

Arterial access complications in patients with extracorporeal membrane oxygenation – literature review

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ABSTRACT

INTRODUCTION: The use of extracorporeal membrane oxygenation (ECMO) has been increasing in recent years. Venous-Arterial ECMO (ECMO-VA) is usually deployed in refractory cardiac failure and is mostly cannulated through the common femoral artery. When present, arterial access complications may have important consequences in these patients. Therefore, this work aims to narratively review the available evidence regarding the impact of arterial access complications in patients undergoing ECMO-VA.

METHODS: A Medline search was performed to identify articles focused on arterial access complications in patients undergoing ECMO-VA since 2010. The keywords were “extracorporeal membrane oxygenation,” “arterial access,” and “complications.” The primary endpoints were the description of the arterial complication with demographic characteristics and the short- and long-term prognosis.

RESULTS: The incidence of vascular complications in patients undergoing ECMO-VA ranges from 9.4% to 43.9%. In the majority of retrospective studies, their presence isn't associated with increased mortality. However, in a meta-analysis, there was an increased mortality in patients with complications (RR 1.36; CI 95% 1.15-1.60; P=0.0004). The main risk factors are peripheral artery disease and female sex, while the reduced case volume can be associated with increased complications.

CONCLUSION: Most available evidence on managing arterial complications associated with ECMO derives from retrospective studies. To decrease the risk of access complications, protocols for cannulation, surveillance, and decannulation should be elaborated. Prospective studies are needed to improve the prevention and management of vascular access complications in patients under ECMO-VA.

Keywords: Extracorporeal membrane oxygenation; Mortality; Peripheral Artery Disease.



INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a support technique employed in intensive care units (ICU) in the setting of severe refractory cardiac or respiratory failure. In patients with cardiac or cardiopulmonary failure, veno-arterial ECMO (VA-ECMO), either through central or peripheral cannulation, is the modality of choice. When peripheral VA-ECMO is performed, arterial access is usually the common femoral artery and can be associated with arterial complications.

Several technical adaptations were developed to reduce arterial access complications. The antegrade reperfusion cannula was associated with reduced incidence of limb ischemia in several studies,^[1-3] including patients of pediatric age.^[4] In one of those studies, the absence of an antegrade reperfusion cannula was identified as the leading risk factor for ischemic limb complications.^[2] In another study, a 10-12 Fr cannula was associated with a lower incidence of limb ischemia when compared with a 6-8 Fr introducer sheath.^[5]

The decannulation method has also received attention, especially using ProGlides (Abbot Vascular). They were safe and effective in several studies,^[6-8] even compared to surgical decannulation.^[9,10] The technical success and complication rates were similar in a study comparing ProGlides in ECMO and ProGlides in endovascular aneurysm repair (EVAR).^[11] Another study with Manta (Teleflex) revealed that it was also effective in obtaining hemostasis; however, it was associated with an increased risk of residual stenosis in the decannulated artery, especially when it was distally to the femoral bifurcation.^[12]

Given these technical developments, the recent increase in ECMO employment during the SARS-CoV-2 pandemic, and the evidence that the increased number of patients under ECMO is associated with the increasing need for urgent surgery for iatrogenic vascular injuries,^[13] this work aims to perform a narrative review of the available evidence regarding arterial access complications and their impact in patients under peripheral VA-ECMO.

METHODS

A Medline search was performed to identify available evidence from 2010 onwards related to arterial access complications in patients under peripheral VA-ECMO. The keywords were "extracorporeal membrane oxygenation," "arterial access," and "complications." Other relevant studies for this work were analyzed, including thorough cross-reference evaluation. Case reports were not included. Only original or review articles in English were considered. The primary endpoints were the description of the association between arterial access complications in peripheral VA-ECMO and patients' comorbidities and short- and long-term prognosis.

RESULTS

Several studies on arterial access complications and their impact on patients undergoing peripheral VA-ECMO are available. All of them are retrospective, although some are based on prospective registries.

