
**Ministry of Health, Kuwait**

# ECMO Committee

# (Policy No 4)

## Veno-Venous Extracorporeal Membrane Oxygenation

## (VV-ECMO) General Management POLICY 2018

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| **Policy owner:**<br>ECMO Committee. MOH | **Applies to:**<br>All Staff in MOH and Private Hospitals in Kuwait |
| **Section Location**:<br>Departments of Anaesthesia, Adult Intensive Care and Pain Management in all MOH and Private Hospitals in Kuwait. | **Effective date:** 01-03-2018<br>**Revision date**: 01-03-2021 |
| **Approved by**:<br>Head of ECMO Committee, ECMO Committee Members | |
| **Final Approval by:** MOH Undersecretary | |

**Purpose:**

1. To provide guidance for the overall management of patients on VV-ECMO (veno-venous extracorporeal membrane oxygenation) for severe respiratory failure in any Intensive Care Unit in Kuwait that deals with ECMO patients.
2. To determine the roles and responsibilities of each member of the ECMO team during the patient management in the Intensive Care unit.

**Policy Statement:**

1. This guideline does not include advice on the referral process, transport process, or ECMO centers conditions as these are outlined in separate policies (see MOH ECMO policies 1, 2 and 3).
2. These guidelines are subject to update whenever there are new international recommendations prior to the policy revision date.

## Introduction

Extracorporeal Membrane Oxygenation (ECMO) is a form of modified cardiopulmonary bypass system (artificial heart and lung) used for patients with severe respiratory and cardiac failure. The ECMO system uses a pump to circulate the patients' blood through an artificial lung where oxygen is added and carbon dioxide is removed. The venous blood is drained from the major veins in the body (the IVC or SVC), actively pumped through a specially designed circuit and then returned to the venous system as in veno-venous ECMO (VV ECMO) for severe respiratory failure or arterial system as in veno-arterial ECMO (VA ECMO) for severe cardiac failure.

There are 2 types of ECMO (VV and VA) each have its own indications and contraindications. This policy will highlight only the ICU management of VV-ECMO, which is used for patients with severe respiratory failure that has failed to respond to conventional supportive therapies and may benefit from a period of lung rest.

The VV-ECMO service has been established in Adan Hospital adult ICU as it has performed the highest number of VV-ECMO for severe respiratory failure out of all the general ICUs in the country to date. In addition, it has fulfilled all conditions for ECMO centre establishment as determined by the MOH (see separate policy). As patients may need the ECMO service in any hospital in Kuwait (both private and governmental), an ECMO team has been established in order to evaluate these patients and make the appropriate decision regarding starting the service if needed (see ECMO indications in ECMO referral policy). The ECMO team will travel to retrieve patients that are not stable for transfer to Adan ICU where they will cannulate the patient and establish the pump at their hospital and then escort them back to Adan ICU where further management of the patient will be taking place (see separate MOH ECMO Transport Policy). For stable patients, they should be transferred to Adan Hospital after being accepted by the ECMO Consultant and the ECMO service will be started in Adan ICU. Once the decision to provide the ECMO service is taken by the ECMO consultant, the following steps should be followed in order to ensure the best possible outcome for the patient:

## Section 1: Preparing for cannulation and establishing the VV-ECMO

### 1.1 Modes of vascular access

- The VV-ECMO circuit circulation can be achieved by establishing drainage of blood from the venous system through a cannula placed in the IVC through different routes **(Access cannula)**, and returning the oxygenated blood back to the patient through a cannula placed in the right atrium through different routes **(Return cannula)**
- Access cannula can be placed in the femoral vein
- Return cannula can be placed in the femoral vein or the jugular vein. The tip of the cannula has to sit in the right atrium.
- Access and return cannulas can be combined together in one cannula called the double lumen cannula (e.g Avalon Elite Bi-Caval Cannula), which is placed through the jugular vein and has 2 lumens (an inflow lumen that takes blood from the IVC and SVC, and an outflow lumen that delivers blood towards the right atrium. The returning blood flow is directed at the tricuspid valve). Cannula placement requires wire visualization guidance through either fluoroscopy or USS. We currently use USS guidance in Adan ICU.
- The Avalon cannula is more difficult to place, as it requires guidance through TOE to ensure placement of the 3 multistage holes in the correct place (see below). Once placed correctly, it provides excellent flow with minimal recirculation.
- Selective CO2 removal is used for hypercapnic patients who have adequate oxygenation using either a double lumen cannula or 2 single lumen cannulas. The double lumen cannula is placed either in the jugular vein or the femoral vein. The 2 single lumen cannulas are placed in a separate central veins.
- Percutaneous access is possible in most adult patients and should be attempted first. If this is difficult, open approach by vascular/cardiac surgeon will be the alternative.
- Placement of the cordis sheath (6Fr) should be done routinely if available to aid the placement of the guidewire prior to the placement of the ECMO cannula.

### 1.2 Types of cannulas

- There are different types of cannulas available with different diameters and lengths, the choice of which will depend on the patient factors and type and site of ECMO access and return:

| Cannula type | Size | Length | Lumens and holes | Vessel access |
|---|---|---|---|---|
| **Single lumen (e.g. Maquet HLS, FreeLife, Medtronic Biomedicus, etc.)** | 15 – 26Fr | Various lengths | Access (Multi-stage/multi-hole) Return (Single hole/ single stage) | Femoral vein Internal jugular vein |
| **Double lumen (e.g. Avalon, OriGen)** | 27 - 33Fr | Various lengths | Multi-stage/Multi-hole (3 holes) | Internal Jugular |
| **Double lumen CO2 removal cannula (e.g. Novaport Twin)** | 22 - 24Fr | 170 - 270 cm | Double lumen | Selective VV-CO2 removal cannula (Internal Jugular or Femoral vein) |

- The access cannula is placed in the IVC via the femoral vein for drainage and the return cannula is placed in the right atrium via the internal jugular vein or the opposite femoral vein for blood return.
- For selective veno-venous CO2 removal 22Fr double lumen cannulae will deliver adequate blood flow for total CO2 removal.
- Cannulas are inserted via serial dilatation through the dilator set.

### 1.3 ECMO Circuit and Equipment

- There are 2 ECMO pumps available in Adan ICU (Xenios and CardioHelp)
- The circuit for the Xenios is the Novalung X-lung kit and for the CardioHelp is the Maquet HLS7 kit.
- For the CO2 removal, the Xenios pump is used with the Novalung Mini-lung circuit
- All disposables for ECMO are kept in the ECMO trolley, which is available next to the nursing station in the surgical ICU. Further stocks are available in the medical ICU outside corridor next to M1.
- The circuit can be primed by either the perfusionist or the ECMO nurse with 0.9% Saline. Heparin dose to be added is determined by the ECMO consultant (usually 2000 IU/L). Some patients should not have heparin in the circuit (e.g. HIT or bleeding). Do not add heparin to the circuit without confirming with the ECMO consultant.
- There should always be one ECMO console primed and ready to be used at all times in the ICU. This can last for 28 days following which it should not be used. It can be used to run training drills for ECMO staff.

### 1.4 Cannulation for VV-ECMO

**Follow the following steps for cannulation:**

- Call the ECMO team to prepare for the cannulation and prime the circuit (2 ECMO doctors, ECMO nurse, perfusionist)
- Determine the insertion site (femoro-jugular for single lumen cannulas or internal jugular for the double lumen cannula. Bi-femoral vein approach can also be done although not the first choice.

