Journal of
CardioRenal Medicine

MDPI

Case Report

Ultrasound-Guided Reverse Needle Cannulation of a Thrombosed Arteriovenous Fistula to Improve Dialysis Adequacy: A Case Report

Mario Martínez-Torija [1,2]

[1] Department of Hemodialysis, University Hospital of Toledo, 45071 Toledo, Spain; mmtorija@sescam.jccm.es
[2] Pathophysiology and Regenerative Medicine Group, Instituto de Investigación Sanitaria de Castilla-La Mancha (IDISCAM), 45004 Toledo, Spain

Abstract

Background: Dialysis adequacy is commonly assessed using Kt, a measure of urea clearance. Vascular access dysfunction, particularly thrombosis and access recirculation, may compromise dialysis efficiency despite apparently adequate treatment parameters. Ultrasound assessment of vascular anatomy can help identify individualized cannulation strategies to optimize dialysis delivery. **Case Presentation:** We report the case of a 78-year-old man undergoing maintenance hemodialysis who exhibited persistently low Kt values despite adequate dialysis time and blood flow. Doppler ultrasound revealed complete occlusive thrombosis involving the cephalic vein, resulting in altered venous drainage. Based on these findings, the conventional cannulation configuration was reversed by exchanging the arterial and venous needle positions. Dialysis adequacy during 11 consecutive sessions using reverse cannulation was compared with that of the previous 12 conventional sessions matched for treatment duration and dialysis volume. **Results:** Reverse needle cannulation was associated with improved dialysis adequacy. Mean Kt increased from 46.9 $\pm$ 6.7 L with conventional cannulation to 57.3 $\pm$ 5.8 L after reverse cannulation (p = 0.002), while dialysis duration and processed blood volume remained comparable between both periods. **Conclusions:** In selected patients with complex vascular anatomy secondary to arteriovenous fistula thrombosis, ultrasound-guided reverse needle cannulation may improve dialysis adequacy without changing treatment duration or the prescribed extracorporeal blood flow rate. This case highlights the value of individualized vascular access assessment and tailored cannulation strategies in patients with vascular access dysfunction.

Keywords: hemodialysis; arteriovenous fistula; vascular access; cannulation; thrombosis; dialysis adequacy; ultrasound

Check for updates

Academic Editor: Caterina Carollo

Received: 2 July 2026
Revised: 2 August 2026
Accepted: 2 September 2026
Published: 3 September 2026

Copyright: © 2026 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Reliable vascular access is a cornerstone of effective maintenance hemodialysis (HD) [1]. Native arteriovenous fistulas (AVFs) are generally preferred over central venous catheters (CVCs) because they provide better long-term performance and are associated with fewer infectious and thrombotic complications. However, even well-developed fistulas may become dysfunctional over time as a result of stenosis, thrombosis, aneurysmal degeneration, altered venous drainage, or changes in access hemodynamics [2].

Vascular access dysfunction can substantially compromise dialysis adequacy [3]. In particular, access recirculation may reduce the effective clearance achieved during

a hemodialysis session despite apparently adequate treatment time, blood flow, and processed blood volume. For this reason, urea clearance, commonly expressed as Kt, remains a clinically useful marker for identifying discrepancies between the prescribed and the effectively delivered dialysis dose [4]. A persistent reduction in Kt should therefore prompt evaluation of both dialysis-related factors and vascular access performance [3].

Ultrasound (US) has become an essential tool for evaluating AVFs in patients undergoing hemodialysis [5]. Beyond identifying stenosis or thrombosis, US allows clinicians to understand the individual vascular anatomy of the access, including inflow, outflow, collateral drainage, aneurysmal segments, and areas unsuitable for cannulation. This information may be particularly relevant in patients with complex or partially thrombosed fistulas, in whom conventional arterial and venous needle positioning may no longer reflect the actual direction of effective blood drainage.

