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Application of an Alternative Technique for Tunneled Hemodialysis Catheter Replacement

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Abstract

Objective: To evaluate the safety and efficacy of two novel surgical techniques for the replacement of tunneled hemodialysis catheters (THCs) in patients experiencing catheter dysfunction.

Materials and Methods: A prospective study was conducted on 13 patients. Seven patients underwent catheter replacement by advancing a guidewire between the fibrous sheath and the catheter, while six patients underwent replacement using a puncture technique through the dysfunctional catheter. Demographic data, flow rates, and clinical follow-up information were collected.

Results: Of the 13 patients, seven (53.8%) underwent catheter replacement using a hydrophilic guidewire passed between the fibrous sheath and the catheter (group 1), and six (46.2%) underwent replacement *via* the catheter puncture technique due to inability to advance the guidewire through the sheath (group 2). All catheters were successfully placed without complications. The average time between the initial THCs placement and replacement was 14 months. Regarding flow rates, the mean pre-exchange flow rate in group 1 was 264.3 mL/min (Std.deviation 12.72) and 317.1 mL/min (Std.deviation 14.96) post-exchange, with a statistically significant difference (p=0.0001). In group 2, the average pre-exchange flow rate was 273.3 mL/min (Std.deviation 13.66), increasing to 336.7 mL/min (Std.deviation 16.33) post-exchange with a statistically significant difference (p= 0.0002).

Conclusions: In HD patients with THCs dysfunction, the described catheter replacement techniques are safe and effective, preserving venous access and avoiding complications. Larger studies are needed to confirm their efficacy.

Keywords: Hemodialysis; Replacement; Tunneled hemodialysis catheters; Dysfunctional catheter

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Introduction

Hemodialysis (HD) is a life-sustaining therapy used to treat patients with end-stage kidney disease (ESKD) worldwide. A properly functioning vascular access is essential for successful HD therapy. Despite their limitations, HD catheters are commonly used as vascular access to initiate HD therapy in both acute and chronic settings. According to data from the Centers for Disease Control and Prevention (CDC) and the United States Renal Data System (USRDS), up to 80% of new patients in the USA begin HD *via* catheters, with more than 100,000 catheters placed each year [1].

A significant percentage of patients depend on tunneled hemodialysis catheters (THCs), which provide vascular access until the creation or maturation of an internal arteriovenous fistula or prosthetic graft. They are also used in patients who have exhausted all long-term vascular access options [2].

Due to arterial stiffness and the resulting difficulty in creating an anastomosis, elderly patients pose a particular challenge for vascular surgeons. Moreover, their increased longevity is associated with a lack of fistula maturation and lower patency rates, making THCs a reasonable option for vascular access [3].

In 2006, the Kidney Disease Outcomes Quality Initiative (KDOQI) clinical practice guidelines for vascular access defined THCs dysfunction as the inability to maintain an extracorporeal blood flow of >300 mL/min [4]. The 2019 KDOQI guidelines redefined catheter dysfunction (CD) as the inability to maintain the prescribed extracorporeal blood flow (Qb) required for adequate hemodialysis without extending the prescribed treatment time [5]. The definition of CD should not be based solely on blood flow; it should also consider relevant parameters such as treatment duration and frequency, type of dialysis, catheter type, ultrafiltration variables, degree of recirculation, and patient weight.

Between 10% and 30% of THCs are removed due to the inability to maintain the prescribed blood flow necessary for adequate HD [6]. Causes include catheter tip malposition or thrombosis, fibrin sheath (FS) formation, or obstruction of the distal lumen against the vessel wall [7]. Additionally, CD is associated with serious health issues such as infections, frequent hospitalizations, multiple surgical interventions, and missed HD sessions [8].

Since the 1970s, the term "fibrin sheath" (FS) has been used to describe the sleeve that forms around catheters [9]. The reported incidence of FS varies widely in the literature, occurring in 10% to 56% of central venous catheters and in 100% of cases in some experimental studies [10,11].

