ECCO2-R: to use or not to use? A new dilemma for the pulmonologist

by Arjola Ustalli

Living in the era of advanced life support and lifesaving technologies, complex dilemmas about the risk-benefits and economic burden of such innovative devices in respiratory intensive care units, arise between pulmonologists. In this context, from all the available forms of extracorporeal gas exchange, the partial lung support, also known as extracorporeal carbon dioxide removal (ECCO2R) (1), is actually attracting interest as one of the most promising devices.

The ECCO2R concept arises from the extracorporeal membrane oxygenation (ECMO) experience. Kolobow and Gattinoni were the first to introduce extracorporeal circuits with the primary purpose of removing CO2 from the body, without significant effect on blood oxygenation (2). The evolution from ECMO to ECCO2R brought to a reduction of cost in hospital care as it is logistically simpler and does not require dedicated personnel (1).

There are 2 main types of ECCO2R: arteriovenous (AV) and veno-venous (VV) systems. Currently, literature evidence depends on both the type of ECCO2R system and the clinical situation in which it is being used.

It looks like the most recent development in these technologies has been a return to old systems, but modern VV-ECCO2R-s are very different from the veno-venous systems used in the 80s and 90s. For the modern VV setup, a pump is used to maintain a low extracorporeal flow rate using only 20-30% of cardiac output. The configuration of these low-flow VV-ECCO2R systems (LFVV-ECCO$_2$R) is similar to that of a haemofilter, with a double lumen venous cannula connected to the circuit driven by the pump (2). More recently, these new generations of LFVV-ECCO2R devices have progressively gained acceptance and, as published data have demonstrated, they are suitable tools to correct rapidly even severe respiratory acidosis.

Nowadays, there is an increasing number of modern LFVV-ECCO2R systems on the market, each with their own characteristics (1, 2). These new minimally-invasive extracorporeal devices offer unique advantages while carrying a low potential for complications, but because of their clinical and management complexity, there is still a limited number of centres using them.

Beside the best standards of technology in the intensive care units, the introduction of these complex and expensive medical devices always poses challenges for respiratory physicians: use LFVV-ECCO2R or not in a respiratory intensive care unit within a Pulmonology dept.?

The argument is of great interest as these techniques are opening the doors towards a possible replacement of mechanical invasive ventilation through the partial removal of CO2. In intensive respiratory care units, the decision-making process varies with the clinical situation, but most would agree that sometimes there comes a point at which adjunctive intervention to the traditional treatment of non-invasive ventilation (NIV) is required. Current guidelines (NICE guidelines) (3) suggest their use only by specialist intensive care teams trained in its use, and only in patients with potentially reversible acute respiratory failure or patients being considered for lung transplantation.

It is important to emphasize that early treatment of LFVV-ECCO2R can avoid the deterioration of the situation and thus avoid invasive mechanical ventilation or ameliorate the prognosis. For the respiratory physician it is a sort of "CO2 pulmonary Dialysis" in cases of severe hypercapnic acidosis that are refractory to mechanical ventilation. In addition, it can be used where ECMO is not applied because of the rigid criteria in patient selection. The decision to start and when to start this kind of treatment is the great challenge. The rationale behind the use of LFVV-ECCO2R is based on case-reports and very small case-series (2), but results are promising.

The aim of this novel technology is to reduce blood CO2 levels, therefore these newer technologies are well suited to acute reversible hypercapnic respiratory failure, which occurs with highest prevalence in chronic obstructive pulmonary disease (COPD) population (4). These devices own a great potentiality in respiratory high-dependency care units (5) functioning as a short-term 'bridge' in patients with acute on chronic respiratory failure, such as those with COPD exacerbation. They may be able to facilitate a reduction on the work of breathing, can potentially reduce exhaustion, speed up NIV weaning, consequently reduce the risk of mortality related to ventilator acquired pneumonia, reduce patients stay in intensive care settings and ultimately impact positively on COPD patients survival (3). LFVV-ECCO2R use is showing to reduce intubation in patients with COPD exacerbation at risk of NIV failure.

Several studies report their use in other clinical scenarios: as a bridge to transplant; in combined head and chest injury; in near fatal asthma; as an aid to weaning from mechanical ventilation; to facilitate thoracic surgery. Emerging data regarding less severe ARDS patients, reveal its efficacy on the control of hypercapnia induced by 'ultra protective' mechanical ventilation strategy to reduce Ventilator-Induce Lung Injury (VILI) (2). Moreover, knowing the deleterious effects of acute pulmonary hypertension in patients with respiratory failure, interesting studies are capturing our attention regarding their effects on the right heart function (6). A case series study showed that initiating LFVV- ECCO2R in patients with severe COPD exacerbation, already treated with invasive mechanical ventilation, has not only the potential to rapidly correct respiratory acidosis by lowering high $PaCO_2$ values but also to reduce elevated mean PAP values significantly (7).

The risks of LFVV- ECCO2R with the newer technologies are reduced compared to ECMO by eliminating the possibility of complications related to arterial connections. These risks must be acknowledged and weighed against the benefits of avoiding intubation (3). The latest generation of these devices are more efficient, more biocompatible, associated with fewer haemorrhagic complications as they require less anticoagulation and do not need for anaesthesia. Other promising solution oriented toward better technological features, major improvements in anticoagulation protocols and updates to clinical practice guidelines are expected in the future (1, 2). Educational programmes will be necessary in the future, in order to reduce asymmetry between increasing technological progress and respiratory physicians' knowledge. The low flow VV extracorporeal CO2 removal devices are one of the greatest challenge of the modern technological respiratory medicine as they are part of the various lung support devices armamentarium in a well-resourced and trained respiratory intensive care setting.

References

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