

## CASE REPORT

# The use of venovenous extracorporeal membrane oxygenation outside a centre of expertise: a case report

D. van Osch<sup>1</sup>, F.W. Rozendaal<sup>1</sup>, K.C. Bokhoven<sup>2</sup>, J. Polad<sup>3</sup>, D. Reis Miranda<sup>2</sup>, F.N. Polderman<sup>1</sup>

<sup>1</sup>Department of Intensive Care and <sup>3</sup>Department of Cardiology, Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands

<sup>2</sup>Department of Intensive Care, Erasmus MC, University Medical Centre Rotterdam, Rotterdam, the Netherlands

## Correspondence

F.N. Polderman - f.polderman@jzbz.nl

**Keywords** - venovenous extracorporeal membrane oxygenation, therapy refractory respiratory failure, case report

## Abstract

The use of venovenous extracorporeal membrane oxygenation (V-V ECMO) in adult patients with acute severe but potentially reversible respiratory failure remains controversial and it is recommended that V-V ECMO is restricted to a small number of specialised centres. We present a case in which initiating V-V ECMO in a large teaching hospital, complemented with mechanical circulatory support using an Impella® device, was lifesaving in a 55-year-old man with severe respiratory failure secondary to massive gastric aspiration and cardiogenic shock following cardiac arrest. V-V ECMO may be lifesaving in some well-selected patients with life-threatening hypoxaemia, even if the hypoxaemia is of combined cardiac and pulmonary origin. For additional circulatory support, Impella® might be a better choice than veno-arterial ECMO, because of avoiding an increase in left atrial pressure. In a rapidly deteriorating patient it may be necessary to initiate V-V ECMO immediately, outside an ECMO centre of expertise. In such situations, it is of paramount importance to have a close collaboration with an ECMO centre of expertise.

