

# Routine use of ultrasound to avert mechanical complications during placement of tunneled dialysis catheters for hemodialysis



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## ABSTRACT

**Objective:** While placement of tunneled dialysis catheters for hemodialysis access is considered a routine procedure, it is associated with a small chance of mechanical complications. Because the literature examining these issues is not recent and our impression of the incidence of these postprocedural complications is at variance with the existing literature, we decided to review our experience.

**Methods:** Since 1998, our vascular service has placed 1766 tunneled hemodialysis catheters in 1065 patients for hemodialysis access. All catheters were placed with ultrasound guidance for the puncture, with selective use of a micro-puncture set for patients with low-volume status. All patients underwent chest radiography at the end of each procedure.

**Results:** The average age of the patients was  $61 \pm 21$  (standard deviation) years. Among the 1065 patients, 44% were female; 93% of catheters were placed in the right internal jugular vein and 7% in the left internal jugular vein. The prevalence of diabetes and hypertension in our population of patients was 52% and 72%, respectively. In this consecutive series, no case of postprocedure hemothorax or pneumothorax was encountered. Two cutdowns had to be performed because of injury to branches of the external carotid artery. Three patients had to have a subsequent revision because of malpositioning of the catheter.

**Conclusions:** Using modern-day techniques, the incidence of mechanical complications during placement of tunneled catheters can be diminished. Hence, routine use of ultrasound guidance for insertion of tunneled dialysis catheters should become the standard of care. (*J Vasc Surg: Venous and Lym Dis* 2019;7:543-6.)

**Keywords:** Duplex ultrasound; Tunneled dialysis catheters; Hemodialysis; Guideline for placement

End-stage renal disease (ESRD) affects nearly 20 million people in the United States, with approximately 120,000 new cases reported every year.<sup>1,2</sup> Since the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI) was first established in 1997, the clinical practice guidelines for hemodialysis access and adequacy have been defined.

The current guidelines recommend a fistula-first approach to prompt use of arteriovenous fistula (AVF) as it reduces access-related complications, leading to better patient survival and access longevity.<sup>3</sup> However, recently published U.S. renal data suggest that hemodialysis is initiated with a tunneled dialysis catheter (TDC) in 80% of ESRD patients as opposed to AVF (17%).<sup>4</sup> In

addition, TDCs are essential in case of urgent hemodialysis, arteriovenous access thrombosis, and maturation failure or delay.<sup>3,5</sup>

Despite placement of a hemodialysis catheter being a routine intervention, published literature has reported severe acute complications including arterial puncture, hematoma, pneumothorax, and hemothorax.<sup>4,6</sup> Routine use of duplex ultrasound (DUS) to identify the targeted vein and to guide vein puncture and catheterization has been reported to reduce the mechanical complications and helped improve the technical success rate of these procedures, increasing the safety and quality of catheter placement.<sup>7-11</sup>

The National Kidney Foundation-KDOQI clinical practice guidelines for vascular access were last published in June 2006.<sup>3</sup> The KDOQI guidelines for TDC suggest use of ultrasound for placement of the catheter. In this study, the objective was to define the role and importance of routine use of DUS for short- and long-term hemodialysis catheter placement based on our experience.

## METHODS

A retrospective review of all patients in whom hemodialysis catheters were placed since 1998 was conducted. The placement of the Tesio (Bio-Flex; MedCOMP, Harleysville, Pa) tunneled hemodialysis catheter was performed

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by three qualified practitioners in a hospital setting. A perioperative chest radiograph was obtained for each patient, and only the internal jugular veins were used to place the hemodialysis catheters. In all cases, DUS guidance was used for puncturing of the targeted vein. The ATL HDI 3000 and 5000 ultrasound systems (ATL Ultrasound, Bothell, Wash) were used for the placement procedure, with 7 MHz frequency. The patients were placed in the Trendelenburg position, with the head turned opposite to the side of the procedure. Routine access in patients with ESRD and acute renal failure was obtained using an 18-gauge needle. The ultrasound transducer was wrapped in a sterile sheath, and the procedure was guided using a dynamic approach tracking the needle entering the vein.

