SHORT COMMUNICATION

Minimally Invasive Venovenous Extracorporeal Carbon Dioxide Removal: How I do it?

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Abstract

Extracorporeal carbon dioxide removal ($ECCO_2R$) is a technique used in hypercapnic respiratory failure without much hypoxia. Here we have depicted a simple reproducible method of CO_2 removal using a conventional dialysis machine and oxygenator.

Keywords: Acute respiratory distress syndrome, Chronic obstructive pulmonary disease, Decap, Extracorporeal carbon dioxide removal.

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Hypercapnic respiratory failure is usually managed by non-invasive or invasive ventilation depending on severity. In this communication, we are going to depict a technique for managing hypercapnia by using extracorporeal technology both in chronic obstructive pulmonary disease (COPD) and in adjunct to the ultraprotective ventilation strategy in acute respiratory distress syndrome (ARDS). Extracorporeal carbon dioxide removal ($ECCO_2R$) is a technique of partial respiratory support that achieves the removal of CO_2 from the blood through a low blood flow extracorporeal circuit, without significant effect on blood oxygenation. There are several methods of $ECCO_2R$, such as arteriovenous $ECCO_2R$, venovenous $ECCO_2R$, etc.; among these methods, the venovenous method is mostly popular and has been followed by different systems of CO_2 removal. Because of low flow, the anticoagulation target is kept higher than the conventional extracorporeal membrane oxygenation (ECMO) circuit.

The device of CO_2 removal essentially is a membrane lung (artificial gas exchanger) through which blood is passed. A flowing gas (sweep gas) runs along the other side of the membrane. The sweep gas contains little or no CO_2 (usually oxygen is used), which creates a diffusion gradient, and CO_2 comes out of the blood accordingly. Apart from the sweep gas, CO_2 removal also depends upon the blood flow to the membrane. The steep slope of the CO_2 dissociation curve means that a small variation in PCO_2 causes a significant variation in CO_2 levels in the blood. This helps in removing CO_2 from blood with much lesser blood flow than that needed for oxygenation.

In COPD patients, who are getting admitted recurrently for hypercapnic respiratory failure and the clinicians want to avoid invasive ventilation, an $ECCO_2R$ can be helpful to come down on CO_2 levels. This will help the patient to regain a pH of more than 7.25 and consciousness, thereby avoiding intubation and ventilation and its complications. Many times, even if they are intubated, using $ECCO_2R$ will be helpful in early extubation and avoid ventilation-associated injuries and pneumonia. The venovenous form is more commonly used and considered the conventional form of $ECCO_2R$.[1] Despite its pathophysiological rationale, studies regarding the use of $ECCO_2R$ in this subgroup of hypercapnic patients are still rare.[2] In the supernova study, $ECCO_2R$ in ARDS with ultraprotective ventilation strategy has given an outcome of 62% discharge with a mean duration of 5 days of $ECCO_2R$.[3]

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Decap System of VV-$ECCO_2R$

This system contains a roller pump. In this device, the membrane lung is connected in series to a hemofilter. The advantage of this assembly is as follows:

- Enhance the performance of the extracorporeal device by extracting the carbon dioxide dissolved in the plasmatic water separated by the hemofilter and recirculated through the membrane lung.
- Minimize the need for heparin by diluting the blood entering the membrane lung by recirculating the plasmatic water separated by the hemofilter.
- Increase the pressure inside the membrane lung by adding the downstream resistance given by the hemofilter and therefore reduce the risk of air bubble formation.

We use a modified decap method (Fig. 1) in which a double-lumen venous catheters/cannulas are placed in the right internal jugular or femoral vein and hemodialysis tubing is connected in the dialysis machine (Fig. 2), but instead of hemofilter, only pediatric oxygenator remains in the circuit which allows a low flow system to work efficiently. The roller pump of the dialysis machine (Fig. 3) is used to ensure blood flow. Sweep gas is usually kept between