- Determine the cannula sizes you want to use (usually 31Fr double lumen, or 25-26Fr access/ multistage and 21-23F return/ single stage)
- Ensure arterial line and CVP line is inserted in addition to a cardiac output monitor (pulmonary artery catheter is preferable).
- Connect inotrope/vasopressor infusions and achieve haemodynamic stability
- Order 2 units packed cells and other blood products as required to allow INR & APTTr < 1.5, platelets >80, fibrinogen > 1.5, Hb between 8-10 g/dL
- Sedate and may need to paralyze the patient
- Use USS guidance for femoral and internal jugular access and TOE for Avalon cannula placements.
- Obtain a baseline echocardiogram as a baseline for cardiac function
- Clip excessive hair at insertion sites
- Full aseptic precautions (gown, hat, mask, gloves).
- Sponge and wash the site of insertion with chlorhexidine soap extensively. Dry the sites with a sterile towel.
- Clean the access and return sites again using chlorhexidine 2% with alcohol 70%.
- Drape with Kimal angiography drape. Ensure entire bed is covered (head to toe) to prevent contamination of guidewires.
- Cannulation should be ultrasound-guided using the Seldinger technique.
- Topicalize the insertion sites with local anaesthetics.
- The vessel should be approached at a shallow angle with the cannulation needle to ensure a straight path for the guidewire

**Single lumen cannula technique**

- 21-26Fr multistage cannula is preferred for access, 21-23 Fr single stage cannula is preferred for return
- Insert a cordis sheath 6 Fr on both the access and return sites to enable easy insertion of the guide wire. Ideally the skin should not be cut.
- Wire insertion, documentation of cannula position and patency should usually be undertaken using USS.
- Use a 140-260cm Amplatz extra stiff/super stiff wire for femoral vein access with the wire demonstrated to be within the hepatic inferior vena cava by USS.
- Use 80cm Amplatz extra stiff/super stiff wire for RIJV return cannula or a 140-260cm Amplatz wire for femoral vein return cannula, with the wire demonstrated to be at the tip of the right atrium by USS with at least 10 cm distance between the two cannula tips.
- Once wires are in place give up to 5000 IU of heparin systemically unless contraindicated.
- Serial dilators should be used to serially dilate the skin and soft tissues to one size above the cannula size (if the dilators are available). If the correct above size dilator is not available, use an artery forceps to dilate the insertion site that is not dilated maximally with the dilator set.
- Once the cannula is inserted and the stylet and guidewire is removed, apply the clamp (you need 2 clamps for access and return).
- The cannula should be inserted under USS guidance to ensure optimal position with the access cannula at the level of the hepatic veins and return within the right atrium.
- Attach 50mL bladder syringe containing heparin-saline (1000 units in 1L 0.9% saline unless contraindicated and after discussion with the ECMO consultant) to the end of each lumen, unclamp, and flush the whole 50 ml then re-clamp.
- Turn on the gas flow to the oxygenator using an FiO2 of 1.0 and a sweep flow of 1L/min increasing gradually as titrated by the CO2 level.
- The perfusionist should hand the clean loop to the cannulating doctor

- The cannulating doctor should cut the circuit between the two clamps, allowing enough length on both access and return lines to prevent any tension on the circuit. (Note: Pump trolley is usually kept at the right hand side of the patient if femoro-jugular or Avalon lines or at the foot of the bed if femo-femoral lines).
- Connect the circuit to cannula using a wet joint avoiding air entrapment and ensure secure connection and then unclamp the circuit and start the ECMO flow with 1L/minute and gradually increasing until reaching the maximum flow that provides adequate oxygenation (SaO2 80-90%).
- The sweep flow rate to be decided in discussion with the ECMO consultant. It usually starts with 1 L/min and increased gradually as guided by the CO2 on the blood gas. Be very cautious with hypercapnic patients not to quickly reduce the PCO2 as this may precipitate intracerebral haemorrhage.
- Increase sweep flow by 0.5l/min every 10 minutes with ABG done every 10 minutes to avoid sudden drop in the CO2. If initial PaCO2>50, increase sweep slowly to bring PaCO2 down slowly (10-20 mmHg/hour).
- Establish baseline anticoagulation if no contraindication with 10units/kg/hr heparin (max1000 units/hour). See appendix 2 for anticoagulation guidelines.
- Manipulate cannula positions to obtain optimal circuit flows and minimize recirculation

**Double lumen cannula (significant modifications only)**

- The bi-caval cannula is inserted via the right internal jugular vein.
- Use a 260cm Amplatz extra stiff/super stiff wire for the insertion, which should be placed using TOE guidance for the entire wire insertion. Use a cordis sheath to aid access into the IVC through the right atrium.
- Serial dilators followed by dual lumen dilators (if available) should be used to serially dilate the skin and soft tissues to one size above the cannula. If not available, use an artery forceps to dilate the skin and subcutaneous tissue.
- The cannula should be inserted under TOE guidance to ensure optimal position with the line positioned to direct the return towards the tricuspid valve and the distal tip within the intra-hepatic IVC. In case ORIGEN Dual lumen cannula the distal tip of the cannula should be in the mid atrium with outflow jet directed towards the Tricuspid valve.
- Origen double lumen canula should have the tip located in the middle of the right atrium.
- Ensure that double lumen canula return port is towards the patient's nose thereby granting direct outflow towards the tricuspid valves.

**Securing access and return lines**

- This must be done by the cannulating doctor
- Lines should be secured with at least 3 points of suture to the skin using a purse-string suture at the skin site.
- Following commencement of VV-ECMO, secure the cannula firmly to the skin with 1.0 sutures placed on 3 different sites (the skin insertion level and 2 sites proximal to that)
- Mark the level of the cannula insertion site with a marker pen and document on the ECMO monitoring form.
- Measure the distance from the skin insertion level to the cannula metal end and document it.

- Insertion site dressed with a large tegaderm, keeping the lines visible.
- The lines should be covered at points of fixed curvature with split tubing to prevent kinking if available.

## Section 2: Management during the VV-ECMO

### 2.1 Admissions investigations

- CT brain/thorax/abdomen/pelvis
- CT thorax with recruitment maneuver
- The routine ICU investigations
- Admission transthoracic echocardiogram if not already done.
- Bronchoscopy with samples for microbiology and cytology.

### 2.2 Ongoing investigations:

- Daily ICU blood tests as per unit policy
- Coagulation measurement as per ECMO anticoagulation protocol
- Daily D-Dimer and fibrinogen
- Daily LDH
- Second daily triglycerides if on parenteral nutrition or on infusion of over 200mg/hour propofol
- CXR daily unless requested otherwise
- Trans-thoracic echocardiography as required for patients on VV ECMO

### 2.3 Circuit related Management

#### 2.3.1 Blood flow:

- Flow: 50-80 ml/kg/min. Max initially, then lowest flow to maintain SaO2>80-85% at rest

#### 2.3.2 Oxygenation:

- Set the ECMO FiO2 to 1.0.
- In the absence of lung function, VV access can supply all metabolic oxygen requirements. The arterial saturation is usually 80-85%, but may be 75-80% (PaO2 45 -55mmHg/ 6 – 7 Kp).
- The double lumen VV approach has a lower recirculation resulting in even higher arterial saturations of 85% to 92%. This is ample oxyhemoglobin saturation for normal systemic oxygen delivery as long as the cardiac output and hemoglobin concentration are adequate to maintain DO2 three times VO2. However the ICU staff may be uncomfortable with arterial saturation under 90, and education regarding oxygen delivery is important. **Avoid the temptation to turn up the ventilator settings or FiO2 above rest settings during VV support.**

#### 2.3.3 CO2 removal:

- Patient PaCO2 is controlled by the sweep gas flow. When the circuit and blood flow are planned for oxygenation, CO2 removal can be excessive, and the

sweep gas flow is titrated to maintain PaCO2 at 40 mmHg / 5 Kp (usually 1:1 ratio of sweep gas flow to blood flow).

