



## **Extracorporeal Life Support Organization (ELSO)**

### **Ultrasound Guidance for Extra-corporeal Membrane Oxygenation**

#### **Veno- Arterial ECMO specific guidelines**

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These guidelines describe useful and safe practice for extracorporeal life support (ECLS, ECMO) but these are not necessarily consensus recommendations. These guidelines are not intended as a standard of care, and are revised at regular intervals as new information, devices, medications, and techniques become available. These guidelines are intended for educational use to build the knowledge of physicians and other health professionals in assessing the conditions and managing the treatment of patients undergoing ECLS / ECMO. These guidelines are not a substitute for a health-care provider's professional judgment and must be interpreted with regard to specific information about the patient and in consultation with other medical authorities as appropriate. In no event will ELSO be liable for any decision made or action taken in reliance upon the information provided through these guidelines.

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## **Introduction**

This guideline “Ultrasound guidance for ECMO- veno-arterial (VA) ECMO specific guidelines” is a supplement to ELSO’s “General Guidelines for all ECLS cases” which describes prolonged extracorporeal life support (ECLS, ECMO). This supplement addresses ultrasound use in VA ECMO. This should be read in conjunction with “Ultrasound guidance for ECMO- General guidelines”.

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The background, rationale and references for these guidelines are found in “ECMO: Extracorporeal Cardiopulmonary Support in Intensive Care (The Red Book)” published by ELSO. These guidelines address technology and patient management during ECLS. Equally important issues such as personnel, training, credentialing, resources, follow up, reporting, and quality assurance are addressed in another ELSO documents or are centre-specific.

### **Pre-ECMO initiation**

A pre-cannulation echocardiogram (echo) will quantify left ventricular and right ventricular function and rule out major contraindications for VA ECMO like severe aortic regurgitation. It also helps to evaluate any co-existing pathologies like massive pulmonary embolism, regional wall motion abnormalities and valvular pathologies.

A pre-cannulation ultrasound of the vessels, particularly artery, is important to determine the diameter of the vessels. A linear or curvilinear ultrasound probe is used. Determination of the diameter is important to estimate the size of the cannula and avoid cannula related injury. (See ultrasound guidance for ECMO-general guidelines)

### **During ECMO initiation**

Venous Cannula insertion

See ultrasound guidance for ECMO- general guidelines

Multi-stage Venous Cannula insertion

The multi-stage access cannula for VA ECMO is a specialised cannula for venous drainage, which requires ultrasound guidance for optimal placement. The tip of the multistage access cannula is positioned in the distal portion of superior vena cava (SVC) to access venous drainage from upper part of the body. This portion of the SVC can be visualised using the modified bi-caval view on transoesophageal echocardiography (TOE) or using a modified subcostal view on transthoracic echo (TTE) and the cannula can be placed in the distal SVC. This means that due to the multiple side ports of the multistage cannula both upper body and lower body venous return can be accessed improving the amount of support. These cannulae are less likely to cause access insufficiency if the distal end is against a vessel wall as the multiple side ports will still access blood. Access to the multistage cannula can be confirmed using Colour Flow Doppler.

Arterial Cannula insertion in common femoral artery

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Real time ultrasound guidance ensures safe puncture of the common femoral artery for the placement of return cannula. This is particularly important during ECMO during cardiopulmonary resuscitation when it is not possible to ascertain which vessel is punctured using blind puncturing of the vessels. It is important to identify the common femoral above the bifurcation of the femoral into superficial and deep femoral artery (profunda femoris). As femoral vascular anatomy can be quite variable it is not possible to do this without ultrasound. Visualisation of the position of the guide wire within the artery is important. This shows the track along which dilatation occurs. This avoids complications such as trans-arterial puncture, trans-venous arterial puncture and puncturing of the adjacent structures- nerves and lymphatic system. Visualisation of the guide wire in the abdominal aorta in subcostal view (TTE) or in the descending aorta (TOE) gives further re-assurance that the catheter will be successfully placed in the appropriate location.

#### Distal perfusion cannula insertion under ultrasound guidance

Distal perfusion cannula insertion maintains lower limb perfusion after the placement of return cannula. This cannula tip needs to be positioned in the superficial femoral artery to ensure leg perfusion. The deep femoral artery is an end-artery in the thigh and distal perfusion cannula placement in it does not prevent leg ischaemia. Hence, it is very important to place the cannula tip in the superficial femoral artery and not in the deep femoral artery. Under real-time ultrasound the superficial femoral artery can be identified and the distal perfusion cannula can be reliably placed.

#### **Post ECMO initiation**

##### Evaluation of cannula position using echo

Post cannulation it is important to assess the position of the access and the return cannula. For a multi-stage access cannula, the cannula tip should be positioned in the distal SVC. For other access cannulae the position should be in the right atrium. This can be confirmed using TTE or TOE. This may also help in detect a malpositioned catheter tip in right ventricle or close to the inter-atrial septum.

