

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

Vikrampal Singh, Gurmeet Singh, Rajesh Chand Arya¹, Samir Kapoor, Arun Garg, Sarju Ralhan², Vivek K. Gupta¹, Bishav Mohan³, Gurpreet Singh Wander³, Rajiv K. Gupta

Departments of CTVS and ³Cardiology, Dayanand Medical College and Hospital, Ludhiana, Punjab, Departments of ¹Cardiac Anaesthesia and ²CTVS, Hero DMC Heart Institute, Ludhiana, Punjab, India

ABSTRACT

Introduction: Veno-arterial extracorporeal membrane oxygenation (ECMO) is well-recognized treatment modality for patients with refractory cardiogenic shock. Uncomplicated cannulation is a prerequisite and basis for achieving a successful outcome in ECMO. Vascular access is obtained either by surgical cut-down. Common vascular access complications are bleeding and limb ischemia.

Objective: To evaluate cannulation technique, the incidence of vascular complications, and their impact on the outcome.

Methods: A retrospective data analysis conducted on 95 patients receiving ECMO from 2013 to 2020 was done. The patients were divided into two groups: no vascular access complications (non-VAC group) and vascular access complications (VAC group). The groups were compared related to the hospital and ICU stays and blood transfusion.

Results: The patients in both groups were demographically and clinically comparable. The Non-VAC group had 75 patients, whereas the VAC group had a total of 20 patients. The main complication observed in the VAC group was bleeding from the cannulation site which required more blood transfusion than the non-VAC group (6.8 ± 1.02 vs 4.2 ± 1.26). Limb ischemia was another complication seen in the VAC group (4.2%, $n = 4$). Two patients had delayed bleeding after decannulation. The overall average length of stay in the hospital was statistically similar in both the groups (22 days in the VAC group vs 18 days in the non-VAC group), but the average ICU stay was more in the VAC group compared to the non-VAC group (18 days vs 12.06 days).

Conclusion: Bleeding and limb ischemia are the important vascular access site complications, which increase blood transfusion requirements, ICU stay, and overall hospital stay.

Keywords: Blood transfusion, cannulation, extracorporeal membrane oxygenation (ECMO), veno-arterial ECMO

Address for correspondence: Dr. Samir Kapoor, Department of Cardiac Surgery, Dayanand Medical College and Hospital, Civil Lines, Ludhiana, Punjab, India. E-mail: drsamir Kapoor82@gmail.com

Submitted: 27-Jan-2022 **Revised:** 17-Feb-2022 **Accepted:** 19-Feb-2022 **Published:** 31-Mar-2022

Access this article online	
Quick Response Code:	Website: www.annals.in
	DOI: 10.4103/aca.aca_22_22

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: 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.

INTRODUCTION

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) is a well-recognized treatment modality for patients with refractory cardiogenic shock (rCS).^[1,2]

Central and peripheral cannulations are the two configurations for initiating VA-ECMO support. Central cannulation is usually done in operation theatre for postcardiotomy shock patients, whereas peripheral VA-ECMO is used for non-cardiotomy shock patients. The femoral artery and vein are the standard vascular access site for peripheral VA-ECMO. Though axillary artery can also be used, peripheral cannulation using femoral vessels is less invasive, and it can be done rapidly at the bedside in the emergency room or intensive care unit, considering the emergent situation like refractory shock and cardiac arrest scenarios. Peripheral access is usually obtained either by surgical cut-down or percutaneously using the Seldinger technique under ultrasound or fluoroscopic guidance.

Uncomplicated cannulation is a prerequisite and basis for achieving a successful outcome in VA-ECMO (2). Vascular complications like bleeding from cannulation sites and limb ischemia are not common but are serious events, affecting the outcome.^[3,4] Various studies in the literature have reported a rate of vascular arterial complications like vascular injuries, bleeding, and limb ischemia in the range of 10%–70%.^[5-9] However, with experience and modifications of the technique, these can be minimized. The aim of this article is to evaluate our technique of surgical cutdown for cannulation (main arterial inflow cannula and distal limb perfusion cannula), analyze the incidence of vascular complications, and their impact on outcome in patients undergoing VA-ECMO.