- For selective CO2 removal blood flow can be as low as 1L/min and sweep gas can be up to 15L/min, titrated to maintain PaCO2 at 40 mmHg.

### 2.3.4 Anticoagulation:

- Do not commence baseline anticoagulation until a CT brain has been performed demonstrating no intracranial haemorrhage and after confirming with the ECMO consultant. If the decision is to start heparin, titrate to the APTTr target set by the ECMO consultant (usually APTTr maintained between 1.5-2 (APTT 40-50 seconds)
- If concern for bleeding, reduce the APPTr to 1.2-1.5.
- See anticoagulation protocol (appendix 2)

### 2.3.5 Circuit pressures limit

- P1 (access cannula/pre-pump pressure)
- P2 (post pump/pre-oxygenator pressure)
- P3 (return cannula/post-oxygenator)
- Delta P (P2-P3)= < 50mmHg or 15mmHg above the trend value or which ever is lowest)

(P1 should not exceed –50mmHg, however some patient might require more negative pressure which will be acceptable as long as no line chattering or excessive haemolysis is taken place. These pressures are dynamic with cannula size and circuit diameters. Always make a note of your base line Delta P and monitor trends).

## 2.4 Patient related Management

### 2.4.1 Hemodynamics:

- On VV support there is no direct hemodynamic support provided by the extracorporeal circuit. The patient should be managed with inotropes, vasodilators, blood volume replacement etc. as if the patient were not on extracorporeal support.
- Echocardiography is an excellent tool to assess hemodynamic function and help guide management during VV ECLS.

### 2.4.2 Ventilator management:

- Patients are on high FiO2 and ventilator settings during cannulation. The goal of ventilator management on ECLS is to use FiO2 <0.4, and non damaging "rest settings (PPlat<25)"
- In many patients the lung may proceed to total consolidation before recovery occurs, but this might be avoided by maintaining some inflation pressure as high pressures are decreased.
- Each patient is different, but a general algorithm for ventilator management is:

a) First 24 hours:

1- Moderate to heavy sedation.
2- Pressure controlled ventilation (inspiratory pressure Pi = 10, PEEP = 10, I:E 1:1, rate 10 (the three 10 role)
3- FiO2 0.5.
4- If initial PaCO2>50, increase sweep slowly to bring PaCO2 down slowly (at a rate of 10-20 mmHg/hour)

b) After 24-48 hours:

1- Stable hemodynamics, off pressors, fluid balance underway, sepsis Rx underway.
2- Moderate to minimal sedation.
3- Pressure controlled ventilation (inspiratory pressure Pi = 10, PEEP = 10, I:E 1:1, rate 10 (the three 10 role) and encourage spontaneous breathing.
4- FiO2 0.4.

c) After 48 hours:

1- Minimal to no sedation.
2- PCV as above or CPAP20 plus spontaneous breathing.
3- Trach or extubate within 3-5 days

- Endotracheal Cuff pressure has to be monitored daily ensuring pressures less than 20-25 cmH2O.

- Progress of pulmonary recovery should be assessed by a daily 100% test unless otherwise specified by the Consultant (100% via ventilator and circuit), in combination with pulmonary dynamic compliance and improvement in the end-tidal CO2 to arterial PCO2 relationship

- Tidal volume has to be monitored daily without changing the ventilatory setting in order to monitor the improvement in the lung function by in increasing trend of the TV.

### 2.4.3 Recruiting trials:

- None until significant aeration on CXR and > 100mls/ min tidal volume.
- After aeration, Cilley test. (Increase FiO2 to 1.0 with no other changes. Positive test is rapid increase to SaO2 100%). If positive Cilley test, start recruitment: Controlled ventilation : PEEP 25 cmH2O , TV to keep P plataue < 25 cmH2O rate of 5 I:E ratio 3 :1 , CPAP with spontaneous breathing at 25cm H2O. OR PSV at 25/10 rate 5, I:E 3:1 , 10 min/hr. then return to rest settings
- Readjust flow if recruitment is successful. No airway PPlat >25.

### 2.4.4 Sedation

- Use precedex and remifentanil for sedation

- Fentanyl and 2% Propofol can also be used and titrated to a Richmond Agitation and Sedation Score as set by the consultant.
- Until stability is achieved patients should remain on an infusion of neuromuscular blocking agents although this should be ceased as soon as appropriate.

### 2.4.5 Feeding

- Nasogastric tubes should be inserted as per standard ICU policy.

- For patients with gastric stasis, nasojejunal tubes should be inserted, guided by Cortrak if available. If NJ feeding is required, the NG should be left on free drainage to start with unless feeding is commenced.

- TPN. See separate ECMO nutrition policy.

### 2.4.6 Aperients

- Dolcolax , docusate , and senna to be commenced to facilitate diarrhoea to allow insertion of a bowel management device if desired

### 2.4.7 Haemostasis and blood volume

Standard transfusion targets for the non-bleeding patient are:
- Hb around 9-10g/dl.
- Platelets >50
- INR <1.5
- Fibrinogen >1.5

If active bleeding, ensure the following:
- Cease heparin
- Keep Platelets >100
- Keep INR and APTTr <1.5
- Keep Fibrinogen >2. Cryoprecipitate is preferred to replace fibrinogen on ECMO for the bleeding patient as this also provides a rich source of von Willebrand's Factor.
- Commence tranexamic acid infusion
- Source control via interventional radiology or surgery

### 2.4.8 Bronchoscopy

- Bronchoscopy and airway lavage are facilitated by extracorporeal support and should be used as indicated.

- Lighter sedation, prone positioning, and chest PT may allow mobilization of distal secretions and may reduce the need for bronchoscopy.

### 2.4.9 Temperature

- Maintain Temperature 36.0-36.5 C

### 2.4.10 Stress ulcers prophylaxis

- All patients should be on a proton pump inhibitor as per ICU stress ulcer prophylaxis guidelines.

### 2.4.11 Infection and Antibiotics

- Giving antibiotics at cannulation (initial broad spectrum) only if patient not on ABX

### 2.4.12 Positioning and Activity Management:

- After 24-48 hours, start sitting several hours/ days.
- Prone positioning if there is posterior consolidation with some open lung anteriorly.
- Be careful not to dislodge cannulas. Exercise in bed. Progress to sitting bedside, standing, walking as tolerated. Increase flows and sweeps during activity to maintain goal SaO2 and PaCO2.

### 2.4.13 Nursing checklist

- This has to be done once per shift by the ECMO nurse (see appendix 3)

### 2.4.14 Doctors checklist

- This has to be done once per day by the ECMO Senior registrar (see appendix 4)

## Section 3: Weaning from VV-ECMO

### 3.1 Weaning and trials off:

- Wean the ECMO flow in steps to 1L/min at sweep (ECMO FiO2) 100% OR decrease flow to 2 L/min then decrease sweep FiO2 to maintain SaO2 >90-95% until reaching ECMO FiO2 of 21%.
- Wean the sweep gas flow gradually to maintain PaCO2 to give pH >7.35 with acceptable respiratory work (RR <30, TV 4-6mL/kg, comfortable pattern).
- If SaO2 is stable on these settings, trial off by reducing sweep gas flow until reaching zero sweep or clamping sweep on vent rest settings PSV of max 14 cm H2O and PEEP of 10 -12 cm H2O
- If SaO2 >95and PaCO2 <50 for 60 minutes with good lung mechanics including SBI , lung compliance for 24 hrs, come off
- Do 100 % FiO2 challenge test to assess lung reserve and confirm readiness .
- If PaCO2 > 50, stay on at a low flow; go to selective CO2 clearance mode.
- It is advisable to wean off ventilator first before ECMO and encourage mobility and physiotherapy with physiological lung mechanics.
- When a patient is weaned off ventilator first, always apply either NIV or High flow O2.

