ECMO for residents

INTRODUCTION AND PHYSIOLOGY:
ECMO is the only form of support useful in cases of hypoxemia due to pulmonary failure and the only device that simultaneously supports the right ventricle (RV).
Veno-Arterial extracorporeal membrane oxygenation (VA-ECMO) provides cardio-pulmonary support for patients in profound cardiogenic shock (CS) as a bridge to myocardial recovery, durable mechanical circulatory support (MCS), or heart transplant (HT).
Veno-venous extracorporeal membrane oxygenation (VV-ECMO) is primarily used in patients with isolated pulmonary disease.

Cardiogenic shock is primarily defined by inadequate Oxygen delivery to the tissues and subsequent ischemia. This in turn is reflected by increased peripheral tissue metabolism. This is related most closely to oxygen consumption, and is determined by measuring the amount of oxygen consumed per minute → VO2. (Rate for adults: 3 cc/kg/min or 120 cc/min/m²) When metabolic rate increases cardiac output needs to increase accordingly in order to maintain homeostasis. Normally during illness it can increase by more than 50% in order to maintain adequate oxygen delivery (DO₂). In cardiogenic shock cardiac output cannot increase adequately and thus this balance is perturbed. There are several factors which play an important part in oxygen delivery to tissues but it boils down to two main components as noted in the accompanying figure,

\[ \text{DO}_2 \text{ (cc/min)} = \text{CaO}_2 \text{ (cc/dL)} \times \text{CO} \text{ (L/min)} \times 10 \text{ (dL/L)} \]

Where CaO₂ denotes oxygen content and CO denotes cardiac output.

CaO₂ is further affected by the outlined variables:

\[ \text{CO}_2 \text{ (cc/dL)} = \text{Hgb} \text{ (gm/dL)} \times \text{SO}_2 \times 1.34 \text{ (cc/gm)} + \text{PO}_2 \text{ (mmHg)} \times 0.003 \text{ (cc/dL/mmHg)} \]
In order to maintain proper homeostasis and fuel proper cellular metabolism a ratio of oxygen delivery to oxygen consumption has to at least be 2 to 1, which supplies 50% This relationship is outlined in the below figure:

Utilizing VA ECMO along with modifying the above mentioned arterial oxygen content variables, it is possible to support oxygen delivery adequate to maintain proper cellular metabolism:

\[ \text{DO}_2 = (\text{native cardiac output} \times \text{CaO}_2 \text{ of native lung}) + (\text{ECMO Flow} \times \text{CaO}_2 \text{ of membrane lung}) \]

Given the aforementioned equations to improve \( \text{DO}_2 \) in VA configuration, it is the combination of manipulating the variables involved. Thus manipulation of cardiac output and arterial O2 content improves \( \text{DO}_2 \):
Cardiac output:
- Increase pump flow with manipulation of RPM’s
- Increase native cardiac output with inotropes

VA ECMO, as a form of partial cardiopulmonary bypass, provides 60–80% of the predicted resting cardiac output. The remaining 20–40% of venous return flows normally through the native pulmonary circulation.

CaO₂:
- Oxygenation is independent of sweep gas flow rate.
- In contrast to oxygenation, carbon dioxide elimination is dependent on sweep gas flow rate and is independent of blood flow
- Transfuse to increase hemoglobin to above 12g/dL as to keep CaO₂ between 15-20 cc/dL

The body responds to a decrease in oxygen delivery (DO₂) by increasing the extraction ratio (ER) of oxygen from the blood. Considering the following:

\[ ER = \frac{VO_2}{DO_2} \]

Expanding this equation yields the following:

\[ ER = \frac{(SaO_2 - SvO_2)}{SaO_2} \]

Assuming SaO₂ of 100%, a normal extraction of 25–35% results in a normal SvO₂ of 65–75%. A state of high extraction (cardiogenic shock) will result in a low SvO₂ of <65–75%. Once oxygen extraction reaches a maximum of 50–60% and the SvO₂ decreases to 40–50%, the body will begin to produce lactate due to the initiation of anaerobic metabolism and thus measuring lactate as well as SvO₂ is a quick way of monitoring if there is adequate ECMO support.

INDICATIONS AND CONTRAINDICATIONS:
Based on UK policies and procedures
Candidates for Extra Corporeal Membrane Oxygenation (ECMO) or Extra Corporeal Life Support (ECLS) are patients with reversible cardiac and/or respiratory failure who are unresponsive to maximal conventional management. Any questionable or marginal cases will be considered and discussed by a multidisciplinary team.