## Introduction

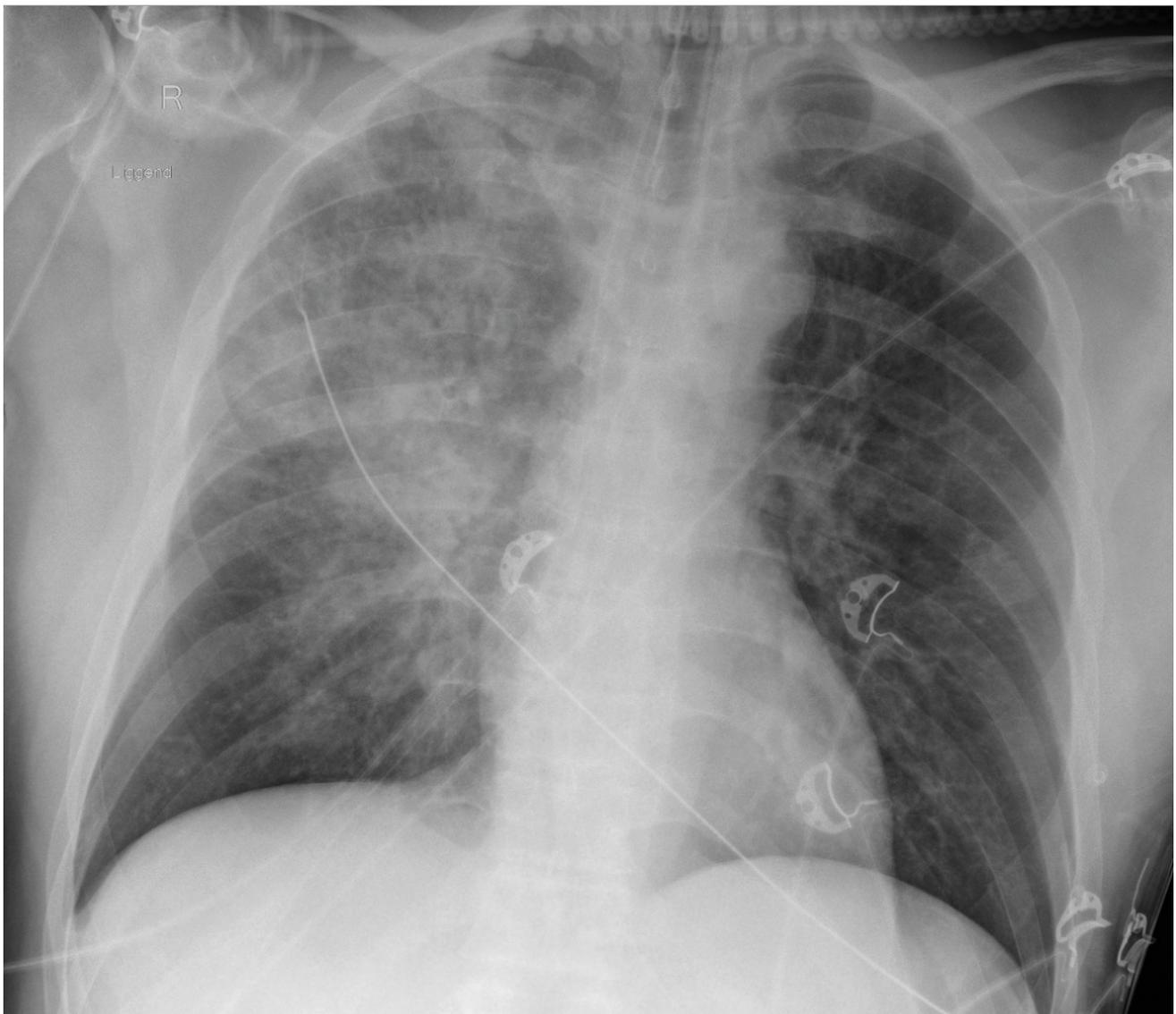
Over the last decade, the use of venovenous extracorporeal membrane oxygenation (V-V ECMO) in patients with refractory respiratory failure has been rapidly increasing worldwide. In 2015, 2046 extracorporeal life support (ECLS) runs for adult respiratory failure were reported to the Extracorporeal Life Support Organization (ELSO) compared with approximately 500 runs in 2009.<sup>[1]</sup> It is likely that this number is even higher because not all ECLS runs are reported to the ELSO. For example, in 2014, 1944 patients received V-V ECMO in Germany alone.<sup>[2]</sup> There are several reasons for this increase. First, technological advances have made ECMO more

accessible and have reduced the rate of complications.<sup>[3]</sup> Second, there is growing evidence supporting the use of V-V ECMO as rescue intervention in refractory respiratory failure.<sup>[4,5]</sup> However, its use remains controversial due to important methodological shortcomings of prior studies.<sup>[6]</sup> The recently published ECMO to Rescue Lung Injury in Severe ARDS (EOLIA) trial was designed to address these methodological shortcomings. The trial showed no significant difference in mortality between the V-V ECMO and the control group, 35% versus 46% respectively (relative risk 0.76;  $p=0.09$ ).<sup>[7]</sup> Of note is that 28% of the control group, consisting of identifiably sicker patients, crossed over to the ECMO group, which may have diluted the potential effect of V-V ECMO. Initiation of V-V ECMO may be useful in some well-selected patients to treat life-threatening hypoxaemia if conventional interventions (optimal ventilation strategy, prone positioning and paralysis) fail. However, no definitive conclusions can be drawn regarding the benefits of V-V ECMO in severe ARDS.<sup>[8]</sup> Until high-quality evidence supporting the use of V-V ECMO in severe respiratory failure is published, the ELSO encourages a great deal of restraint when applying this new technique. Furthermore, the ELSO recommends its use only in ECLS centres, because of an improved outcome in more experienced centres.<sup>[9]</sup> The Dutch Society of Intensive Care (NVIC) has defined two types of ECLS centres dealing with V-V ECMO (ECLS centre and ECLS centre of expertise) on the basis of the total number of ECLS runs.<sup>[10]</sup> However, there may be reasons why large teaching hospitals should perhaps gain experience with V-V ECMO in an emergency situation.<sup>[11]</sup> For example, there may not be enough time for referral and retrieval in a rapidly deteriorating patient. In this article we describe a case illustrating this problem and the benefits of the close collaboration with other ECMO centres.