### 3.2 Decannulation:

- Cease heparin 2 hours prior to decannulation
- Prepare 2 units of RCC.
- Lie patient flat to reduce risk of air embolism, consider neuromuscular blockade for patients with jugular cannulae
- Using an aseptic technique and local anaesthetic, place a deep vertical mattress or purse-string suture at the insertion site
- Clamp circuit at the access and return cannulae
- Stop circuit. The haematocrit in the circuit and patient are the same and blood does not routinely need to be transfused back into the patient. However if a restrictive approach to transfusion is required then cell salvage might be indicated, discuss with perfusion/ECMO consultant.
- Remove access cannulae.
- Tie suture as cannula is removed.
- Venous duplex of the decannulated, vessel(s) should be performed 24-48 hours following the removal of cannulae to assess for the presence of deep vein thrombosis
- If USS is positive for thrombus, then start therapeutic anticoagulation.

## Section 4: Troubleshooting and disease specific management

### 4.1 Hypoxaemia

- Hypoxaemia on VV ECMO should be managed by:

1- Maximizing circuit blood flow

2- Minimizing circuit recirculation – if line reposition required, this must be discussed with the ECMO consultant prior to any cannula manipulation

3- Reducing oxygen consumption

- Controlling temperature to 36-36.5 degrees C
- Sedation
- Neuromuscular blockade

4- Beta-blockade to reduce native cardiac output

5- Increasing oxygen delivery

- Blood transfusion

6- Optimize mechanical ventilation

### 4.2 Access insufficiency

- Access insufficiency should be managed by:

1- Avoidance of raised intra-abdominal pressure

2- Avoidance of raised intra-thoracic pressure

3- Control of coughing/movement if required

4- Optimizing cannula position

5- Optimizing patient position

6- Optimizing circulating blood volume (usually aim to avoid giving volume)

### 4.3 Bleeding

For bleeding:

- Decrease heparin to APTT ratio of 1.2-1.5.
- D/C heparin if still bleeding
- Platelet transfusion
- FFP for factors, VWF replacement.
- Check D-Dimers, If anti-fibrinolytics is present, Change the circuit.
- Local control, reop as needed with a low threshold.
- Do ROTEM

### 4.4 Management of air leaks

- Chest tube placement is frequently accompanied by bleeding complications and need for thoracotomy, so a conservative approach is often taken to pneumothoraxes.
- A small pneumothorax (estimated 50% or less with no hemodynamic compromise and no enlargement over time) can be managed by waiting for absorption with no specific treatment.
- A symptomatic pneumothorax (> 50%, enlarging, or causing hemodynamic compromise) should be treated by external drainage, although a small tube can be used with appropriate preparation (see section IV:9).
- Massive air leak or bronchopleural fistula (less than half of the inspired volume comes out as expired volume) can be managed by ECLS, in fact it is sometimes a specific indication for ECLS. As in any bronchopleural fistula, the first objective is to evacuate the pleural space so that the lung contacts the chest wall, leading to adhesions with closure of the visceral pleura. During ECLS this can almost always be managed by a single chest tube placed on high continuous suction (20-50 cm/H2O), then limiting inspiratory pressure and volume. In some cases, it may be necessary to manage the airway by continuous positive airway pressure at 10, 5 or even 0 cm/H2O for hours or days leading to total atelectasis. When the air leak has sealed, airway pressure is gradually added until conventional rest settings are reached. Recruitment of the totally atelectatic lung may take one or more days.
- Bronchopleural fistula with a massive air leak directly from a bronchus or the trachea (after lung resection or trauma for example) should be managed initially as outlined above, but direct endoscopic or thoracotomy closure is often required.

### 4.5 Selective CO2 removal

- If the primary goal is CO2 clearance (asthma, COPD exacerbation, avoiding high P in ARDS, Bronchopleural fistula, weaning from severe ARDS) VV access, DLC via IJ is preferred.
- Use Novoport Twin (22 or 24Fr) dual lumen cannula. Larger cannulas are more desirable
- Cannula can be smaller size, but should allow 1 L/min flow.
- Recirculation is acceptable.
- Use a Novalung mini-lung circuit
- For status asthmaticus and other conditions in which blood PaCO2 is very high, reduce the blood pCO2 gradually to avoid acid base imbalance or cerebral complications. A suggested rate of decreasing **arterial pCO2 is 10-20 mmHg/hr**.
- When selective CO2 removal is used to treat permissive hypercarbia and to achieve rest lung settings in ARDS, CO2 can be normalized at acceptable rest lung settings with low blood flow (20% of cardiac output). If the lung failure is severe this can result in major hypoxemia. If the cardiac output and hemoglobin concentration are adequate, arterial saturation as low as 75% is safe and well tolerated. However, increasing extracorporeal blood flow to improve oxygenation is preferable to increasing ventilator pressure or FiO2 when selective CO2 removal is used. This is not an option with arteriovenous CO2 removal. . In choosing the cannulation approach in such patients it is important not to undersize the cannula so that the maximum flow is less than the required flow to facilitate oxygenation.

### 4.6 Pulmonary embolism

- Many patients with primary or secondary ARDS will have small (segmental) pulmonary emboli on contrast CT or angiography. Such emboli do not require any specific treatment aside from the heparinization, which accompanies ECLS. When major or massive pulmonary embolism is the cause of respiratory/cardiac failure, veno-arterial ECLS is very successful management if cannulation and extracorporeal support can be instituted before brain injury occurs. After VA access and successful ECLS is established, document the extent of pulmonary embolism by appropriate imaging studies. Massive pulmonary emboli will usually resolve or move into segmental branches within 48-72 hours of ECLS support. Heparinization is required for the circuit, and adding thrombolytic drugs to speed up clot lysis often results in extensive spontaneous bleeding, so it is best to avoid lytics. The patient can be weaned from ECLS then from ventilation and managed by pulmonary embolism prophylaxis. Almost all such patients are managed with placement of an inferior vena caval filter.

### 4.7 ARDS from secondary lung injury (following shock, trauma, sepsis, etc.)

- Once the patient is on ECLS support there is a temptation to be less aggressive treating the primary problem, however this is generally a mistake. The threshold for operations should be lower rather than higher despite ECLS and anticoagulation (for example pancreatic resection and drainage for necrotizing pancreatitis, fasciotomy and/or amputation for compartment syndromes and gangrene, excision and drainage of abscesses, etc.).

### 4.8 Membrane failure

#### 4.8.1 Signs of membrane failure:

- Rising trans-membrane pressure (double from baseline over the course of a shift or over 50mmHg).
- Falling blood flow for the same RPM or a need to increase RPM for the same blood flow.
- Falling post-membrane PaO2. If a reduction in post-membrane PaO2 is the only sign of a failing membrane, assessment of oxygen transfer is required using the formula: (post membrane oxygen content – pre membrane oxygen content) x 10 x blood flow. Should there be no other sign of a failing membrane other than a reduction in post-membrane PaO2, a faulty blender should be excluded by connecting to an oxygen cylinder. Another sign of significant membrane thrombus may be the development of disseminated intravascular coagulopathy (fall in platelets and fibrinogen).

