Tunneled versus Non-Tunneled Haemodialysis Catheters in Patients Prior to Arteriovenous Fistula

Abd Elkader Ahmed Hashem Mohammed[a], Aya Yahya Ahmed Amin[a*], Yousry Lotfy Sharkawy Radwan[a]

[a]Internal Medicine Department, Faculty of Medicine, South Valley University, Qena, Egypt

Abstract

Background: Non-tunneled and Tunneled Hemodialysis Catheters are used for prompt renal replacement therapy via vascular access.

Objectives: To estimate the complications of tunnelled haemodialysis catheters and non-tunnelled catheters and compare the outcome of them.

Patients and methods: A total of 50 patients undergoing renal dialysis were enrolled and divided into two groups based on the type of the dialysis catheter. Group I (25 patients) included patients managed with non-tunneled catheters (NTCs), while group II (25 patients) included patients managed with Tunneled dialysis catheters (TDCs).

Results: The mean age of group I (NTC group) was 58.6 ± 8.0 years,13 (52%) patients were males, the mean BMI was 38±4.3 kg/㎡. In TDC group, the mean age was 56 ± 8.8 years, 10 (40%) patients were males, the mean BMI was 37.1 ±3.9 kg/㎡. NTC and TDC groups were compared in terms of complications. The premature removal rate was 36% and 12% in group I and II respectively. Bleeding was reported in 32% and 8% in group I and II respectively. In the NTC group, 32% had functional complications, while 28% had procedural complications, and in only 4% of the TDC group. In the TDC group, only 4% had either procedural or functional complications. Multiple sticks were encountered in 32% and 2% in group I and II respectively.

Conclusion: TDCs have substantially fewer complications and better performance characteristics than NTCs.

Keywords: Renal replacement therapy (RRT); Non-tunneled catheters (NTC); Tunneled dialysis catheters (TDC).

DOI: 10.21608/svuijm.2023.230410.1662

***Correspondence:** toty0yahya0@gmail.com

Received: 31 August, 2023.
Revised: 13 September, 2023.
Accepted: 13 September, 2023.
Published: 28 December, 2023

Cite this article as: Abd Elkader Ahmed Hashem Mohammed, Aya Yahya Ahmed Amin, Yousry Lotfy Sharkawy Radwan (2024). Tunneled versus Non-Tunneled Haemodialysis Catheters in Patients Prior to Arteriovenous Fistula. *SVU-International Journal of Medical Sciences*. Vol.7, Issue 1, pp: 95- 105 .

Introduction

End-stage renal disease (ESRD) is a primary outcome of chronic kidney disorder (CKD) and has a substantial impact on health-related quality of life and healthcare utilization **(Vanholder et al., 2012**). The prevalence of end-stage renal disease (ESRD) in Egypt has increased in 1996 to 2004 from 225 to 483 patients per million population (pmp) **(Afifi, 2008).**

Hemodialysis (HD) is a widely employed renal replacement therapy (RRT) for individuals with ESRD. The introduction of HD has led to a significant reduction in mortality rates among patients with ESRD **(Amini et al., 2011**).

HD involves a process by which accumulated solutes are removed from the blood of patients who have experienced a near-total or complete renal function loss. During the HD procedure, solutes are diffused from the blood into a dialysate solution, which is a physiological salt solution. This separation of solutes from the blood occurs across a thin semipermeable membrane, which serves as the central component of the dialyzer **(Saeed and Sinjari, 2018).**

The survival of patients with ESRD is influenced by various factors, including the adequacy of dialysis, the chosen method of renal replacement therapy, the underlying cause of renal failure, and the presence of additional medical conditions **(Abd El-Sattar et al., 2021).**

Central venous catheters (CVC) are a commonly used vascular access approach for ESRD patients who are undergoing hemodialysis. However, the use of CVCs is associated with elevated mortality and morbidity compared to other options such as arteriovenous fistulas (AVFs) and grafts (AVGs). This presents a significant health challenge for the nephrology community thus highlighting the importance of optimizing vascular access strategies to improve outcomes and minimize complications in patients undergoing hemodialysis **(Haddad et al., 2012).**

In certain clinical scenarios, patients may encounter the failure of arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs), which are the preferred long-term vascular access options for hemodialysis patients **(Cheng et al., 2019).** In such instances, tunneled hemodialysis catheters (TDCs) become a crucial alternative. TDCs are surgically inserted into a large vein, often the internal jugular or femoral vein, and are tunneled subcutaneously to an exit site on the patient's chest or neck. A cuff is incorporated into the catheter design, anchoring it in place and creating a barrier against infection **(Cheng et al., 2019).** While TDCs offer a viable method to initiate hemodialysis when other options are limited, they are generally considered less favorable for long-term use when compared to AVFs and AVGs. This preference stems from the higher risk of complications, particularly infections, associated with TDCs over extended periods (**Cheng et al., 2022).**

