

ORIGINAL ARTICLE AND META-ANALYSIS

The “Vascular Donut Sign”: when a thrombus envelops the fibrin sheath

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Abstract

Catheter-related thrombosis is a common condition associated with various complications. In many cases, what appears to be catheter-related thrombosis is actually a fibrin sheath. Ultrasound examination serves as an effective diagnostic tool, particularly when a specific and intriguing ultrasound marker can aid in differentiation. Here, we present a clinical case that highlights this ultrasound marker, known as the “Vascular Donut Sign”.

Keywords: Catheter-related thrombosis, ultrasound examination, fibrin sheath, “Vascular Donut Sign”

Introduction

Central venous catheters (CVCs) are essential devices in the management of critically ill patients in the intensive care unit (ICU). The most common catheter-related complications include mechanical, septic, and thrombotic events. Thrombotic complications, among the most feared, may lead to pulmonary embolism, upper sagittal sinus thrombosis, intracranial hypertension, edema, septic embolism, chylothorax, and superior vena cava syndrome [1]. The risk of thrombosis associated with internal jugular vein (IJV) catheters is four times higher than that of subclavian vein catheters. Approximately 66% of patients with IJV catheters exhibit evidence of thrombus formation on ultrasound or autopsy [2]. Thrombi can develop along the entire length of the IJV, from the puncture site to the subclavian vein [3]. Ultrasonography (US), particularly with color Doppler, is a non-invasive and readily available tool capable of detecting intraluminal thrombi at early

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stages. Additionally, US can help distinguish between true thrombi and fibrin sheaths, although both may coexist. Does ultrasound imaging enable precise diagnosis in such scenarios? We present a clinical case featuring a distinctive ultrasound marker, termed the “Vascular Donut Sign,” resulting from unilateral IJV thrombosis with a fibrin sheath.

Clinical Case

A 72-year-old patient with a history of arterial hypertension, type II diabetes mellitus (on oral hypoglycemic therapy with suboptimal glycemic control), and peripheral vasculopathy (with previous right thigh amputation) was admitted to the ICU for suspected metformin intoxication and sepsis. During hospitalization, the patient was diagnosed with a right colonic tumor abscess, which subsequently led to septic shock.

Upon ICU admission, an arterial catheter was placed in the left radial artery, and a CVC was inserted into the right IJV under ultrasound guidance (due to inadequate axillary vein diameter). The clinical pretest probability of deep vein thrombosis, assessed using the Wells score (>2), indicated a high risk of thrombosis [4]. Compression ultrasound (CUS) of the jugular, subclavian, and bilateral axillary veins showed complete venous wall collapse without endoluminal material. Bilateral femoral CUS revealed hyperechoic endoluminal material with partial coaptation in the right femoral vein.

The patient's sepsis, caused by an extended-spectrum beta-lactamase (ESBL)-producing strain of *Escherichia coli*, was treated with initially empirical and subsequently with targeted antibiotic therapy. Severe sepsis-related thrombocytopenia prompted the initiation of reduced-dose prophylactic anticoagulant therapy (enoxaparin 4000 IU/day subcutaneously).

The onset of anuria and electrolyte imbalances due to severe renal failure necessitated continuous veno-venous hemodiafiltration (CVVHDF). A GamCath Dual-lumen© hemodialysis catheter was then placed in the left femoral vein. Ultrasound evaluation (using the RAFEVA and RACEVA protocols) was performed with a linear probe (5.3–10 MHz) in B-mode, optimizing image depth and attenuation [5,6,7]. The evaluation

criteria included vein caliber, depth, collapsibility during respiration, proximity to critical structures, and feasibility of emergency site access for catheter management.