However, in patients with intravascular volume depletion and collapse of vessel wall (<1%) with each respiratory cycle, a micropuncture needle set was preferred. DUS helped locate the position of the vein and define its caliber and patency. The ultrasound probe was aligned at transverse or longitudinal axis to the targeted vessel as needed and the needle for catheterization inserted at the middle of the axis of the probe. After venous return was confirmed, using the Seldinger technique, a 10F TDC was then placed and its position confirmed using intraoperative fluoroscopy. On the right side, the catheter was not advanced over a guidewire because of the anatomy. However, on the left, the catheter is placed over the wire for anatomic reasons using intraoperative fluoroscopy guidance. All patients underwent chest radiography at the end of each procedure in the operating room to identify any potential complications or a malpositioned catheter. If any difficulty was noted in passing the guidewire or TDC despite presence of patent internal jugular vein on DUS, intraoperative balloon venoplasty was performed with an 8-mm balloon in 19 procedures. The TDC was then placed in routine manner.<sup>12</sup>

The position and laterality of placement of the TDC along with presence of AVF were noted for the study population. Data relating to mechanical complications from the procedure, including pneumothorax, hemothorax, and arterial puncture, were also noted. In patients with concomitant cardiovascular comorbidities, with pre-existing pacemakers or automatic implantable cardioverter-defibrillators noted on the preoperative chest radiograph, the TDC was placed ipsilateral to the device. In our clinical experience, we noted no catheter malfunction, stenosis, or dislodgment, and the technique also spares the contralateral arm for permanent vascular access.<sup>13</sup>

The data collection and interpretation conformed to the principles set by the Declaration of Helsinki. The Institutional Review Board granted a waiver for informed consent as the study was of minimal risk and the data were retrospective.

## ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective cohort study
- **Key Findings:** Routine use of duplex ultrasound for placement of 1766 tunneled dialysis catheters (Tesio) in 1065 patients for hemodialysis access resulted in no postprocedural hemothorax or pneumothorax. In 0.01% of patients, cutdown was required for injury to branches of the external carotid artery.
- **Take Home Message:** Mechanical complications during placement of tunneled dialysis catheters can be diminished with the routine use of duplex ultrasound.

## RESULTS

Since 1998, our vascular service has placed 1766 Tesio dialysis catheters in 1065 patients for hemodialysis access. The mean age of the study population was 61 (standard deviation,  $\pm 21$ ) years. Among them, 44% were female. The majority of hemodialysis TDCs, 93%, were placed in the right internal jugular vein and 7% in the left internal jugular vein. The prevalence of diabetes and hypertension in the study population was 52% and 72%, respectively.

In this consecutive series, no case of postprocedural hemothorax or pneumothorax was encountered. Two cutdowns, however, had to be performed from injury to branches of the external carotid artery. Three patients had a subsequent revision because of a malpositioned catheter on postoperative chest radiography. For all patients, chest radiography was performed immediately after the procedure to look for any complication or malposition. In these three patients, immediate chest radiography after the procedure showed correctly positioned catheters. However, the catheters flipped out and were noted to be malpositioned on a subsequent radiograph. Hence, they were revised at a later time.

## DISCUSSION

Although the current KDOQI guidelines recommend a fistula-first approach, the role of the TDC has been defined. A recent report suggested that in approximately 80% of ESRD patients, a hemodialysis catheter is required at some point in long-term care.<sup>2</sup> The current KDOQI recommendations suggest that the right internal jugular vein is the preferred site of insertion for the TDC because of its more direct route compared with the left. The subclavian vein is not preferred because of a high risk of central vein stenosis (Grade A). Although the use of DUS during catheter placement has been suggested, it has been included as Grade B evidence, and its routine use has not been established.<sup>3</sup>

