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Variance in Management of Extracorporeal Membrane Oxygenation-Associated Fibrin Sheaths at a Single Institution

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From the Eastern Vascular Society

Variance in management of extracorporeal membrane oxygenation-associated fibrin sheaths at a single institution

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ABSTRACT

Objective: Extracorporeal membrane oxygenation (ECMO) support for patients with cardiac or respiratory failure has been increasingly used by advanced critical care practitioners. The thromboembolic complications of ECMO have been extensively discussed and researched; however, research and discussion on the development, risks, and management of cannulae-associated fibrin sheaths are lacking.

Methods: Institutional review board approval was not required. We have presented three cases detailing the identification and individualized management of ECMO-associated fibrin sheaths at our institution. The three patients provided written informed consent for the report of their case details and imaging studies.

Results: Of our three patients with ECMO-associated fibrin sheaths, two were managed successfully with anticoagulation alone. One could not receive anticoagulation therapy and underwent inferior vena cava filter placement.

Conclusions: Fibrin sheath formation around indwelling ECMO cannulae is an unresearched complication of ECMO cannulation. We would recommend an individualized approach to the management of these fibrin sheaths and have provided three examples of successful management. (J Vasc Surg Cases Innov Tech 2023;9:1-4.)

Keywords: COVID-19; ECMO; Fibrin sheath; Thrombectomy; Thromboembolic complications

Extracorporeal membrane oxygenation (ECMO) is a rescue treatment for patients with respiratory, cardiac, or combined cardiac and respiratory failure. Venovenous (VV) or venoarterial (VA) ECMO support is accomplished by cannulae placed either peripherally or centrally.[1] With the onset of the coronavirus disease 2019 (COVID-19) pandemic and the hypoxic respiratory failure it can cause, VV ECMO to support a patient's oxygenation has become increasingly popular in both hospitals and the media.[2,3] Patients undergoing ECMO cannulation and support have a risk of a host of complications, both well-documented and unknown. Depending on the indication, patients undergoing VV ECMO have had a mortality rate of 35% to 50%, and patients undergoing VA ECMO have had a mortality of 60%.[4-6] In addition, ECMO poses an increased risk of bleeding and thromboembolic complications such as intracranial hemorrhage, deep vein thrombosis (DVT), and pulmonary embolism.[7,8]

An additional, less-studied thromboembolic complication is the development of fibrin sheaths. The development of a fibrin sheath around an indwelling central venous catheter is a well-described phenomenon that is surprisingly common. However, retention of the fibrin sheath within the vessel after removal of the catheter has been less common. One study described a 13.6% fibrin sheath retention rate in patients who had undergone computed tomography scan after removal of a central venous catheter.[9] These sheaths have been theorized to form when the foreign body of the catheter activates the coagulation cascade, coating the catheter with fibrinogen and, subsequently, platelets. The catheter causes injury to the vein wall, resulting in activation of smooth muscle cells, which migrate into the

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thrombus surrounding the catheter and create a cellular–collagen tissue covered by endothelial cells.[10]

During ECMO initiation, cannulae ranging from 17F to 25F will be deployed into large veins. These are significantly larger than the 7F to 9F central venous catheters used throughout intensive care units for central venous access. As such, the fibrin sheaths associated with these larger cannulae have the potential to be more clinically impactful and might pose a greater risk to the patient if retained. Specifically, these sheaths might limit future cannulation options, embolize fragments of the sheath, or become a nidus for infection. Additionally, interventions to address these sheaths have their own risk of complications (whether through anticoagulation or mechanical thrombectomy).

Although the recognition and description of these sheaths have improved, the optimal management of retained ECMO-associated fibrin sheaths has largely been unexplored.[11,12] We have presented three cases of retained ECMO-associated fibrin sheaths and described a variety of management challenges and presentations (Table).

CASE REPORT

Patient 1. The first patient was a 53-year-old man with a medical history of hypertension, hyperlipidemia, and obesity who had presented with shortness of breath to the emergency room. He was found to have COVID-19. Despite optimal medical management, he required intubation and, eventually, ECMO support. He underwent cannulation for VV ECMO via a femorofemoral approach with a 25F drainage cannula and a 24F return cannula on day 10 of his hospitalization. The patient received a low-dose heparin intravenous infusion. However, given the clinically significant hemoptysis, the heparin infusion was held. After 26 days of ECMO support, he was deemed suitable for decannulation. Transesophageal echocardiography (TEE) was performed concurrently with decannulation, which revealed evidence of a fibrin sheath extending to the level of the proximal hepatic inferior vena cava (IVC; Fig 1). Additionally, routine surveillance ultrasound after decannulation showed bilateral femoral DVTs. After decannulation, a trial of anticoagulation was attempted, and the patient tolerated the therapeutic dose anticoagulation without clinically significant bleeding.

