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Non-Fluoroscopic Techniques to Insert a Tunneled Hemodialysis Catheter

Pallavi Prasad[1] and Tushar J. Vachharajani[2]

[1]Department of Nephrology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India; and [2]Department of Medicine, John D. Dingell Veterans Affairs Medical Center and Wayne State University School of Medicine, Detroit, Michigan, USA

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See Clinical Research on Page 2001

The KDOQI clinical practice guidelines for vascular access recommends image guided placement of tunneled cuffed hemodialysis catheter (tHDC). Alternate imaging techniques may be used to ensure correct catheter tip position if fluoroscopy is unavailable. The age-old anatomical landmark guided method is unsafe due to its lower success rate and a higher complication risk.[1]

The historical use of a radiographic landmark (fourth and fifth thoracic intervertebral disc space, inferior margin of the medial end of the clavicle, junction of mediastinal border/right heart border and bifurcation of the right bronchus from the trachea) on a biplanar image of a 3-dimensional structure, to identify the superior vena cava/right atrial (SVC/RA) junction is prone to parallax error.[2] Further, the alignment of the catheter tip to a radiographic landmark does not exclude tip malposition into an accessory vessel (such as azygos vein) or extravascular space.[2]

Direct visualization of the guidewire into the inferior vena cava and catheter tip positioning under fluoroscopy is considered the gold standard for tHDC insertion because it allows for early diagnosis and timely intervention of any procedural complication.[3]

In the October issue of KI reports, Kächele *et al.*[4] describe their experience of ultrasound (USG) guided tHDC insertion without fluoroscopy in 134 patients during the COVID era. The technique involved USG guided vein localization and puncture. The guidewire position in the RA was confirmed in 130 cases using a subcostal cardiac view. Intracardiac electrocardiogram monitoring or agitated saline infusion were additionally used in 4 cases. The catheter was inserted over the guidewire with J-tip just protruding from the catheter and placed at mid-RA. The USG visualization ensured that the catheter tip did not touch the atrial walls or the tricuspid valve. The primary success rate, defined as a composite outcome of catheter position and function, was achieved in 97.7% of patients with USG guidance. The success with tip position in the RA using USG was 70% compared to 60% in the historical cohort with fluoroscopy. The authors report significant complication rates, including immediate procedure-related mortality in 2 cases, and 2 cases with massive bleeding requiring blood transfusion therapy.

The ideal catheter tip position for a central venous catheter remains controversial, especially between a tunneled and nontunneled dialysis catheter.[2] There is consensus for the tip of the tHDC to be placed in the mid-RA with the arterial lumen facing the mediastinum.[1] The softer tip of a tHDC compared to a stiff tip of a nontunneled catheter minimizes the risk of cardiac perforation and atrial wall damage. Fluoroscopic guided wire placement in the inferior vena cava reduces the risk of sustained arrhythmias often encountered with blind technique. A correctly placed tHDC tip including the most proximal side hole (''functional tip'') in the mid-RA provides higher blood flow with lower risk for dysfunction related to intraluminal thrombosis.[2,5]

The direct visualization of the catheter tip in the mid-RA while confirming the catheter tip does not touch the RA walls or tricuspid valve is an advantage of the technique used by Kächele *et al.*[4] The study does not provide the level of training and expertise of an interventionist. A high level of skill is required for the USG localization described in the current study with 2 well-trained operators. As point of care, ultrasound and echocardiography are user dependent techniques, we believe training requirement needs to be defined.

Despite USG RA localization, the tip of the catheter was found to be in the upper RA (i.e., between the SVC and mid atrium) in 70% of cases.[4] The tip placement in the

Correspondence: Tushar Vachharajani, Department of Medicine, John D. Dingell Veterans Affairs Medical Center, 4646 John R Street, Detroit, Michigan, USA. E-mail: Tushar.vachharajani@va.gov

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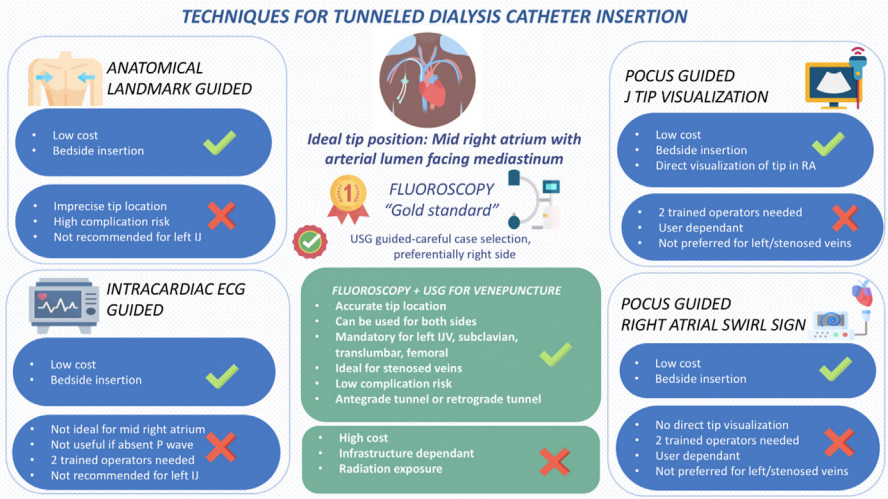

