

# Venovenous ECMO in a teaching hospital

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## Introduction

Over recent years, the use of extracorporeal membrane oxygenation (ECMO) has increased in the adult intensive care both worldwide and in the Netherlands. Due to technological improvements in ECMO machines and catheters, this type of support is not only accessible for university hospitals, but also for intensive care units (ICUs) of large non-university hospitals. This is especially true for the use of ECMO in the support of severe acute respiratory failure. At the moment, evidence for this type of ECMO is weak and the Netherlands does not yet have a national ECMO organisation and guideline. Nationally and internationally, increased use of ECMO outside university hospitals leads to an ongoing debate:<sup>1-3</sup> is it justified to use this relatively new technique for critically ill patients in an ICU of a large teaching hospital?

## Types of ECMO

A basic ECMO circuit is composed of a blood pump, a membrane lung, cannulas and tubing.

Depending on the patient's needs, partial to complete cardiopulmonary support (venoarterial-ECMO, vaECMO) or partial to complete pulmonary support (venovenous-ECMO, vvECMO) can be achieved.<sup>2</sup> For use of vaECMO in the ICU, backup of cardiothoracic expertise is mandatory.

In a typical vvECMO circuit, venous blood is drained out of a major vein, passed through a pump and a membrane lung for gas exchange. Decarboxylated and oxygenated blood is then returned to a major vein. By variation of blood flow, the extent of pulmonary support by vvECMO can be regulated. Using a low-flow pump the respiratory system is only partially supported by effectively removing carbon dioxide without significant oxygenation (extracorporeal CO<sub>2</sub> removal). With a high-flow pump (almost) complete pulmonary support can be achieved. Higher blood flow is more often associated with unfavourable side effects.<sup>2</sup> Because of technological innovations, vvECMO can be used in a setting independent of cardiothoracic expertise.

Most cannulas are placed echo-guided in the ICU using the Seldinger technique.

## Evidence for vvECMO

Mechanical ventilation can cause lung injury (ventilator-induced lung injury, VILI). Various strategies have been used to minimise VILI: low tidal volumes, higher positive end-expiratory pressures (PEEP) and recruitment manoeuvres.<sup>4</sup> Additionally, patients with acute respiratory distress syndrome (ARDS) and severe hypoxaemia benefit from a prone position by increasing homogeneity of ventilation and short-term neuromuscular blockade reduces barotrauma in early ARDS.<sup>5,6</sup> In some patients these strategies are insufficient to ensure lung protective ventilation. A part of the gas exchange could be taken over by vvECMO: tidal volumes and respiratory frequency could be reduced decreasing the risk of VILI (ultra-protective ventilation). After the recent H1N1 pandemic, vvECMO regained interest accompanying new indications besides ARDS.<sup>7</sup> As published by Zampieri et al., various robust studies investigating the effectiveness of vvECMO in ARDS had conflicting results.<sup>8</sup> Besides, multiple case reports published in recent years reported a reduction in observed mortality compared with predicted mortality. The strongest evidence for the effectiveness of vvECMO comes from the CESAR trial; however, this randomised trial is widely criticised because of its methodological shortcomings.<sup>7,9</sup>

Thus, available data are weak and more studies are needed. Hopefully, the multicentre international EOLIA trial will clarify the role of vvECMO in patients with severe ARDS. Another trial, the SUPERNOVA trial, is designed to evaluate the role of the latest generation of extracorporeal CO<sub>2</sub>-removal devices in patients with moderate ARDS.<sup>7</sup> If proven effective, uniform guidelines regarding the organisation and the use of vvECMO should be developed and implemented. That will be the moment to decide which hospitals are eligible for offering ECMO care.

### If vvECMO is proven effective

Several arguments support the use of vvECMO in ICUs of larger non-university hospitals, assuming safety measures are adequate. Critically ill patients eligible for vvECMO might be present in both larger teaching hospitals and in university hospitals. Possibly the number of patients will even be comparable. Thus, as a rescue treatment, vvECMO support is desirable for these patients.