Table. Basic characteristics of and management strategies for three patients with retained fibrin sheaths

Pt. No.	ECMO type	Disease process	ECMO duration, days	Management
1	VV	COVID-19	26	Monitoring, AC
2	VV	COVID-19	43	IVC filter
3	VV	COVID-19	58	Monitoring, AC

AC, Anticoagulation therapy; *COVID-19,* coronavirus disease 2019; *ECMO,* extracorporeal membrane oxygenation; *IVC,* inferior vena cava; *Pt. No.,* patient number; *VV,* venovenous.

Patient 2. The second patient was a 52-year-old man with a history of hyperlipidemia and a 15 pack-year smoking history who had presented as a transfer from an outside hospital for consideration of ECMO support in the setting of COVID-19–induced acute respiratory distress syndrome. Despite optimal medical management, his respiratory distress progressed, and he was cannulated via the bilateral femoral veins for VV ECMO and a low-dose heparin infusion was started. The patient required a long and tenuous intensive care unit course, which included multiple mixed bacterial infections, such as *Haemophilus influenzae* ventilator-associated pneumonia, *Serratia* bacteremia, and pseudomonas pneumonia. Additionally, his course was complicated by bleeding and thromboembolic events. He was found to have multiple segmental and subsegmental pulmonary emboli. Despite this, anticoagulation therapy had to be held because the patient began having severe hemoptysis and pulmonary hemorrhage requiring a prolonged withholding of anticoagulation, serial bronchoscopies, and, eventually, placement of an endobronchial blocker. The patient improved from a respiratory perspective and was suitable for decannulation. Given the inability for adequate anticoagulation in the setting of a known pulmonary embolism and bilateral DVTs, an IVC filter was deployed at decannulation to prevent further embolic events. The procedure was uneventful. Intravascular ultrasound was used during placement of the IVC filter and identified a retained fibrin sheath extending to the hepatic IVC (Fig 2). The IVC filter was placed infrarenally. On the completion venogram, the ICV filter appeared incompletely expanded, presumably from external compression by the known fibrin sheath (Fig 3). We did not perform suction thrombectomy or ballooning of the fibrin sheath. We believed the risk of target the sheath was too great, because we believed the sheath was organized thrombus with a low risk of embolization. However, an IVC filter was placed in the hope of providing protection against the known bilateral DVTs. The patient continued to improve and was discharged to a rehabilitation facility. With continued pulmonary recovery, he was able to tolerate apixaban without any bleeding complications.

Patient 3. The third patient was a 40-year-old man with a history significant for asthma and myasthenia gravis who had presented with progressive cough and dyspnea due to COVID-19 pneumonia. The patient developed worsening acute respiratory distress syndrome and required VV ECMO cannulation via bilateral femoral veins. Low-dose heparin was continued with minimal interruptions. His respiratory status slowly improved, and he was decannulated after 40 days of support. Shortly after decannulation, the patient became decompensated secondary to worsening pneumonia and required recannulation for VV ECMO. The patient was recannulated via the right internal jugular vein with an Avalon BiCaval Cannula (Getinge, Göteborg, Sweden). During recannulation, the guidewire could not be advanced to the infrahepatic IVC because of significant