The objective of this study was to present and evaluate two alternative surgical techniques for HCT replacement in elderly patients with CD, all of whom are contraindicated for placement of an internal arteriovenous fistula or prosthetic graft, with the intention of preserving the contralateral jugular vein for future vascular access.

Materials and Methods

We retrospectively studied 13 patients over 60 years of age who were referred to the General Surgery Service of the Hospital Universitario "Dr. José Eleuterio González" between January 1, 2022, and December 31, 2024, for CD. All patients underwent THCs replacement for CD in accordance with the KDOQI 2006 clinical practice guidelines. Informed consent for the procedure was obtained in all cases.

Two study groups were established:

- Group 1 included 7 patients who underwent catheter replacement using a hydrophilic guidewire inserted between the FS and the catheter.
- Group 2 included 6 patients treated using the catheter puncture technique.

The following data were collected: age, sex, etiology of end-stage renal disease (ESRD), number of previous THCs, puncture site vein, catheter type, time from initial placement to exchange, procedural success rate, pre- and post-exchange flow rates, and complications. During this study, the fibrin sheath on the dysfunctional catheter was not removed.

Inclusion and Exclusion criteria

Patients with ESRD who had a THCs placed in the internal jugular vein and did not respond to irrigation or to the administration of three doses of Alteplase 2 mg per lumen (ACTILYSE, Boehringer Ingelheim) were included.

Exclusion criteria were: patients with folded or malpositioned THCs, cuff extrusion, cuff infection, or central venous stenosis.

Catheter exchange process

Patients were placed in a supine position with their heads rotated 20° to 30° to the left. The procedure was performed under local anesthesia and sedation, with electrocardiographic, blood pressure, and oxygen monitoring. The neck and chest wall were aseptically prepared using 2% chlorhexidine. One hour before transfer to the hemodynamic laboratory, patients received prophylactic antimicrobial therapy. In all cases, 14.5 Fr palindrome-type HD catheters, ranging in length from 19 cm to 23 cm (Covidien®), were used.

The success of the procedure was determined by confirming the proper positioning of the catheter tip (THCs) and adequate blood aspiration. Below, we describe the two surgical techniques used for THCs exchange.

Placement of a guidewire between the fibrin sheath and the catheter (Group 1)

A 5 mm incision was made in the skin over the curve of the catheter, just above the internal jugular vein entry site. The THCs and FS were secured using 2-0 silk. A 3 mm incision was made in the FS with a fine scalpel (Figure 1a), and by gently stretching the sheath with a toothed Adson forceps, a peripheral intravenous catheter (Jelco® 16–18 gauge, 1-1/4 inch) was introduced between the THCs and the FS. A 0.035-inch straight-tip hydrophilic guidewire (Boston Scientific/Medi-tech, Watertown, MA) was introduced under fluoroscopic guidance until it exited the catheter tip (Figure 1b). Next, an incision was made below the right clavicle to create a new subcutaneous tunnel for the THCs (Figure 1c). After removing the dysfunctional catheter, the new THCs was inserted over the guidewire using a sheath and dilator. Proper placement of the new THCs was confirmed *via* fluoroscopy.

Catheter puncture technique (Group 2)

Following the same initial steps as in Group 1, after exposing the dysfunctional THCs, a peripheral intravenous catheter (Jelco® 16-18 gauge, 1-1/4 inch) was used to puncture the catheter (Figure 2a). A 0.035-inch straight-tip hydrophilic guidewire (Boston Scientific/Medi-Tech, Watertown, MA) was then introduced under fluoroscopic guidance until it exited through the catheter tip (Figure 2b).

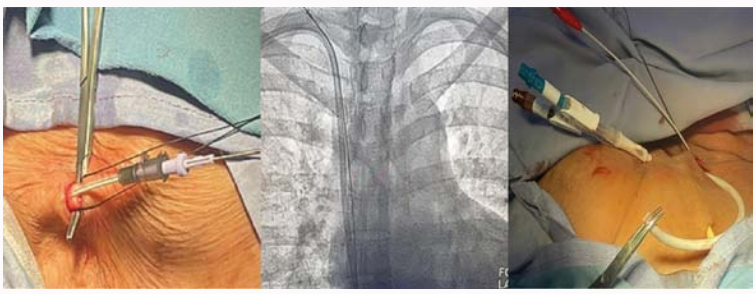

Figure 1: a) Introduction of a hydrophilic guidewire between the sheath and the CHT. b) Radiologic image of the hydrophilic guidewire. c) Creation of a new subcutaneous tunnel.

