

Feasibility and safety of transcaval venoarterial extracorporeal membrane oxygenation in severe cardiogenic shock

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Among patients with refractory cardiogenic shock (CS), venoarterial extracorporeal membrane oxygenation (VA-ECMO) provides complete cardiocirculatory support; however, it is associated with high rates of vascular and bleeding complications and peripheral limb ischaemia¹. Transcaval (TC) aortic access is a percutaneous technique to deliver large-bore catheter devices from a femoral vein into the abdominal aorta in patients with inadequate peripheral arterial access². In the setting of CS, TC access may enable VA-ECMO in patients with diseased iliofemoral arteries that are unsuitable for accommodating arterial cannulas. To date, the use of TC access for VA-ECMO is limited to only single case reports and has not been previously investigated³. Here we report the in-hospital outcomes of the largest case series to date of TC-VA-ECMO.

A total of 22 consecutive patients who were in refractory CS but whose peripheral arterial access was unsuitable underwent VA-ECMO cannulation via TC access between 2018 and 2023 at a large tertiary shock centre. Our technique for TC-VA-ECMO without the use of preplanning contrast computed tomography (CT) has been previously described³. Left ventricular (LV) unloading, when indicated, was performed per operator discretion using a transaortic microaxial flow pump or transeptal left atrial venoarterial cannula placement (LAVA-ECMO), as previously described³. A schema of the various configurations of TC-VA-ECMO compared with a regular VA-ECMO is illustrated in **Figure 1**. Vascular and bleeding complications and their relatedness to TC access were reported according to a modified version of the Valve Academic Research Consortium (VARC)-2 definitions². The study was approved by the Institutional Review Board of Henry Ford Health.

Baseline clinical, haemodynamic, and procedural characteristics of patients who underwent TC-VA-ECMO are

reported in **Table 1**. The mean age was 60.9±16.0 years, and 50% were female. All patients were in CS stage D or E according to the Society for Cardiovascular Angiography and Interventions' classification. All cases were performed without dedicated CT planning. In most of the patients, the aetiology of CS was valvular (40.9%), and 4 patients (18.2%) had a cardiac arrest at the time of presentation. LV unloading was performed in most of the cases (81.8%) using a LAVA-ECMO configuration.

In-hospital death occurred in 12 patients (54.6%), of which 4 deaths occurred from non-cardiovascular causes. TC access and VA-ECMO cannulation was successful in all patients. TC-related major vascular complications occurred in 4 patients (18.2%), all due to retroperitoneal haematomas associated with a haemoglobin drop ≥3 g/dL. There were 7 major or life-threatening VARC-2 bleeds (31.8%), of which 5 were related to VA-ECMO. There were no cases of acute lower limb ischaemia. ECMO decannulation was attempted in 15 patients, for all of whom TC closure was successful. For closure, an Amplatzer duct occluder (Abbott) was used in 10 patients, and a covered stent was used as the primary closure in 4 patients to achieve immediate closure of the cavaoortic shunt.

TC access has emerged as an alternative vascular access for large-bore sheaths but has been primarily investigated in the setting of transcatheter aortic valve replacement². In this series, TC access for VA-ECMO appeared to be feasible and associated with acceptable rates of vascular complications. Rates of all-cause mortality and bleeding complications were in line with recent trials of VA-ECMO¹. As TC obviates the need for peripheral arterial access, no cases of acute limb ischaemia were observed. Importantly, TC track access and closure was technically successful in all patients. In this series, LV unloading was mostly applied in a LAVA-ECMO configuration.

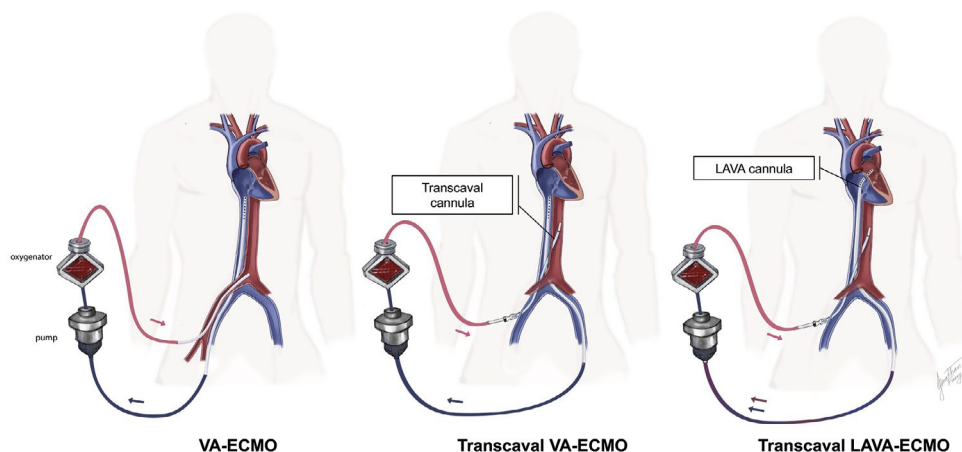


Figure 1. Configuration of TC-VA-ECMO and TC-LAVA-ECMO compared with conventional VA-ECMO. ECMO: extracorporeal membrane oxygenation; LAVA: left atrial venoarterial; TC: transcaval; VA: venoarterial

Table 1. Clinical characteristics, haemodynamics and outcomes of patients who underwent transcaval extracorporeal membrane oxygenation.