MATERIAL AND METHOD

This is a retrospective study conducted in our institute. Between 2013 and 2020, VA-ECMO was instituted in 95 patients with varied aetiologies [Table 1]. All these patients had refractory cardiogenic shock not responding to conventional conservative treatment. The patients were in a low cardiac output state with severe left ventricular (LV) dysfunction, systemic hypoperfusion, metabolic acidosis,

and impending multi-organ failure. Femoral vessels were the usual site chosen for placement of ECMO cannula. We studied the data of 95 patients who had VA-ECMO done at our institute. The patients were divided into two groups: Vascular access complication (VAC group) and no vascular access complication (Non-VAC group). The two groups were compared with each other related to the morbidity, mortality i.e., the impact on the outcome of the patient. The approval of ethics committee was taken wide IEC no. 2022-713 dated 22.01.2022, reference no. DMCH/R&D/2022/125.

Patient preparation before ECMO cannulation:

ECMO initiation was a multidisciplinary decision, involving treating physicians, cardiac surgeons, cardiologists, and anesthesiologists. As these patients were already in cardiogenic shock, all patients had a central line in place (for transfusion of inotropes and monitoring of central venous pressure), an arterial line in one of the radial arteries (for monitoring of invasive blood pressure and blood sampling for arterial blood gas). Many of these patients were already intubated with controlled ventilation, the patients who were spontaneously breathing were electively intubated, and ventilation was controlled.

Cannulation technique: All surgical open cannulations were done under vision by a cardiac surgery team, and right femoral vessels were the usual site for cannulation. Under all aseptic precautions, the inguinal area was cleaned and draped. A transverse incision (3–5 cm) was made just below the inguinal ligament over the mid-inguinal point to expose the femoral vessels. For cannulation, only the anterior surface of the vessels was exposed, preserving the adventitia over the vessels, without any looping of the artery. The patient was heparinized with 1 mg/kg body wt. Inj. Heparin sulfate. Once the target activated clotting time (ACT) of ≥ 200 s was achieved, at the same time purse-string sutures were taken, two on the femoral artery and one on the femoral vein,

Venous cannulation: The venous cannula was placed in the femoral vein using the modified Seldinger technique. The position of the guidewire and the position of the cannula were checked constantly with echocardiography. The venous cannula used were 25 or 27 Fr (Bio-Medicus Medtronic NextGen) size. The tip of the venous cannula was kept in the intrahepatic part of the inferior vena cava (IVC) below the junction of the inferior vena cava (IVC) and right atrium.

Arterial cannulation: Using the modified Seldinger technique, arterial cannula and distal perfusion were placed. The position of the guidewire in the true lumen

Table 1: Variety of diseases in the study population for ECMO

Etiology	Number (% of total)
Aluminum phosphide toxicity	73 (76.8%)
Viral myocarditis	11 (11.6%)
ECMO CPR (Acute coronary syndrome)	4 (4.2%)
Pulmonary embolism	2 (2.1%)
Post PTCA	4 (4.2%)
Postpartum cardiomyopathy	1 (1.1%)

was confirmed in the descending thoracic aorta, using echocardiographic. The arterial cannulas were 15 or 17 Fr size (Bio-Medicus Medtronic NextGen), depending upon flow requirements and size of vessels. Along with the arterial return cannula, 7 or 8 Fr arterial sheath was placed in the superficial femoral artery for distal limb perfusion.^[10,11]

Initiation of ECMO: Primed and deaired ECMO circuit was connected to the arterial and venous cannulas. The entire circuit was checked again, and then flows were started by opening venous and arterial clamps. The pump flows were gradually increased to reach the cardiac index of 2.2 to 2.6 L/min/m² with an aim to maintain a mean arterial pressure of 60–70 mm Hg. At the same time, the cardiac functions and volume status were assessed with echocardiography. A pulsatile arterial trace on ECMO was a good sign of LV ejections as the LV contractions could open the aortic valve against the increased afterload in the aorta generated by retrograde ECMO machine flows.

