Application of Intravascular Ultrasound in End-Stage Renal Patients with Central Venous Occlusive Disease

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ABSTRACT: Central venous occlusive disease is frequently observed in patients with end-stage renal disease. Venography remains the gold standard for diagnosis, but intravascular ultrasound is a potentially beneficial adjunct that may positively influence intervention.

INTRODUCTION

Central venous stenosis and occlusive disease (CVOD) is an increasingly frequent finding on venography. In the end-stage renal disease (ESRD) population, the majority of whom are initiated on catheter-based hemodialysis, the incidence ranges from 20% to 40%, depending on the series.[1,2] These patients may have adapted to their ≥ 50% intraluminal narrowing but more commonly exhibit an array of symptoms such as ipsilateral edema, pain, and access malfunction.[3] The number, location, and duration of central venous catheters are all important factors in the development of CVOD.[4-6] Moreover, the well-documented concurrent prevalence of chronic indwelling pacemaker and defibrillator wires in this population can further exacerbate CVOD symptoms.[7] Although the precise mechanism of CVOD is unclear, a likely etiology is a combination of direct trauma, inflammation, and chronic endothelial injury.[2,8,9]

INTRAVASCULAR ULTRASOUND VERSUS VENOGRAPHY

Intravascular ultrasound (IVUS) uses a 10 MHz to 40 MHz catheter-mounted probe to provide cross-sectional imaging within the vessel. This modality is commonly used for coronary interventions to assist with sizing, stent deployment, and assessments after percutaneous coronary interventions.[10-12] Recently, the Venogram vs IVUS for Diagnosing Iliac Vein Obstruction (VIDIO) trial demonstrated that IVUS showed a greater number of stenotic lesions and intraluminal diameter reductions in the iliofemoral system compared to traditional venography.[13] Several studies have looked at using IVUS to assess CVOD in dialysis access patients, but consensus is lacking (Table 1).

Single-plane contrast venography and digital subtraction angiography (DSA) are the classic standard for evaluating CVOD, and the National Kidney Foundation Kidney Disease

AUTHORS	TYPE	NUMBER OF PATIENTS	MODALITIES	FINDINGS
Matthews and Thomas	Case report	1	• IVUS • Pullback pressures	Successful angioplasty and stenting of CVS
Tsai et al.	Case report	1	• Venogram • IVUS • Pullback pressures	Residual stenosis identified via IVUS and pullback pressures
Graaf et al.	Retrospective review	12	• Venogram • IVUS	• Residual stenosis identified on 6/12 patients with IVUS and 3/12 patients with DSA • Intraluminal trabeculations visualized on IVUS

Table 1.
Current literature on central venous occlusive disease and intravascular ultrasound. IVUS: intravascular ultrasound; CVS: central venous stenosis; DSA: digital subtraction angiography

