Bedside intravascular ultrasound-guided fibrin sheath balloon maceration and inferior vena cava filter placement during extracorporeal membranous oxygenation decannulation

William M. Sherk, MD, Minhaj S. Khaja, MD, MBA, Alexandria Jo, MD, Xhorlina Marko, MD, *and* David M. Williams, MD, *Ann Arbor, Mich*

ABSTRACT

Inferior vena cava filter placement during extracorporeal membranous oxygenation decannulation has been described as a technique to prevent potentially lethal pulmonary embolism in this critically ill population. With long-standing extracorporeal membranous oxygenation cannulae, venous fibrin sheaths may develop, which may predispose to filter maldeployment or inadequate embolus filtration. This report describes the use of a balloon catheter to disrupt a fibrin sheath at patient bedside using intravascular ultrasound guidance to facilitate inferior vena cava filter placement. (J Vasc Surg Cases and Innovative Techniques 2020;6:56-8.)

Keywords: ECMO; IVC filter; Fibrin sheath; IVUS

Given the frequent presence of deep vein thrombosis (DVT) in patients undergoing extracorporeal membranous oxygenation (ECMO),[1-5] inferior vena cava (IVC) filter placement can be performed in tandem with ECMO decannulation to avoid the potentially lethal complication of pulmonary embolism.[4,5] However, the presence of a fibrin sheath in the cava may complicate filter placement, leading to inadequate expansion of the filter struts and insufficient caval filtration.[6] This report describes the bedside use of a balloon catheter under intravascular ultrasound (IVUS) guidance to disrupt an ECMO cannula-related fibrin sheath and facilitate IVC filter placement. The patient reported herein has provided consent for publication of procedural details and images.

CASE REPORT

Institutional review board approval was not required for the preparation of this case report. A 41-year-old man with disseminated blastomycosis complicated by acute respiratory distress syndrome (ARDS) required a total of 30 days of venovenous ECMO support for refractory hypoxemia. His course was complicated by heparin-induced thrombocytopenia and thrombosis, for which he was transitioned to an argatroban infusion for anticoagulation during ECMO. The patient demonstrated partial recovery, and the critical care team planned ECMO decannulation. The patient did not have prior confirmed lower extremity DVT, but owing to concerning thrombus noted in the cava on abdominal ultrasound examination and poor cardiopulmonary reserve with intermittent hemodynamic instability, interventional radiology was consulted for bedside IVC filter placement in conjunction with ECMO decannulation, because the critical care service felt the patient was too unstable for transport.

The existing 23F, 64-cm transfemoral venous cannula was exchanged over a wire by the surgical critical care service for a 14F, 23-cm sheath at patient bedside in the critical care unit. A pursestring suture was placed around the sheath in anticipation of sheath removal after filter placement. An 8F IVUS catheter (Volcano, Philips, Amsterdam, the Netherlands) was advanced through the femoral sheath over a J-tipped guidewire and entered a cast-like, echogenic, fibrin sheath measuring approximately 10 mm in diameter and extending from the femoral sheath through the intrahepatic cava, corresponding with the course of the previous ECMO cannula (Fig 1). There was adherent, nonocclusive thrombus outside the fibrin sheath within the cava (not shown).

To allow symmetric distribution of filter struts around the entire IVC wall, an 8- × 40-mm balloon (Mustang, Boston Scientific; Marlborough, Mass) was advanced over a guidewire alongside the IVUS catheter to disrupt the fibrin sheath. The authors intended to use a 10-mm balloon afterward; however, the guidewire was passed across and outside of the fibrin sheath into the infrarenal cava just below the renal vein confluence. The balloon sizes were chosen because they could be advanced alongside the IVUS catheter through the 14F sheath, permitting direct visualization of the balloon catheter. The balloon was advanced to the segment where the wire passed from the fibrin sheath and was inflated (Fig 2). The technique was repeated to increase

From the Division of Vascular and Interventional Radiology, Department of Radiology, University of Michigan Health Systems.

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Correspondence: Minhaj S. Khaja, MD, MBA, Division of Vascular and Interventional Radiology, University of Michigan Health System, 1500 East Medical Center Dr, Ann Arbor, MI 48109 (e-mail: mkhaja@mac.com).