Monitoring of ECMO: Besides hemodynamic monitoring, regular serial echocardiography examinations were performed to monitor left ventricular (LV) function, filling status, and cannula position. All attempts were made to taper the requirement of inotropes, though a low dose of inotropes was continued to maintain good LV ejection and opening of the aortic valve to prevent LV distension and blood stasis. A close watch was also kept on the cannulation site, and lower limb perfusion status was carefully monitored for any sign of ischemia.

Weaning from ECMO: Once the patient had been metabolically stabilized and cardiac ejection fraction improved (more than 25%), pump flows were gradually reduced. Echocardiography was used repeatedly to monitor the weaning process. Those patients who remained hemodynamically stable during the weaning process were scheduled for discontinuation of ECMO.

ECMO explantation: After successful weaning and good LV function, the decision was made to stop the ECMO machine flows. The decannulation procedure was done bedside. Under all aseptic precaution, the cannulation site was opened, first venous cannula was removed, and the purse-string suture was tied, making sure that there was no bleeding. Next, the distal perfusion cannula was removed, and the purse-string suture was tied. Lastly, for removal of the femoral artery, proximal and distal control was taken on the femoral artery. The arterial cannula was taken out, and the femoral artery was repaired directly using 6-0 polypropylene suture ensuring good hemostasis. After repairing the femoral artery, distal pulses were confirmed

to rule out any compromised repair. Again, at end of decannulation, the distal limb perfusion was checked with peripheral Doppler ultrasound and pedal pulses.

Failure of weaning: The patients in whom the serial weaning trials were not successful and echocardiographic criteria were not satisfactory, the ECMO was continued. In patients, in whom the weaning from ECMO was not possible and who got multi-organ dysfunction despite all possible support, mechanical circulatory support was considered futile, and the ECMO was stopped after multidisciplinary meetings and family counseling. Counseling of patient's family and decision making in patients undergoing mechanical circulatory support was an essential part of every step in management.

Complications of procedure: Vascular access complications (VAC) were defined as those occurring at the time of cannulation and during the run of VA-ECMO and requiring surgical intervention and include as follows:

- a. *Significant bleeding:* Bleeding or hematoma at cannulation site (with fall in Hb more than 1 gm⁰): Bleeding events were defined according to the Extracorporeal Life Support Organization (ELSO) definition.^[12,13] We defined a bleeding event if there was clinically overt bleeding recorded in the medical and/or nursing charts associated with either administration of two or more RBC units in 24 h or a drop in hemoglobin greater than 2 g/L over 24 h. We recorded only cannulation site-related bleeding or retroperitoneal bleeding, or bleeding due to injury to vessels in our study.
- b. *Limb ischemia:* In patients of refractory cardiogenic shock undergoing femoral artery cannulation, for mechanical circulatory support, the cannula itself can obstruct the blood flow distal to cannulation point, as arteries are small and prone to spasm due to circulatory collapse and high vasoconstrictor drugs. The latest American College of Cardiology/American Heart Association (AHA/ACC) guidelines include a specific section on limb ischemia during hemodynamic support and called this as "Asymptomatic Artery Disease," the obstructive disease in patients who require large-diameter catheter access for life-saving procedures.^[12,13] Pain in the calf or thigh, calf swelling, tenderness, and cold limb are signs of limb ischemia. This was confirmed with Doppler ultrasound studies.
- c. *Retroperitoneal bleeding:* As these patients were anticoagulated, minor injury could cause major retroperitoneal hematoma. The retroperitoneal space provides a low-pressure chamber where the blood accumulates in large quantities, sufficient enough to cause hemodynamic instability without any obvious blood loss clinically.

- d. *Dissection or laceration of femoral artery*: This is a serious surgical complication and is suspected if there is difficulty in placement of cannula or no backflow in the arterial cannula. Ultrasonographic visualization of the guidewire in the true lumen of the aorta is an important step before pushing the cannula over the guidewire to prevent dissection of the artery. Wherever there is a doubt, it is better to cannulate the contralateral artery. Management of dissection is surgical or endovascular repair.
- e. *Arterial thrombosis*: This can happen if there is a local injury to arterial endothelium or patients with diseased arteries during cannulation.