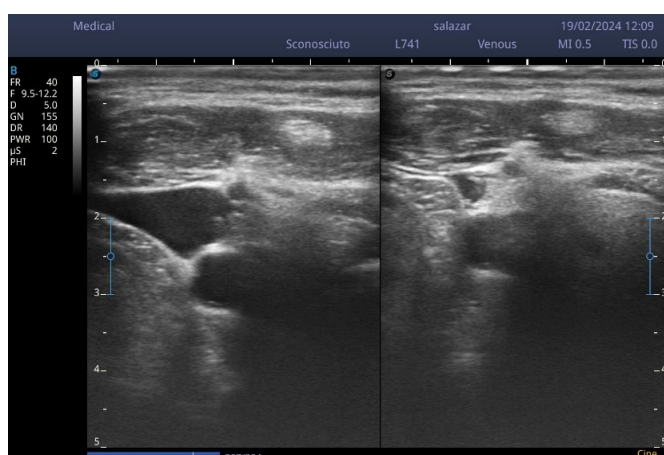
Seven days after placement of the dialysis catheter in the left femoral vein, a malfunction of the catheter occurred, necessitating its removal. Therefore, re-potting of the catheter was necessary because the patient still required dialysis treatment. US examination revealed partial thrombosis of the right femoral vein. A CVC had already been inserted into the right jugular vein, while both axillary veins were unobstructed but measured <6 mm in diameter [7,8]. Consequently, the right IJV CVC was replaced with a hemodialysis catheter, and a new CVC was inserted into the left subclavian vein.

Forty-eight hours after catheter placement, ultrasound revealed a unique image - a hyperechoic circular structure with an anechoic center, resembling a concentric “donut” (Figure 1-2). This structure extended from the venipuncture site to the ipsilateral innominate vein, with a clear subclavian entry. A centrally inserted central catheter (CICC) was placed in the left subclavian vein, and a dialysis catheter was inserted into the right jugular vein. Based on the hypothesis of a thrombus overlying a fibrin sheath, calcium heparin therapy (10,000 IU/day) was initiated, considering the patient's eGFR <10 mL/min.

The neoformation was monitored by ultrasound at 3, 7, 10, and 14 days and it resolved completely by day 31 (Figure 3).

FIGURE 1 - Round fibrin sheath of pericatheter in the internal jugular vein



FIGURE 2 - Round fibrin sheath of pericatheter as “Donut’s Sign”**FIGURE 3** - Resolution of fibrin sheath in thirty-three-first day

Discussion

This patient exhibited multiple pro-thrombotic risk factors, including septic shock, malignancy, prolonged bed rest, diabetes, vasculopathy, arterial hypertension, and a Wells score >2. CVC placement was performed in accordance with recommendations for preventing catheter-related thrombosis [7].

Thrombosis, once diagnosed, necessitates treatment, with CVC removal guided by clinical circumstances and ultrasound findings. Differentiating a fibrin sheath from a thrombus is crucial for clinical and ultrasound-based decision-making. Catheter-related thrombosis is defined as a mural thrombus encircling the catheter intraluminally, causing partial or total occlusion with or without symptoms. Common symptoms include inflammation and vascular obstruction (e.g., edema, pain). However, as in this case, symptoms may be absent or undetectable.

Catheter-related thrombosis can result in catheter dysfunction, manifesting as aspiration and infusion failure. Thrombus formation is triggered by venous wall damage from catheter insertion or mechanical/chemical trauma, initiating the pro-thrombotic imbalance described by Virchow [9]. Thrombi typically adhere to the vein wall and may partially envelop the catheter. On ultrasound, thrombi appear as rounded, hypoechoic, and compressible structures that can partially or completely occupy the venous lumen [10].

A fibrin sheath, in contrast, forms around the catheter as a foreign-body reaction initiating fibrinogenesis. This sheath consists of fibrinogen, albumin, erythrocytes, fibroblasts, collagen, and smooth muscle cells. Formation begins within 24 hours from catheter insertion [11]. While fibrin sheaths are generally asymptomatic, they may lead to catheter malfunction by creating a one-way valve at the catheter tip, obstructing aspiration while allowing infusion [12]. Ultrasound imaging shows the fibrin sheath as a hyperechoic ring in cross-sectional view or a tubular structure in longitudinal view. Distinguishing a fibrin sheath from thrombus requires correlating clinical findings, ultrasound features, and the time since catheter insertion (24-72 hours for fibrin sheaths vs. ~6 days for thrombi) [12].