Figure 1. Imaging techniques for tunneled dialysis catheter insertion.

upper RA bears the risk of cephalad migration of catheter tip with patient position and respiration. A median cephalad migration of 0.9cm, (up to 2–3 cm), was seen to occur both with respiration and with supine to sitting position in a study assessing migration of catheter tip.[6] A change in tip position is more pronounced in the in female patients, obese patients, and subclavian catheters.[2,6]

The authors describe 2 additional techniques to confirm the tip position: intracardiac electrocardiogram monitoring and agitated saline infusion.[4] The first method involves using either the guidewire or a column of saline inside the hemodialysis catheter as an electrocardiogram electrode. As the catheter is advanced in the SVC, the height of the P wave increases to a maximum at the SVC/RA junction. Appearance of a small negative deflection before the P wave signifies entree into the RA. This technique, although useful for nontunneled dialysis catheter insertion, is not ideal for tHDC insertion requiring RA placement because the detection of a maximal P at the SVC/RA junction is the only constant finding, other P wave variations once catheter is pushed deeper are not precise for localization.[7] The second method described is the use of agitated saline or the RA swirl sign, which involves using a 10 ml saline flush (or agitated saline) injected into one of the catheter hubs while echocardiography is performed by another operator. The immediate appearance (within 1 s) of a swirl of fluid in the RA (or microbubbles if using agitated saline) signifies correct tip positioning. The use of a combination of techniques in resource-limited settings may help in achieving an overall high success rate.

In the current study, 87.3% of the cases were right sided internal jugular vein (IJV) catheters.[4] The right IJV drains in almost a straight line into the RA. In contrast, the left IJV bears 3 sharp angulations. Two of these are visible on a biplanar chest X-ray, one between the left IJV and left brachiocephalic vein and the second between the left IJV and the SVC. The third angle, visible only in the coronal plane and not on a frontal chest X ray, is underappreciated by clinicians, a relatively sharp angulation of the left brachiocephalic vein as it crosses the rigid fulcrum formed by the aortic arch and the brachiocephalic artery.[8]Therefore, pressure at an incorrect angle on a rigid dilator while inserting a left tHDC bears not just the risk of venous injury but also that of a catastrophic injury to the arch of aorta. In addition, in case of an incorrectly placed high tip position in a left tHDC, the tip may-abut against the lateral wall of the SVC or the wall of RA. Chronic vessel injury and late vascular or cardiac perforation may occur due to its repeated movement with cardiac activity, respiration, and patient position.[3] Therefore, fluoroscopy is indispensable for safe insertion of left sided tHDC.

The study notes that 65.7% of patients who received a tHDC had a history of previous dialysis catheter insertion but fails to mention the catheter duration, whether tunneled or not and their location.[4] In general, in patients with a prolonged history of jugular nontunneled dialysis catheter or tHDC, fluoroscopic guidance is preferred over non-fluoroscopic insertion. The current study may have suffered from a selection bias considering the known risk of central venous stenosis with multiple catheter insertions.

In this study, the authors use retrograde tunneling technique of tHDC.[4] The retrograde technique involves positioning the tip first followed by creation of a tunnel from the venipuncture site to the exit site. The retrograde technique has the advantages of more consistent tip position, the option of replacing the hubs in case of damage and easy catheter removal.

Lastly, USG-guided technique can be an innovative and efficient strategy to reduce cost and ensure safe tHDC insertion by converting nontunneled dialysis catheter to tHDC without compromising catheter dysfunction and catheter related bloodstream infection rate.[9]

In summary, the fluoroscopic technique, despite all the advantages, comes with a significantly higher cost and limitations to access in several regions of the world. The COVID-19 pandemic has given the medical fraternity a

view into the unpredictability of working in resource-limited settings both in the high-income and low-income countries, leading to the innovation of new techniques (Figure 1). These novel ways to place tunneled dialysis catheters in a safe, efficient, and cost-effective manner needs to be better studied in various health care settings.

DISCLOSURE

All the authors declared no competing interests.

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