Apart from the above mentioned, there may be complications (not directly related to vascular cannulation) related to other organs e.g., neurologic, renal, hemostatic disorders, gastrointestinal [Table 2]. Late complication after decannulation includes pseudoaneurysm at cannulation site, lymph leak, or lymphocele.

Data collection: The data were collected from the records of 95 patients enrolled for the study, based on the complications related to surgical cannulation. Out of 95 patients, 20 patients had complications related to vascular access (VAC group), and 75 patients had no complications (non-VAC group) during mechanical circulatory support. For analysis, vascular access complications (VAC), in-hospital mortality, the success of weaning from ECMO, or any other major complication were studied. Outcomes in the VAC group and non-VAC groups were also compared with respect to mortality and morbidity. All the data were collected and analyzed statistically using mean, standard deviation, the percentage using SPSS software, and *P*-value < 0.05 was considered significant.

RESULTS

Baseline demographics, preprocedure laboratory values, and hemodynamic values were statistically similar in both the groups as shown in Table 2 (*P*-value 0.581).

The mean age in the non-VAC group was 40.63, and in the VAC group was 38.6, and the difference was statistically not significant (*P*-value 0.581). Out of total of 95 patients, 70 were male, and 25 were female. The sex ratio of patients was similar in both groups. The most common etiology for VA-ECMO support was aluminium phosphide poisoning in 76.8% (*n* = 73), postviral myocarditis in 11.6% (*n* = 11), and acute coronary syndrome in 4.2% (*n* = 4) and others in 7.4% (*n* = 7). All patients were in cardiogenic shock and were on the support of at least two inotropes at the time of initiation of ECMO. Both the group patients had similar cardiac functions as assessed by left ventricle ejection fraction (LVEF) (*P*-value 0.706), the same severity of disease Sequential Organ Failure Assessment (SOFA score) (*P*-value 0.749). Both group patients had same blood pH (*P*-value > 0.05), lactate levels (*P*-value 0.737), bicarbonate levels (*P*-value 0.392) at the time of start of ECMO [Table 2].

All were electively intubated and were ventilated. All open surgical cannulations were done by a cardiovascular surgeon under vision. ECMO was maintained with drainage, and return cannula (femoral vessels) and distal limb perfusion were maintained with a distal perfusion cannula.

The arterial blood gas reports and other laboratory investigations reflected that patients were in a low output state with poor tissue perfusion due to cardiogenic shock. The high rise in lactate level indicated impending multi-

Table 2: Table comparing demography data, pre-op status, ECMO run hours, and complications between the two groups. (data presented as number %, ± standard deviation, and *P*)

	All patients <i>n</i> =95	Non-VAC group	VAC group	<i>P</i>
Age (in yrs.)	39.8±14.8	40.63±15.20	38.6±11.8	0.581
Males	70 (73.6%)	56 (74.6)	14 (70%)	0.674
Females	25 (26.4)	19 (25.4)	6 (30%)	
Mean arterial pressure (mmHg)	58.45±13.5	53.5±7.81	54.12±7.4	0.751
Ejection fraction (%)	23.33±6.33	24.38±6.8	25.04±7.4	0.706
Vasoactive inotropic score	49.81±19.90	50.68±20.9	50.33±19.37	0.946
SOFA score	9.57±2.08	9.84±2.1	10.01±2.11	0.749
pH	7.15±0.14	7.15±0.12	7.14±0.11	0.737
Lactate levels	14.13±4.5	13.42±4.7	14.45±5.0	0.392
Bicarbonates	10.94±6.65	10.52±4.28	10.15±4.65	0.736
ECMO run h\min (mean)	56.84±34.64	56.02±28.4	58±30.43	0.786
Mean ICU stay (days)	14.18±11.04	12.06±11.06	18±11.07	0.035
Hospital stays (days)	21±10.03	18±13.0	22±14.0	0.232
Blood transfusion	5.5±1.16	4.2±1.26	6.8±1.02	0.001
Renal replacement therapy	24	22	2	0.077
GI complications	5	5	0	0.785
Neurological	2	2	0	0.693

organ dysfunction. Overall SOFA score was 9.57. The SOFA score in the VAC group was 10.01, and in the non-VAC was 9.84, which was statistically nonsignificant ($P = 0.749$). Overall mean LVEF at the start of ECMO was 23.33% and when compared in both groups, the difference was statistically nonsignificant ($p = 0.706$).

