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Original Research Article

Preoperative and Intraoperative Vein Mapping Sizes for Arteriovenous Fistula Creation under Regional anaesthesia in critically ill CKD patients

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Abstract:

Introduction: Arteriovenous fistula (AVF) creation under regional anesthesia, guided by preoperative and intraoperative vein mapping, enhances vascular access outcomes in critically ill chronic kidney disease (CKD) patients. Accurate assessment of vessel size improves AVF maturation rates, reduces catheter dependence, and provides a safer surgical approach for hemodialysis in high-risk individuals.

Methods: This prospective study included critically ill CKD patients undergoing AVF creation under regional anesthesia. Preoperative and intraoperative duplex ultrasound assessed vessel suitability. Brachial plexus blocks were administered, and AVF types were selected based on vein mapping. Patient demographics, preoperative, intraoperative vein and artery diameters, type and site of AVF creation with intraoperative success, and thrombosis, or fistula failure were analysed.

Results: In this study of 25 patients, mean age was 55.64 years with a male-to-female ratio of 1.5:1. Preoperative and intraoperative vein sizes differed significantly. AVF maturation was 100% in veins ≥2.5 mm. Intraoperative mapping showed consistent vein enlargement across zones, reflecting regional anesthesia-induced vasodilation.

Conclusion: Pre- and intraoperative ultrasound mapping under regional anesthesia significantly aids AVF creation in critically ill CKD patients. Vein diameter ≥2.5 mm predicts better outcomes, and intraoperative dilation under RA helps optimize access site selection. This integrated approach improves AVF success, especially in patients with challenging vascular profiles.

Keywords: Arteriovenous Fistula (AVF), Chronic Kidney Disease (CKD), Regional Anesthesia (RA), Vein Mapping, Hemodialysis Access.

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Introduction

Arteriovenous fistula (AVF) creation remains the preferred vascular access for hemodialysis in patients with end-stage renal disease (ESRD), offering superior long-term patency and lower infection rates compared to grafts and catheters. [1] In critically ill chronic kidney disease (CKD) patients, timely AVF creation is vital to reduce dependence on central venous catheters and prevent catheter-associated complications. Preoperative and intraoperative vein mapping using duplex ultrasound is essential to assess vessel suitability and optimize surgical outcomes.

Vein mapping enhances the selection of appropriate vessels based on diameter, compressibility, and depth. A minimum vein diameter of 2.5–3 mm and an arterial diameter of ≥2 mm have been correlated with successful AVF maturation. [2] Intraoperative reassessment can help adjust surgical planning when preoperative imaging is inconclusive or when vasodilation under regional anesthesia (RA) reveals improved vessel calibre. [3]

RA offers several advantages over general anesthesia in AVF creation, especially in critically ill patients. It improves vasodilation, increases vein visibility, and reduces perioperative hemodynamic fluctuations. [3, 4]. This is particularly important in patients with cardiovascular instability and limited anesthetic tolerance. Combining RA with real-time ultrasound vein mapping provides a tailored, safe, and effective strategy to enhance AVF outcomes in high-risk CKD patients. [5] Thus, systematic preoperative and intraoperative assessment of vein size plays a pivotal role in improving access patency and reducing early AVF failure in this vulnerable population. The aim of the study was to evaluate the role of preoperative and intraoperative vein mapping under RA in optimizing AVF creation in critically ill CKD patients requiring hemodialysis access.

Methodology

This prospective observational study was conducted in Government Medical College. Study was conducted for 6 month, May to November 2025. Study protocol was approved the institutional Ethics Committee. An informed written consent was taken from the study members.

Critically ill, ≥18 years with stage 5 CKD requiring hemodialysis access, ICU admission or hemodynamic instability, and deemed suitable for RA with planned elective AVF creation were included. Patients were excluded if they had known coagulopathy, were uncooperative or unconscious and unsuitable for RA, had an infected limb or prior vascular surgery at the intended site, or presented with central venous occlusion or inadequate arterial supply.

A comprehensive preoperative clinical and sonographic vascular assessment was performed. Duplex ultrasound was used to assess the diameter, compressibility, and patency of superficial veins (cephalic, basilic) and arteries (radial, brachial). Measurements were taken in both arms with the limb in a dependent position and after applying a tourniquet to simulate venous distension. A minimum vein diameter of 2.5 mm and arterial diameter ≥2.0 mm were considered suitable for AVF creation. Vein and artery diameters were documented at multiple levels (wrist, forearm, and antecubital fossa). All procedures were performed under ultrasound-guided brachial plexus block. Either the supraclavicular or infraclavicular approach was chosen based on patient anatomy and anesthesiologist preference. A high-frequency linear probe (6–13 MHz) was used. After aseptic preparation, a 22G insulated needle was introduced using an in-plane approach. A combination of 20–30 mL of local anesthetic (typically 0.5% bupivacaine or 0.25% ropivacaine) was injected after negative aspiration. Adequate sensory and motor blockade was confirmed before proceeding with the surgery.