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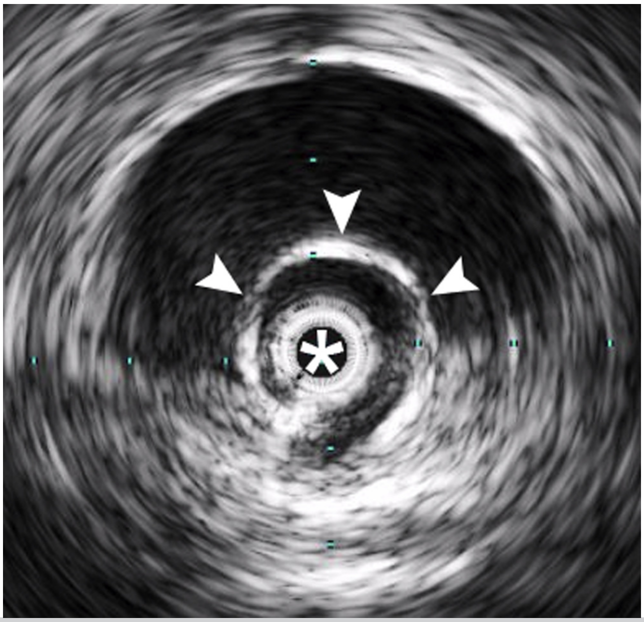

Fig 1. Intravascular ultrasound (IVUS) of the infrarenal inferior vena cava (IVC) showing the IVUS catheter (*) centered within a rounded fibrin sheath (*arrowheads*). Hashmarks on the image delineate a distance of 5 mm.

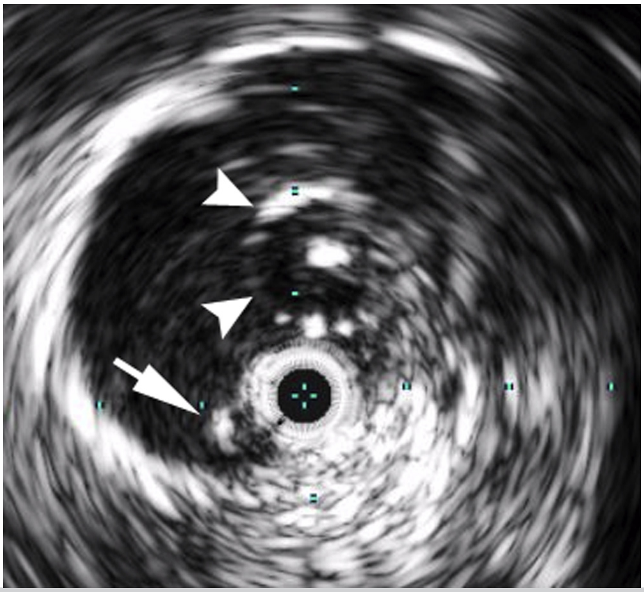

Fig 2. Intravascular ultrasound (IVUS) demonstrating inflation of an 8-mm balloon (*arrowheads*) across the fibrin sheath (*arrow*).

the size of the fenestration caudally until the anterior border of the fibrin sheath was eliminated in the infrarenal cava (Fig 3). The cava was reexamined with IVUS and deemed appropriate for filter-apex placement at the renal vein level. After marking the distance to the desired filter location with the IVUS catheter at the level of the renal veins, the IVUS and balloon catheter were removed over a guidewire, and the 9F introducer sheath of the IVC filter (Gunther Tulip, Cook, Bloomington, Ind) positioned at the same measured length to allow for filter placement. The filter was then unsheathed for deployment. Postdeployment IVUS examination and abdominal radiograph (Fig 4) showed excellent expansion of the filter struts to the entire circumference of the IVC, with the hook just below the renal veins.

DISCUSSION

DVT has been reported to affect up to 18% of patients on venovenous ECMO,[5] although this number is likely underestimated and could result in death.[1-3] Additionally, authors have reported an increased risk of VTE in patients with ARDS owing to influenza A H1N1, which may be seen in other etiologies resulting in ARDS.[3] DVT has also been seen in patients with venoarterial ECMO resulting in massive pulmonary embolism.[4] Pulmonary embolism may be a lethal complication of ECMO decannulation in this patient population, many of whom were treated for severe acute respiratory and/or cardiac failure with poor cardiopulmonary reserve. IVC filter placement concurrently during ECMO decannulation has been described,[5] but may not be possible in the presence of a fibrin sheath when using the same percutaneous access as the cannula. If the filter introducer sheath enters the fibrin sheath of the previous ECMO cannula, the filter may remain constrained when deployed and fail to protect against emboli or even potentially migrate.[6]

Our preferred approach to IVC filter placement during ECMO decannulation is to introduce the filter via the same venous access as the femoral ECMO cannula.[7] This step obviates the need for a second venous access in these critically ill patients who may have additional central venous catheters, previous transfemoral vascular accesses (and resulting hematomas), and/or contralateral iliofemoral DVT. A two-access method of filter placement, in which the IVUS is advanced from the previous ECMO cannula site and the filter introducer sheath from a separate site, may mitigate the risk of deployment within the fibrin sheath, but does not guarantee full strut expansion when deployed alongside the fibrin sheath. Similarly, incomplete filtration and filter migration may potentially be encountered. We perform IVC filter placement during ECMO decannulation at bedside in the ICU. Although these patients are typically stable enough for ECMO decannulation, they still may require significant vasopressor support, multiple infusions, and mechanical ventilation. The bedside approach avoids transportation to another unit and quick access to necessary team members, including perfusionists and critical care staff.