Vascular access complications: In 21% of the patients ($n = 20$), vascular access complications were seen, local cannulation site bleeding was present in these patients, and the bleeding was managed by re-exploring the surgical incision site [Table 3]. Out of the above 20 patients, four patients also had lower limb ischemia and its sequel. Fasciotomy and debridement were done in these four patients. In two of these patients, below-knee amputation was done. None of our patients had dissection or laceration of the artery and there was no case of a retroperitoneal bleed. Once the cannulae were removed, there were no complications e.g., formation of pseudoaneurysm or lymphocele or limb ischemia. Two patients had delayed arterial bleeding from the cannulation site (five days of decannulation). They presented with fever and hematoma at the surgical site. Surgical repair with a vein patch was done, and they recovered subsequently.

Table 2 shows that the overall average length of stay in the hospital was 21 days, which was slightly more in patients with VAC (22 days in the VAC group vs 18 days in the non-VAC group). The VAC group patients had an average ICU stay of 18 days, whereas non-VAC group patients had an average ICU stay of 12.06 days. This difference in ICU stay between the groups was statistically significant ($P = 0.035$). Similarly, the average blood transfusion in total patients on ECMO was 5.5 ± 1.16 units. The patients in the VAC group received 6.8 ± 1.02 units of blood transfusion, whereas the patient in the non-VAC group received 4.2 ± 1.26 units of blood transfusion. This difference between the two groups was statistically significant ($P = 0.001$). The mean duration of ECMO support was 56.84 h. Both the groups had almost the same hours of ECMO run (58 in the VAC and 56 in the non-vac group). Out of the total 95 patients, 62.11% ($n = 59$) were successfully weaned from ECMO and were discharged from the hospital, rest 37.89% ($n = 36$) patients died in the hospital. Out of the died, 35.75% patients ($n = 34$) were from the non-VAC group and 2.11% patients ($n = 2$) were from the VAC group. Out of the survived 59 patients, 43.16% ($n = 42$) were from the non-VAC group and 18.94% ($n = 18$) were from the VAC group [Table 4]. The mean overall ICU stay of patients was 14.18 days. There was no direct association between with and without vascular access complications with respect to overall mortality in patients undergoing VA-ECMO in the current study.

Table 3: Table showing Vascular access complications and their management

Event	n	Incidence	Outcome	Management
Bleeding during cannulation site	20	21%	Recovered	Required blood Transfusion
Limb ischemia	4	4.2%	Recovered ($n=2$)	Amputation ($n=2$)
Post ECMO bleeding	2		Recovered	Arterial repair

Table 4: Overall outcome after ECMO in all study group patients

	All patients ($n=95$)	Without VAC ($n=75$)	With VAC ($n=20$)
Successful weaning and discharge			
No	36 (37.89%)	34 (35.79%)	2 (2.11%)
Yes	59 (62.11%)	41 (43.16%)	18 (18.94%)
Total	95 (100%)	75 (78.95%)	20 (21.05%)

DISCUSSION

We retrospectively analyzed data of our patients who underwent VA-ECMO using femoral vessels. Cannulation site bleeding and limb ischemia were the two common complications observed. A review of the literature also shows these two as the most common complications of peripheral cannulation for ECMO, with a wide range of incidence that may be related to different patient demographic variables, indications, cannulation technique, and distal perfusion strategies for VA- ECMO.^{19,10}