##### Evaluation of access Insufficiency

Echocardiography for the location of cannula is very important for assessment of access insufficiency. Migration of cannula into either inferior vena cava or superior vena cava can be identified. Also, pericardial collections causing compression of cardiac chambers can be detected by echocardiography.

##### Evaluation of loss of pulsatility

Loss of pulsatility on VA ECMO is of concern. Echo in this setting may help to diagnose a reversible cause like tamponade. Intra-cardiac thrombus may influence the patient's inotropic and anticoagulation management.

##### Evaluation of pulmonary oedema

Patients who develop pulmonary oedema on ECMO should be evaluated with echo for distension of left ventricle (LV), often seen in the setting of aortic or mitral regurgitation. In the absence of forward

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flow, even the most trivial aortic regurgitation jet may lead to this complication. It is very important to identify these patients, as they might benefit from LV venting or trans atrial-septal perforation.

#### Evaluation of lower limb perfusion

Ischaemia of the lower limb, in which the return cannula is inserted, is a preventable complication. Vascular ultrasound can help in the monitoring of lower limb perfusion, both in patients with and without distal perfusion cannula. A post cannulation vascular scan of the lower limb by a trained vascular sonographer is recommended to confirm position of the distal perfusion cannula and describe adequacy of lower limb perfusion in both limbs. As flow may be non-pulsatile on VA ECMO support, time averaged bulk-flow may be used. Repeated vascular ultrasound should be performed if any concerns arise, like bleeding or swelling, at the site of cannulation.

#### Evaluation for weaning from VA ECMO

Weaning from VA-ECMO is an important decision making point in the management of VA-ECMO. This should be guided by both clinical and echo parameters. Echo provides the best assessment of native ventricular and valvular function in this setting. Either TTE or TOE can be used to determine this.

Prior to commencing an ECMO weaning study the patient's volume state, inotropic support and ventilator support should be optimised for the wean. A baseline echo is performed and any contraindications to weaning should be noted. Relevant members of the team involved in the care of the patient should be present for the weaning study. Anticoagulation is optimised to ensure therapeutic anticoagulation, if no contraindication. A formalised weaning process should be used in order that weaning studies are comparable. An example of such a process is attached in the addendum.

During the weaning study, the VA-ECMO flows are reduced in a stepwise fashion. Some centres describe weaning by a set percentage of flow. The authors prefer to wean to the next whole l/min then stepwise by 1 l/min increments to a minimum of 1 l/min. It is more important to have a systematic process that is repeatable rather than the detail of the exact incremental change in flow.

Following a period of stabilisation at each lower level of support (5 minutes) the patients haemodynamic parameters, inotropic requirements, ventilator requirements and echo parameters are recorded. Echo parameters may include left and right ventricle dimensions, qualitative and quantitative descriptors of left and right ventricle function (e.g. Biplane Ejection fraction, TAPSE, MV lateral s' and RV s') and left and right sided cardiac output are noted. Changes in valvular function with increase preload to right or left ventricle should also be evaluated.

During a successful wean a patient is hemodynamically stable, without requirement for significant increase in inotropic or vasopressor support. Expected findings on echo to support a successful wean include evidence of recruitment of LV and /or RV function (qualitatively or quantitatively) and a recruitment of stroke volume demonstrated on echo by an increase in LVOT VTI or RVOT VTI. In an observational study looking at the echocardiography parameters associated with successful ECMO weaning, aortic VTI  $\geq 10$ cm, LVEF  $>20-25\%$  and lateral mitral annulus peak systolic velocity  $\geq 6$  cm/sec when the ECMO flow was reduced to  $<1.5$  L/minute were predictive of successful weaning from VA-ECMO.<sup>1</sup> Recently ECMO weaning guided by miniaturised TOE probes (hTEE, Imacor USA) has been described.<sup>2</sup>

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### **Post-ECMO removal assessment**

After the cannulae are removed, it is important to follow up with a vascular ultrasound of the lower limbs to assess the lower limb perfusion and assess for pseudoaneurysms, stenosis or thrombus in the vessels. This is particularly important if the arterial cannula is removed using a closed technique where cannula is removed and external compression is applied.

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## References

1. Cavarocchi NC, Pitcher HT, Yang Q et al., Weaning of extracorporeal membrane oxygenation using continuous hemodynamic transesophageal echocardiography. *J Thorac Cardiovasc Surg* 2013;146: 1474-9.
2. Aissaoui N, Luyt CE, Leprince P et al., Predictors of successful extracorporeal membrane oxygenation (ECMO) weaning after assistance for refractory cardiogenic shock. *Intensive Care Med* 2011; 37: 1738-45.

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