The condition of a critically ill patient can deteriorate fairly quickly, without enough time for a proper consultation and transfer to a university hospital. If transfer is possible at all, this will expose a critically ill patient to an increased risk, despite the fact that medical ICU transport is considered to be relatively safe.<sup>10</sup> After stabilising the patient's condition and if necessary expertise is not available, transfer to a university hospital could always be an option.

Besides ARDS, severe status asthmaticus and severe air leak syndromes are also indicated for vvECMO support by the Extracorporeal Life Support Organisation (ELSO).<sup>11</sup> Both conditions could be life-threatening requiring quick treatment and could also be present in a non-university hospital with a large cohort of lung patients. With optimal treatment status asthmaticus will often be of short duration. However, in the early phase, lung protective ventilation is difficult to achieve as (extremely) high inspiratory pressures are needed. In this phase, vvECMO support could be a bridge to recovery and prevent VILI.<sup>12,13</sup> Possibly, bridging of a severe acute exacerbation of chronic obstructive lung disease is an indication as well.<sup>2</sup> Severe air leak syndrome is caused by thoracic trauma, barotrauma (possibly in combination with ARDS) or complicated lung surgery (bronchopleural fistula or damage to lung parenchyma). Despite optimal drainage, this syndrome could lead to complicated mechanical ventilation. By reducing intrapulmonary pressures on vvECMO support, air leakage could be minimised awaiting spontaneous recovery or definite treatment.<sup>14</sup>

When vvECMO is indicated because of a complication encountered in the ICU or after (thoracic) surgery, it is desirable to manage the complication in the same hospital. This will prevent inevitable loss of (vital) medical information and loss of contact of relatives with the treating medical team, when the patient is transferred to another hospital.

### Future perspectives

If proven effective as a rescue treatment in severe ARDS, use of vvECMO will probably expand even more. It may be justified in an earlier phase of ARDS or exacerbation of obstructive pulmonary disease.<sup>15</sup> Possibly, patients with less severe ARDS in combination with acute kidney injury may benefit from low-flow CO<sub>2</sub> removal integrated into a renal-replacement circuit.<sup>16,17</sup> In case of a new pandemic (similar to the H1N1 pandemic in 2009), there will be an appeal to ECMO centres. With these

future perspectives, the availability of vvECMO in a number of large non-university hospitals might be needed to guarantee sufficient capacity. When there is enough experience with vvECMO in a large non-university hospital, vaECMO might be used in a selected group of circulatory unstable cardiac patients in need of coronary bypass surgery. After consultation with a heart surgeon and while waiting for a specialised medical ICU, the patient could be cannulated while awaiting transportation to a centre.<sup>18</sup>

### General requirements

Without doubt, an ECMO centre has to fulfil a large list of basic requirements to guarantee safe and adequate care. The ELSO has published general guidelines and in a recent position paper an international group with ECMO expertise gave their opinion about the optimal approach to organise ECMO programs for acute respiratory failure in adult patients.<sup>3,11</sup> According to these guidelines and position paper there is no clear difference between vvECMO and vaECMO regarding required expertise. While providing vaECMO support, cardiothoracic expertise is mandatory. This expertise is not always needed for vvECMO support (depending on the level of blood flow and type of cannulation).

Because of cerebrovascular bleeding as a possible complication of vvECMO, neurosurgical expertise is advised. However, neurosurgical intervention with limited therapeutic options is probably not realistic in a critically ill patient when on ECMO support.

Except for cardiothoracic and neurosurgical expertise, most large teaching hospitals fulfil all the basic requirements. Still, this is not a guarantee for delivering safe and adequate care. The ICU must have an enthusiastic, ambitious and flexible team, willing to cooperate with frequent theoretical education and hands-on training. In addition, participation in a network of ECMO centres facilitates inter-collegial consultation, education, research, registration and updating protocols.

### Conclusion

If proven effective in patients with severe respiratory failure, several arguments support the use of vvECMO in an ICU of a non-university hospital. Without doubt, an ECMO centre has to fulfil a large list of basic requirements to guarantee safe and adequate care.

### Disclosure

The author declares no conflict of interest.

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