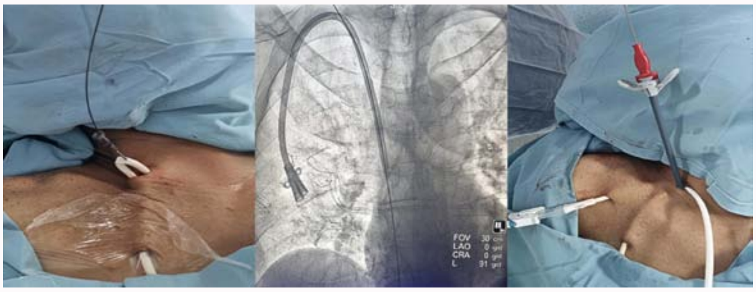

Figure 2: a) Puncture of a dysfunctional catheter. b) Radiological image of the hydrophilic guidewire. c) Introduction of the sheath and dilator.

An incision was then made below the right clavicle to create a new subcutaneous tunnel. Once the tip of the dysfunctional catheter was removed from the vascular portion, the catheter was withdrawn over the guidewire. The new THCs was then inserted over the guidewire using a sheath and dilator. Its final position was confirmed *via* fluoroscopy (Figure 2c).

Statistical analysis

Demographic data, along with pre- and post-replacement blood flow measurements, were compared between the two groups. Continuous variables are expressed as mean ± standard deviation (SD). An independent-samples Student's t-test was employed to compare group means. Statistical analyses were conducted using GraphPad Prism version 10.0 (GraphPad Software, San Diego, CA, USA). A p-value of less than 0.05 was considered statistically significant.

Results

Of the total group of 13 patients, 7 were male and 6 were female, with a mean age of 69.6 years. Ten patients had undergone one prior THCs placement, and three had undergone two. The main cause of end-stage renal disease (ESRD) was diabetes mellitus in 10 cases and hypertension in 3. In all cases, the right internal jugular vein was accessed, and the average interval between the previous THCs placement and the new catheter repositioning was 14 months. In both groups, pre- and post-exchange flows were 264.3 ml/min and 317.1 ml/min, respectively. Although the frequency of HD sessions varied among patients, flow rate measurements were conducted at least once a week.

Seven patients (53.8%) were treated using a hydrophilic guidewire inserted between the fibrous sheath and the catheter (Group 1), while six patients (46.2%) were treated using the catheter puncture technique (Group 2). Group 2 patients were selected after the failure of the Group 1 technique, due to a poorly formed or very thick fibrous sheath (FS) adhered to the dysfunctional catheter, preventing guidewire placement.

In Group 1, six patients had a history of one prior THC placement, and one patient had undergone two. In Group 2, four patients had received one prior placement, and one patient had undergone two THC placements.

The differences between the two groups in terms of demographic characteristics and the parameters evaluated are shown (Table 1). The average interval between the first and replacement catheter was 13.14 months (SD 12.1) in Group 1 and 15 months (SD 5) in Group 2.

Regarding flow rates, the mean pre-exchange flow rate in Group 1 was 264.3 mL/min (Std.deviation 12.72) and 317.1 mL/min (Std. deviation 14.96) post-exchange, with a statistically significant difference (p=0.0001).

In Group 2, the average pre-exchange flow rate was 273.3 ml/min (Std.deviation 13.66), increasing to 336.7 mL/min (Std.deviation 16.33) post-exchange with a statistically significant difference (p=0.0002).

In all cases, technical success was achieved, with proper placement of the new THC. No complications such as hematoma, wound or catheter infection, pneumothorax, or hemothorax were observed.

Discussion

The use of THCs remains a common option for HD access despite recommendations against its long-term use.

