Extracorporeal Life Support Organization (ELSO)

Ultrasound Guidance for Extra-corporeal Membrane Oxygenation
Veno-Venous ECMO specific guidelines

Authors:

Vinodh Bhagyalakshmi Nanjayya MBBS, MD, EDIC, FCICM, DDU (Melbourne, Australia)
Deirdre Murphy MB BCh BAO, MRCPI, FCARCSI, FCICM, PGDipEcho, DDU (Melbourne, Australia)

Editors:

Nicolas Brechot, MD, PhD (Paris, France)
Eddy Fan, MD, PhD (Toronto, Canada)
Vin Pellegrino, MBBS, FRACP, FCICM (Melbourne, Australia)
Dan Brodie, MD (New York, United States)

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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

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Introduction

This guideline "Ultrasound guidance for ECMO- veno-venous (VV) 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 specific discussion for ultrasound use in VV ECMO. This should be read along 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 evaluation

Cardiac evaluation with echocardiogram (echo) prior to VV-ECMO cannulation is very important.[1] Acute cardiac failure masquerading as acute respiratory illness can be diagnosed using echocardiography which will influence the management plan. Determining cardiac output will be useful to estimate the ECMO flow rate required for oxygenation of the patient. Vascular ultrasound precannulation is important to rule out deep vein thrombosis, vascular malformations and anatomical variations. Before internal jugular vein cannulation it is important to rule out occlusive deep vein thrombus in the contralateral internal jugular vein to prevent the risk of cerebral oedema.

During ECMO initiation

Complications associated with blind percutaneous cannulation can be easily prevented by the use of real-time vascular ultrasound (see the Ultrasound guidance for ECMO- general guidelines). It helps in detecting and preventing the complications like malposition, kinking and excessive introduction of guidewire.

Echo guidance helps in positioning the tips of the access and return cannulae appropriately. Usually, the tip of the return cannula is positioned in right atrium or at cavo-atrial junction and the access cannula is positioned 10 cm away from it. This helps in minimising recirculation.

Bi-caval double lumen ECMO cannulation under ultrasound guidance

Echo guidance of bi-caval dual lumen cannulation is an alternative to fluoroscopy guided approach.[2] The approach used will depend on the skillset at the institution. One of the main risks associated with placement of bi-caval double lumen ECMO cannula is cardiac perforation. Real-time ultrasound guidance during insertion prevents such complications. The main advantage of ultrasound in this scenario is that it can be performed at the bed-side.

The cannula can be positioned using trans-oesophageal echocardiography (TOE) guidance (usually), transthoracic echocardiography (TTE) guidance using the subcostal view or a combination of both.[3]

An experienced echocardiographer who is well versed with TOE or TTE should perform the study as positioning the cannula can be difficult. The dual lumen cannula has multiple ports. The distal ports drain blood from the inferior vena cava (IVC) and the proximal ports drain blood from the superior vena cava (SVC). The return port should be oriented such that the return flow is directed towards the tricuspid valve. For the success of this mode all the ports should be appropriately positioned. This can be accomplished with real-time echo guidance.

The modified bi-caval TOE view is commonly used. The main advantage of this view is that one can visualise SVC, IVC and right atrium in the same view. Using this view, the proceduralist can be guided to place the guidewire safely in SVC, right atrium and intra-hepatic portion of IVC. The tip of the guidewire (J loop) needs to be visualised at all time and this requires clear and concise communication between the echocardiographer and the proceduralist with slow advancement of the wire. This avoids inadvertent placement of the distal end of the guidewire in hepatic vein or right ventricle. Subsequent dilatation over appropriately positioned guidewire prevents the risks of cardiac perforation and malposition in hepatic vein. A combination of the modified bi-caval TOE view and a subcostal TTE view can be used if the IVC is difficult to visualise on TOE. The echocardiographer can switch between the 2 probes on the same platform.

After dilatation, modified bi-caval view is used to position the catheter appropriately. The return flow from ECMO cannula can be interrogated using colour flow Doppler and the cannula can be manipulated to direct the return flow towards tricuspid valve.

Post ECMO initiation

Assessment of access insufficiency

Evaluation of the problem of access insufficiency (chattering of access line) should include echo. This will help in determining position of the distal end of access cannula. Using the subcostal view on echocardiography, femoral access cannula tip in hepatic vein or SVC can be easily detected and catheter can be repositioned under ultrasound guidance. Position of the femoral access catheter too low in the IVC can also be detected. Other pathologies like

cardiac tamponade and hypovolemia which can lead to access insufficiency can be diagnosed using echocardiography.

For the dual lumen bi-caval cannula one of the potential causes of access insufficiency is mal-positioning of the distal tip in a hepatic vein. Another cause is that the cannula is sitting too proximal in the SVC such that the SVC access ports are positioned too high. All these can be diagnosed and optimal re-positioning of the cannula can be achieved under echocardiography guidance.

Assessment of hypoxia on VV ECMO

Hypoxia in a VV ECMO patient can occur for several reasons. Commonly these include inadequate venous return being captured and recirculation in the circuit. Echocardiography is very useful to evaluate both of these conditions.

As the severity of disease progresses cardiac output of the patient may increase. When this happens, the fixed venous return captured by the access cannula may not be enough to achieve safe oxygenation. One of the strategies adopted in these situations is initiation of high flow configuration. Echo will help in calculating cardiac output which may help in determining how much of venous return needs to be accessed for safe oxygenation.

Assessment of recirculation on VV ECMO

Trouble-shooting algorithm of re-circulation should include checking the position of the cannulae. If they are too close, the access cannula needs to be withdrawn until the recirculation is minimised. Again, this can be done in real-time using subcostal view on echo.

References

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