In our experience before 1998, using a blind approach of traditional anatomic landmarks alone does not help visualize the vessel anatomy and can lead to higher mechanical complications. Previous literature has reported a 35% failure rate using anatomic landmarks alone, without DUS for central vein catheterization.<sup>14</sup> Also, up to 9% of patients have been noted to have abnormal central venous anatomy; thus, relying on traditional methods is associated with higher risks and complications.<sup>15</sup> This led to adoption of standard routine DUS guidance for catheter placement in our practice to maximize patient care. In our experience, the trainees, including residents and fellows, have been actively involved in catheter placement for these patients under supervision and have demonstrated easy reproducibility of good clinical and technical outcomes. Routine use of DUS is also a cost-effective approach because of its high availability in most centers.

The complications associated with catheterization have been categorized as early, which are usually mechanical, and late due to infective or thrombotic causes. The frequency of mechanical complications has been reported to be between 5% and 19%.<sup>1,6</sup> The most common mechanical complication noted after jugular or femoral vein catheterization is an arterial puncture. For a subclavian vein catheterization, pneumothorax has been reported as most common. Routine use of a micropuncture needle can help prevent inadvertent arterial punctures. Thus, regular use of these needles for access should be adopted on the basis of each physician's skill, considering each patient's volume status and anatomic landmark identification.

Employing routine DUS for catheterization not only enables direct visualization of the targeted vein and surrounding structures but also helps identify a thrombosed vein before puncture. Established literature exists for an increased clinical and technical success, with fewer technical complications, with routine use of ultrasound during catheterization.<sup>4,11</sup> In a recent study by Sazdov et al<sup>11</sup> comparing ultrasound-guided central vein catheterization with landmark technique, the overall success was reported to be higher in ultrasound-guided technique (98% vs 90.5%;  $P = .0013$ ), and first attempt success was higher (77% vs 60.5%;  $P = .0032$ ). The complication rate was also lower with ultrasound-guided catheterization (arterial puncture, 1% vs 8%; pneumothorax, 0% vs 4%; and hematoma, 4% vs 10%). Another important observation in this study was the similarity in clinical success and complication rate between the different physicians involved, thus making it a reliable method irrespective of the physician's experience.

In our clinical experience, we noted 0% pneumothorax and hemothorax and <1% arterial puncture with routine use of DUS during catheter placement. The reality is the lack of guidelines on behalf of the critical care and surgery committees for routine use of DUS during

placement.<sup>16-19</sup> The KDOQI guidelines (2.4.2) do suggest the role of DUS during placement of the TDC. Hence, we need to push for these existing guidelines to be endorsed and to have the two groups approve routine use of this technology worldwide as a standard of care. Use of a guidewire before placement of the catheter, irrespective of laterality, is safer and should usually be used for placement of a TDC, especially in the hands of trainees. The position of the TDC along the anatomic landmarks of the central veins should be confirmed using the color of the aspirated blood as a determining factor. In case inadvertent common carotid artery puncture or placement is suspected, pulsatile flow, visualization with DUS, and arterial blood gas sampling can be used to confirm position. Our data thus substantiate these guidelines and provide clinical evidence to standardize the role of routine DUS. Routine DUS will not only help identify and confirm patency of the targeted vein before the procedure but also guide with puncture, thus minimizing the rate of mechanical complications during placement of TDCs.

## CONCLUSIONS

Using modern-day techniques, the incidence of mechanical complications during placement of tunneled hemodialysis catheters can be diminished. Hence, routine use of ultrasound guidance for insertion of TDCs should become the standard of care.

## AUTHOR CONTRIBUTIONS

Conception and design: AnH, EA  
Analysis and interpretation: AA, AmH, AnH  
Data collection: AA, AmH, AnH, NM, EA  
Writing the article: AA, AnH  
Critical revision of the article: AA, AmH, AnH, NM, EA  
Final approval of the article: AA, AmH, AnH, NM, EA  
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