Motin et al. first reported the formation of an FS around a central venous catheter in 1964 [12], while in 1996, O'Farrell demonstrated that the FS is composed of fibroblasts and collagen, rather than fibrin [13]. Xiang et al. later showed in a murine model that the FS consists of smooth muscle cells covered by a layer of endothelial cells, beginning to form 7 days after catheter insertion [14].

Long-term encapsulation of the THCs by an FS is a complication that impairs catheter function and hinders effective HD [10], particularly when the FS involves the catheter tip.

Table 1: Demographic characteristics and parameters evaluated in both groups.

	Age Years	Sex	Diagnosis	AV	Time between changes (months)	Pre-exchange Flow ml/min	Post-exchange Flow ml/min
Group 1	67.4	4 Males	Diabetes Mellitus:	IJV	13.1	264.3 mL/min	317.1 mL/min
	SD 5.2	3 Females	4 Pt		SD 12.1	SD 12.7	SD 14.9
			Hypertension:				
			3 Pt				
Group 2	72.3	3 Males	Diabetes Mellitus 5	IJV	15	273.3 mL/min	336.7 mL/min
	SD 7	3 Females	Hypertension 1		SD 5	SD 13.6	SD 16.3

PT: Patient; AV: Accessed Vein; IJV: Internal Jugular Vein; SD: Standard Deviation

In 2024, Rozember et al. studied 625 THCs in 361 patients, finding that 234 (37.4%) required replacement due to dysfunction [15]. Brevetti et al. (1996) were the first to use the FS for central venous catheter replacement [16], and subsequent authors described similar techniques following accidental catheter removal [17,18].

In 2010, Masumoto et al. reported replacement in 7 patients by incising the anterior wall of the FS and using the opening to exchange the old catheter for a new one [19].

Some authors [20,21] have reported 100% success rates in HD catheter replacement using the over-the-wire exchange technique, with six-month patency rates of 37% and 82%, respectively. Other studies have shown that guidewire exchange does not increase bacteremia rates and offers similar longevity compared to new-site placement [22].

In 2016, Wang et al. described a catheter replacement technique involving puncture of the internal jugular vein prior to catheter removal in 84 elderly patients. All THCs were successfully placed, with a 30-day patency rate of 97.7% [23]. In a later study, the same author [24] reviewed 56 patients who underwent catheter replacement by sectioning the dysfunctional catheter at the neck incision and inserting a guidewire through its proximal end.

In our study, the techniques applied in both Group 1 and Group 2 prevented the catheter tip from slipping into the vascular tract and eliminated the risk of air embolism.

Zhang et al. [25] reported successful replacement of dysfunctional THCs in 39 patients in 2024. Their technique involved puncturing the catheter with a metallic needle and introducing a guidewire into its lumen, with a 100% success rate. Our second technique is similar, but instead of a needle, we puncture and canalize the catheter using a short peripheral intravenous catheter, allowing easier guidewire passage.

This paper presents a surgical alternative to conventional techniques described in the literature, offering the advantage of reduced contamination risk by avoiding manipulation of the catheter lumen. With these methods, the dysfunctional THCs does not need to be removed until the hydrophilic guidewire is passed between the FS and the catheter. Group 2's technique is straightforward and prevents the risk of air embolism by directly puncturing the catheter. All patients in our study were older than 60 and unsuitable candidates for arteriovenous fistula or prosthetic graft placement.

Of all patients in this study, 53.8% underwent successful THCs replacement using the guidewire method alone, without the need for catheter puncture.

In cases of CD unresponsive to local fibrinolytic therapy, we prefer to use one of these two techniques, which help preserve venous access for as long as possible before considering alternative sites such as the left internal jugular, subclavian, or femoral veins, or more complex procedures.

No surgical or wound complications were observed in any of the patients.

Conclusion

In patients undergoing HD with THCs dysfunction, catheter replacement using the two described techniques offers a safe and effective alternative, preserving future venous access and avoiding complications associated with new catheter placements.

A larger cohort is necessary to fully evaluate the effectiveness of these procedures, as this study included a limited number of cases.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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