### Case

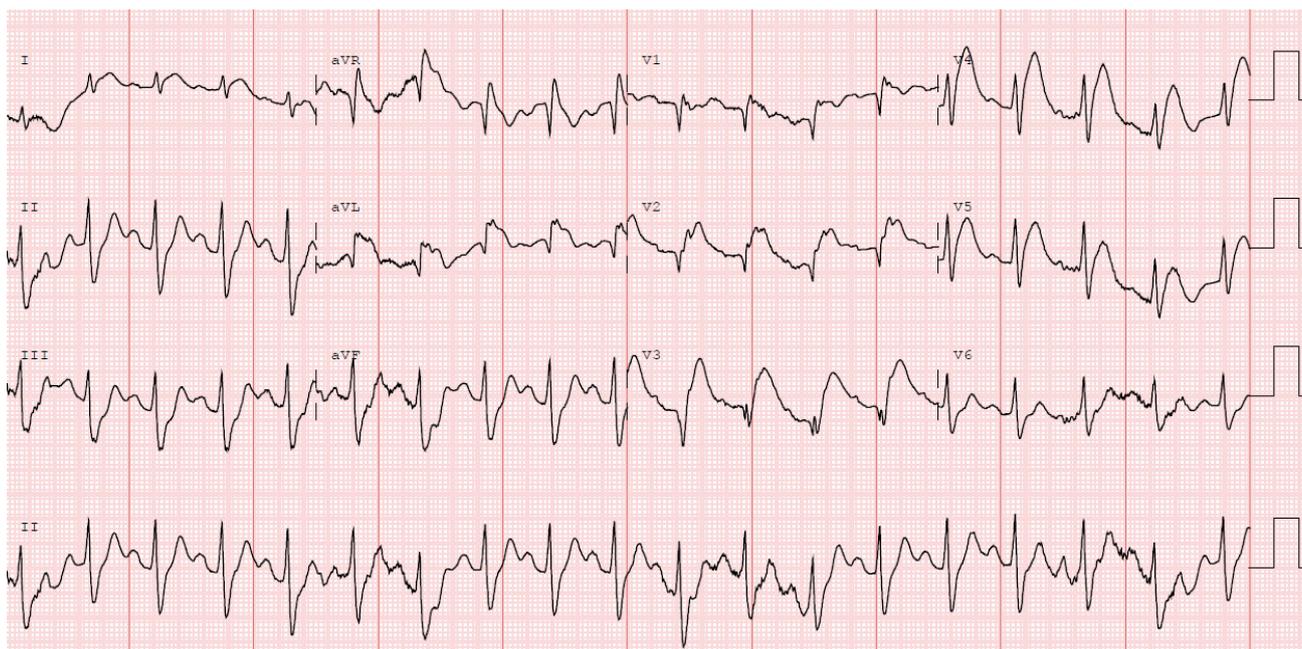
A 55-year old man with an unremarkable medical history suffered a witnessed cardiac arrest while playing tennis. Bystanders initiated cardiopulmonary resuscitation (CPR) immediately and an automated external defibrillator that was present at the tennis club was connected within minutes and delivered three shocks. When the ambulance arrived the patient had sinus rhythm with output and was breathing spontaneously, however was unconscious. The ambulance staff probably concluded that a quick transportation to the hospital nearby outweighed the risks of waiting for the Mobile Medical Team to secure the airway. During transport to the hospital the patient suffered from massive gastric aspiration and was hypoxaemic with a non-rebreather mask (pO<sub>2</sub> 9.2 kPa) on arrival to the emergency department. The relevant laboratory results are presented in