For certain patients, temporary vascular access becomes a necessity. This requirement can arise due to various clinical circumstances, including acute kidney injury, delayed maturation of AVFs, the failure of permanent access sites, or the need for a bridge to other renal replacement therapies such as kidney transplantation or peritoneal dialysis. In such cases, non-tunneled catheters (NTCs) are employed as a short-term solution. NTCs are inserted directly into a vein, often the subclavian or femoral vein, without the subcutaneous tunneling characteristic of TDCs. The selection between TDCs and NTCs depends on the patient's specific clinical condition, anticipated duration of vascular access need, and overall treatment plan **(Kazemzadeh et al., 2019).**

The objective was to estimate the complications of tunneled hemodialysis catheters and non-tunneled catheters and compare the outcome of them.

Patients and methods

We conducted a study involving 50 patients who were undergoing renal dialysis. These patients were categorized into two distinct groups, with their division determined by the specific type of dialysis catheter they were utilizing:

Group I: which consisted of 25 patients, was comprised of individuals who were managed using non-tunneled catheters (NTCs).

Group II: (25 patients) included patients managed with tunneled dialysis catheters (TDCs).

The inclusion criteria encompassed two specific patient groups: Firstly, those who initiated dialysis before the establishment of an arteriovenous (AV) fistula, and secondly, patients diagnosed with ESRD who lacked a functional AV fistula or graft.

Exclusion criteria included patients with INR >2 or other significant coagulopathy, critically ill patients, patients with evidence of infection and patients with known hypercoagulable state.

All patients signed informed consent before participation in the study. Additionally, an approval from the institutional ethical committee of the Faculty of Medicine, Qena was obtained.

All patients underwent to the following:

I. Complete history taking which include Age, sex, primary cause of ESRD, duration of dialysis, and site of AVF creation. History of other comorbid conditions. We collected information regarding potential risk factors, such as diabetes mellitus, pregnancy complications, hypertension, urinary lithiasis and nephrotoxic drug exposure.

Hypertension was defined as a blood pressure measurement equal to or exceeding 140/90 mmHg **(Beaney et al., 2020).** The diagnosis of hypertension as a contributing factor to end-stage renal disease (ESRD) was established in cases where persistent hypertension predated the onset of ESRD and there were no indications of other underlying causes **(Lo et al., 2009).**

Diabetic nephropathy was diagnosed when longstanding diabetes was accompanied by proteinuria and correlated with diabetic retinopathy **(Gross et al., 2005).**

Chronic glomerulonephritis (GN) was inferred from historical data corroborated by urinary findings and validated through renal histology. In cases of chronic GN, an episode of acute nephrotic syndrome may serve as a defining event. The presence of renal hematuria, persistent proteinuria, dysmorphic red blood cells, and urinary casts were indicative of nephrotic syndrome. For early-stage diagnosis, renal biopsy is a more accessible and informative procedure **(Tomino, 2014).**

Obstructive uropathy was diagnosed through imaging studies. Common radiographic techniques employed to diagnose obstructive uropathy included abdominal ultrasound and intravenous pyelogram.

II. General examination encompassed a thorough assessment of the patient's overall well-being, with particular emphasis on the state of consciousness and vital signs.

III. Anthropometric measurements were obtained, including weight and height, from which the body mass index (BMI) was evaluated by dividing the weight in kilograms by the square of the height in meters.

IV. Detailed local examinations of the abdomen, chest, and heart were conducted, with a specific focus on identifying indicators of chronic renal disease.

V. Laboratory Investigations:

- A total of five milliliters of venous blood were drawn from each participant and subsequently divided into two distinct samples. The initial sample, comprising three milliliters, was collected in a plain vacutainer tube.
- After centrifugation, the resulting sera were utilized for biochemical analyses. The remaining two milliliters were collected in a tube containing an anticoagulant, designated for the following purposes:

1- Serum creatinine levels were determined using the COBAS 501 chemistry auto analyzer (Roche Diagnostics, USA).

2- A complete blood picture was conducted using the Erma Automated Blood Count Machine (Tokyo, Japan).