Venous ECMO cannulae, like other indwelling venous catheters, may lead to intravascular fibrin sheath formation as quickly as the first week after placement.[8] In many of our patients on ECMO with long runtimes, we have seen either DVT or a fibrin cast around the central aspiration venous cannula. In these cases, the cannula

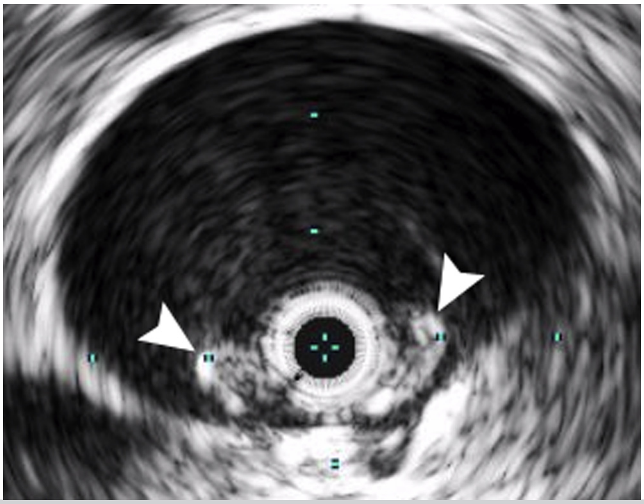

Fig 3. Intravascular ultrasound (IVUS) after balloon disruption of the sheath showing collapsed appearance of the fibrin sheath (*arrowheads*) with elimination of the border anterior to the IVUS catheter.

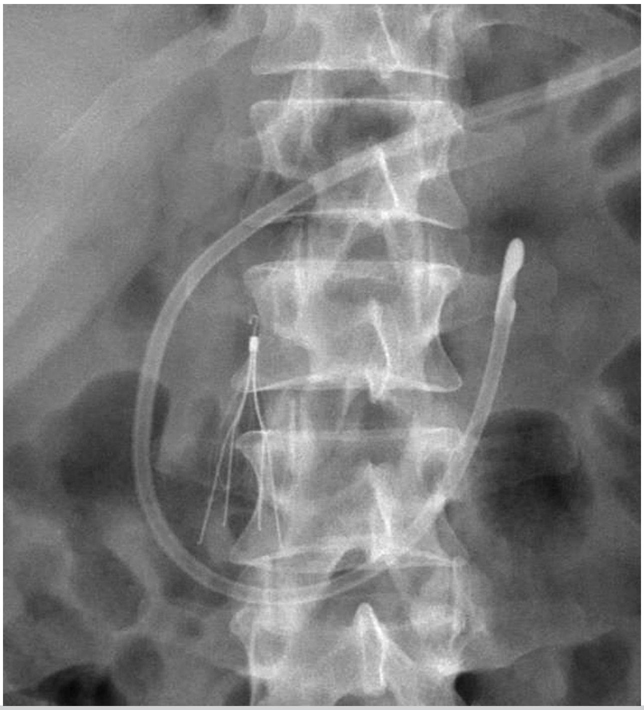

Fig 4. Portable abdominal radiograph performed immediately after filter placement showing the inferior vena cava (IVC) filter tip at the mid L2 level with appropriately expanding struts.

had been present for nearly 1 month and developed a clearly defined sheath on IVUS after removal. There was no evidence of ECMO circulation dysfunction related to the sheath. Because there was no mobile or acute (hypoechoic) thrombus during our initial IVUS evaluation of the cava, we felt that balloon angioplasty of the fibrin sheath, similar to the well-described technique performed during fibrin sheath disruption around central venous catheters,[8] would not risk mobilization and embolization of the chronic sheath. Of note, when the balloon was inflated across the sheath, only nominal pressure was required to cause a relatively large fenestration, suggesting that the sheath was relatively pliable. After two additional inflations of the balloon, the sheath along an approximately 10-cm length developed a deflated, crescentic appearance.

Because they may remain clinically occult, fibrin sheaths should be excluded with strict IVUS evaluation of the cava before filter placement during bedside ECMO decannulation. The same evaluation may be considered in other patients if the same venous access as a previous central venous catheter (eg, hemodialysis catheter) is used for the filter introducer sheath. Further investigation is warranted to evaluate if other described means of fibrin sheath disruption,[6] such as infusion of a thrombolytic agent or use of a balloon occlusion catheter, are equally as effective in this setting and patient population. However, the described technique adds only a brief additional step to bedside filter placement, allows continuous visualization under IVUS guidance and can potentially avoid complications of improper filter expansion.

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