*table 1*. The patient was intubated directly and a chest X-ray showed extensive consolidation in the right lung secondary to the aspiration (*figure 1*) for which he received antimicrobial therapy. Because of anterolateral ST-segment elevation on the ECG (*figure 2*) the patient received antithrombotic therapy and was transferred to the catheterisation room for an urgent percutaneous coronary intervention (PCI). During catheterisation the patient became progressively more hypoxaemic (pO<sub>2</sub> 5.8 kPa) despite optimal ventilatory management (FiO<sub>2</sub> 100%, PEEP 14 mmH<sub>2</sub>O, I:E ratio 1:1 and paralysis). The most likely cause of this respiratory failure was chemical pneumonitis due to massive aspiration. Cardiogenic pulmonary oedema was considered, however the patient was haemodynamically stable, there was no bloodstained frothy sputum and chest X-ray showed massive unilateral consolidation



**Figure 1.** Chest X-ray

Chest X-ray showing extensive consolidation in the right lung secondary to aspiration



**Figure 2.** Electrocardiography

Electrocardiography showing a ST-segment elevation myocardial infarction of the anterolateral wall

in the upper right lobe, normal perihilar vasculature and no sign of cardiogenic pulmonary oedema in the left lung. Prone position ventilation was considered but was postponed until after the PCI, because a PCI would not have been possible in the prone position. Coronary angiography showed an occluded left anterior descending artery which was successfully treated. Afterwards, the patient was transferred to the intensive care unit (ICU) where prone position ventilation was initiated; however, this only temporarily improved oxygenation (pO<sub>2</sub> 8.2 kPa). In addition, arterial blood gas analysis showed a severe respiratory acidosis (pH 6.88, pCO<sub>2</sub> 16.8 kPa, bicarbonate 23 mmol/l). Subsequent bronchoscopy showed no airway obstruction. Just before turning the patient into the prone position, chest X-ray showed worsening of the right-sided consolidations without any signs of cardiogenic pulmonary oedema in the left lung, explaining increased hypoxaemia due to pulmonary shunting. Because of acute severe but potentially reversible respiratory failure refractory to conventional ventilation strategies, V-V ECMO was considered. At that time, there were no signs of cardiogenic shock (systolic blood pressure >100 mmHg without vasopressors and inotropy, adequate urine output and a decreasing lactate level). Therefore, there was no indication for mechanical circulatory support. At that point no echocardiography was performed. The predicted neurological outcome was considered to be good given the fact that it had been a witnessed cardiac arrest, bystander CPR had been initiated promptly and the first shock had been delivered early. Given these considerations and rapid clinical deterioration, it was decided to initiate V-V ECMO. Shortly after turning the

patient into the supine position the jugular and femoral veins were cannulated easily. The oxygenation worsened during cannulation and at the end of the procedure (before initiating extracorporeal flow) the patient developed bradycardia and hypotension, which was partially corrected with fluid resuscitation, norepinephrine and epinephrine. Shortly after initiating V-V ECMO the patient's oxygenation improved. The ventilator settings could be reduced substantially. However, shortly afterwards, the patient developed cardiogenic shock for which high-dose inotropic therapy was started. ECG showed no signs of stent thrombosis, with resolution of the prior ST-segment elevations. Echocardiography demonstrated an overall poor left ventricular function with anterolateral akinesia. The cardiogenic shock probably had a multifactorial aetiology: myocardial ischaemia, myocardial stunning secondary to prolonged acidosis, sedation and possibly a systemic inflammatory response syndrome secondary to V-V ECMO. Given the combination of respiratory and circulatory failure, the patient was transferred to a tertiary hospital, because of the potential need for veno-arterial ECMO (V-A ECMO). However, V-A ECMO was not initiated because it increases left ventricular afterload due to retrograde infusion in the aorta, potentially worsening left ventricular function. Because myocardial stunning was assumed to be the main cause of the cardiogenic shock, an Impella CP® was inserted with an initial flow of 1.7 l/min (and a maximum of 3 l/min). In expectation of recovery from myocardial stunning, V-V ECMO was left in place for respiratory support. Repeat angiography showed a possible dissection proximal from the stent, which was