#### 4.8.2 Causes of membrane failure

- The development of thrombus (common).
- Membrane infection (rare).
- Hypertriglyceridemia (>10), or if the patient is on total parenteral nutrition, then lipid may disrupt gas exchange.

#### 4.8.3 Management of membrane failure:

- Change the circuit

### 4.9 Haemolysis

#### 4.9.1 Signs of haemolysis

- Increased bilirubin and LDH.
- Blood film demonstrating fragments.
- Red (or dark brown in extreme cases) urine;
- Increasing plasma free Hb (> 0.5)
- High potassium.
- Renal failure.
- Jaundice, (late sign).

#### 4.9.2 Causes of haemolysis

- Thrombus formation within the pump head.

- Sustained periods of access insufficiency with very negative access pressures.
- Sepsis, drug reactions or patient factors such as fragile red blood cells.

#### 4.9.3 Management of haemolysis

- Change the circuit

### 4.10 Air in the circuit (air embolism)

#### 4.10.1 Signs of air embolism

- Air within the circuit

#### 4.10.2 Causes of air embolism

- Allowing any access for air into the patient or extracorporeal circulation, for example having vascular access on the negative pressure side of the circuit or leaving caps off other intravascular devices/
- Inadequately de-airing infusions.

#### 4.10.3 Management of air embolism

- De-air the circuit
- Circuit change may be required

### 4.11 Circuit/Console failure (hand crank for CardioHelp and pump change for Xenios)

#### 4.11.1 Signs of console failure

- Sudden loss of console functions.

#### 4.11.2 Causes of console failure

- Loss of power or due to a fundamental problem with the ECMO pump.

#### 4.11.3 Management of console failure

- Hand crank initially
- Ensure console connected to UPS
- Change the console if required

### 4.12 Unplanned Decannulation

#### 4.12.1 Signs of decannulation

- Removal of the cannula from the vessel – either partial removal or complete removal.
- If partial removal the only sign may be the cannula insertion site measurement has changed.
- If the decannulation occurs on the access cannula, massive air embolism may occur.
- Total decannulation leads to massive blood loss (return cannula) or massive air embolism (access cannula).

#### 4.12.2 Causes of decannulation

- Decannulation is secondary to inadequate fixation of the cannulae and/or inappropriate tension being placed on cannulae (e.g. during transfer).

#### 4.12.3 Management of decannulation

- If partial, simultaneously reinsert cannula until side holes are covered, de-air circuit, replace patient's circulating volume and inform ECMO consultant/perfusionist
- If cannula completely removed then simultaneously clamp the return line and turn pump off, apply pressure to the cannula site, establish emergency ventilation settings, replace patient's circulating volume and inform ECMO consultant/perfusionist

### 4.13 Cardiac arrest

- The ECMO consultant should be informed of any episode of cardiac arrest in an ECMO patient.
- If cardiac arrest occurs during VV ECMO, the usual ACLS algorithm should occur, including CPR. The circuit should be assessed for function and providing it is adequately functioning and not the cause of the cardiac arrest, should continue to run. If the circuit is the cause of cardiac arrest, then the problem leading to circuit failure should be addressed.

### 4.14 Gas failure

- All ECMO carts are equipped with a small C/D sized oxygen cylinder. It should be full, open and have a 1/4" tubing adapter attached to the outlet.
- In the event that a gas failure is identified (or suspected), this cylinder should be turned on at the same rate that the air/02 blender was set at, gas seen to be flowing from it and the green tubing removed from the blender and attached to the cylinder outlet.
- The reason for the gas failure should then be identified, rectified and the gas supply returned to the blender. If the blender is thought to be at fault, replacements can be found on vacant ECMO carts.
- The on call perfusionist should be informed of the failure at the earliest opportunity. It should be noted that in the event of a central gas supply failure, all ECMO patients would require cylinders. Plans should be made to ensure that sufficient oxygen is available until wall gas supplies are restored.

### 4.15 Membrane fiber rupture

- Membrane fiber rupture is identified by evidence of blood in the gas exhaust port at the bottom of the oxygenator. It is rare that membranes spontaneously rupture. It is usually a result of a manufacturing defect or damage in transit. It is also extremely rare that a rupture will noticeably compromise gas exchange.
- Membrane fiber ruptures generally clot of their own accord and circuit change is seldom indicated. Any blood dripping from the exhaust port of the oxygenator should be reported to the ECMO consultant and monitored. Should it not stop then a circuit change will be undertaken.

### 4.16 Circuit change (infection/ blocked circuit)

Patients dependent upon ECMO for life support, either veno-arterial or veno-venous may at times have significant circuit related problems, including air embolus, thrombosis or leakage requiring change. The urgency of this change is dependent upon the individual circumstances of the patient, including their ability to be supported by conventional means.

#### 4.16.1 Preparation

Conventionally ventilate the patient using the emergency ventilator settings (Pressure AC PEEP 10, Pinsp 20, rate 20, Tinsp 1sec, FiO2 1.0 – NB may need to increase Pinsp to higher level (eg 30-40) to have a life sustaining tidal volume).

- **Perfusion**
  - Prime a circuit
  - 4x3/8" straight connectors
- **Nursing**
  - Set up a trolley with a procedure pack
  - Make up a solution of 10000 units heparin in 1L of 0.9% sodium chloride solution in a sterile jug
  - 2 x 50mL catheter tipped syringe
  - 6 sterile ECMO clamps
  - 2 x Circuit scissors
  - Betadine (aqueous) and bowl
  - 6 sterile green drapes (loose, without central hole)
  - Ensure gloves/gowns/masks available (x3)
  - Ensure cardiac arrest trolley at bedside
  - Ensure atropine (3mg) and adrenaline (1mg 1:10000) are available at bedside
  - Transfusion may be required, assess Hb following circuit change.

**Method (min 2 people required, one of which must be consultant)**

- Using non-alcoholic betadine clean the circuit currently attached to the patient
- Lay one drape under the current circuit and one over the circuit distal to where you intend to clamp the access and return, so that the working area is sterile (distal is towards the pump)
- Clamp and cut the replacement circuit and add in a straight 3/8 inch connector onto both the access and return aseptically.
- Lay the new circuit on top of the drape ensuring access and return are on the correct sides
- Clamp both the access and return limbs of the current circuit distal to the cannula join
- Cut the circuit between the clamps
- Connect the replacement circuit using a wet join with heparinised saline
- Remove all clamps and go back onto ECMO

- Ensure that circuit joins are gun-tied

## Section 5: Post ECLS recovery and management

- Patients who experience severe lung injury from necrotizing pneumonia, or from very high plateau pressures prior to ECLS will have the physiologic syndrome of very high alveolar level dead space. This is characterized by adequate oxygenation on low FiO2 but CO2 retention, respiratory acidosis, the need for hyperventilation (either spontaneous or via the ventilator) to maintain PaCO2 under 60, and an emphysematous (honeycomb) appearance on chest x-ray or CT scan. This condition has the characteristics of chronic irreversible obstructive lung disease, however this condition almost always reverts to normal within 1-6 weeks. It is analogous to the condition of alveolar level dead space CO2 retention that occurs in children with severe staphylococcal pneumonia leaving large bullae at the alveolar level. These conditions heal by contracture eliminating the alveolar level dead space.
- 10% of post ECMO patients die in hospital Stay in the home ICU until off vent x 24 hours. Avoid return to sedation and more ventilation. Scan for DVT within 48 hours of coming off ECMO. Consider IVC filter if there are signs of DVT.