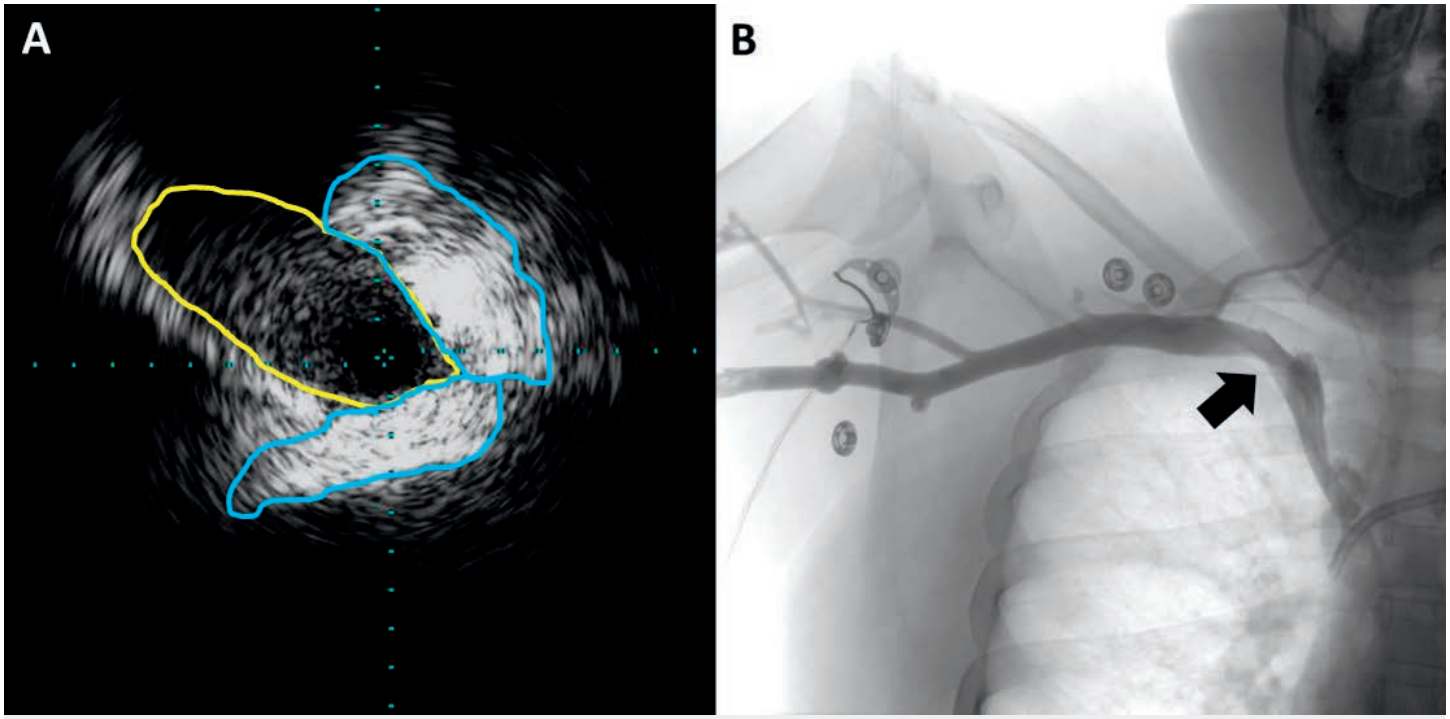

Figure 1.
Central venous stenosis on intravascular ultrasound (A) with reduced intraluminal diameter (yellow) and extrinsic compression (blue) compared to digital subtraction angiography (B).

Outcomes Quality Initiative (NKF KDOQI) guidelines recommend an endovascular-first approach to addressing COVD lesions.[14] However, the accuracy of venography is limited in standard anterior-posterior projections, and multiplanar venographic studies are not common. Neglén and Raju found that single-plane venography significantly underestimates the degree of stenosis in the iliofemoral system, and our unpublished institutional experience supports a similar assertion in hemodialysis patients with suspected CVOD (Figure 1).[15] In the iliocaval system, stenosis is associated with decreased cross-sectional area and altered flow dynamics, but these outcomes have yet to be explored in the ESRD population.[16-18] We would expect a similar result, although it has been observed that vessel shape has a significant impact on cross-sectional area. Kabnick et al. showed that elliptical vessels had decreased cross-sectional areas compared to circular vessels with the same perimeter.[19]

Initial reports focused on using IVUS as an alternative modality for diagnosing CVOD. In 2008, Matthews and Thomas described using IVUS in an ESRD patient with severe left upper extremity edema and discomfort.[20] The patient had a known anaphylactic reaction to iodinated contrast despite multiple pretreatment attempts. IVUS identified a focal area of stenosis confirmed with pullback pressures and amendable to balloon angioplasty.[21,22] Carbon dioxide angiography had previously been the preferred modality for patients with severe reactions to iodinated contrast, but use in the thoracic cavity is relatively contraindicated due to concerns for air trapping and hemodynamic compromise.[23]

Tsai et al. later reported using IVUS in another ESRD patient with extremity edema to diagnose left brachiocephalic vein compression by the innominate artery.[24] These findings were confirmed intraoperatively with venography prior to angioplasty and stenting. Pullback pressures and IVUS were able to identify residual stenosis missed on completion venography. Lin et al. reported similar findings in their series of 94 ESRD patients, wherein they observed that pullback pressure gradients were better predictors of long-term patency than venography; pressure gradients ≤ 5 mm Hg correlated with better outcomes.[22] We do not routinely measure pressure gradients for CVOD in our practice but have anecdotally found that patients with gradients > 3 mm Hg may have significant stenoses. This echoes the experiences in the coronary and iliofemoral systems where IVUS was instrumental in guiding therapy.[10,25]

More recently, Graaf et al. compared DSA to intravascular ultrasound in a series of 12 patients with CVOD.[26] IVUS showed residual areas of > 50% stenosis after angioplasty in six patients, whereas venography only identified those conditions in three patients. IVUS additionally identified trabeculae within the central vasculature that could not be visualized with standard venography. Although the authors could not establish the impact of these trabeculae, they postulated that such features may one day serve as additional criteria to guide intervention. Similarly, they note that the hyperechogenicity within the walls of stenotic vessels may represent fibrinous changes consistent with venous stenosis.

CONCLUSION

The growing body of data suggests that IVUS is a potentially useful adjunct in the diagnosis and management of CVOD in patients with ESRD. Although we cannot advocate for its routine use at this time, additional investigation in this patient population may lead to stronger recommendations.

KEY POINTS

- Central venous stenosis and occlusive disease (CVOD) is frequently observed in end-stage renal disease (ESRD) patients.
- Intravascular ultrasound (IVUS) may be better suited than traditional venography to identify intraluminal narrowing and pre-/post-intervention outcomes.
- Additional study is warranted to better characterize the value of IVUS in the ESRD patient population.

Conflict of Interest Disclosure:
The authors have completed and submitted the *Methodist DeBakey Cardiovascular Journal* Conflict of Interest Statement and none were reported.

Keywords:
end-stage renal disease, ESRD, intravascular ultrasound, IVUS, central venous stenosis

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