		TC-ECMO (N=22)			TC-ECMO (N=22)
Clinical characteristics					
Age, years		60.9±16.0	Pulmonary artery mean pressure, mmHg		34 [23-40]
Female		11 (50)	Pulmonary capillary wedge pressure, mmHg		28 [18-32]
Body mass index, kg/m ²		30.7±8.7	Cardiac index		1.9 [1.4-2.2]
Cardiogenic shock aetiology			Mixed venous saturation, %		57 [53-62]
Ischaemic		7 (31.8)	Clinical outcomes		
Valvular		9 (40.9)	In-hospital all-cause death		12 (54.6)
Myocarditis		1 (4.6)	Cardiovascular death		8 (66.7)
Ventricular tachycardia storm		1 (4.6)	Non-cardiovascular death		4 (33.3)
Mixed		4 (18.2)	30-day all-cause death		13 (59)
Cardiac arrest at presentation		4 (18.2)	TC-related VARC-2 major vascular complication*		4 (18.2)
Lactate at presentation		5.6 [2.7-8.8]	Major or life-threatening VARC-2 bleeding		7 (31.8)
Procedural characteristics			ECMO-related		5 (22.7)
Inflow venous cannula site			Non-ECMO-related		2 (9.1)
Right femoral vein		2 (9.1)	Retroperitoneal haemorrhage		4 (18.2)
Left femoral vein		20 (90.9)	Acute limb ischaemia		0 (0)
Inflow venous cannula size, Fr		22.9±1.1	Acute kidney injury requiring renal replacement therapy		8 (36.4)
Outflow arterial cannula site			Attempted ECMO decannulation		15 (68.2)
Right femoral vein		21 (95.5)	Successful decannulation		15
Left femoral vein		1 (4.6)	Successful transcaval closure		15
Outflow arterial cannula size, Fr		18.3±1.6	Closed with Amplatzer duct occluder device		10
Left ventricular unloading			Closed with aortic covered stent		4
None		4 (18.2)	Exchanged with an Impella 5.0		1
Transseptal left atrial cannula		18 (81.8)	Procedures during the same hospitalisation		
Impella		1 (4.6)	Heart transplant		3
Anaesthesia technique			Transcatheter aortic valve replacement		6
General anaesthesia with mechanical ventilation		13 (59.1)	Transcatheter mitral valve replacement or repair		1
Conscious sedation		9 (40.9)	Percutaneous coronary intervention		5
Haemodynamic characteristics			Coronary artery bypass grafting		1
Preimplant haemodynamics			Ventricular septal defect closure		1
Right atrial mean pressure, mmHg		12 [10-20]			
Right ventricular systolic pressure, mmHg		49 [35-62]			

Categorical variables are reported as n (%). Continuous variables are reported as mean±standard deviation or median [interquartile range]. *Defined according to a modified VARC-2 classification for transcaval vascular complications which includes the presence of a large retroperitoneal haematoma, or a small or moderate retroperitoneal haematoma associated with a haemoglobin drop ≥3 g/dL or requiring blood transfusion, any aortic dissection requiring intervention, any TC-related vascular injury requiring intervention (except aortocaval fistula), distal embolisation requiring intervention, early or delayed endograft therapy for urgent or persistent bleeding, or any new ipsilateral lower extremity ischaemia². ECMO: extracorporeal membrane oxygenation; TC: transcaval; VARC: Valve Academic Research Consortium

A strategy of TC-LAVA-ECMO allows complete cardiocirculatory support with additional active LV unloading without the need for peripheral arterial access; conversely, a strategy of conventional VA-ECMO plus an additional LV venting device would require 2 large-bore arterial access sites, potentially further increasing the risk of bleeding and vascular complications. Compared with the recent ECLS-SHOCK trial, which reported similar rates of in-hospital death, our series mostly included patients with non-ischaemic CS of which valvular heart disease-related CS was the most common aetiology. Our strategy could be particularly attractive for these patients.

The limitations of the current report are its observational, retrospective design and the lack of an independent clinical event adjudication committee. In addition, our findings may lack external validity for centres that are less experienced in TC access. Finally, the rates of major or life-threatening bleeding, despite the use of TC access, remain high. Larger studies evaluating the use of an alternative access for mechanical circulatory support are necessary.

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Conflict of interest statement

P.A. Villablanca is a consultant for Edwards Lifesciences and Teleflex. D.D. Wang is a consultant for Abbott, Boston

Scientific, and Edwards Lifesciences; and receives research grant support from Boston Scientific, assigned to her employer Henry Ford Health. B.P. O'Neill is a consultant to Abbott, Edwards Lifesciences, and Medtronic; and receives research support from Edwards Lifesciences, assigned to his employer Henry Ford Health. T. Frisoli is a clinical proctor for Edwards Lifesciences, Abbott, Boston Scientific, and Medtronic. W.W. O'Neill is a consultant to Abiomed, Medtronic, and Boston Scientific. The other authors have no conflicts of interest to declare.

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