## ECMO Team

1- ICU ECMO Consultant
2- ICU ECMO SR/ Registrar
3- Perfusionist
4- ECMO nurse
5- Cardiac/vascular surgeon ( if open approach is required)

The roles and responsibilities of each member of the team is as follows:

***a- ECMO Consultant***

Adan Hospital ICU ECMO consultant will be responsible for receiving the referrals, assessment, approval of all patients referred for VV-ECMO from Adan Hospital or any other hospital (private or governmental) in Kuwait. The ICU ECMO consultant is also responsible for the overall management of the ECMO patient once accepted for VV-ECMO. Assessment and management involve the following:

- Accepting the patient for starting the ECMO after confirming the suitability and the indication

- Cannulation or supervision of cannulation by the ICU SR
- Initial ECMO parameters setup and further parameter changes
- Retrieval of the patient if unstable for transfer
- Daily review of all ECMO patients
- Medical reference for all other ECMO staff
- Involvement in all key decision making (e.g. weaning, withdrawal of therapy, bleeding and other complications management)
- Supervision of junior staff in Adan ICU.

***b- ECMO Registrar/Senior Registrar***

- Retrieval of the patient if unstable for transfer
- Insertion and removal of the percutaneous cannula under supervision of the ECMO consultant.
- General management of the ECMO patient and ECMO circuit under the supervision of the ECMO consultant.
- Be familiar with all the complications that may develop and its management.

***c- Perfusionist***

The perfusionist will provides 24 hr cover for:

- Initiation of ECMO
- Priming of circuits
- Circuit maintenance and nursing support
- Retrieval of the patient if unstable for transfer
- Three times daily review of patients on ECMO
- Attendance for all inter and intra-hospital transport of patients
- Attendance at all procedural interventions.

***d- ECMO Nurse***

All patients on ECMO require overview by a second ECMO nurse, in addition to a dedicated bedside nurse. 24 hour nursing cover is required to:

- Maintain a safe environment for the management of a critically ill, ventilated patient with a wide range of complex care needs.

- Ensure safe monitoring of the ECMO patient including monitoring all the ecmo parameters as illustrated in the ECMO monitoring form (appendix 4).

- Immediate call to the medical staff and perfusionist whenever any of the parameters are outside the determined range indicated by the ECMO consultant as documented in the ECMO monitoring form.

- Be familiar with the different kits needed for the ECMO cannulation as per the ECMO equipment list (appendix 5), which should be all available in the ECMO Cart and ensuring its availability and replacement whenever it's been used.

***e- Cardiac surgeon/vascular surgeon***

- Responsible for surgical cannulation if percutaneous approach fails and opens approach is required.

## References


1. Clinical Guideline. Extracorporeal Membrane Oxygenation (ECMO) for acute respiratory failure. Guy's and St Thomas NHS Foundation Trust. October 2011. Dr Nicholas Barrett.
2. ELSO (extracorporeal life support organization) patients care practice guidelines. https://www.elso.org/Resources/Guidelines.aspx
3. ELSO guidelines for adult respiratory failure. Version 1.3. December 2013.
4. ECMO: Extracorporeal Cardiopulmonary Support in Intensive Care (The Red Book)" published by ELSO.

# APPENDIX 1
## ECMO Referral Form (page 1)

**MINISTRY OF HEALTH**
KUWAIT

وزارة الصحـــة
الكويت

### Adan Adult ICU ECMO Referral Form

**Please complete this consultation form for all ECMO referrals to Adan Hospital.**

Referring Hospital ---------- Patient name ----------
Referring Specialty ---------- civil ID number ----------
Referring consultant ---------- Gender M / F Age --------
Referral date ---------- Unit ----- Ward ----- Bed -----
Admission diagnosis ---------- File no ----------

History (including comorbidities) ----------

---

***Patient parameters*** ***(*has to be completed, otherwise the consultation will be rejected):***

* Pre-morbid functional status □ bed bound □ chair bound □ mobile
* Pre-morbid conscious status □ Alert and oriented □ Demented □ Coma/ vegetative status
*Current GCS E --- V --- M --- Total score ----/15

**Ventilation**

*Duration of conventional mechanical ventilation -------- Days
*SpO2 -----% PO2 ------ mmHg *FiO2 ------ ****PaO2/FiO2 ratio*** ---------- mmHg
*PIP (peak insp pressure/ PAW) ---------- cmH2O ****PEEP*** ------ *TV ---------- *RR -------
****Lung Compliance (mls/cmH2O)*** ---------- (calculated as TV/(PIP – PEEP)
****CXR quadrants*** (number of quadrants with infiltrations seen on CXR: alveolar consolidation) 1 point per quadrant, minimum 0, maximum 4) ----------

**Cardiovascular parameters:**

*HR ---------- *BP ---------- *CVP ---------- *Temp ----------
*CO ---------- *cardiac index ---------- L/min/m2 *left ventricular ejection fraction ---------- %
Inotropes/vasopressors) Agent: ---------- Dose ---------- mcg/kg/min
Agent: ---------- Dose ---------- mcg/kg/min
Sedation : Agent: ---------- Dose ----------
Agent: ---------- Dose ----------
Muscle relaxants: Agent: ---------- Dose(bolus/infusion) ----------

**Investigation results:**

*wbc ----- *Hb ------ *Plt ------ *INR ------ *PT ------ *APTT ------ *Bil ------ *AST ------ *ALT ------
*urea ----- *Cr ------ *Lactate ---------- *UO --------mls/hr *Dialysis Yes / NO
*Blood Gas : PH --- PO2 --- ****PCO2*** ------ HCO3 ---- BE -----

**Signature and stamp of referring Doctor**---------- Date: ----------
**Designation (minimum Specialist)** ---------- Telephone number----------

***Consultations has to be discussed verbally with the ECMO Consultant in Adan Hospital. For adult ICU ECMO referral please contact the ICU on-call doctor by phone (96623263) as well as filling this form and Faxing it to (23946102) to ensure a prompt response to the referral.***

# APPENDIX 1
## ECMO Referral Form (page 2)

**MINISTRY OF HEALTH**
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**INDICATIONS for VV-ECMO:**

Any reversible, life-threatening form of respiratory failure where the risk of mortality is 80%* or greater and where cardiac function is adequate. This includes the following (see table below):

1- PaO2/FiO2 < 100 despite optimal ventilator support.
2- Murray score 3-4** despite optimal care for 6 hours or more
3- PH<7.2 due to CO2 retention on mechanical ventilation despite optimal ventilation with high Pplat (>30 cm H2O)
4- Severe air leak syndromes (e.g. pneumothorax secondary to trauma, fistula)
5- Need for intubation in a patient on lung transplant list

**VV-ECMO should also be considered for:**

1- PaO2/FiO2 < 150 despite optimal ventilator support
2- Murray score 2-3** despite optimal care for 6 hours or more
3- Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care)
4- Duration of conventional mechanical ventilation >7 days, with single organ dysfunction.