Risk Factors

In a retrospective study that included 143 patients with VA-ECMO, 10% (n=15) had vascular complications and peripheral artery disease (PAD) was the only associated risk factor.^[14] Yeo et al. included 63 patients who underwent compression after decannulation, and 18% (n=11) had vascular complications. The majority were hemorrhagic. Patients under dual antiplatelet therapy and those with an activated partial thromboplastin time higher than 56 had a higher risk of complications.^[15] Augusto et al. evaluated vascular complications in 82 patients under peripheral VA-ECMO. Vascular complications were present in 29% (n=15) of the patients, the majority (n=12) being acute limb ischemia. The presence of PAD and coronary artery disease were associated with vascular complications.^[16] In another study with 95 patients, 21% (n=20) had vascular complications. The main complication was bleeding through the cannulation site. Patients with complications had a higher need for blood transfusions and lengthier stays in the ICU.^[17] In a retrospective study that included 573 patients, Schaefer et al. compared femoral and axillary access regarding complications. Patients who underwent axillary access had a higher incidence of stroke, while those with femoral access had a higher incidence of limb ischemia.^[18]

Impact of arterial access complications on mortality

Wong et al. included 103 patients in a retrospective study, 26 under central VA-ECMO. Cannulation-associated complications were present in 32% (n=33) of the patients, the most common being hemorrhage and limb ischemia. Femoral access was associated with an increased risk of limb ischemia. There were no statistically significant differences in major interventions or mortality between the type of access.^[19] Other studies also showed no increase in mortality in patients with vascular complications,^[15,17] including in the mortality rates at 30 days and one year.^[18]

On the other hand, a recent meta-analysis that included 10 studies and 1643 patients revealed different findings. The cumulative rate of vascular complications was 23%, ranging between 9% and 44%. There was a significant association between complications and mortality, with a relative risk of 1.36 (IC 95% 1.15-1.60; P=0.0004). There also was an inverse relationship between age and mortality and a direct relationship between the female gender and mortality.^[20]

A study that included a total of 221 700 hospitalizations between 2015 and 2019 compared the rate and impact of vascular complications between several mechanical circulatory support strategies, including ECMO. ECMO was associated with a higher rate of vascular complications and was the one with the absolute higher risk between all evaluated strategies (aOR: 5.35, p < 0.001). In-hospital mortality was also higher in patients with vascular complications after ECMO.

Table 1. Characteristics of studies included in the review

Study	ECMO Patients (N)	Risk Factors	Mortality
Bisdas, 2011 (14)	143	PAD	Similar
Yeo, 2016 (15)	63	DAPT aPTT > 56 s	Similar
Wong, 2017 (19)	103	-	Similar
Augusto, 2019 (16)	82	PAD CAD	Similar
Gulkarov, 2021 (20)	1643	-	Increased
Singh, 2022 (17)	95	-	Similar
Schaefer, 2022 (18)	573	-	Similar
Lemor, 2022 (21)	7525	Female Gender PAD Arteriotomy Size	Increased
Wilhelm, 2022 (22)	402	Female Gender PAD	Similar

ECMO – Extracorporeal Membrane Oxygenation; **PAD** – Peripheral Artery Disease; **DAPT** – Dual Antiplatelet Therapy; **aPTT** – activated Partial Thromboplastin Time; **CAD** – Coronary Artery Disease

Predictors of complications were increased arteriotomy size, female gender and PAD.^[21]

Management and risk reduction strategies

The presence of complications is associated with the volume of each center. In a study that included 10 207 VA-ECMO patients between 2013 and 2016 from a German administrative registry, the 30-day mortality (aOR: 1.13; 95% IC 1.01–1.27; P = 0.034) and the risk of complications (aOR: 1.46; 95% CI 1.29–1.66; P = 0.001) is higher in low volume centers (≤ 50 VA-ECMO per year).^[23]

There are no guidelines for the management of arterial complications after VA-ECMO, and therefore, it should be done on an individualized basis. There are, however, strategies that can prevent or reduce the risk of complications.