ADULT RESPIRATORY FAILURE PATIENT should meet the following criteria before he/she can be placed on ECMO.

A: Potential Indications for Adult Veno-venous (VV) ECMO:
   1. For hypoxic respiratory failure due to any cause (primary or secondary) ECLS should be considered when the risk of mortality is 50% or greater, and is indicated when the risk of mortality is 80% or greater.
      a. 50% mortality risk is associated with a PaO2/FiO2 < 150 on FiO2 > 90% and/or Murray score 2-3.
      b. 80% mortality risk is associated with a PaO2/FiO2 < 100 on FiO2> 90% and/or Murray score 3-4 despite optimal care for 6 hours or more.
   2. CO2 retention on mechanical ventilation despite high Pplat (>30 cm H2O)
   3. Severe air leak syndromes
   4. Need for intubation in a patient on lung transplant list
   5. Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care)

Murray score calculator: [http://cesar.lshtm.ac.uk/murrayscorecalculator.htm](http://cesar.lshtm.ac.uk/murrayscorecalculator.htm)

B: Contraindications for Adult VV ECMO:
   There are no absolute contraindications to ECLS, as each patient is considered individually with respect to risks and benefits. There are conditions, however, that are associated with a poor outcome despite ECLS, and can be considered relative contraindications.
   1. Mechanical ventilation at high settings (FiO2 > .9, P-plat > 30) for 7 days or more
   2. Major pharmacologic immunosuppression (absolute neutrophil count <400/mm3)
   3. CNS hemorrhage that is recent or expanding
   4. Non recoverable co-morbidity such as major CNS damage or terminal malignancy
   5. Age: no specific age contraindication but consider increasing risk with increasing age
   6. Morbid obesity since cannulation imposes greater risk of major vascular injury and since large body masses are difficult to adequately support
   7. Underlying diagnoses with predicted survival < 1yr

Examples when there should be a strong consideration for VV ECMO:
- Hypoxemic respiratory failure with a PaO2/FiO2 ratio <100, measured with ABG’s at least 2 hours apart or 2 consecutive blood gases.
- Hypercapnic respiratory failure with arterial pH < 7.20 on 2 consecutive blood gases

Special Considerations for Adult VV ECMO:
   1. Recent surgery or trauma places patient at high risk of bleeding
   2. Size of patient: No weight limit established, although obese patients (especially >100kgs) have high risk of decubiti and are more difficult to cannulate and support during ECLS management.
   3. Patients with chronic respiratory failure (COPD, emphysema) may be candidates based on pre-ICU status. Prognosis for long-term survival should be considered prior to offering ECMO.
   4. Patients with cancer in remission with single organ system failure are candidates for ECMO.
   5. Relapsed cancer patients with multiple organ system failure are not good ECMO candidates.
      Again, prognosis for long term survival should be considered prior to offering ECMO.
6. Cystic fibrosis patients should not be placed on ECMO unless it is a bridge to lung transplantation

ADULT CARDIAC FAILURE PATIENT should meet the following criteria before he/she can be placed on ECMO.

A: Potential Indications for Adult Veno-Arterial (VA) ECMO
   1. Inability to come off cardiopulmonary bypass following cardiac surgery or early cardiogenic shock following cardiac surgery.
      a. Poor cardiac function and perfusion indicated by high doses of vasopressors and inotropic support, increasing lactate, metabolic acidosis, and decreased urine output are reasons to consider ECMO, but still may continue observation with conventional management. This is a clinical decision based on many factors.
   2. Cardiogenic Shock due to causes such as MI, cardiomyopathy, myocarditis, toxic drug overdose, and pulmonary embolus.
   3. Cardiac arrest with return of spontaneous circulation, but remains hemodynamically unstable.

Special Considerations for ADULT VA ECMO:
   1. Bridge to heart transplant.
      a. Discussion with heart failure cardiology and the thoracic transplant surgery service should occur as to whether the patient is a heart transplant and/or VAD candidate. If the patient is stable, other procedures (such as ventricular assist device placement) should be considered.
   2. eCPR: This type of VA ECMO is initiated during conventional cardiopulmonary resuscitation or when repetitive arrest events occur without a return of spontaneous circulation (ROSC) for greater than 15-20 min.
      a. Adult eCPR Criteria
         o eCPR is considered a rescue/salvage therapy that is associated with very high costs and very poor outcomes.
         o Potential candidates are patients who were previously healthy and functional, who have had a witnessed arrest, with immediate initiation of CPR/ACLS protocol, who have received high-quality CPR continuously since arrest, and who have not had return of spontaneous circulation in 15-20 minutes.