Major bleeding is the most reported complication, with an estimated prevalence of 10%–40% in patients receiving extracorporeal life support, 25%–63% of whom require operative management.^{13,6} In a patient with cardiogenic shock, the peripheral vessels are small and prone to spasm, requiring utmost careful handling and cannulation strategy to avoid adverse vascular events. A recent study by Bonicolini, *et al.*¹¹³ showed that the survival rates for patients on ECMO depend on vascular complications and concluded that only 18% survive with VAC vs 49% without VAC. In our study groups, the surgical cutdown technique made a major difference to prevent the VAC as one can directly visualize and cannulate the vessels, thus minimizing the risk of injury to the artery and vein. In our study group, 20 patients had significant local bleeding from the cannulation site, requiring blood transfusion and/or surgical intervention to control the bleeding. The usual causes of bleeding were displacement of the cannula which was corrected by tightening the purse strings suture or adding another purse-string suture around the cannula. In our experience, minimal dissection, exposing only the anterior surface, preserving adventitia, and avoiding looping of vessels besides using proper visualization, guide wires, state of art cannulas, and dilators helped in minimizing bleeding complications.

Another major complication of peripheral cannulation for ECMO is limb ischemia which ranges from 10% to 70% in the literature. The reason for this wide range is different study populations have different baseline characters, varied indications for ECMO, cannulation technique, and distal perfusion modalities.^[13-15]

Yang *et al.*,^[16] in their large study of major vascular complications in postcardiotomy adults receiving femoral VA-ECMO support by surgical cutdown, reported a lower incidence of limb ischemia (8.6%), which may be explained in part by the potential advantages of surgically inserted cannulas, with a preventive distal perfusion cannula placement in most of the patients. In our study, the limb ischemia incidence is low as compared to those reported in the literature. Four patients had critical limb ischemia, requiring fasciotomies and multiple debridement. Out of these, two patients had below-knee amputation. Two patients recovered with low molecular weight heparin only, and none of them required thrombectomy or other intervention. Bonicolini *et al.*^[13] have reported the risk factors for limb ischemia are the use of larger arterial cannulas (more than 17Fr), female patients, patients with peripheral arterial disease, and difficult cannulation. We used distal perfusion cannula (DPC) in all patients to prevent limb ischemia. We ensured that despite the presence of distal perfusion cannula, we were vigilant for signs of ischemia like pain, pallor, paresthesia, motor-sensory deficit, compartment syndrome, and ultrasonographic assessment of distal limb circulation was done. Tanaka *et al.* found a 12% incidence of distal limb ischemia requiring fasciotomy, even in the presence of a prophylactically inserted distal perfusion cannula.^[4] In a patient with suspicion of ischemia, early decompression with fasciotomies may be needed to prevent limb loss.

None of our patients had arterial dissection or laceration during cannulation. The probable reason why we could avoid this complication was the placement of cannula over the guidewire, smooth insertion of guidewire without resistance by confirming this under ultrasound guidance. Besides, the open surgical method provides direct visualization of the artery, hence there is a less chance of injury to vessels.

ECMO patients are heparinized and anticoagulated hence prone to large internal hematoma with minor vascular injuries. We could avoid this complication by keeping a close monitoring of the bleeding profile and also keeping a close watch on any sudden drop in hemoglobin, increase in abdominal girth, blood lactate levels, or sudden hemodynamic instability. Whenever required, an ultrasound abdomen was performed to rule out this major complication.

Post decannulation delayed bleeding from the cannulation site occurred in two patients after 5 days and required arterial vein patch repair. Deep wound infection can cause weakening of arterial wall tissue, leading to bleeding or arterial blowout, seen usually on 4 or 5 days after decannulation. Serosanguinous discharge from the surgical site and fever are ominous signs of wound infection, and surgical repair is the treatment to stop the bleeding. To prevent the local site infection, strict aseptic precautions should be followed both during insertion and explantation of ECMO.

Limitations of the study: Our study was a single center study, and it was a retrospective observational study. The only source of data was as recorded from the patient file. We did not include the other preprocedure comorbidities which can affect the complications of vascular cannulation e.g., peripheral vascular disease, etc. The urgent nature of the procedure did not permit analytical documentation in every case, and the high levels of catecholamines at the time of ECMO implantation might also produce bias.