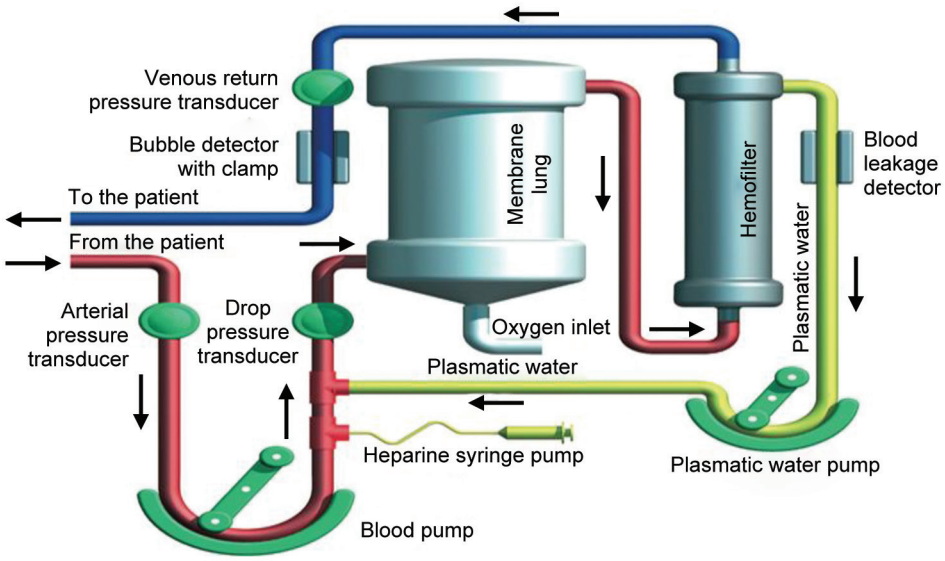

Fig. 1: Modified decap method

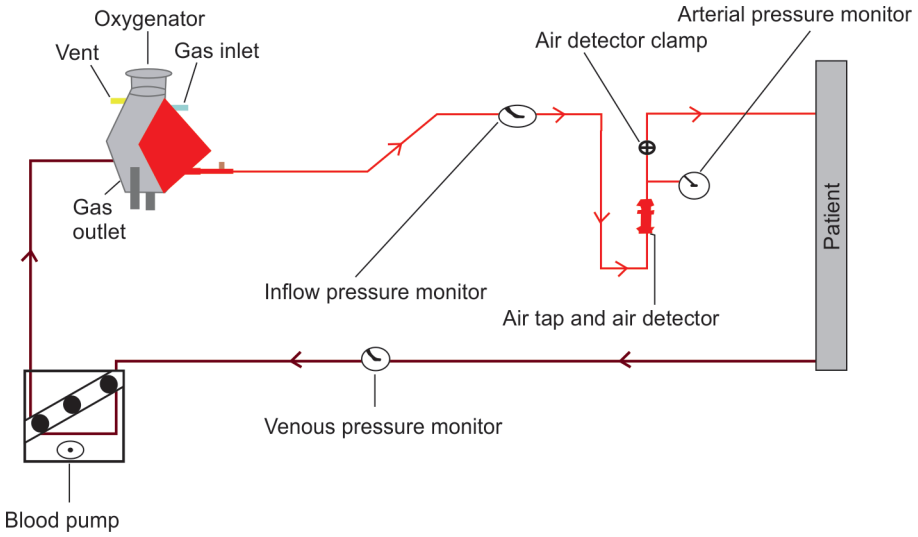

Fig. 2: Schematic representation of dialysis machine

Fig. 3: In-process machine

4 and 8 L/minute. Blood flow is maintained between 300 and 600 mL as the hemodynamics tolerates. The requirement of heparin or other anticoagulation is there to maintain activated partial thromboplastin time (APTT) >2 or activated clotting time (ACT) around 200. This method is less invasive than ECMO and is reproducible at non-ECMO centers without much expertise around.

Fig. 4: Venovenous $ECCO_2R$ is getting practiced in respiratory critical care

Though $ECCO_2R$ has been found beneficial in ARDS with low-tidal volume strategies and acute exacerbations of COPD with type II respiratory failure, large trials are needed to prove its evidence. The modified decap technique is getting popular in different Indian centers due to the low-cost reproducible method. Awake venovenous $ECCO_2R$ is getting practiced in respiratory critical care (Fig. 4) for COPD with recurrent admissions as an adjunct to non-invasive ventilation.

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