B: Contraindications for Adult VA ECMO:
There are no absolute contraindications to ECLS, as each patient is considered individually with respect to risks and benefits. However, there are conditions that are associated with poor outcomes despite ECLS, and can be considered relative contraindications:

1. Unwitnessed arrest, significant delay in initiation of ACLS/CPR, poor-quality CPR
2. Untreatable underlying diseases and/or congenital malformations in a patient who is not a candidate for a surgical correction or heart transplant
3. Non reversible multi-system organ failure
4. Severe neurologic injury, such as in a result of low flow secondary to cardiac arrest, or other pre-existing severe neurologic injury
5. CNS hemorrhage that is recent or expanding
6. Non recoverable co-morbidity such as major CNS damage or terminal malignancy
7. Major pharmacologic immunosuppression (absolute neutrophil count <400/mm3)
8. Age: no specific age contraindication but consider increasing risk with increasing age
9. Morbid obesity since cannulation imposes greater risk of major vascular injury and since large body masses are difficult to adequately support
10. Underlying diagnoses with predicted survival < 1yr
11. Other causes of futility, or irreversible cardiac or medical condition

CIRCUITS:
In its most simple form, the ECMO circuit is composed of cannulae, tubing, a pump, and an oxygenator. There are minimal connections to reduce turbulence and fibrin deposition. Additionally, medication and blood product administration is performed via the patient instead of via the circuit.

Although there are several ways of cannulations, most commonly encountered in CCU, peripheral VA ECMO provides partial hemodynamic support and can provide ventricular decompression, augmentation of perfusion pressure, and oxygenation and removal of carbon dioxide in the blood; however, it also increases the afterload against which the left ventricle (LV) works. The balance of the beneficial effect of decompression against the detrimental effect of increased afterload depends on the level of support and the state of the myocardium. This in turn is associated with LV stasis and increased propensity for chamber thrombosis.

The components of an ECMO circuit include: Cannulae, Pump, Oxygenator, Blender, Water Heater, Pressure Monitors, and Flowmeter. Circuit components are chosen to allow for at least 50–75 cc/kg/min of flow in adults (compared with 80 cc/kg/min for pediatric patients and 100 cc/kg/min for neonates). Larger patients may require additional inflow or outflow cannulas if adequate flows cannot be achieved with a given set of circuit components.

VV-ECMO:

![VV-ECMO Diagram](image-url)
VA-ECMO:

OXYGENATOR:
Gas exchange occurs in the membrane oxygenator. Extracorporeal venous blood is exposed to fresh gas (or sweep gas) that oxygenates and removes carbon dioxide.

BLENDER:
Oxygenation is affected by the fraction of delivered oxygen (F\textsubscript{\text{r}}O\textsubscript{2}) and the blood flow rate. A gas blender attached to the oxygenator mixes air and oxygen and allows for a range of F\textsubscript{\text{r}}O\textsubscript{2}. Increases in F\textsubscript{\text{r}}O\textsubscript{2} will
increase the partial pressure of oxygen in the blood (PaO₂). In addition, increases in blood flow will also increase oxygenation as a greater volume of blood is exposed to the surface of the membrane. Augmentation of oxygenation only occurs up to a certain point after which the time for oxygen transfer becomes too short.

**FLOW METER:**
A flowmeter regulates gas flow to the membrane. An increase in the sweep gas flow rate results in a decreased concentration of carbon dioxide as it is more soluble than O₂ and thus diffuses approximately 10 times more efficiently.

**MONITORING:**
- Always check the circuit during pre-rounding: Looking for chattering, fibrin, thrombus, circuit temperature.
- SvO₂ measurement:
  - In VA configuration measurement of SvO₂ is accurate when obtained from RA, PA as well as drainage limb.
  - Both give indication of appropriate support
- Frequent calculation of DO₂ if either of the parameters not optimal. May need to increase DO₂ by either increasing CO (flow) or CaO₂ (Hgb, etc)

Other important variables to monitor daily are LDH as well as free hemoglobin, which may indicate excessive amount of hemolysis. *It is important to note that changes in LDH should correlate with changes in free hemoglobin as isolated elevation of LDH may indicate tissue/muscle ischemia, needing to pay attention to the cannulated extremity as this may indicate compartment syndrome.*