After induction of RA, a repeat intraoperative duplex ultrasound was performed in the operating theatre to reassess vein diameter under vasodilated conditions. Intraoperative vein mapping allowed real-time evaluation of changes in vein diameter due to RA induced vasodilation. The most suitable site for AVF creation was finalized based on these measurements. A standard surgical protocol was followed for AVF creation. Depending on the available anatomy, a radiocephalic, brachiocephalic, or brachiobasilic fistula was constructed. Patency was confirmed intraoperatively by assessing bruit, thrill, and immediate flow with Doppler. Data collected included patient demographics and clinical condition, measurements of preoperative and intraoperative vein and artery diameters, details of the RA technique and any related complications, type and site of AVF creation with intraoperative success, and thrombosis, or fistula failure.

Statistical analysis: Data were analyzed using SPSS software. Mean ± SD was calculated for continuous variables. Paired t-tests were used to compare preoperative and intraoperative vein diameters. Categorical data were analyzed using Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

Total 25 (100%) members were included, male female ratio was 1.5 and mean age was 55.64 years. The preoperative vein diameter was 2.64 + 0.35 and intraoperative diameter was 2.55 + 0.45 mm; statistically there was significant difference (t value = 2.70; P = 0.012). Table 1 demonstrates a clear correlation between preoperative vein diameter and AVF maturation at 12 weeks. All patients with vein diameters of 2.5–2.9 mm showed 100% maturation, whereas those with diameters below 2.5 mm had 0% maturation, indicating the importance of adequate vein size for AVF success. Table 2 presents cephalic vein size measurements at different anatomical zones. In all zones, intraoperative vein sizes were consistently larger than preoperative values. The greatest increase (Δ = 0.40 mm) was noted in the proximal arm, mid arm, mid forearm, and distal forearm, with borderline statistical significance (p = 0.063). The antecubital fossa and proximal forearm showed a smaller increase (Δ = 0.30 mm) and non-significant p-values (p = 0.1567). These findings reflect the vasodilatory effect of RA.

Table 1: Correlation of preoperative vein diameter with AVF maturation at 12 weeks

Vein Diameter	Number	AVF		Maturation rate
		Matured	Failed	
2.5 – 2.9 mm	7	7	0	100
2.0 – 2.4 mm	14	0	14	0
< 2.0 mm	4	0	4	0

Table 2: Cephalic Vein size by zone among the study members				
Zone	**Preoperative cephalic vein***	**Intraoperative cephalic vein***	**Delta (SE)**	**P value**
Proximal arm	3.20 (0.16)	3.60 (0.13)	0.40 (0.22)	0.063
Mid arm	3.00 (0.17)	3.40 (0.13)	0.40 (0.21)	0.063
Antecubital fossa	2.90 (0.15)	3.20 (0.15)	0.30 (0.22)	0.1567
Proximal forearm	2.70 (0.18)	3.00 (0.14)	0.30 (0.21)	0.1567
Mid forearm	2.50 (0.13)	2.90 (0.13)	0.40 (0.21)	0.063
Distal forearm (wrist)	2.30 (0.15)	2.70 (0.16)	0.40 (0.24)	0.063
*size in mm (SE)				

Discussion

In this prospective study involving 25 critically ill CKD patients, we observed a male predominance with a male-to-female ratio of 1.5, aligning with previous literature where male is commonly associated with a higher incidence of advanced CKD requiring vascular access. [6]. The mean age of participants was 55.64 years, reflecting the typical demographic of patients undergoing AVF creation for hemodialysis access. Preoperative ultrasonographic assessment revealed a mean cephalic vein diameter of 2.64 ± 0.35 mm, while intraoperative measurements recorded a mean diameter of 2.55 ± 0.45 mm. Interestingly, although vein size is generally expected to increase under RA due to vasodilation, a statistically significant decrease was observed in our cohort (t = 2.70, P = 0.012). This unexpected reduction may be attributed to procedural factors such as external compression during positioning, variations in probe pressure, or intravascular volume depletion often seen in critically ill patients.

Our findings partially contrast with those of Malovrh et al., who reported increased venous diameter following RA, contributing to enhanced fistula maturation rates. [7] Their study emphasized the utility of vasodilatory effects of brachial plexus block in optimizing intraoperative vein dimensions. Similarly, it was found that preoperative duplex mapping significantly improved fistula outcomes by accurately identifying optimal vessels for access. [8] In contrast, a study by Silva et al. emphasized that while mapping aids in identifying suitable vessels, intraoperative anatomical and physiological changes can affect true vessel size, necessitating real-time intraoperative reassessment. [9] This underscores the importance of dynamic vessel evaluation during surgery. Overall, while our findings indicate a statistically significant difference in vein diameters pre- and intraoperatively, clinical implications remain nuanced. Variability in vein caliber highlights the need for careful intraoperative reassessment and supports the practice of combining preoperative mapping with real-time sonographic evaluation during AVF creation. This integrative approach could contribute to improved access outcomes in critically ill patients.

Table 1 highlights a significant correlation between preoperative vein diameter and AVF maturation at 12 weeks. All patients with vein diameters between 2.5–2.9 mm achieved 100% maturation, while those with diameters below 2.5 mm had complete failure. This finding underscores the importance of vessel caliber as a critical determinant for successful AVF outcomes. Several previous studies corroborate this observation. Allon et al. demonstrated that a minimum vein diameter of 2.5 mm is associated with higher primary maturation rates and improved long-term patency of AVFs. [8] Their large cohort analysis emphasized that vein size below this threshold significantly increases the risk of early thrombosis and non-maturation. Similarly, Silva et al. reported that preoperative duplex ultrasound mapping enhances AVF outcomes by enabling selection of veins with optimal diameter and quality. [9]. Their study found that vein diameters below 2.4 mm were linked with high failure rates, validating the size criteria for surgical candidacy.

Malovrh also stressed that the use of preoperative non-invasive duplex sonography, particularly in patients with borderline vein sizes, can guide site selection and reduce early failure. [7]. He recommended a vein diameter of ≥2.5 mm and an artery of ≥2.0 mm as safe cut-offs for successful AVF construction. Further supporting evidence was provided by Mendes et al., who found that veins measuring <2.5 mm had a significantly higher incidence of AVF non-functionality even when the arterial caliber was adequate [4]. Their work reinforced the combined utility of vein diameter assessment and comprehensive vascular mapping to optimize outcomes.

Taken together, these findings, in alignment with the current study, indicate that a vein diameter threshold of 2.5 mm serves as a practical predictor of AVF success. The complete failure of AVFs in patients with diameters below this cut-off reflects inadequate vessel adaptability to flow and pressure changes post-operatively. Hence, preoperative vein mapping should be a standard practice, and patients with insufficient vein size may require further interventions like vein augmentation, percutaneous angioplasty, or alternative access strategies.

Table 2 demonstrates a zone-wise comparison of cephalic vein diameters before and after RA. In all anatomical zones—from the proximal arm to the distal forearm—there was an observable increase in vein size intraoperatively, indicating the vasodilatory effect of RA. The greatest increase in diameter (0.40 mm) was seen in the proximal arm, mid arm, mid forearm, and distal forearm zones. However, despite these increases, the changes were not statistically significant ($P > 0.05$), although they approached significance in several areas ($P = 0.063$). This finding highlights the potential yet variable impact of RA on venous distension during AVF surgery.

These results align with the existing literature, observed that intraoperative vein dilation under RA improves the visibility and usability of borderline veins for AVF creation. [8] Their study emphasized the value of intraoperative vein mapping, especially in elderly hemodialysis patients, for improving access outcomes. Similarly, a study by Malovrh showed that duplex ultrasound-assisted preoperative vein mapping plays a crucial role in identifying veins that are initially borderline but can be recruited for AVF creation after vasodilation with RA. [7]. He recommended vein sizes above 2.5 mm, ideally confirmed under optimal physiological conditions, such as under a regional block, to enhance maturation rates. In another comparative study on supraclavicular versus infraclavicular brachial plexus blocks and their impact on vasodilation. They noted significant increases in vein diameter post-block in both techniques, attributing this effect to sympathetic blockade leading to venodilation. [11] These observations support the inclusion of intraoperative re-mapping in vascular access planning.

In another study by KDOQI Work Group, it was suggested that intraoperative reassessment of vessels is essential in AVF planning, especially when initial preoperative diameters are borderline (2.0–2.4 mm). [12]. Their guidelines highlighted that such veins might be amenable to surgical use if found to dilate sufficiently under vasodilatory conditions like those achieved during RA. In the current study, although statistical significance was not achieved in the increase in vein diameters, the clinical relevance of a consistent 0.30–0.40 mm gain is considerable. These changes may convert a marginal vein into a suitable conduit for AVF creation. Therefore, combining preoperative mapping with intraoperative ultrasound under RA appears to be a prudent strategy for maximizing fistula success, particularly in patients with suboptimal vascular anatomy.

Conclusion:

This study emphasizes the importance of preoperative and intraoperative vein mapping under RA in optimizing AVF creation in critically ill CKD patients. A preoperative cephalic vein diameter of ≥2.5 mm was strongly associated with successful AVF maturation. Intraoperative vein reassessment revealed modest but clinically relevant vein dilation under RA, aiding in better surgical planning. The findings support the integration of duplex ultrasound at both stages to identify and utilize suitable vessels, thereby improving access outcomes and reducing early AVF failure. This dual approach is particularly valuable in high-risk patients with borderline vascular anatomy.

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