The “Vascular Donut Sign” described in this case - a concentric, hypoechoic image with a hyperechoic periphery - represents the coexistence of a fibrin sheath and pericatheter thrombus. Vessel compressibility further aids differentiation, with thrombi becoming increasingly non-compressible over time [13]. Doppler examination of the IJV - including spectral analysis - is crucial for assessing vessel patency and detecting intravascular thrombi. Reduced or absent flow suggests thrombus formation. Comparative evaluation with contralateral veins enhances diagnostic accuracy.

In this case, the absence of IJV thrombotic symptoms or CICC malfunction underscores the importance of routine ultrasound monitoring in high-risk patients.

Conclusion

The “Vascular Donut Sign” observed in this patient reflects the coexistence of a fibrin sheath and pericatheter thrombosis. This pathognomonic ultrasound marker highlights the importance of distinguishing these entities for accurate diagnosis and management (**Figure 3**).

References

1. R.S. Boersma, K.-S.G. Jie, A. Verbon, E.C.M. van Pampus, H.C. Schouten, *Thrombotic and infectious complications of central venous catheters in patients with hematological malignancies*, *Annals of Oncology*
2. Timsit, J F et al. "Central vein catheter-related thrombosis in intensive care patients: incidence, risks factors, and relationship with catheter-related sepsis." *Chest* vol. 114,1 (1998): 207-13. doi:10.1378/chest.114.1.207
3. Hübsch, P J et al. "Internal jugular and subclavian vein thrombosis caused by central venous catheters. Evaluation using Doppler blood flow imaging." *Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine* vol. 7,11 (1988): 629-36. doi:10.7863/jum.1988.7.11.629
4. Simon MA, Klaeffling C, Ward J, Rauchfuss S, Miesbach W. *Clinical Outcome of Deep Vein Thrombosis Is Related to Thrombophilic Risk Factors*. *Clin Appl Thromb Hemost*. 2023 Jan-Dec;29:10760296231152898. doi:10.1177/10760296231152898.
5. Brescia, Fabrizio et al. "Rapid Femoral Vein Assessment (RaFeVA): A systematic protocol for ultrasound evaluation of the veins of the lower limb, so to optimize the insertion of femorally inserted central catheters." *The journal of vascular access* vol. 22,6 (2021): 863-872. doi:10.1177/1129729820965063
6. Spencer, Timothy R, and Mauro Pittiruti. "Rapid Central Vein Assessment (RaCeVA): A systematic, standardized approach for ultrasound assessment before central venous catheterization." *The journal of vascular access* vol. 20,3 (2019): 239-249. doi:10.1177/1129729818804718
7. Brescia, Fabrizio et al. "A GAVeCeLT bundle for PICC-port insertion: The SIP-Port protocol." *The journal of vascular access* vol. 25,6 (2024): 1713-1720. doi:10.1177/11297298231209521
8. Mandalà, M et al. "Management of venous thromboembolism (VTE) in cancer patients: ESMO Clinical Practice Guidelines." *Annals of oncology: official journal of the European Society for Medical Oncology* vol. 22 Suppl 6 (2011): vi85-92. doi:10.1093/annonc/mdr392
9. Passaro G, Pittiruti M, La Greca A. *The fibroblastic sleeve, the neglected complication of venous access devices: A narrative review*. *J Vasc Access*. 2021 Sep;22(5):801-813. doi: 1177/1129729820951035.
10. Abbruzzese, Chiara et al. "Incidence of asymptomatic catheter-related thrombosis in intensive care unit patients: a prospective cohort study." *Annals of intensive care* vol. 13,1 106. 19 Oct. 2023, doi:10.1186/s13613-023-01206-w
11. Hechler, Béatrice, and Christian Gachet. "Comparison of two murine models of thrombosis induced by atherosclerotic plaque injury." *Thrombosis and haemostasis* vol. 105 Suppl 1 (2011): S3-12. doi:10.1160/THS10-11-0730
12. Baskin, Jacquelyn L et al. "Management of occlusion and thrombosis associated with long-term indwelling central venous catheters." *Lancet (London, England)* vol. 374,9684 (2009): 159-69. doi:10.1016/S0140-6736(09)60220-8
13. Murphy, T P, and J J Cronan. "Evolution of deep venous thrombosis: a prospective evaluation with US." *Radiology* vol. 177,2 (1990): 543-8. doi:10.1148/radiology.177.2.2217798