**COMPlications/Troubleshooting:**

**VENO-VENOUS ECMO**

**Worsening Hypoxia**

**Causes:**
- Decreased circuit flows
- Increased Cardiac Output (increasing the shunt from the ECMO circuit)
- Recirculation of returned oxygenated blood into the access line
- Decreased FiO₂
- Oxygenator failure
- Gas tubing leak or disconnection

**Ensure:**
- Pump flow is adequate (> 2/3 cardiac output)
- 100% oxygen is being supplied to the oxygenator
- Oxygenator is functioning correctly (outflow pO₂ > 150mmHg)
- Recirculation minimized
  - Hypoxia will improve after lowering CO (decreased agitation)
  - SpO₂ pre- approaching or > SpO₂ from patient

(If the access and return cannula are too close together, recirculation of blood may occur between them (oxygenated blood is drawn down the access cannula). Hence increasing ECMO flow may not
improve the patient’s oxygenation. To diagnose recirculation, take a blood gas from the venous side of the oxygenator. Check venous pO2. If the pO2 is higher than the patient’s venous pO2, reposition (withdraw) the Venous line. Consider adding a second Drainage line via a Y-connector).

**Consider:**
Increasing pump flow / increasing ventilation / cooling patient to 35°C. These changes **MUST NOT** be performed without the approval of the ECMO Intensivist or medical MCS staff on-call.

**Worsening Hypercarbia**

**Causes:**
- Decreased gas flow
- Oxygenator failure

**Ensure:**
- Pump flow is adequate (>2/3 cardiac output)
- Oxygen flow to oxygenator is at least twice the pump flow rate 2

**Consider:**
Increasing ECMO flow rate / increasing ventilation /cooling patient to 35°C

**Low Flows**

**Causes:**
- Hypervolemia (look for a kicking access line)
- Clot in oxygenator (look for increased trans- membrane pressures)
- Access insufficiency
  - **Internal**
    - Hypovolemia
      - Bleeding
    - Catheter kink
    - Catheter against vessel wall
    - Clot
      - Tubing causes SIRS and activation of clotting cascade
  - **External:**
    - Catheter against vessel wall
    - Tension
    - Tamponade
    - Valsalva
    - Ab compartment syndrome

**Diagnosis:**
- Decline in venous inlet pressures
- Chatter/Kicking of the access line
- Intermittent drops in flow
- Hypoxemia

**Action:**
- Check/”Reposition” circuit/tubing
• Obtain CXR (looking for pneumothorax or positioning of cannulas)
• Reduce RPM’s
• Fluid resuscitation, monitor CVP
• Assess for clot formation and inform ECMO Intensivist and MCS staff.

*Increasing flow rate does not improve oxygenation (Veno-Venous)*

• Reduce airways pressures
  - Reduce airway pressures
    - High PEEP \(\rightarrow\) reduces venous return

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**VENO-ARTERIAL ECMO**

**Worsening Hypoxia**

Differential hypoxemia (lower pO2 in the upper body compared to the lower body) can occur during peripheral veno-arterial ECMO when there is severe respiratory failure and thus non-functional lungs combined with a high cardiac output and thus improving native cardiac function. In this situation, the heart is supplying the upper body with de-oxygenated blood, while the ECMO circuit supplies the lower body with oxygenated blood. To detect this problem, patient blood gases should be sampled as close to the heart as possible (hence a *right radial arterial line* is preferable to a left radial line). Similarly, monitoring of the oxygen saturation of the upper body should be performed with a pulse oximeter on the *right hand* or with a *transcutaneous oximeter* attached to the patient’s forehead.

**Therapy:**

- Treat the lung disease / optimize the Vent
- Evaluate for D/C VA ECO
- Convert to VAV ECMO
- Increase AC flows
- Convert to central ECMO

**Increasing LDH**

- If associated with increasing free Hgb then consider hemolysis
- If increasing without increase in free hemoglobin then need to consider tissue damage (compartment syndrome)

**Diagnosis:**

- Optimize anticoagulation
- Recheck free Hgb, slowly through widest and shortest IV
- Check TEG
- Evaluate arterial or patient side of oxygenator as well as tubing
- Evaluate extremity, especially cannulated extremity for compartment syndrome

**Circuit Air Embolism (Veno – Arterial Response)**

**Effects:**
1. Massive air embolus into the pump head will deprime the pump and stop it pumping leading to hemodynamic collapse and hypoxemia of varying severity (depending on underlying cardiac and respiratory reserve)
2. Possible introduction of air embolus into the patient

**Causes:**
- Introduction of air into the circuit via a peripheral cannulation site
- Fracture of connector on the inlet side of the pump (Vent port on arterial cannula or Y connector if on Hi-flow VV).