During cannulation, ultrasound guide puncture and the liberal use of anterograde perfusion cannula can reduce the risk of complications.^[24] A recent study revealed that the Preclose technique with Proglides can be associated with a probability of risk reduction of 80%.^[10] A prospective observational study confirmed that this approach is safe and effective.^[8] Conversely, Wilhelm et al. assessed the incidence of acute limb ischemia between several types of cannulation in 402 patients. There were no statistically significant differences regarding mortality and incidence of acute limb ischemia in all groups. However, there was a trend towards increased risk of limb ischemia in patients who underwent percutaneous cannulation (P=0.0501). Overall, female gender and younger age were risk factors for acute limb ischemia.^[22]

At the ICU, monitoring with near-infrared spectroscopy

(NIRS), careful clinical evaluation, and personnel training may allow early detection of complications.^[24] Hipocoagulation with a bolus of 5000 UI of unfractionated heparin at cannulation followed by weight-based infusion to prevent ECMO circuit thrombosis can also reduce the incidence of limb ischemia.^[24] Institutional decannulation protocols are also recommended, with some centers advocating surgical decannulation as first-line strategy.^[24] However, several studies that directly compared both strategies suggested that percutaneous decannulation can have similar results.^[6-9] Overall, up to 14% of patients who develop acute limb ischemia may need amputation.^[24]

CONCLUSION

Most of the available evidence regarding arterial access complications in patients under VA-ECMO is from retrospective studies. The main risk factors are PAD and the female gender, although younger age and coronary artery disease can also be associated. The volume of ECMO cases can also impact the rate of complications and can be increased in centers with fewer than 50 patients per year.

The clinical context of patients under VA-ECMO is usually severe, and mortality is inherently high. There is no consensus in the literature regarding the impact on mortality, but some evidence suggests an increase in 30-day mortality.

The elaboration of institutional protocols for cannulations, surveillance, and decannulations is recommended to reduce and prevent arterial access complications. Given the fact that PAD is associated with an increased risk

of complications, the involvement of Vascular Surgery in a multidisciplinary team can lead to a reduction in complications in these patients. Prospective studies are needed to understand better how to prevent and manage arterial access complications in patients under peripheral VA-ECMO.