**Absolute contraindications to veno-venous ECMO:**

1. Severe (medically unsupportable) heart failure/cardiogenic shock
2. Severe chronic pulmonary hypertension and right ventricular failure (mean pulmonary artery pressure approaching systemic blood pressure)
3. Cardiac arrest (ongoing)
4. Advanced/ terminal malignancy
5. Graft versus host disease
6. Cachexia due to an underlying progressive chronic disease

****Murray Score**

Each parameter scores between 0 and 4 and an average of the 4 parameters scoring is calculated to get the final Murray score. A score of ≥ 3 is an indication of VV-ECMO.

| Murray Score | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| PaO2/FiO2 on 100% O2 | ≥40kPa (300mHg) | 30-40kPa (225-299 mmHg) | 23-30kPa (175-224 mmHg) | 13-23kPa (100-174 mmHg) | <13KPa (100mmHg) |
| CXR quadrants | Normal | 1 | 2 | 3 | 4 |
| PEEP (cmH2O) | ≤5 | 6-8 | 9-11 | 12-14 | ≥15 |
| Compliance (ml/cmH2O) | ≥80 | 60-79 | 40-59 | 20-39 | ≤19 |

**Murray score can be calculated through the CESAR trial website (conventional ventilation or ECMO for severe adult respiratory failure) on:**
http://cesar.lshtm.ac.uk/murrayscorecalculator.htm

## APPENDIX 2
## Heparin Protocol for VV ECMO

1. Upon initiation of ECMO, give intravenous loading dose of 5000 unit of unfractionated heparin
2. Start infusion rate of 15-18 unit/kg/min
3. Monitor aPTT Q6hr (target aPTT 40-60 sec; aPTT ratio 1.5-2.0)
4. Adjust heparin infusion rate as following:
5. For high risk patients for intracerebral hemorrhage, reduce Heparin infusion to achieve a target of APTT values of 1.2 – 1.5. Consult the doctor (go down or up by one box in the below table).

| aPTT | Bolus | Stop infusion | Rate change |
|---|---|---|---|
| <30 | 2000 unit | No | Increase by 300 unit/hr |
| 31-40 | 1000 unit | No | Increase by 100 unit/hr |
| 41-60 | 0 | No | No change |
| 61-70 | 0 | No | decease by 100 unit/hr |
| 71-80 | 0 | 30 minutes | decrease by 200 unit/hr |
| 81-100 | 0 | 60 minutes | decrease by 300 unit/hr<br>And call MD |

# APPENDIX 3 – A

## Safety Checklist - Cardiohelp

**Appendix 3 - A**

**Patient Name:** _____ **CID No.** _____ **Bed No.** ____ **Day:** ____ **Date:** _____

| Bedside ECMO Safety Inspection Checklist (Cardiohelp) | 7-2 | 2-10 | 10-7 |
|---|---|---|---|
| **Cannula and Circuit Check** (with a light source) | | | |
| • Tip to tip check with manual feel of all tubing and connections | | | |
| • Access and return cannula position, no bleeding, no infection (ensure transparent dressing, if covered with gauze remove to inspect) | | | |
| • Color comparison – Strong / Mild / No | | | |
| • No Chattering | | | |
| • No Air | | | |
| • No Clots (If yes, document on the diagram) | | | |
| • No Kinking | | | |
| • Flow sensor check → Correct direction and tube (return/arterial line) | | | |
| **Oxygenator / Pump Check** | | | |
| • No Clot | | | |
| • Pre – Post membrane pressure | | | |
| • No Water / Blood leaks | | | |
| • No Air → Should listen | | | |
| • Pressure transducer connections | | | |
| • Position (lower than the patient's heart level) | | | |
| **Oxygen / Gas Blender Check** | | | |
| • Sweep flow set value: _____ Sweep flow reading: _____ | | | |
| • ECMO FiO2 set at _____. | | | |
| • Sight test to eliminate condensation | | | |
| • O2 source connected to main O2 pipelines | | | |
| • Spare O2 Cylinder (Full and connected to flow meter) | | | |
| **Heater / Cooler Check** | | | |
| • Tight connections switched on and plugged to power source. | | | |
| • Temperature set value: _____ Temperature reading: _____ | | | |
| **Hand Crank Check** | | | |
| • Visible and accessible (Should be at the level of the oxygenator) | | | |
| • Tested (with flow to green lighting) | | | |
| **Console Check** | | | |
| • Check reading against the set value (If different inform the doctor) | | | |
| • RPM | | | |
| • Blood Flow | | | |
| • P int, P vent, ΔP | | | |
| • Appropriate intervention alarms<br>* ΔP should be 15 mmHg above baseline trend or 50 mmHg or whichever is lower | | | |
| **Extras Check** | | | |
| • Clamps x4 | | | |
| • 50 ml lower lock syringes x 3 | | | |
| • Light source | | | |
| • ECMO plugged to maintain power source | | | |
| • ECMO support cart available and properly stocked. | | | |
| • Pedal pulses and peripheral pulses checked | | | |
| • Correct cannula placement is checked by Dr. _____ | | | |

| 7-2 | | 2-10 | | 10-7 | |
|---|---|---|---|---|---|
| IN | OUT | IN | OUT | IN | OUT |
| | | | | | |

# APPENDIX 3 – B

## Safety Checklist - Xenios

**Appendix 3 - B**

**Patient Name:** _____ **CID No.** _____ **Bed No.** ____ **ECMO Day:** ___ **Date:** _____

| Bedside ECMO Safety Inspection Checklist (Xenios) | 7-2 | 2-10 | 10-7 |
|---|---|---|---|
| **Cannula and Circuit Check** (with a light source) | | | |
| • Tip to tip check with manual feel of all tubing and connections | | | |
| • Access and return cannula position (no migration and correct skin marking), sutures, no bleeding, and no infection. (Ensure transparent dressing, if covered with gauze remove to inspect) | | | |
| • Color comparison – Strong/Mild/ No | | | |
| • No Chattering | | | |
| • No Air | | | |
| • No Clots (If yes, document on the diagram) | | | |
| • No Kinking | | | |
| • Flow sensor check → Correct direction and tube (return/arterial line) | | | |
| **Oxygenator / Pump Check** | | | |
| • No Clot | | | |
| • Pre and Post membrane pressure, ΔP | | | |
| • No Water / Blood leaks | | | |
| • No Air → Should listen | | | |
| • Pressure transducer connections | | | |
| • Position (lower than the patient's heart level) | | | |
| **Oxygen / Gas Blender Check** | | | |
| • Sweep flow set value: _____ Sweep flow reading: _____ | | | |
| • ECMO FiO2 set at _____. | | | |
| • Sight test to eliminate condensation | | | |
| • O2 source connected to main O2 pipelines | | | |
| • Spare O2 Cylinder (Full and connected to flow meter) | | | |
| **Heater / Cooler Check** | | | |
| • Tight connections, switched on and plugged to power source.<br>• Temperature set value: _____ Temperature reading: _____ | | | |
| **Backup Pump Drive and Battery Check** | | | |
| • The backup pump is tested, back-up battery is fully charged | | | |
| **Console Check** | | | |
| • Check reading against the set value (If different inform the doctor) | | | |
| • RPM | | | |
| • Blood Flow | | | |
| • P1, P3, ΔP | | | |
| • Appropriate intervention alarms | | | |
| **Extras** | | | |
| • Clamps x4 | | | |
| • 50 ml lower lock syringes x 3 | | | |
| • Light source | | | |
| • ECMO plugged to maintain power source | | | |
| • Pedal pulses and peripheral pulses checked | | | |
| • ECMO support cart available and properly stocked. | | | |
| • Correct cannula placement is checked by Dr. _____ | | | |

| 7-2 | | 2-10 | | 10-7 | |
|---|---|---|---|---|---|
| IN | OUT | IN | OUT | IN | OUT |
| | | | | | |

# APPENDIX 3 – C
# ECMO Data Sheet

Appendix _____

## ECMO DATA SHEET

| | |
|---|---|
| **ECMO TYPE** | ☐ V-A<br>☐ V-V<br>☐ Other _____ |
| ☐ Single Lumen<br>☐ Dual Lumen | |

| | |
|---|---|
| **Date** | |
| **Location** | |
| **ECMO Cannula Inserted by:** | |
| **Nurse** | |
| **Perfusionist** | |