**Table 1.** Laboratory results

| Venous blood sample | T=0h  | T= +1.5h | T= +2.5h | T=+3.5h | T= +6.5h* | T= +7h | T= +8h | Reference value |
|---------------------|-------|----------|----------|---------|-----------|--------|--------|-----------------|
| Creatinine (µmol/l) | 107   |          | 124      |         |           |        | 150    | 64-104          |
| eGFR (ml/min)       | 67    |          | 56       |         |           |        | 45     | >90             |
| CK (U/l)            | 188   |          |          |         |           |        | 2098   | 0-170           |
| Troponin-I (µg/l)   | 0.064 |          |          |         |           |        | >25    | 0.0-0.045       |

| Arterial blood gas                     | T=0h  | T= +1.5h | T= +2.5h | T=+3.5h | T= +6.5h* | T= +7h | T= +8h | Reference value |
|--|-------|----------|----------|---------|-----------|--------|--------|-----------------|
| pH                                     | 6.95  | 6.94     | 6.88     | 6.91    | 7.05      | 7.16   | 7.18   | 7.35-7.45       |
| pCO <sub>2</sub> (kPa)                 | 13.4  | 15.8     | 16.8     | 15.9    | 8.1       | 6.0    | 6.5    | 4.7-6.4         |
| pO <sub>2</sub> (kPa)                  | 9.2   | 5.8      | 8.2      | 8.0     | 20.4      | 14.9   | 11.0   | 11.0-14.4       |
| HCO <sub>3</sub> <sup>-</sup> (mmol/l) | 22    | 25       | 23       | 23      | 16        | 16     | 18     | 22-29           |
| Base excess (mmol/l)                   | -12.8 | -10.5    | -13.9    | -13.2   | -14.5     | -12.8  | -10.6  | -3-3            |
| SaO <sub>2</sub> (%)                   | 81    | 56       | 74       | 76      | 98        | 98     | 95     | 94-98           |
| Lactate (mmol/l)                       | 5.5   | -        | 3.8      | -       | -         | 5.4    | 4.6    | 0.7-2.1         |

T=0 indicates the laboratory tests that were taken upon arrival to the emergency department

\*The blood sample at T=+6.5 h was drawn after venovenous extracorporeal membrane oxygenation was initiated

CK = creatine kinase; eGFR = estimated glomerular filtration rate

successfully treated with a new stent. The dissection was considered unlikely to be the cause of the cardiogenic shock given the TIMI 3 flow. With the support of the Impella CP<sup>®</sup>, his left ventricular function improved and the Impella CP<sup>®</sup> could be removed. A repeat chest X-ray showed resolution of the previous abnormalities and the patient could be weaned off V-V ECMO. The maximal value of creatine kinase muscle-brain was 602 µg/l. After four days, the patient was transferred back to the intensive care unit of our hospital. The inotropes were tapered and stopped and he was extubated. Fifteen days after his cardiac arrest he was discharged to the cardiology ward and 20 days later he was discharged from hospital to a rehabilitation centre. At discharge, he was still recovering from ICU-acquired weakness but was able to walk unassisted and had no loss of motor function. Six months later he was seen in the outpatient clinic. He was playing tennis again without any problems and reported no residual symptoms. Echocardiography showed a normal left ventricular ejection fraction.

## Discussion

This article describes the successful initiation of V-V ECMO outside a centre of expertise in a 55-year-old man with severe respiratory failure refractory to conventional ventilation strategies. This case illustrates that V-V ECMO is a potentially lifesaving treatment in well-selected patients with acute severe but potentially reversible respiratory failure. However, the benefits of the routine use of V-V ECMO in patients with refractory respiratory failure remain controversial. This case also illustrates that there is not always time for referral for ECMO and retrieval