CONCLUSION

Bleeding and limb ischemia are the important vascular access site complications, though less common, they increase the morbidity of patients. Sometimes, it is difficult to comprehend whether the complications rates are related to the inherent disease condition for which the patient was started ECMO or are related to the technique of cannulation performed for ECMO. Complications of vascular cannulation result in increased ICU stay and the requirement of blood transfusion. Close monitoring of the coagulation profile is required to avoid any complications related to bleeding as well as thrombosis. In our experience, surgical exposure of femoral vessels and placement of ECMO cannulae with modified Seldinger's technique is a safe method for cannulation, as it provides better visualization of the femoral vessels and has a lesser incidence of vascular access complications.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Marasco SF, Lukas G, McDonald M, McMillan J, Ihle B. Review of ECMO (extra corporeal membrane oxygenation) support in critically ill adult patients. *Heart Lung Circ* 2008;17 Suppl 4:S41-7.
2. Lorusso R, Centofanti P, Gelsomino S, Barili F, Di Mauro M, Orlando P, *et al.* Venoarterial extracorporeal membrane oxygenation for acute

- fulminant myocarditis in adult patients: A 5-year multi-institutional experience. *Ann Thorac Surg* 2016;101:919-26.
3. Aubron C, Cheng AC, Pilcher D, Leong T, Magrin G, Cooper DJ, *et al.* Factors associated with outcomes of patients on extracorporeal membrane oxygenation support: A 5-year cohort study. *Crit Care* 2013;17:R73.
 4. Tanaka D, Hirose H, Cavarocchi N, Entstle JW. The impact of vascular complications on survival of patients on venoarterial extracorporeal membrane oxygenation. *Ann Thorac Surg* 2016;101:1729-34.
 5. Foley PJ, Morris RJ, Woo EY, Acker MA, Wang GJ, Fairman RM, *et al.* Limb ischemia during femoral cannulation for cardiopulmonary support. *J Vasc Surg* 2010;52:850-3.
 6. 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.
 7. Pozzi M, Koffel C, Djaref C, Grinberg D, Fellahi JL, Hugon-Vallet E, *et al.* High rate of arterial complications in patients supported with extracorporeal life support for drug intoxication-induced refractory cardiogenic shock or cardiac arrest. *J Thorac Dis* 2017;9:1988-96.
 8. Vallabhajosyula P, Kramer M, Lazar S, McCarthy F, Rame E, Wald J, *et al.* Lower-extremity complications with femoral extracorporeal life support. *J Thorac Cardiovasc Surg* 2016;151:1738-44.
 9. Augusto R, Passos Silva M, Campos J, Coelho A, Coelho N, Semião AC, *et al.* Arterial vascular complications in peripheral venoarterial extracorporeal membrane oxygenation support. *Rev Port Cir Cardiorac Vasc* 2019;26:45-50.
 10. Ma RW, Huilgol RL, Granger E, Jackson A, Saling S, Dower A, *et al.* Does a distal perfusion cannula reduce ischaemic complications of extracorporeal membrane oxygenation? *ANZ J Surg* 2016;86:1002-6.
 11. 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.
 12. Yen CC, Kao CH, Tsai CS, Tsai SH. Identifying the risk factor and prevention of limb ischemia in extracorporeal membrane oxygenation with femoral artery cannulation. *Heart Surg Forum* 2018;21:E018-22.
 13. Bonicolini E, Martucci G, Simons J, Raffa GM, Spina C, Lo Coco V, *et al.* Limb ischemia in peripheral veno-arterial extracorporeal membrane oxygenation: A narrative review of incidence, prevention, monitoring, and treatment. *Crit Care* 2019;23:266.
 14. Extracorporeal Life Support Organization ELSO Guidelines. Available from: <https://www.else.org/Resources/Guidelines.aspx>. 2019. [2019 Jul].
 15. Zangrillo A, Landoni G, Biondi-Zoccai G, Greco M, Greco T, Frati G, *et al.* A meta-analysis of complications and mortality of extracorporeal membrane oxygenation. *Crit Care Resusc* 2013;15:172-8.
 16. Yang F, Hou D, Wang J, Cui Y, Wang X, Xing Z, *et al.* Vascular complications in adult postcardiotomy cardiogenic shock patients receiving venoarterial extracorporeal membrane oxygenation. *Ann Intensive Care* 2018;8:72.