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REFERENCES

- Lamb KM, DiMuzio PJ, Johnson A, Batista P, Moudgill N, McCullough M, et al. Arterial protocol including prophylactic distal perfusion catheter decreases limb ischemia complications in patients undergoing extracorporeal membrane oxygenation. *J Vasc Surg.* 2017;65:1074-9.
- Kaufeld T, Beckmann E, Ius F, Koigeldiev N, Sommer W, Mashaqi B, et al. Risk factors for critical limb ischemia in patients undergoing femoral cannulation for venoarterial extracorporeal membrane oxygenation: Is distal limb perfusion a mandatory approach? *Perfusion.* 2019;34:453-9.
- Ohira S, Kawamura M, Ahern K, Cavarocchi N, Hirose H. Aggressive placement of distal limb perfusion catheter in venoarterial extracorporeal membrane oxygenation. *Int J Artif Organs.* 2020;43:796-802.
- Schad CA, Fallon BP, Monteagudo J, Okochi S, Cheung EW, Morrissey NJ, et al. Routine Use of Distal Arterial Perfusion in Pediatric Femoral Venous Arterial Extracorporeal Membrane Oxygenation. *Artif Organs.* 2017;41:11-6.
- Mohite PN, Fatullayev J, Maunz O, Kaul S, Sabashnikov A, Weymann A, et al. Distal limb perfusion: Achilles' heel in peripheral venoarterial extracorporeal membrane oxygenation. *Artif Organs.* 2014;38:940-4.
- Xu X, Liu Z, Han P, He M, Xu Y, Yin L, et al. Feasibility and safety of total percutaneous closure of femoral arterial access sites after veno-arterial extracorporeal membrane oxygenation. *Medicine (Baltimore).* 2019;98:e17910.
- Hayakawa N, Tobita K, Kodera S, Koyama E, Miyashitani H, Sahashi S, et al. Efficacy and Safety of Percutaneous Venous Arterial Extracorporeal Membrane Oxygenation Decannulation Using Endovascular Balloon Dilation and Perclose ProGlide Closure Device: Results from the Multicenter SKYLINE Study. *Ann Vasc Surg.* 2023;96:357-64.
- Martin-Tuffreau AS, Bagate F, Boukantar M, Saiydoun G, Mangiameli A, Rostain L, et al. Complete percutaneous angio-guided approach using preclosure for venoarterial extracorporeal membrane oxygenation implantation and explantation in patients with refractory cardiogenic shock or cardiac arrest. *Crit Care.* 2021;25:93.
- Hwang JW, Yang JH, Sung K, Song YB, Hahn JY, Choi JH, et al. Percutaneous removal using Perclose ProGlide closure devices versus surgical removal for weaning after percutaneous cannulation for venoarterial extracorporeal membrane oxygenation. *J Vasc Surg.* 2016;63:998-1003.
- Chandel A, Desai M, Ryan LP, Clevenger L, Speir AM, Singh R. Preclosure technique versus arterial cutdown after percutaneous cannulation for venoarterial extracorporeal membrane oxygenation. *JTCVS Tech.* 2021;10:322-30.
- Liu Z, Xu Y, Xu X, He M, Han P, Shao C, et al. Comparison of Success Rate and Complications of Totally Percutaneous Decannulation in Patients With Venous Arterial Extracorporeal Membrane Oxygenation and Endovascular Aneurysm Repair. *Front Med (Lausanne).* 2021;8:724427.
- Bemtgen X, Heidt T, Zotzmann V, Rilingger J, Wengenmayer T, Biever PM, et al. Venous Arterial Extracorporeal Membrane Oxygenation Decannulation Using the Novel Manta Vascular Closure Device. *Eur Heart J Acute Cardiovasc Care.* 2020;9:342-7.
- Silverberg D, Hater H, Halak M. Rise in Percutaneous Vascular Procedures and Extracorporeal Membrane Oxygenation Is Associated With Increase in Emergent Vascular Operations. *Vasc Endovascular Surg.* 2023;57:53-9.
- Bisdas T, Beutel G, Warnecke G, Hoepfer MM, Kuehn C, Haverich A, et al. Vascular complications in patients undergoing femoral cannulation for extracorporeal membrane oxygenation support. *Ann Thorac Surg.* 2011;92:626-31.
- Yeo HJ, Kim HJ, Jang JH, Kang LH, Cho WH, Kim D. Vascular Complications Arising from Hemostasis with Manual Compression Following Extracorporeal Membrane Oxygenation Decannulation. *J Card Surg.* 2016;31:123-6.
- Augusto R, Passos Silva M, Campos J, Coelho A, Coelho N, Semião AC, et al. Arterial Vascular Complications in Peripheral Venous Arterial Extracorporeal Membrane Oxygenation Support. *Rev Port Cir Cardiorac Vasc.* 2019;26:45-50.
- Singh V, Singh G, Arya RC, Kapoor S, Garg A, Ralhan S, et al. Vascular access complications in patients undergoing veno-arterial ECMO and their impact on survival in patients with refractory cardiogenic shock: A retrospective 8-year study. *Ann Card Anaesth.* 2022;25:171-7.
- Schaefer AK, Distelmaier K, Riebandt J, Goliasch G, Bernardi MH, Zimpfer D, et al. Access site complications of postcardiotomy extracorporeal life support. *J Thorac Cardiovasc Surg.* 2022;164:1546-58.
- Wong JK, Melvin AL, Joshi DJ, Lee CY, Archibald WJ, Angona RE, et al. Cannulation-Related Complications on Venous-Arterial Extracorporeal Membrane Oxygenation: Prevalence and Effect on Mortality. *Artif Organs.* 2017;41:827-34.
- Gulkarov I, Khusid E, Worku B, Demissie S, Guerges M, Salemi A, et al. Meta-Analysis of the Effect of Vascular Complications on Mortality in Patients Undergoing Femoral Venous Arterial Extracorporeal Membrane Oxygenation. *Ann Vasc Surg.* 2021;71:488-95.
- Lemor A, Dabbagh MF, Cohen D, Villablanca P, Tehrani B, Alaswad K, et al. Rates and impact of vascular complications in mechanical circulatory support. *Catheter Cardiovasc Interv.* 2022;99:1702-11.
- Wilhelm MJ, Inderbitzin DT, Malorgio A, Aser R, Gülmez G, Aigner T, et al. Acute limb ischemia after femoro-femoral extracorporeal life support implantation: A comparison of surgical, percutaneous, or combined vascular access in 402 patients. *Artif Organs.* 2022;46:2284-92.
- Becher PM, Goßling A, Schrage B, Twerenbold R, Fluschnik N, Seiffert M, et al. Procedural volume and outcomes in patients undergoing VA-ECMO support. *Crit Care.* 2020;24:291.
- Lamb KM, Hirose H. Vascular Complications in Extracorporeal Membrane Oxygenation. *Crit Care Clin.* 2017;33:813-24.