**Prevention:**
- Only ECMO trained consultants to perform cannula insertion
- Only perfusion and MCS staff to manipulate the inlet side of the pump
- Do not allow connectors to come into contact with alcohol or organic solvent

**Response:**
- Clamp the circuit (anywhere on circuit)
- Switch off pump to prevent further introduction of air into the patient
- Call for help. Contact Perfusionist and ECMO Intensivist
- Assign roles for concurrent patient and circuit management

**Take care of the Patient**
- Position patient head down
- Inotropic support to maintain MAP
- Establish rescue ventilation
- Volume load
- Consider hypothermia to 34°, barbiturates, steroids, mannitol, iv lignocaine, HBO for air embolus

**Circuit Management** (removal of air or circuit exchange by ECMO tech/perfusionint)
Anticoagulation:

HEPARIN PROTOCOL FOR ALL ECMO
(ADHERENCE TO PROTOCOL IS AT THE DISCRETION OF THE ATTENDING)

**General principles:**
- For ECMO patients, elevated INRs should be addressed by primary team.
- When the aPTT is < 95, follow the anti-Xa protocol as ordered in SCM and highlighted below. Do NOT bolus these patients with heparin unless instructed by the CCM attending/CT surgery/HF service/CA1 MD.
- When the aPTT is > 95, refer to the tables below for guidance.

**Patient Examples (full dose protocol):**
- If aPTT is 105 and anti-Xa is 0.85, you would hold the infusion 1 hour and decrease by 3 units/kg/hr and recheck in 6 hours.
- If the aPTT was 130 and the anti-Xa was 1.01, then you would hold the infusion for 2 hours and decrease by 3 units/kg/hr and recheck in 6 hrs.

If the patient has any bleeding, signs of clotting, or device malfunction, for ICU call 330-8753. If you are unsure of the next step, for ICU call CCM attending at 330-8755 for CT Surgery patients and CCU MD for CA1 patients.

### FULL DOSE HEPARIN PROTOCOL:

<table>
<thead>
<tr>
<th>aPTT</th>
<th>Anti-Xa</th>
<th>Hold Infusion</th>
<th>Rate Change</th>
<th>Repeat Labs (anti-Xa + aPTT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;95</td>
<td>&lt;0.2</td>
<td>0</td>
<td>Increase by 2 units/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.2 - 0.29</td>
<td>0</td>
<td>Increase by 1 unit/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.3 - 0.7</td>
<td>0</td>
<td>Decrease by 1 unit/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.71 - 0.8</td>
<td>1 hour</td>
<td>Decrease by 2 units/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&gt;95</td>
<td>(anything &lt;1)</td>
<td>1 hour</td>
<td>THIS IS FOR ECMO PATIENTS IN THE ICU</td>
<td>6 hours</td>
</tr>
<tr>
<td>&gt;95</td>
<td>(anything ≥ 1)</td>
<td>2 hours</td>
<td>When restarting heparin, transition to low-intensity anti-Xa protocol (goal 0.15 - 0.5)</td>
<td>6 hours</td>
</tr>
<tr>
<td>Anytime &gt;200</td>
<td>Anticoagulation &gt;1.10</td>
<td>CALL CCOM for CT or CCU/CA1 Night Coverage for CA1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### LOW DOSE HEPARIN PROTOCOL:

<table>
<thead>
<tr>
<th>aPTT</th>
<th>Anti-Xa</th>
<th>Hold Infusion</th>
<th>Rate Change</th>
<th>Repeat Labs (anti-Xa + aPTT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;95</td>
<td>&lt;0.11</td>
<td>0</td>
<td>Increase by 2 units/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.11 - 0.24</td>
<td>0</td>
<td>Increase by 1 unit/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.25 - 0.5</td>
<td>0</td>
<td>Decrease by 1 unit/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&lt;95</td>
<td>0.51 - 0.7</td>
<td>1 hour</td>
<td>Decrease by 2 units/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>&gt;95</td>
<td>(anything &lt;0.9)</td>
<td>1 hour</td>
<td>THIS IS FOR ECMO PATIENTS IN UNIT</td>
<td>6 hours</td>
</tr>
<tr>
<td>&gt;95</td>
<td>(anything ≥ 0.9)</td>
<td>2 hours</td>
<td>Decrease by 3 units/kg/hr</td>
<td>6 hours</td>
</tr>
<tr>
<td>Anytime &gt;200</td>
<td>Anticoagulation &gt;1.10</td>
<td>CALL CCOM for CT or CCU/CA1 Night Coverage for CA1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please utilize available ECMO order sets:

ECMO

<table>
<thead>
<tr>
<th>Nursing</th>
<th>Order</th>
<th>Date</th>
<th>Priority</th>
<th>Frequency</th>
<th>Special Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIC All Other Heparin Products</td>
<td>04-Aug-2018</td>
<td>Routine</td>
<td></td>
<td></td>
<td>When heparin drop started.</td>
</tr>
<tr>
<td>Assess Sit of Blood</td>
<td>04-Aug-2018</td>
<td>Routine</td>
<td></td>
<td></td>
<td>Notify physician for signs of increased bruising, bleeding gums, blood in urine or stool, bleeding at arterial stick sites and bleeding at surgical sites</td>
</tr>
<tr>
<td>Infusion Rate Adjustment per Protocol</td>
<td>04-Aug-2018</td>
<td>Routine</td>
<td></td>
<td></td>
<td>CHART ALL DOSE ADJUSTMENTS DOUBLE CHECK ANY RATE CHANGES</td>
</tr>
<tr>
<td>Notify Physician For</td>
<td>04-Aug-2018</td>
<td>Routine</td>
<td></td>
<td></td>
<td>Call Physician for Anti Xa greater than or equal to 1 units/ml, or signs and symptoms of bleeding, hematoma or thrombosis NOTIFY MD IF NOT IN THERAPEUTIC RANGE</td>
</tr>
</tbody>
</table>

**Initial Heparin Bolus**

| Initial Heparin Bolus, 1 unit(s) | 8000 units | Intravenous | once | | |

**Heparin Drip**

| Heparin Drip, 1 unit(s) | 1600 units | Intravenous | every 6 hours | | |

**Rebicoll Heparin (4000 units) or 0.4-3 units**

| Rebicoll Heparin (4000 units) or 0.4-3 units | 5000 units | Intravenous | every 6 hours | | |

**Laboratory**

<p>| Start Labs - 2 items | 04-Aug-2018 | STAT | | | |</p>
<table>
<thead>
<tr>
<th>Monitoring - 5 item(s)</th>
<th>Order</th>
<th>Date</th>
<th>Priority</th>
<th>Frequency</th>
<th>Telemetry Frequency</th>
<th>Special Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vital Signs</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td>q1h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Cardiac Monitor</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td>&lt;Continuous&gt;</td>
<td></td>
<td></td>
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<tr>
<td>3. Temperature</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Arterial Line Monitoring</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td>&lt;Continuous&gt;</td>
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<tr>
<td>5. SaO2 Monitoring</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Based on criteria, the Central Monitoring Station (CMS) will determine whether this patient is a candidate for central or remote monitoring.

- With femoral cannulation, SaO2 probe must be on right hand.

- Record flows and pump parameters.

- Blood pressure, HR, saturation, and pressures.

- Monitor and record blood pressure, HR, saturation, and pressure.

- Perform neurological checks.

- Record vital signs.

- Check lower extremity pulses q1h in the presence of femoral cannulation.

<table>
<thead>
<tr>
<th>Checks - 3 item(s)</th>
<th>Order</th>
<th>Date</th>
<th>Priority</th>
<th>Special Instructions</th>
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</thead>
<tbody>
<tr>
<td>1. Intake &amp; Output</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td></td>
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<tr>
<td>2. Weight</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td>daily</td>
</tr>
</tbody>
</table>

- Check upper extremity pulses q1h in the presence of femoral cannulation.

- At least two sets of vital signs q4h.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Order</th>
<th>Date</th>
<th>Priority</th>
<th>Duration</th>
<th>Frequency</th>
<th>Mobility Orders</th>
<th>Weight Bearing Orders</th>
<th>Spinal Precaution Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mobility Orders</td>
<td></td>
<td>22-Aug-2016</td>
<td>Routine</td>
<td>000</td>
<td></td>
<td>&lt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Head of Bed Elevated</td>
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<td>22-Aug-2016</td>
<td>Routine</td>
<td>&lt;30</td>
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<td>3. Turn</td>
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<td>Routine</td>
<td>q1h</td>
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<tr>
<td>4. Open Chest/Offload Pressure Only With ES</td>
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<td>q1h</td>
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<td>5. Knee Extremity Straight</td>
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<td>Routine</td>
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<td>6. Bedrest</td>
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<td>22-Aug-2016</td>
<td>Routine</td>
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