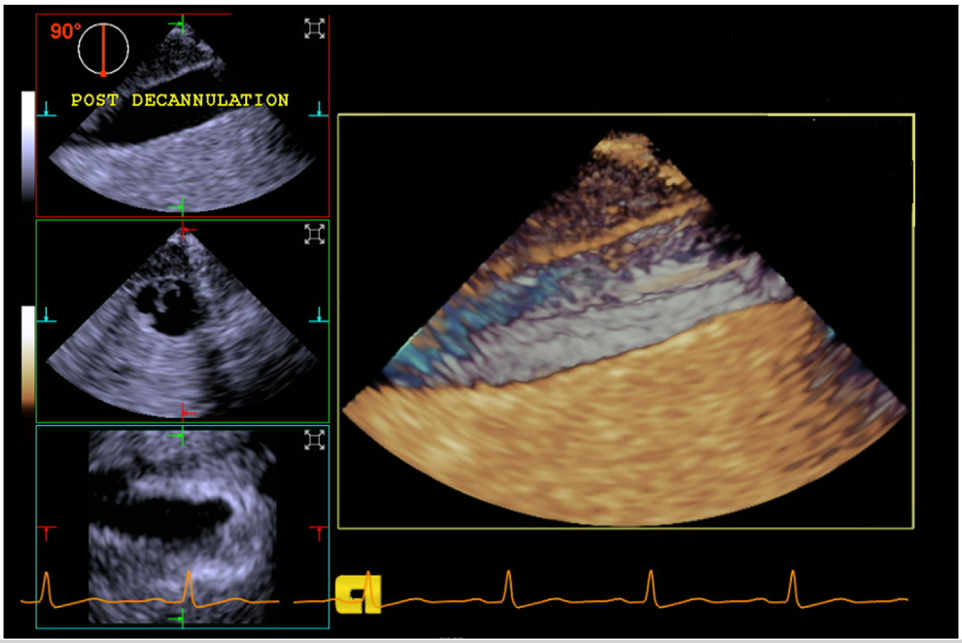

Fig 1. Transesophageal echocardiography (TEE) of patient 1 performed at decannulation showing fibrin sheath in hepatic inferior vena cava (IVC).

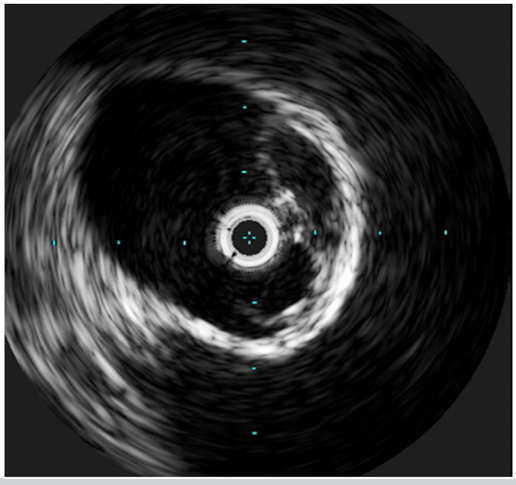

Fig 2. Intravascular ultrasound of patient 2 showing a double barrel fibrin sheath after decannulation.

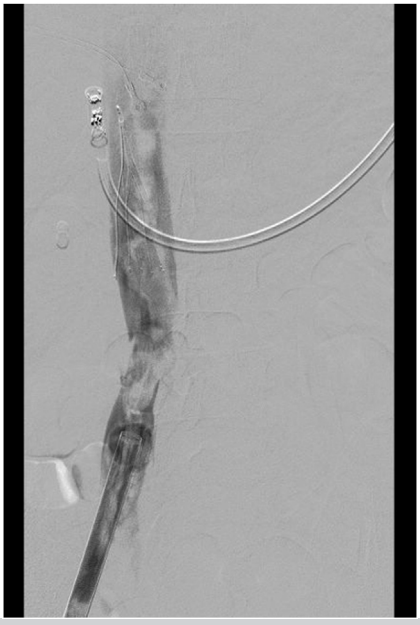

Fig 3. Venogram during inferior vena cava (IVC) filter placement for patient 2 showing incomplete expansion.

resistance. However, the cannula could be deployed over the guidewire and terminated just above the level of the diaphragm. Given this difficulty, immediately after cannulation, TEE was performed, which revealed a nonocclusive echodenisty near the IVC–right atrium junction thought to represent a retained fibrin sheath vs a clot from a prior cannula. The new cannula was 1.1 cm from the echodensity. After recannulation, issues occurred with recirculation; however, the proximity of the fibrin sheath at the IVC–right atrium junction to the cannula made advancement of the cannula of very high risk owing to the potential for embolization. Thus, optimal positioning of the cannula was not possible. Despite the positioning challenges, the patient received adequate support, and ECMO was slowly weaned. The findings were reevaluated by TEE before decannulation with no change in the size or extent found. The patient was successfully decannulated and discharged to a rehabilitation facility with a prescription for apixaban.

DISCUSSION

Patients receiving support with VA or VV ECMO have an increased risk of thromboembolic events. Additionally, they have a risk of thrombus and fibrin accumulation around the catheter, which can lead to the formation of a fibrin sheath that might be removed with decannulation or retained. Identification of these retained fibrin sheaths is crucial. The presence of a fibrin sheath should influence clinical decision-making with respect to future cannulation options, the need for anticoagulation, and the risk of infection.

At present, no standard of care has been established for the management of ECMO-associated fibrin sheaths. As such, they should be managed on a case-by-case basis through a multidisciplinary approach with input from cardiac anesthesiology, critical care, vascular surgery, and interventional radiology.