Although standard cannulation techniques are appropriate for most mature fistulas [6], selected patients with altered vascular anatomy may require individualized strategies [7]. However, the potential role of alternative needle cannulation as a tailored strategy for improving dialysis adequacy in complex AVFs has been scarcely described [8].

We report the case of a patient undergoing maintenance hemodialysis through a thrombosed AVF who presented persistently reduced Kt values despite adequate treatment parameters. US assessment revealed altered venous drainage, leading to the implementation of a reverse needle cannulation strategy. We describe this individualized approach and evaluate its impact on dialysis adequacy compared with previous conventional cannulation sessions.

2. Case Presentation

A 78-year-old man with end-stage kidney disease secondary to multifactorial chronic kidney disease had been receiving maintenance HD three times weekly for two years. Vascular access was provided through a mature left upper-arm native AVF after failure of a previous radiocephalic AVF. His medical history included hypertension, type 2 diabetes mellitus, ischemic heart disease, peripheral arterial disease, and dyslipidemia.

Despite an unchanged dialysis prescription, stable treatment time, and adequate extracorporeal blood flow, routine monitoring revealed a progressive reduction in dialysis adequacy, with Kt values consistently below those expected for the delivered dialysis dose. No technical problems were identified during HD sessions, and prescribed blood flow rates (>350 mL/min) were consistently achieved, suggesting that the discrepancy could not be explained by insufficient dialysis delivery alone.

Given the persistent mismatch between delivered dialysis volume and Kt, vascular access dysfunction associated with increased recirculation was suspected. To investigate the underlying cause, the AVF was evaluated by US.

US examination demonstrated complete occlusive thrombosis of the proximal cephalic vein. The thrombosed segment was identified by lack of compressibility, the presence of intraluminal hyperechoic material, and the absence of detectable Doppler flow. US mapping also showed that venous outflow no longer followed the usual proximal superficial cephalic pathway but was redirected toward the deep venous system through a collateral vein.

These findings indicated that the conventional anatomical positions of the arterial and venous needles no longer corresponded to the functional direction of blood flow within the vascular access. Under the conventional configuration, the relative positions of the withdrawal and return needles could therefore favor access recirculation. An individualized reverse cannulation strategy was consequently implemented by exchanging the arterial and venous needle positions. This configuration was selected to better align the extracorporeal circuit with the US-defined venous drainage pathway toward the deep venous system, as

illustrated in Figure 1. The aim of this strategy was to reduce presumed access recirculation while maintaining the prescribed treatment duration and extracorporeal blood flow.

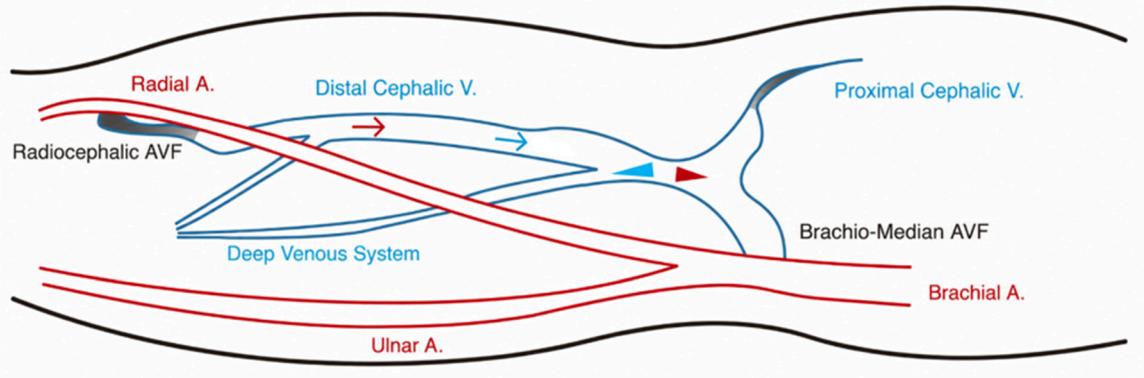


Figure 1. Schematic representation of the patient's vascular access anatomy and cannulation configurations. The diagram shows the arteriovenous anastomosis, complete occlusive thrombosis of the proximal cephalic vein, a vessel coursing toward deeper tissue planes and draining toward the deep venous system, and the positions and directions of the arterial and venous needles during conventional and reverse cannulation. Shaded areas indicate thrombosed segments; arrows indicate the direction of blood flow; red and blue markers indicate the arterial withdrawal and venous return needles, respectively.

To evaluate the clinical impact of this intervention, 11 consecutive HD sessions performed using reverse cannulation were compared with the previous 12 sessions performed using conventional cannulation. Only sessions lasting at least 210 min and achieving extracorporeal blood flow rates above 350 mL/min were included to minimize the influence of treatment-related variables. Dialysis adequacy, expressed as Kt, treatment duration, and processed blood volume were recorded for each session.

Continuous variables are presented as mean ± standard deviation. Data distribution was assessed using the Kolmogorov–Smirnov test, and comparisons between conventional and reverse cannulation sessions were performed using Student's *t*-test. Statistical analyses were conducted using GraphPad Prism version 7.0, and statistical significance was defined as a two-sided p value < 0.05.

3. Results

Reverse cannulation was successfully performed during 11 consecutive HD sessions without procedural complications or difficulties related to vascular access cannulation. Treatment-related variables remained comparable between conventional and reverse cannulation sessions (Table 1). No significant differences were observed in treatment duration (230.0 ± 14.8 vs. 226.3 ± 15.7 min, $p = 0.817$) or delivered dialysis volume (89.6 ± 9.8 vs. 90.0 ± 8.2 L, $p = 0.917$), indicating that dialysis prescription and delivery were maintained throughout both study periods.

Table 1. Comparison of variables between conventional and reverse cannulation. *n*: Sample; $\overline{X}$: mean; *S*: standard deviation.

	Conventional Cannulation			Reverse Cannulation			*p* Value
	n	$\overline{X}$	*S*	*n*	$\overline{X}$	*S*	
Volume (L)	12	89.6	9.8	11	90.0	8.2	0.917
Kt (L)	12	46.9	6.7	11	57.3	5.8	**0.002**
Time (min)	12	230.0	14.8	11	226.3	15.7	0.817
Arterial pressure (mmHg)	12	−178.4	15.1	11	−180.5	7.8	0.692
Venous pressure (mmHg)	12	226.1	8.9	11	198.2	7.1	**0.001**

Bold values indicate statistically significant differences ($p < 0.05$).

Despite these comparable treatment conditions, dialysis adequacy improved significantly following implementation of the US-guided reverse cannulation strategy. Mean Kt increased from 46.9 ± 6.7 L during conventional cannulation to 57.3 ± 5.8 L with reverse cannulation, representing an absolute increase of 10.4 L (22.2%; $p = 0.002$). Individual session data was consistent with higher Kt values after implementation of the individualized cannulation strategy, supporting the reproducibility of the observed improvement across consecutive HD sessions. Detailed session-by-session data are provided in the Supplementary Materials.

Regarding the safety profile, mean dynamic arterial pressure was similar during conventional and reverse cannulation (−178.4 vs. −180.5 mmHg, respectively), whereas mean dynamic venous pressure was lower during reverse cannulation (226.1 vs. 198.2 mmHg, respectively). No extravasation, localized hematomas, or cannulation difficulties were observed during the 11 reverse cannulation sessions. Post-dialysis bleeding time was prolonged in both periods in the context of chronic oral anticoagulation with acenocoumarol, with no worsening after implementation of reverse cannulation. Detailed session-by-session arterial and venous pressure measurements are provided in the Supplementary Materials.

Access recirculation was not systematically measured during all sessions because this parameter was not routinely recorded and the measurement function was not available on all dialysis monitors. Nevertheless, monitor-derived recirculation estimates were documented in selected clinical records. The available measurements showed recirculation values around 60% during conventional cannulation and approximately 15–30% after implementation of reverse cannulation (Supplementary Table S1). Although residual recirculation remained substantial, the documented values were markedly lower after reversal of the needle positions. Because measurements were not available for all sessions and were not collected according to a predefined protocol, no formal statistical comparison was made.

4. Discussion

This case illustrates how US-guided functional assessment of AVF anatomy may change vascular access management and improve HD adequacy in selected patients with complex access dysfunction. The main finding was that reverse cannulation, implemented after US demonstrated altered venous drainage due to AVF thrombosis, was associated with a clinically relevant improvement in Kt despite comparable treatment duration, extracorporeal blood flow, and delivered dialysis volume. Therefore, the observed improvement was unlikely to be explained by changes in the dialysis prescription alone, but rather by a more efficient alignment between needle configuration and the functional venous outflow of the access.

The clinical relevance of this case lies not only in the increase in Kt, but also in the reasoning that led to the intervention. In routine practice, conventional AVF cannulation assumes that arterial and venous needle placement corresponds to a predictable direction of blood flow and venous drainage [4,7]. This assumption is appropriate in most mature AVFs with preserved anatomy and outflow. However, when thrombosis, stenosis, aneurysmal degeneration, collateralization, or deep venous diversion modify the access circuit, the anatomical orientation of the fistula may no longer represent its functional hemodynamics. In such circumstances, standard cannulation may become physiologically inappropriate, even if adequate extracorporeal blood flow can still be achieved [6].

In the present case, the patient showed persistently reduced Kt values despite apparently adequate HD parameters. This discrepancy suggested that the delivered dialysis volume did not correspond to the effective solute clearance achieved during treatment [4]. During our exploration, US demonstrated complete thrombosis of the proximal cephalic

vein, which provided a plausible mechanism for increased access recirculation during conventional cannulation. By reversing the arterial and venous needle positions, the cannulation strategy was adapted to the modified drainage pathway identified by US, thereby improving the efficiency of extracorporeal blood circulation. This strategy did not eliminate recirculation, as documented values remained approximately 15–30%, but it was associated with a marked reduction compared with the conventional configuration and with a consistent increase in Kt. It's important to note that recirculation values exceeding 15% are considered abnormal and should prompt investigation for AVF dysfunction [9]. Nevertheless, because recirculation was not systematically measured in all sessions, this interpretation should be considered supportive rather than definitive.

This case therefore supports a broader clinical concept: US should not be considered only a diagnostic tool for identifying AVF stenosis or thrombosis, but also a functional tool for guiding individualized cannulation strategies. The ability of US to define inflow, outflow, thrombotic segments, collateral pathways, vessel depth, and safe cannulation areas makes it particularly valuable in patients with complex or previously modified vascular access. In a study by Darbas-Barbé et al. [10], the authors concluded that US is a useful tool for tailoring the cannulation technique to the specific characteristics of the AVF.

The improvement observed after reverse cannulation was substantial. Mean Kt increased from 46.9 $\pm$ 6.7 L during conventional cannulation to 57.3 $\pm$ 5.8 L after implementation of the US-guided reverse strategy. This represents a relative improvement of approximately 22%. Importantly, treatment duration and delivered dialysis volume remained comparable between both periods. This reinforces the hypothesis that the increase in Kt was related to improved access performance rather than to longer sessions or greater processed volume. However, the available evidence is inconclusive. While some studies suggest that higher dialysis doses improve surrogate outcomes, such as ionic balance [11], a recent review highlighted that neither increasing the dialysis dose nor increasing treatment frequency resulted in better clinical outcomes compared with conventional hemodialysis [12].

An additional strength of this observation is that the improvement was assessed across consecutive HD sessions rather than in an isolated treatment. Although this remains a single-patient case report, the consistency of the Kt increase across repeated sessions provides greater clinical plausibility than a single before-and-after measurement. Moreover, the intervention did not require a change in vascular access such as CVC placement, thereby increasing the risk of vascular access infection [13]. From a clinical perspective, this is relevant because individualized cannulation may offer a simple, low-cost, and immediately applicable strategy in carefully selected patients while definitive vascular access decisions are being considered.

Nevertheless, this strategy should not be interpreted as a general recommendation to reverse needle position in thrombosed AVFs. In standard AVF anatomy, reverse cannulation would be expected to increase recirculation and reduce HD efficiency. The key message of this case is not that reverse cannulation is intrinsically superior, but that cannulation should follow the functional vascular anatomy demonstrated by US. In other words, the intervention was appropriate because the patient's vascular anatomy had changed. Standard cannulation is designed for standard anatomy; when functional anatomy changes, cannulation strategies may need to evolve accordingly.

Several limitations must be acknowledged. First, this is a single case report, and the findings cannot be generalized to all patients with AVF thrombosis or access dysfunction. Second, the comparison was performed using repeated HD sessions from the same patient rather than a randomized or prospective design; therefore, residual confounding and temporal effects cannot be completely excluded. Third, access recirculation was not

measured systematically in all sessions, as it was not routinely recorded and the measurement function was not available on all dialysis monitors. Therefore, the available values were descriptive and could not be subjected to a formal statistical comparison. We also highlight routine biochemical parameters were not assessed at standardized paired time points immediately before and after implementation of the reverse cannulation strategy; consequently, isolated laboratory measurements could not be reliably attributed to the change in cannulation technique. Finally, long-term outcomes such as AVF patency, need for intervention, access survival, and sustained dialysis adequacy were not evaluated.

Despite these limitations, the case provides a clinically meaningful example of how US-guided assessment can inform vascular access decision-making beyond diagnosis. In selected patients with complex AVF anatomy, individualized cannulation may improve HD adequacy without changing the dialysis prescription or abandoning the existing access. Future studies should evaluate whether structured US assessment of functional AVF anatomy can identify patients who may benefit from tailored cannulation strategies and determine which anatomical or hemodynamic patterns predict improvement in dialysis adequacy.

5. Conclusions

In this single-patient case, ultrasound-guided reversal of the arterial and venous needle positions was associated with an increase in Kt despite comparable treatment duration and processed blood volume. This observation suggests that ultrasound assessment of functional vascular anatomy may help individualize cannulation in selected patients with markedly altered AVF drainage. However, no causal or generalizable conclusions can be drawn from a single case, and these findings require confirmation in larger prospective studies.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/jcrm2030011/s1, Table S1. Individual hemodialysis session data comparing conventional and ultrasound-guided reverse needle cannulation. C: Conventional cannulation. R: Reverse cannulation. Kt: Urea clearance. AP: Arterial pressure. VP: Venous pressure.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Complejo Hospitalario Universitario de Toledo (protocol code: 167; 10 February 2021).

Informed Consent Statement: Written informed consent was obtained from the subject involved in the study.

Data Availability Statement: The data generated and analyzed during this study are provided in the Supplementary Materials.

Acknowledgments: I would like to express my sincere gratitude to Rafael Díaz-Tejeiro and Maria Ángeles Fernández-Rojo for his guidance and support throughout the clinical practice, and for encouraging the publication of this work.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Manov, J.J.; Mohan, P.P.; Vazquez-Padron, R. Arteriovenous fistulas for hemodialysis: Brief review and current problems. *J. Vasc. Access* **2022**, *23*, 839–846. [CrossRef] [PubMed]
2. Al-Jaishi, A.A.; Liu, A.R.; Lok, C.E.; Zhang, J.C.; Moist, L.M. Complications of the Arteriovenous Fistula: A Systematic Review. *J. Am. Soc. Nephrol.* **2017**, *28*, 1839–1850. [CrossRef] [PubMed]
3. Cortez, A.J.; Paulson, W.D.; Schwab, S.J. Vascular access as a determinant of adequacy of dialysis. *Semin. Nephrol.* **2005**, *25*, 96–101. [CrossRef] [PubMed]

4. Prado, M.; Roa, L.M.; Palma, A.; Milán, J.A. Double target comparison of blood-side methods for measuring the hemodialysis dose. *Kidney Int.* **2005**, *68*, 2863–2876. [CrossRef] [PubMed]
5. Hu, S.; Guo, J.; Guo, Y.; Yang, Z.; Wu, S.; Zhou, W.; Han, Y.; Zhang, C.; Shen, H.; Zhang, Q. A summary of the best evidence on ultrasound-guided autologous arteriovenous fistula cannulation in maintenance hemodialysis patients: A systematic review. *J. Vasc. Access* **2026**. [CrossRef] [PubMed]
6. Shu, P.; Wang, X.; Wen, Z.; Li, C.; Luo, Y.; Xu, F. The effect of multiple single cannulation technique on complications of arteriovenous fistulae: A meta-analysis. *Medicine* **2024**, *103*, e39748. [CrossRef] [PubMed]
7. Ozen, N.; Aydin Sayilan, A.; Sayilan, S.; Mut, D.; Akin, E.B.; Ecder, S.T. Relationship between arteriovenous fistula cannulation practices and dialysis adequacy: A prospective, multicenter study. *J. Ren. Care* **2022**, *48*, 41–48. [CrossRef] [PubMed]
8. Karkhah, S.; Pourshaikhian, M.; Vajargah, P.G.; Mahdiabadi, M.Z.; Mollaei, A.; Maroufizadeh, S.; Hosseini, S.J.; Osuji, J.; Moghadamnia, M.T. Needle Direction and Distance of Arteriovenous Fistula Cannulation in Hemodialysis Adequacy; a Systematic Review and Meta-Analysis. *Arch. Acad. Emerg. Med.* **2023**, *11*, e39. [CrossRef] [PubMed]
9. Bodington, R.; Hazara, A.M.; Lamplugh, A.; Syed, A.; Bhandari, S. Reassessing the utility of access recirculation and Kt/V for the prediction of arteriovenous fistula failure using online clearance monitoring: The SHUNT STUDY. *J. Nephrol.* **2023**, *36*, 677–686. [CrossRef] [PubMed]
10. Darbas-Barbé, R.; Roca-Tey, R.; Franco, C.C.; Iborra, G.T.; Sancho, C.B.; Taboada-Álvarez, M.J.; Domínguez-Orgaz, C.; Moliner-Calderón, L.; Tornel-García, S.; Curado-Soto, T.; et al. Cambio de técnica de punción de la fístula arteriovenosa nativa a partir de los hallazgos ecográficos. *Enferm. Nefrol.* **2016**, *19*, 366–371. [CrossRef]
11. Jardine, M.J.; Zuo, L.; Gray, N.A.; De Zoysa, J.R.; Chan, C.T.; Gallagher, M.P.; Monaghan, H.; Grieve, S.M.; Puranik, R.; Lin, H.; et al. A Trial of Extending Hemodialysis Hours and Quality of Life. *J. Am. Soc. Nephrol.* **2017**, *28*, 1898–1911. [CrossRef] [PubMed]
12. Deira, J.; Murea, M.; Kalantar-Zadeh, K.; Casino, F.G.; Basile, C. Does delivering more dialysis improve clinical outcomes? What randomized controlled trials have shown. *J. Nephrol.* **2022**, *35*, 1315–1327. [CrossRef] [PubMed]
13. Soleymanian, T.; Sheikh, V.; Tareh, F.; Argani, H.; Ossareh, S. Hemodialysis vascular access and clinical outcomes: An observational multicenter study. *J. Vasc. Access* **2017**, *18*, 35–42. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.