3- Renal filtration rate (eGFR) was calculated employing the CKD-EPI equation (**Levey et al., 2009**). The diagnosis of chronic kidney disease (CKD) was established when the eGFR remained below 60 ml/min/1.73 m^2 for a period exceeding three months **(Eriksen & Ingebretsen, 2006).**

Insertion of cuffed hemodialysis catheters was performed by Dr. Mustafa Abdullah Ahmed (specialist of internal medicine and Nephrology at South Valley

University), in Damanhour Medical National Institute interventional Nephrology Unit, so we thank him for his valuable participation (**Figs 1-5).**

Fig.1. Left external iliac cuffed hemodialysis catheter at Damanhour Medical National Institute Interventional Nephrology Unit

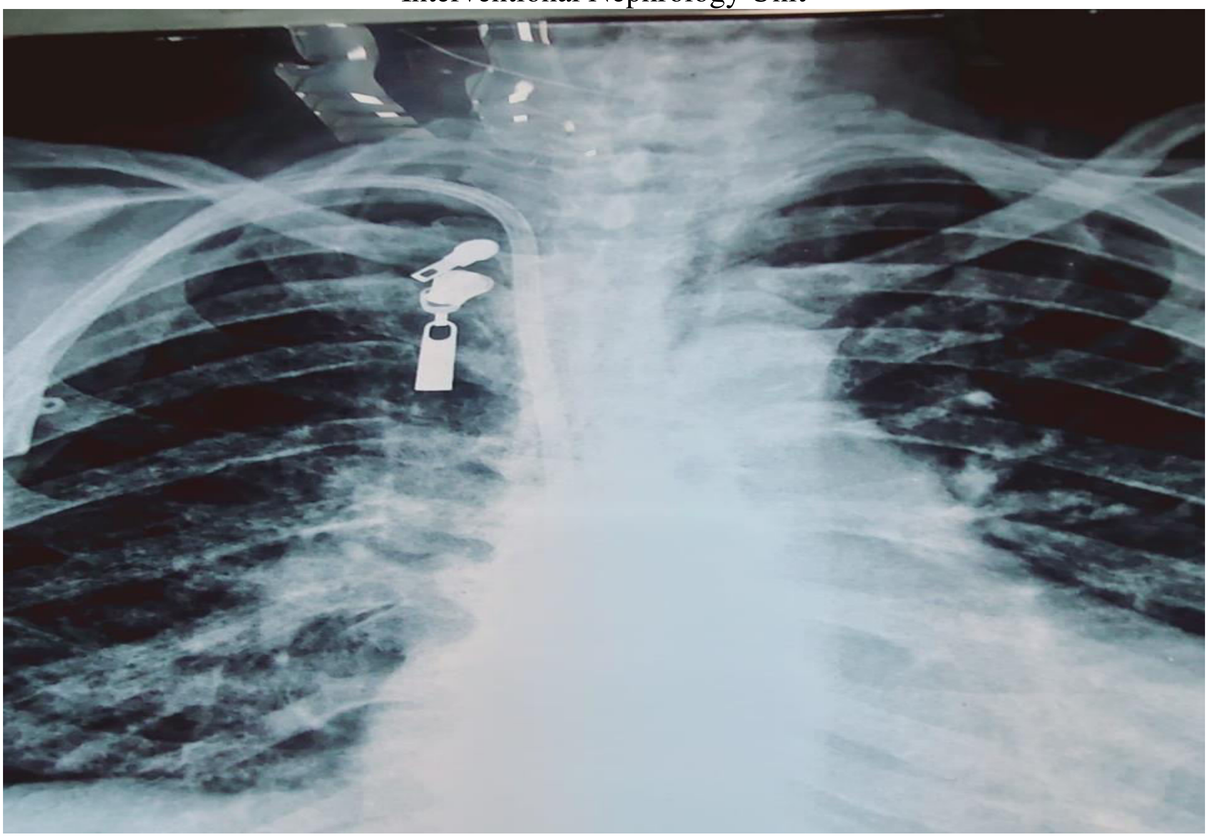

Fig.2. CXR showing post insertion functioning Rt int. Jugular cuffed HD catheter with tip in the optimum site. At Damanhour Medical National Institute Interventional Nephrology Unit.