by an ECMO team in a rapidly deteriorating patient. It was felt that, in this case, initiation of V-V ECMO should not have been delayed in view of the inability to achieve adequate oxygenation causing bradycardia and hypotension, despite optimal mechanical ventilation and 100% inspired oxygen. Furthermore, this case shows that in cardiogenic shock complicated by life-threatening hypoxaemia, V-V ECMO might also be a life-saving option in selected cases. In this case, pulmonary oedema due to cardiogenic shock in combination with massive gastric aspiration was the reason for the life-threatening hypoxaemia. Although the main cause of the hypoxaemia was probably of combined cardiac and pulmonary origin, emergent restoration of oxygenation by V-V ECMO was life-saving. The other possibility would have been to insert a V-A ECMO; however, we think a V-A ECMO would have increased the left ventricular afterload and thereby left atrial pressure, aggravating the pulmonary oedema.<sup>[12]</sup> In this case, an Impella CP<sup>®</sup> device did seem to restore tissue perfusion, while decreasing left atrial pressure which led to rapid restoration of gas exchange within a few days. A disadvantage of additional use of an Impella CP<sup>®</sup> besides V-V ECMO is the higher expense of this set-up. Furthermore, currently there is no evidence showing benefit of an Impella CP<sup>®</sup> versus V-A ECMO.<sup>[13]</sup> Before initiation of V-V ECMO in this patient, there were two important considerations. First, the neurological outcome was presumed to be good. Second, initially there were no signs of left ventricular or biventricular failure. At presentation and just before turning the patient into the prone position, our patient was haemodynamically stable without vasopressors and inotropy. There was no bloodstained frothy sputum and subsequent chest X-ray showed progressive massive

unilateral consolidation in the right lung, without any signs of cardiogenic pulmonary oedema in the left lung. We concluded there was no indication for mechanical circulatory support. Retrospectively, we should have performed an echocardiography to confirm our clinical thoughts, as this is considered mandatory before institution of V-V ECMO. Severe respiratory failure is sometimes accompanied by right ventricular failure, for example in 10-25% of patients with ARDS. Recent data have shown that initiation of V-V ECMO in patients with isolated right ventricular failure improves right ventricular function by normalising the pO<sub>2</sub>, pCO<sub>2</sub> and pH. Therefore, V-V ECMO can be safely chosen as initial strategy in patients with right ventricular failure.<sup>[14]</sup> Our patient developed cardiogenic shock after initiation of V-V ECMO and was therefore transferred to an ECMO centre of expertise, where he received temporary additional support with an Impella CP®. This underlines the importance of having a close relation with an ECMO centre of expertise that can be consulted without hesitation and is willing to retrieve a patient when necessary. Naturally, large teaching hospitals offering V-V ECMO have to fulfil certain conditions to guarantee safe and adequate care. Close collaboration with established ECMO centres and other disciplines specialised in ECMO (for example pulmonology, interventional radiology, surgery) is of paramount importance to deliver safe care as well as having an ambitious and flexible team of nurses and intensivists, willing to participate in frequent hands-on skills training sessions and attend lectures.<sup>[9]</sup> The ICU where the patient first presented is part of a large teaching hospital. In 2011 extracorporeal CO<sub>2</sub> removal and V-V ECMO were introduced in a selected group of patients in the ICU. Since 2012, the average number of ECMO runs was 3 each year. We agree that this low average number conflicts with the national guideline, which recommends ≥6 V-V ECMO runs/year.<sup>[10]</sup> However, an emergency situation as described in this case report, justified initiation of V-V ECMO outside an ECMO centre of expertise. While acknowledging our limitations, close collaboration with established ECMO centres and other disciplines in the hospital, as well as extensive team training, have enabled us to provide safe ECMO care. All ECMO-related data are registered in an international database. Without doubt, our centre will need enough exposure to maintain its expertise in delivering safe and adequate V-V ECMO care.

## Conclusion

This case illustrates that V-V ECMO might be useful in some well-selected patients to treat life-threatening hypoxaemia, even if the hypoxaemia is of combined cardiac and pulmonary origin. In these patients, circulation can secondarily be supported by Impella®. In a rapidly deteriorating patient it may be necessary to initiate V-V ECMO immediately, outside an ECMO centre of expertise. Having a close collaboration with an ECMO centre of expertise is of paramount importance here.

## Disclosures

All authors declare no conflict of interest. No funding or financial support was received.

The patient described in this case report provided written informed consent to publish this case report.

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