As with patients 1 and 2, a fibrin sheath can be asymptomatic with the procedural risks of removal outweighing the benefits. For such cases, we propose treating the sheath with anticoagulation and monitoring alone via a "watch and wait" strategy. For other cases, the presence of an ECMO-associated fibrin sheath could limit future ECMO cannulation or other central venous access options such as occurred with patient 3. If further mechanical circulatory support or vascular access is necessary, the patient might benefit from procedural evacuation of the fibrin sheath. If the goal is to for patients to progress to transplant, these sheaths might also need to be addressed. Additionally, patients 2 and 3 had had multiple mixed bacterial infections, including gram-negative rod bacteremia, increasing the chance of biofilm formation, which could have had an effect on fibrin sheath development.

At our institution, ECMO support for respiratory failure in patients with COVID-19 is typically performed with a femorofemoral strategy to facilitate a prone position and reduce the risk of cannula dislodgement. With this cannulation strategy, two cannulas will be in very close proximity in the IVC, which could increase the risk of fibrin sheath formation or thrombus generation. It is unclear whether this cannulation strategy will confer a higher risk of thrombus or fibrin sheath formation, and this should be investigated further.

As the use of ECMO continues to increase, more fibrin sheaths will be identified, and further research should be aimed at identifying the risk factors for the formation of fibrin sheaths and their optimal management. Until then, clinicians should address these phenomena on a case-by-case basis.

Study limitations. Our case series was limited by the lack of a standardized follow-up protocol at our institution for patients with these fibrin sheaths. Ideally, patients who survive to discharge should undergo serial imaging studies to monitor these sheaths and the efficacy of their anticoagulation regimen. An ideal post-discharge follow-up plan and regimen have not yet been established, and future research on this would be valuable. Additionally, the present case series included fibrin sheaths that had been incidentally found at our institution. A truer representation of the effect of these sheaths found through more standardized monitoring would be realized in a larger cohort.

REFERENCES

1. Makdisi G, Wang IW. Extra corporeal membrane oxygenation (ECMO) review of a lifesaving technology. J Thorac Dis 2015;7:E166-76.
2. Augoustides JG. Extracorporeal membrane oxygenation—crucial considerations during the coronavirus crisis. J Cardiothorac Vasc Anesth 2020;34:1720-2.
3. Curwen T. She was dying of COVID-19. Her last hope was a device that would save or kill her. LA Times. March 3, 2021. Available at: https://www.latimes.com/california/00000178-8957-da9d-a17a-dfd75bc00001-123. Accessed April 11, 2022.
4. Combes A, Hajage D, Capellier G, Demoule A, Lavoué S, Guervilly C, et al; EOLIA Trial Group, REVA, and ECMONet. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. N Engl J Med 2018;378:1965-75.
5. Barbaro RP, MacLaren G, Boonstra PS, Combes A, Agerstrand C, Annich G, et al; Extracorporeal Life Support Organization. Extracorporeal membrane oxygenation for COVID-19: evolving outcomes from the international Extracorporeal Life support Organization Registry. Lancet 2021;398:1230-8.
6. Rao P, Khalpey Z, Smith R, Burkhoff D, Kociol RD. Venoarterial extracorporeal membrane oxygenation for cardiogenic shock and cardiac arrest. Circ Heart Fail 2018;11:e004905.
7. Menaker J, Tabatabai A, Rector R, Dolly K, Kufera J, Lee E, et al. Incidence of cannula-associated deep vein thrombosis after veno-venous extracorporeal membrane oxygenation. ASAIO J 2017;63:588-91.
8. Cavayas YA, Del Sorbo L, Fan E. Intracranial hemorrhage in adults on ECMO. Perfusion 2018;33(Suppl):42-50.
9. Capitanini A, Ricci E, Frosini P, Cupisti A. Massively calcified intravascular cast after removal of a tunneled central vein catheter for hemodialysis. J Vasc Access 2013;14:196-8.
10. Xiang DZ, Verbeken EK, Van Lommel AT, Stas M, De Wever I. Composition and formation of the sleeve enveloping a central venous catheter. J Vasc Surg 1998;28:260-71.
11. Essandoh M. Fibrin sheath formation during mechanical circulatory support: another reason for transesophageal echocardiographic monitoring. Anesthesiology 2019;130:1036.
12. Yaport M, Pisano DV, Joyce MF, Irshad A, Ortoleva J. The ghosts of cannulae past. J Cardiothorac Vasc Anesth 2022;36:1827-31.

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