**PATIENT DATA**

| | | | |
|---|---|---|---|
| **Name** | | **Age / Sex** | |
| **Nationality** | | **Weight / Height** | |
| **Civil ID** | | **Blood Group** | |
| **Hospital No** | | **EF %** | |
| **Diagnosis** | | **Murray Score** | |
| **ECMO Indication** | | **Resp Score** | |

| **ECMO ACCESS LINE** | | **ECMO RETURN LINE** | |
|---|---|---|---|
| **Site** | | **Site** | |
| **Cannula Brand** | | **Cannula Brand** | |
| **Cannula Size** | | **Cannula Size** | |
| **Inserted Length** | | **Inserted Length** | |
| **Skin Marking Length** | | **Skin Marking Length** | |

**DUAL LUMEN CANNULA**

| | |
|---|---|
| **Site** | |
| **Cannula Brand** | |
| **Cannula Size** | |
| **Inserted Length** | |
| **Skin Marking Length** | |

**Skin marking is from the insertion site up to the end of the metal rim of the cannula

**PERFUSION DATA**

| | | | | | | |
|---|---|---|---|---|---|---|
| **ECMO Console** | | **Priming Solution** | | | | |
| **Oxygenator** | | VITAL SIGNS DURING CANNULATION | | | | |
| **Gas Blender** | | **HR** | **BP** | **MAP** | **SPO2** | **CVP** |
| **Heater/Cooler** | | | | | | |
| **IABP** | | **PUMP TIMING** | | | | |
| **CRRT** | | **DATE & TIME ON** | | **DATE & TIME OFF** | | |
| | | **TOTAL TIME ON ECMO:** _____ | | | | |

**COMMENTS:** _____

_____

**Reason for Termination of ECMO:** _____

_____

Adan ICU. Updated March 23, 2018.

# APPENDIX 4
## ECMO Monitoring Form

**Appendix 4**

**Patient Name:** _____ **CID No.** _____ **Bed No.** ____ **Day:** ____ **Date:** _____

### ECMO Monitoring Form

**(Hourly observation unless stated otherwise)**

| DATE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | | | | | | | | | | |
| SPO2 | | | | | | | | | | | |
| Ventilator FiO2 | | | | | | | | | | | |
| TV | | | | | | | | | | | |
| PIP | | | | | | | | | | | |
| PEEP | | | | | | | | | | | |
| Plateau | | | | | | | | | | | |
| Compliance | | | | | | | | | | | |
| ECMO FiO2 | | | | | | | | | | | |
| Sweep Flow | | | | | | | | | | | |
| FLOW | | | | | | | | | | | |
| RPM | | | | | | | | | | | |
| P- Ven (P1) | | | | | | | | | | | |
| P-Art (P3) | | | | | | | | | | | |
| Del-P (P2-P3) | | | | | | | | | | | |
| Et CO2 | | | | | | | | | | | |
| pH (3 hourly) | | | | | | | | | | | |
| PCO2 (3 hourly) | | | | | | | | | | | |
| PO2 (3 hourly) | | | | | | | | | | | |
| HCO3 (3 hourly) | | | | | | | | | | | |
| B.E. (3 hourly) | | | | | | | | | | | |
| ABG SaO2 (3 hourly) | | | | | | | | | | | |
| ABG Lac (3 hourly) | | | | | | | | | | | |
| APTT (6 hourly) | | | | | | | | | | | |
| APTT Ratio (6 hourly) | | | | | | | | | | | |
| Heparin Infusion | | | | | | | | | | | |
| D-Dimer (daily) | | | | | | | | | | | |
| Fibrinogen (daily) | | | | | | | | | | | |
| Hb (daily) | | | | | | | | | | | |
| Platelet (daily) | | | | | | | | | | | |
| Lac (daily) | | | | | | | | | | | |
| LDH (daily) | | | | | | | | | | | |
| Triglyceride (daily) | | | | | | | | | | | |
| Heart Rate | | | | | | | | | | | |
| MAP | | | | | | | | | | | |
| CVP | | | | | | | | | | | |
| CO | | | | | | | | | | | |
| CI | | | | | | | | | | | |
| PWP | | | | | | | | | | | |

Targets to be filled daily by the ECMO consultant (please specify targets if different from the set value)

| | | | |
|---|---|---|---|
| ECMO FiO2 _____ | Plateau _____(< 25cm H2O) | Platelets _____ (>50) | HR _____ (50-70bpm) |
| ECMO Flow____ L/min | PaO2 _____ (8-12 kPa) | Heparin _____ ml/min | MAP _____ (65-80mmHg) |
| PIP _____ (5-10) | PaCO2 _____ (4-6 kPa) | APTT Ratio _____(1.5-2.0) | CVP _____ (10-14mmHg) |
| PEEP _____ (10-15) | | APTT _____ (40-60s) | CO _____ (4-5L/min) |
| | PWP _____ 14-16mmHg) | Fibrinogen _____ (>2) | CI _____ (2.2-2.5L/min) |

Other instruction: _____ Length from incision site to the end of metal rim _____

Adan ICU. Updated March 23, 2018

**APPENDIX 5**
**ECMO CANNULATION ITEMS**

| | |
|---|---|
| Hibiscrub | 1 bottle |
| Surgical Scrub Brush | 2 |
| Sterile Gown | 4 |
| Sterile Gloves (All sizes) | 2 each |
| CHLORHEXIDINE(70%ALCOHOL+2% CHLORHEXIDINE) | 1 bottle |
| ANGIO STERILE DRAPE L | 2 |
| ULTRASOUND PROBE COVER | 2 |
| ULTRSONIC GEL (sterile) | 1 |
| INSERTION KIT WITH DILATORS | 2 |
| CORDIS 6FR VASCULAR SHEATH | 2 |
| AMPLATZ EXTRA STIFF GUIDE WIRE | 2 |
| BMW (Hi-Torque guide wire) | 2 |
| Surgical Blade with handle | 2 |
| Desired CANNULA (as per the Doctor's request) | 1 |
| 50 CC CATHETER TIP SYRINGE (filled with heparinized saline, if not contraindicated) | 8 |
| Heparinized Saline 0.9 % (5000 IU in 500 mL) | |
| DRESSING SET | 2 |
| CUTDOWN SET | 1 |
| Clamps (Sterile) | 8 |
| Sterile Gauze (4x4) | 1 pack |
| 20 CC SYRINGE | 2 |
| 10 cc Syringe | 2 |
| MERSILK SUTURE '0' and '1' | 3 each |
| BIOPATCH | 2 |
| Chlorhexidine Dressing | 2 |
| Sterile marker | 1 |
| Tegaderm | 2 |

# ECMO Committee

# (Policy No 4)

## Veno-Venous Extracorpeal Membrane Oxygenation

## (VV-ECMO) General Management POLICY 2018

| | |
|---|---|
| **Policy owner:**<br>ECMO Committee. MOH | **Applies to:**<br>All Staff in MOH and private Hospitals in Kuwait |
| **Section Location**:<br>Departments of Anaesthesia, Adult Intensive Care and Pain Management in all MOH and private Hospitals in Kuwait. | **Effective date:** 01-03-2018<br>**Revision date**: 01-03-2021 |
| **Approved by**:<br>Head of ECMO committee, ECMO committee members | |
| **Final Approval by:** MOH Undersecretary | |

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MOH Undersecretary Date: