Worcestershire NHS
Acute Hospitals NHS Trust

Use of *venous* extra-corporeal carbon dioxide removal ($ECCO_2R$, Novalung) in the Critical Care Unit

This guidance does not override the individual responsibility of health professionals to make appropriate decision according to the circumstances of the individual patient in consultation with the patient and /or carer. Health care professionals must be prepared to justify any deviation from this guidance.

Introduction

Extra-Corporeal CO_2 Removal ($ECCO_2R$, Novalung) is a device used within the WRH Critical Care Unit to provide extrapulmonary carbon dioxide removal in patients with profound hypercapnic respiratory failure resulting in severe acidosis. This guideline replaces WHAT-CRI-027 (arterio-venous system) and details the use of the venous system.

Title of Guideline

Use of veno-venous extra-corporeal carbon dioxide removal ($ECCO_2R$, Novalung) in the Critical Care Unit

Introduction

The Novalung is a device used within the Critical Care Unit to provide extrapulmonary carbon dioxide removal in patients with profound hypercapnic respiratory failure associated with severe acidosis.
This guideline supports the use of the veno-venous Novalung.

The venous Novalung is a pumped system consisting of an extra corporeal circuit containing a heparin coated membrane connected via venous cannulae. Blood is pumped through the circuit to the membrane where a sweep gas (oxygen) is passed. This allows the diffusion of CO_2 out. Blood is then returned to the patient.
Rate of CO_2 removal is determined by sweep gas flow.
The Novalung provides some oxygenation. Degree of oxygenation is proportional to blood flow through the system.

As the $PaCO_2$ falls, the tidal volume delivered to the patient through the ventilator is gradually reduced, thus facilitating lung protective ventilation.
There is no evidence that the use of $ECCO_2R$ improves patient outcomes. There is good evidence that it significantly reduces $PaCO_2$ and allows the use of ultra-low tidal volume ventilation in patients with the most profound ventilatory failure.
There are also recognised complications in the use of the device. These include those associated with central venous cannulation and systemic heparinisation.

Details of Guideline

1.0 Indications for use:

1.1 Severe hypercapnic ventilatory failure with pH <7.2.

1.2 To facilitate lung protective ventilation (Vt < 6mls/kg, Ppeak < 35cmH_20) in patients with severe respiratory failure and reduced compliance.

1.3 Adjunct to NIV in patients with type 2 respiratory failure (not currently indicated at WAHNHST).

1.4 **The decision to use the Novalung is made jointly by two Consultants in Intensive Care Medicine**

1.5 **If ECMO indicated, patients must be referred to the ECMO centre before considering use of Novalung**

2.0 Contraindications:

2.1 Severe Type 1 respiratory failure – consider referral for ECMO instead (Novalung can be considered if ECMO declined).

2.2 Heparin-Induced thrombocytopenia (HIT).

3.0 Cannula options:

3.1 There are 2 options for venous cannulation:

- Two single lumen cannulae. Access from femoral vein, return to right internal jugular vein. Size in the range of 17 – 21Fr gauge.
- One dual lumen cannula (24Fr gauge) sited in the femoral vein only.

3.2 The preferred option is for two single lumen cannulae. Size selection will depend upon USS assessment of the femoral and jugular vessel, and desired flow dependent on clinical condition.

3.3 Two cannula lengths are available:

- 14cm suitable for jugular return flow (Novaport).
- 38cm suitalbe for IVC (via femoral) drain flow (Maquet).

4.0 Establishing VV-Novalung therapy:

Note – instructions available on machine and user guide available on intranet critical care pages

4.1 Simultaneous cannulation of femoral and jugular vessels and priming / calibration of the circuit is required.

4.2 Personnel required:

- Two ICU consultants to establish venous access (ICM trainee under supervision can be considered).
- One trained Nurse / Doctor to prime circuit (Aseptic technique).
- One Nurse to assist priming.
- One Nurse to assist cannulation.
- One Nurse to continue to monitor patient.

4.3 Cannulation:

- Full Matching Michigan aseptic line insertion technique.
- **Return line:**
- Minimum 17Fr 14cm Novaport line.
- Location: Right Internal Jugular (minimises kinking of line and most direct route back to right atrium).
- If RIJ CVC already in situ, will need re-siting prior to Novalung and infusions established on new line.
- Acceptable to re-wire a recent existing RIJ line.
- If new cannulation then USS guidance is indicated.

- **Drain Line:**
- Line choice dependent on size of patient and desired flow rate.
- Minimum 19Fr 14cm Novaport line (if small patient). This will not reach the IVC and flow might be compromised.
- Ideally 21Fr – 23 Fr 38cm Maquet HLS Cannula to ensure optimal flow.
- USS guidance indicated if new line insertion.
- If using larger (23Fr) lines, then ensure adequate femoral vein caliber by utilising USS measurement of vessel.

4.4 Priming circuit: (Detailed instructions on Novalung machine)

- Aseptic technique. Person priming line needs to be scrubbed with a large aseptic working area (large trolley).
- Equipment required: filter set, priming fluid (1000mls CSL with 1iu/ml heparin in addition).
- Open filter set with membrane uppermost.
- Connect priming giving set to fluid.
- Open de-airing ports on membrane.
- Allow passive filling of circuit.
- Attach 3 way taps to P1, P2 and P3.
- ENSURE ALL CONNECTIONS SECURE.
- Ensure 3 way taps flushed and no air bubbles in circuit.

- Check all tubing for air bubbles. If detected then tap gently to allow them to pass to the de-airing ports.
- Circuit primed when flow from priming fluid stops.
- Attach membrane into holder on console and clip pump chamber onto pump head.
- Ensure pump head is orientated so that the tubing from pump to membrane is vertical. This allows easy passage of any residual air bubbles.
- Attach pressure transducer set to flush line.
- Ensure transducer sets flushed with no air bubbles.
- Connect P1, P2 and P3.
- Attach flow sensor to return limb of circuit – close to patient to ensure accurate monitoring of flow to patient.

4.5 Callibrating circuit:

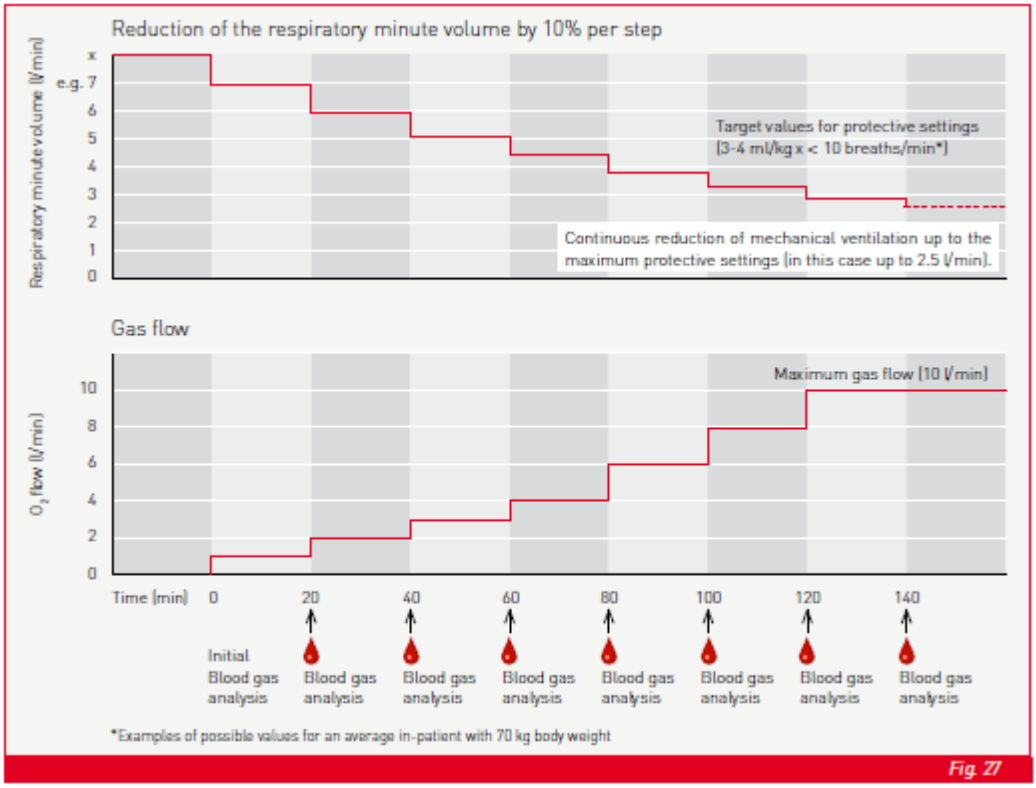
- Turn on console.
- Callibrations required include flow sensor and pressure transducers.
- Follow on screen prompts.
- Keep priming fluid flowing around circuit until ready to attach to cannulae.

4.6 Attaching circuit to cannulae:

- Clamp both cannulae.
- Stop pump and clamp tubing at both ends .
- Snap off U-connector at end of circuit and snap fit the seperated flow and return lines to respective cannulae.
- Ensure minimal air at site of connection by flushing with saline from a bladder syringe as connection made.
- Line up any air with the aspiration ports at site of connection.
- Aspirate any air using blunt access device supplied with line set.
- Examine tubing for any air bubbles.

4.7 Establishing therapy.

- Ensure patient heparinised as per anti-coagulation procedure utilised for CVVH:
  - If not currently anticoagulated then patient will need a bolus of 40iu/kg heparin.
- HEPARIN INFUSION TO BE DELIVERED DIRECT TO PATIENT, NOT VIA CVVH FILTER – this is to minimse the risk of heparin not being delivered if the CVVH filter is down.
- Release clamps on lines and tubing.
- Increase pump speed slowly to aim for initial flow of 200mls/min.
- Observe circuit carefully for signs of air or leak.
- If tollerated then increase pump speed gradually aiming for initial flow of 1L/min.
- Attach oxygen to membrane and start flow at 2 L minute.
  Monitor AGB every 20 minutes initially and increase sweep oxygen flow gradually to a maximum of 10L/min. If oxygen sweep is increased too quickly, the resultant increase in mixed venous oxygen saturation may prevent hypoxic pulmonary vasoconstriction and increase intrapulmonary shunt, thus worsening arterial PaO2.
- Reduce tidal volumes and respiratory rate accordingly as $PaCO_2$ improves – see graph below for an example. Aim for 3mls/kg tidal volume and rate <24.



- Adjust flow as required for oxygenation: Flow rates of 1L/minute adequate for just CO_2 removal. Higher flow rates will allow some oxygenation. Oxygenation is directly proportional to flow rate.
- Maintain PEEP.
- Consider APRV if oxygenation problematic.

4.8 Nursing care

- Ensure clamps are available in bedspace.
- Maintain APTT 2-2.5.
- If flow is <1.5L then it is imperative that APTT is maintained aroudn 2.5 – the lower the flow, the higher the risk of clotting.
- Daily check of cannula sites, 3-way tap conneciton sites.
- Daily re-zero of pressure transducers.
- Re-positioning patient requires additional personnel to ensure lines are not stretched or dislodged.
- Flush membrane every 8 hours by turning up oxygen sweep flow to 15L/min for 10 seconds. This reduces condensation in the membrane.
- Observations to be recorded: Hourly blood flow, P1, P2, P3.
- Active patient warming likely to be required. Monitor core temperature.
- If high access pressures / reduced flow then check cannulae position and adjust.
- If disconnection then immediately clamp drainage and return lines and clamp cannulae with blue clamps.

4.9 Weaning therapy

- Weaning indicated when respiratory parameters are compatable with spontaneous, unassisted ventilation.
- Reduce sweep gas gradually over 24 hours to zero. Monitor CO_2.
- Keep pump running until patient is ready to extubate. This is to allow for a return to $ECCO_2R$ therapy if clinical deterioration.
- Keep heparin running (APTT<2.5) to remove cannulae (reduces risk of DVT).
- Remove lines and apply pressure or suture over line site until haemostasis.

5.0 ELSO registory

5.1 All patients managed with VV $ECCO_2R$ therapy must be recorded on the ELSO registory. (Dr Bhardwaj)