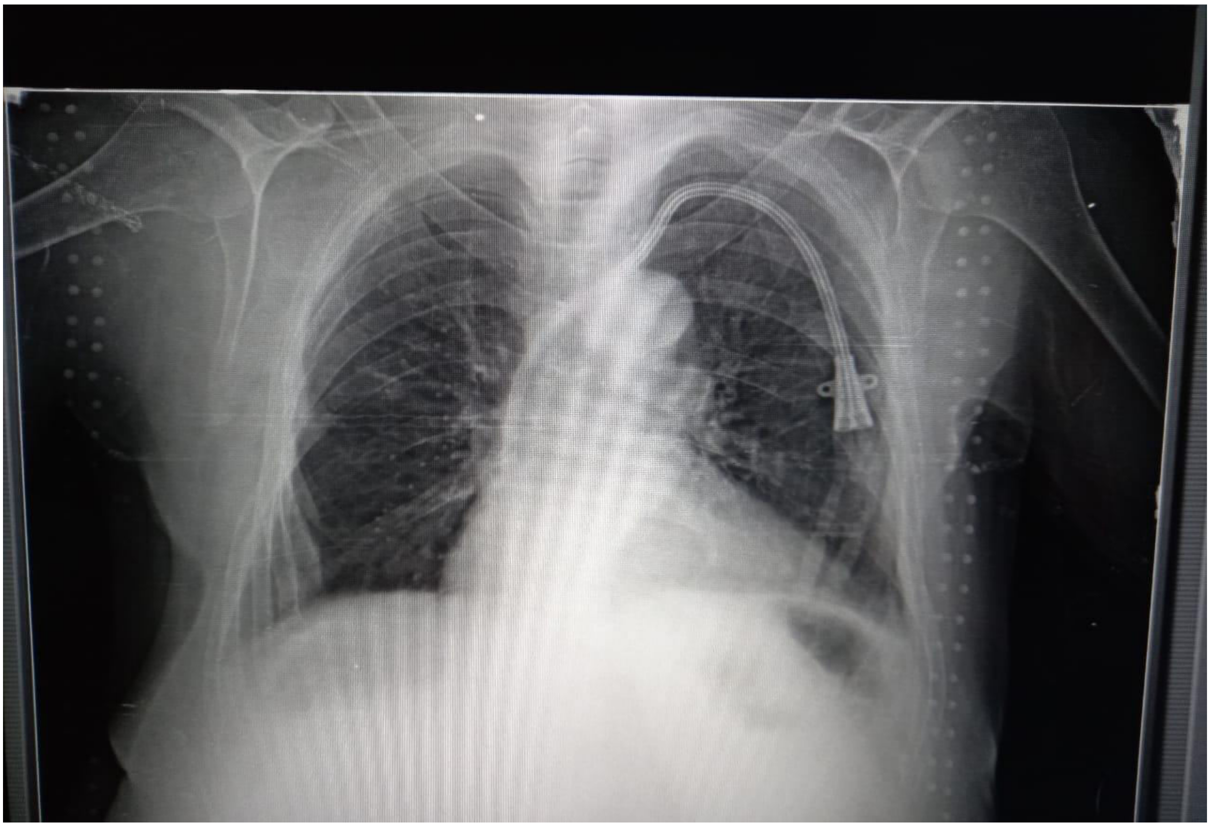

Fig.3. CXR showing post insertion functioning Lt subclavian cuffed HD catheter with tip in the optimum site. At Damanhour Medical National Institute Interventional Nephrology Unit.

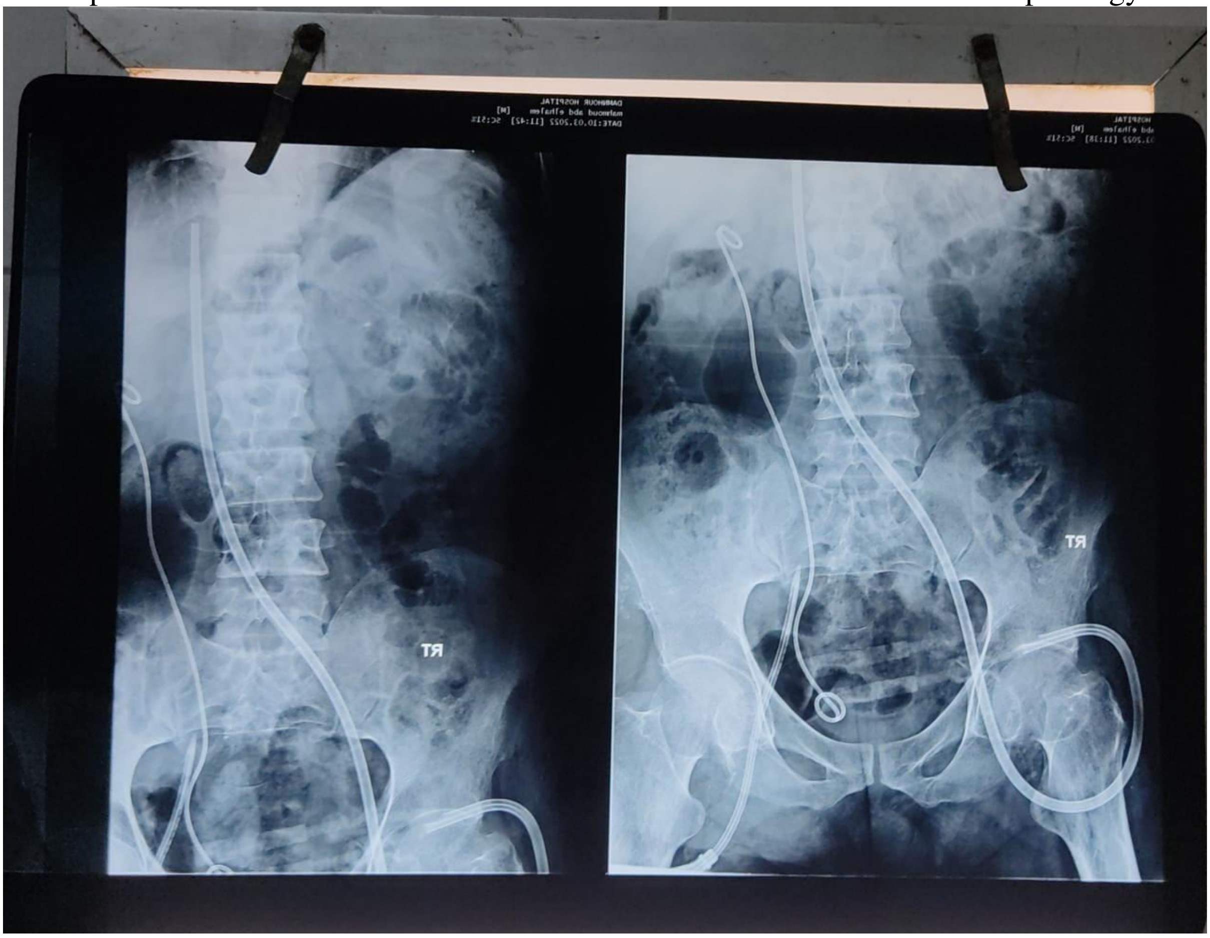

Fig.4. CXR showing post insertion functioning Lt external iliac cuffed HD catheter with tip in the optimum site At Damanhour Medical National Institute Interventional Nephrology Unit.

Fig.5. Right femoral Non tunneled hemodialysis catheter at nephrology unit Qena university Hospital.

IV. Outcome measures: The evaluation of our study was based on the rate of complications, specifically focusing on the occurrence rates of infection and thrombosis. Both of these adverse events were combined to calculate a composite complication rate.

Ethical code: SVU-MED-MED018-1-22-2-340

Statistical analysis

The collected data were analyzed using Statistical Software for Social Sciences (SPSS) version 26.0. Numerical data were presented as mean ± standard deviation (M ± SD), while qualitative data were expressed as frequency and percentage (%) and were subjected to comparison using Student's t-test. For non-parametric data, the Chi-square test was employed. A significance level of $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics

A total of 50 patients undergoing renal dialysis, were divided into two categories based on the type of the dialysis catheter. Group I (25 patients) included patients managed with non-tunneled catheters (NTCs), while group II (25 patients) included patients managed with tunneled dialysis catheters (TDCs). No significant variation was found between groups regarding basic characteristics (P>.05). In NTC group, the mean age was 58.6±8.0 years, ranging between 41 and 70 years, 13 (52%) patients were males, and 12(48%) were females, the mean BMI was 38 ±4.3 kg/m^2.In TDC group, the mean age was 56±8.8 years, ranging between 40 and 70 years, 10 (40%) patients were males, 15 (60%) were females, the mean BMI was 37.1±3.9 kg/㎡, ranging between 30.2 and 42.5 kg/㎡. Underlying Renal Pathology, in NTC group, five (20%) patients had unidentified renal pathology, six (24%) had diabetic nephropathy, five (20%) had hypertensive nephropathy, six (24%) had glomerulonephritis, two (8%) had polycystic kidney disease, and one (4%) patient was diagnosed with malignancy. In TDC group, six (24%) patients had unidentified renal pathology, five (20%) had diabetic nephropathy, four (16%) had hypertensive nephropathy, four (16%) had glomerulonephritis, two (8%) had polycystic kidney disease, and four (16%) were diagnosed with malignancy. No statistically significant difference was found between groups regarding time on dialysis (Chi-square test, P=.778).In NTC group, 16 (64%) patients have been on longstanding dialysis for ESRD, and nine (36%) have undergone dialysis recently. In TDC group, 15 (60%) were on longstanding dialysis, while 10 (40%) were recent dialysis patients. As demonstrated in (**Table 1).**

Table.1. Demographic data of studied groups.

Variables	NTC(N=25)	TCC(N=25)	P value
Age, years*			.290a
Mean ±SD	58.6±8.0	56±8.8	
Range	41-70	40-70	
Gender**			.395b
Male	13(52%)	10(40%)	
Female	12(48%)	15(60%)	
BMI, kg/m2*			.468a
Mean ±SD	38±4.3	37.1±3.9	
Range	30.4-44.7	30.2-42.5	
Race**			.395b
Black	10(40%)	13(52%)	
Caucasian	15(60%)	12(48%)	
Renal Pathology**			.778b
Unknown	5(20%)	6(24%)	
Diabetic Nephropathy	6(24%)	5(20%)	
Hypertensive Nephropathy	5(20%)	4(16%)	
Glomerulonephritis	6(24%)	4(16%)	
Polycystic Kidney Disease	2(8%)	2(8%)	
Malignancy	1(4%)	4(16%)	
Duration of Dialysis, months*			.771b
Recent	9(36%)	10(40%)	
Longstanding	16(64%)	15(60%)	

Data are presented as mean ± SD; ** Data are presented as frequency (percentage).
a Independent sample t test ;b chi-square test.

Complications

NTC and TDC groups were compared in terms of complications, including premature removal, infection, bleeding, functional, procedural, and multiple sticks. The premature removal rate was 36% and 12% for the NTC and TDC, respectively. Bleeding was reported in 32% in the NTC group, and 8% in the TDC group. In the NTC group, 32% had functional complications (3 catheter malfunction and 5 thrombosis), while 28% had procedural complications (3 need to pull back catheter, 2 cuff migration, and 2 missing the internal jugular vein), and in only 4% of the TDC group. In the TDC group, only 4% had either procedural or functional complications. Multiple sticks were encountered in 32% of the NTC group, and in 2% of the TDC group. NTC had a significantly higher complication rate compared to the TDC (Chi-square test, P< .05). As demonstrated in (**Table. 2).**

Table. 2. Complications (N=50)

Variables	NTC(N=25)	TCC(N=25)	P value
Premature Removal	15(60%)	8(32%)	.045
Infection	9(36%)	3(12%)	.043
Exit-Site	8(32%)	1(4%)	.010
CRB	6(24%)	1(4%)	.042
Bleeding	8(32%)	2(8%)	.034
Functional	8(32%)	1(4%)	.010
Procedural	7(28%)	1(4%)	.021
Multiple Sticks	8(32%)	2(8%)	.034

CRB: Catheter related bacteraemia, Chi-square test.

Survival Analysis

By running a Kaplan-Meier survival model, a statistically significant difference was observed in event-free rates in favour for the NTC and TDC groups (Log Rank test, P= .045). "Event" was defined as premature removal of the catheter secondary to any complication. The mean time to premature removal for the entire study group was 3.2± 0.1 weeks. The mean time to premature removal was 2.8±0.2 for the NTC group, and 3.5 ±0.2 weeks for the TDC group as demonstrated in (**Table .3).**

Table 3. Survival Time

Variables	NTC(N=25)	TCC(N=25)	Total (N=50)	P. Value
Mean ±SE	2.8±0.2	3.5±0.2	3.2±0.1	0.045
95% Confidence Interval	2.3-3.3	3.2-3.8	2.8-3.5	

Log Rank test of Kaplan-Meier survival

Discussion

These study's results demonstrated that the average age of the participants was 58.6 years in group I and 56 years in group II.

A separate study by **Hafez et al. (2019)** involving 1000 ESRD patients undergoing regular hemodialysis in Aswan governorate, Upper Egypt, reported an average age of 50.38±14.41 years.

Similarly, El-Ballat et al. (2019) found that the mean age of their patient cohort was 52.80±13.82 years.

Almutairi et al. (2017) conducted an analysis of demographic data from 349 hemodialysis (HD) patients in Tabuk City, Saudi Arabia. Their study indicated a mean age of 51.3±17.6 years for the patients.

Afifi (2008) noted a progressive increase in the mean age of Egyptian patients, rising from 45.6 to 49.8 years in 1996 to 2008. This upward trend in the mean age of individuals with ESRD reflects advancements in healthcare and improved patient management. However, there remains a disparity between these figures and those observed in more developed countries. For instance, the mean age of ESRD patients in the United States was reported as 59.2 years **(United States Renal Data System, 2015),** and in Europe, it stood at 60.3 years **(Pippias et al., 2015).**

The results of this study demonstrated that the predominant causes of end-stage renal disease (ESRD) included hypertension, diabetic nephropathy, and glomerulonephritis.

This pattern is consistent with reports from various governorates in Egypt. **Ahmed et al. (2015)** conducted a study within haemodialysis units in the Kafer El-Shakh Governorate in 2012. They found that the primary known causes of ESRD were hypertension (34%) and diabetic nephropathy (14%).

Similarly, in the El-Sharkia governorate, **Ghonemy et al. (2016)** documented that hypertension (31.8%) was the leading cause, followed by diabetes mellitus (DM) (15.5%). These parallels suggest a prevailing trend of hypertension and diabetic nephropathy as significant contributors to ESRD across different regions in Egypt.

In a similar vein, **El-Ballat et al. (2019)** documented comparable findings regarding the prevalent causes of ESRD in their study. They observed that hypertension (31.7%), diabetes mellitus (18.0%), and obstructive nephropathy (10.8%) were the most common contributing factors.

In the current study's results, it was revealed that 22% of the patients had ESRD of unknown causes. This proportion mirrors observations made by **El-Arbagy et al. (2016),** who identified ESRD of unknown etiology in 25% of their patient cohort. Furthermore, **El-Ballat et al. (2019)** reported that unknown causes accounted for 21.6% of all cases of ESRD, and **Ahmed et al. (2015)** indicated that unknown causes constituted 25.3% of all ESRD cases. These consistent figures underscore the presence of an appreciable portion of ESRD cases with undetermined origins across different studies.

These trends are similarly reflected in data from other countries within the Middle East. For instance, **Almutairi et al. (2017)** reported that 25.2% of ESRD patients in Saudi Arabia had unknown causes. In Libya, **Alsaeiti et al. (2021)** conducted an evaluation of 292 dialysis patients and found that 21.6% of them were attributed to unknown causes.

The present study's results revealed a notably higher rate of complications in patients with nontunneled catheters (NTC) in comparison to those with tunneled dialysis catheters (TDC) (Chi-square test, $P < 0.05$). These findings align with **Mendu et al. (2017),** who conducted a prospective cohort study spanning 16 months and involving 154 AKI-RRT patients. They demonstrated that patients receiving TDCs experienced significantly better renal replacement therapy (RRT) delivery, both for continuous venovenous hemofiltration (CVVH) and intermittent hemodialysis (IHD), when contrasted with patients using non-tunneled dialysis catheters (NTCs). Notably, NTCs were associated with considerably higher rates of mechanical complications (relative risk 13.6, $p = 0.001$).

In a similar vein, **Weijmer et al. (2004)** conducted a retrospective study encompassing both acute kidney injury (AKI) and ESRD patients. Their findings indicated notably higher infection rates among patients with non-tunneled catheters (NTCs) (15.6-20.2/1000 catheter days) in contrast to tunneled catheters (TDCs) (2.9/1000 catheter days).

Furthermore, **Klouche et al. (2007)** conducted a limited-scale randomized controlled trial involving 30 AKI patients, comparing NTCs with femoral TDCs. The results showed reduced occurrences of catheter-related bacteremia alongside significant enhancements in dialysis adequacy with TDCs as opposed to NTCs.

Conclusion

Tunneled dialysis catheters (TDCs) exhibit significantly reduced complications and superior performance characteristics when compared to non-tunneled dialysis catheters (NTDCs). Therefore, TDCs should be regarded as the preferred catheter option for renal replacement therapy (RRT) prior to the establishment of an arteriovenous fistula. Also, TDCs should be used in cases of ESRD when there are contraindications to the insertion of AV fistula.

References

- **Abd El-Sattar SS, El-Arbagy AR, Yassein YS, and Kasem HE. (2021).** Recirculation and adequacy of dialysis in end stage renal disease patients on regular hemodialysis at Menoufia university hospitals. Journal of The Egyptian Society of Nephrology and Transplantation, 21(1): 36.
- **Afifi A. (2008).** Annual reports of the Egyptian renal registry; 1996-2008. Egyptian Society of Nephrology and Transplantation, 9: 256-261.
- **Ahmed HA, Yassine YS, Tawafe AR, and Ebazaway MM (2015).** Epidemiological study of patients on regular haemodialysis at the Kafer El-Shakh Governorate,

Egypt. Menoufia Medical Journal, 28(2): 267-273.

- **Almutairi FM, Al-Duais MA, Shalaby KA, and Sakran MI. (2017).** Analysis of patients with end-stage renal disease on dialysis in Tabuk City, Saudi Arabia: a single-center, three-year retrospective study. Saudi Journal of Kidney Diseases and Transplantation, 28(2): 349-354.
- **Alsaeiti KD, Hamedh MA, Albarasi SM, Alagoory MM, Isawi YS, Benali SM, et al. (2021).** Current clinical situation of hemodialysis patients in nephrology center, Benghazi, Libya. Journal of The Egyptian Society of Nephrology and Transplantation, 21(1), 43-54.
- **Amini M, Aghighi M, Masoudkabir F, Zamyadi M, Norouzi S, Rajolani H, et al. (2011).** Hemodialysis adequacy and treatment in Iranian patients a national multicenter study, 5(2): 103-109.
- **Beaney T, Schutte AE, Stergiou GS, Borghi C, Burger D, Charchar F, et al. (2020).** May Measurement Month 2019: the global blood pressure screening campaign of the International Society of Hypertension. Hypertension, 76(2): 333-341.
- **Cheng L, Ren Q, Yu G, Gou S, Cui T, and Fu P. (2022).** Catheter failure and mortality in hemodialysis patients with the tunneled-cuffed catheter tip positioned in the inferior vena cava. Chinese Medical Journal, 135(19): 369-371.
- **Cheng YL, Tang HL, and Tong MKL (2019).** Clinical practice guidelines for the provision of renal service in Hong Kong: Haemodialysis. Nephrology, 24: 41-59.
- **El-Arbagy AR, Yassin YS, and Boshra BN. (2016).** Study of prevalence of end-stage renal disease in Assiut governorate, upper Egypt. Menoufia Medical Journal, 29(2): 222-231.
- **El-Ballat MAF, El-Sayed MA, and Emam HK. (2019).** Epidemiology of end stage renal disease patients on regular hemodialysis in El-Beheira governorate, Egypt. The Egyptian Journal of Hospital Medicine, 76(3): 618-625.
- **Eriksen BO, and Ingebretsen OC (2006).** The progression of chronic kidney disease: a 10-year population-based study of the effects of gender and age. Kidney international, 69(2): 375-382.
- **Gross JL, De Azevedo MJ, Silveiro SP, Canani LH, Caramori ML, and Zelmanovitz T. (2005).** Diabetic nephropathy: diagnosis, prevention, and treatment. Diabetes care, 28(1): 164-176.
- **Haddad NJ, Van Cleef S, and Agarwal AK. (2012).** Central venous catheters in dialysis: the good, the bad and the ugly. The Open Urology & Nephrology Journal, 5(1): 12-18.
- **Hafez MZE, Kassem SA, Gafaar HA, and Ali OM. (2019).** Epidemiology and risk factors of end stage renal disease in Aswan Governorate, Upper Egypt. The Egyptian Journal of Hospital Medicine, 74(6): 1298-1305.
- **Kazemzadeh G, Bazrafshan M, Kamyar MM, Fard AH, Kazemzadeh GH, and Hashemi Fard A. (2019).** Efficacy of Using Non-tunneled Dialysis Catheters During Arteriovenous Fistula till its Maturation: A Retrospective Study. Urology Journal, 16(6): 578-560.
- **Klouche K, Amigues L, Deleuze S, Beraud JJ, and Canaud B. (2007).** Complications, effects on dialysis dose, and survival of tunneled femoral dialysis catheters in acute renal failure. American journal of kidney diseases, 49(1): 99-108.
- **Lo LJ, Go AS, Chertow GM, McCulloch CE, Fan D, Ordoñez JD et al. (2009).** Dialysis-requiring acute renal failure increases the risk of progressive chronic kidney disease. Kidney international, 76(8): 893-899.
- **Nwankwo EA, Nwankwo B, and Mubi B. (2006).** Prevalence of impaired kidney function in hospitalized hypertensive patients in Maiduguri, Nigeria. The internet journal of internal medicine, 6(1): 1-7.
- **Pippias M, Stel VS, Abad Diez JM, Afentakis N, Herrero-Calvo JA, Arias M, et al. (2015).** Renal replacement therapy in Europe: a summary of the 2012 ERA-EDTA Registry Annual Report. Clinical kidney journal, 8(3): 248-261.

- **Saeed HS and Sinjari HY (2018).** Assessment of hemodialysis efficacy in patients with end-stage renal failure in the Erbil hemodialysis center. Medical Journal of Babylon, 15(4): 276-280.
- **Somji SS, Ruggajo P, and Moledina S (2020).** Adequacy of hemodialysis and its associated factors among patients undergoing chronic hemodialysis in dar es Salaam, Tanzania. International journal of nephrology, 1: 1-6.
- **Tomino Y (2014).** Pathogenesis and treatment of chronic kidney disease: a review of our recent basic and clinical data. Kidney and Blood Pressure Research, 39(5): 450-489.
- **Vanholder R, Davenport A, Hannedouche T, Kooman J, Kribben A, Lameire N, et al. (2012).** Reimbursement of dialysis: a comparison of seven countries. Journal of the American Society of Nephrology, 23(8): 1291-1298.
- **Weijmer MC, Vervloet MG, and Wee PM. (2004).** Compared to tunnelled cuffed haemodialysis catheters, temporary untunnelled catheters are associated with more complications already within 2 weeks of use. Nephrology Dialysis Transplantation, 19(3): 670-677.