series, we observed a lower infection rate (1.3 per 1000 catheter-days) than that reported in other studies [7,17]. This difference can be attributable to the routine use of empirical antibiotics and antibiotic lock solution in some centers and low reporting.

Drawbacks of the study:

- This was a retrospective study, and a small number of patients were included from a single center.
- Catheter dysfunction was not included in survival analysis.
- We did not include catheter interventions and secondary patency.
- We did not consider reinsertion of the catheter

CONCLUSION:

TDCs have a reasonably long survival duration. Catheter survival doesn't differ whether placed with or without fluoroscopic control.TDCs can be inserted through the right internal jugular vein by an expert in resource-limited and economically weaker populations with a limited fluoroscopy facility, although fluoroscopic-guided placement is the desirable or the standard method.

DECLARATIONS

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Availability of Data and Materials: All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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