


# Veno-arterial extracorporeal membrane oxygenation support for severe cardiac failure in a pediatric patient with intracranial hemorrhage after spontaneous aneurysmatic rupture

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## Abstract

*Introduction:* Extracorporeal life support in adult patients with extended intracranial hemorrhage is controversial. In pediatric patients, it has traditionally been considered a contraindication as systemic anticoagulation may worsen the hemorrhage and neurological outcome.

*Case history:* We present a nine-year-old female patient who was admitted with extended intracranial hemorrhage after spontaneous rupture of an aneurysm. On day four after the emergency craniotomy, she required veno-arterial extracorporeal membrane oxygenation for septic shock. Using an adapted anticoagulation protocol aimed at lower activated partial thromboplastin time target values, we did not observe any new bleeding or clotting complications during systemic anticoagulation and the patient had good neurological recovery.

*Conclusion:* Extracorporeal life support with low dose systemic anticoagulation can be considered as a treatment option in pediatric patients after craniotomy for intracranial aneurysmatic hemorrhage.

## Keywords

extracorporeal membrane oxygenation; ECMO; intracranial bleed

## Introduction

Intracranial hemorrhage after the rupture of cerebral aneurysms in pediatric patients is rare and bears less than 2% of the overall mortality.<sup>1</sup>

Cardiovascular complications often occur in the early phase after spontaneous aneurysmatic rupture.<sup>2</sup> Even though extracorporeal life support (ECLS) is well-established in patients suffering from acute catecholamine refractory myocardial failure, it is traditionally considered contraindicated in pediatric patients with extended intracranial hemorrhage.<sup>3</sup>

We present the case of a nine-year-old female patient who suffered a spontaneous intracranial hemorrhage after aneurysmatic rupture, with the necessity of veno-arterial extracorporeal membrane oxygenation (V-A ECMO) support to treat sepsis-induced cardiac failure.

Informed consent was obtained from the parents for publication of this report, including the accompanying images.

## Case History

This previously healthy nine-year-old girl with spontaneous out-of-hospital collapse, a Glasgow Coma Score of 3 and a fixed and dilated right pupil was intubated for airway protection at the scene. Cranial computed tomography revealed an extended right-sided fronto-temporal and subarachnoid hemorrhage coterminous to a middle cerebral artery (MCA)- communicating giant aneurysm (Figure 1). The hematoma was evacuated and the aneurysm clipped by the neurosurgeon,

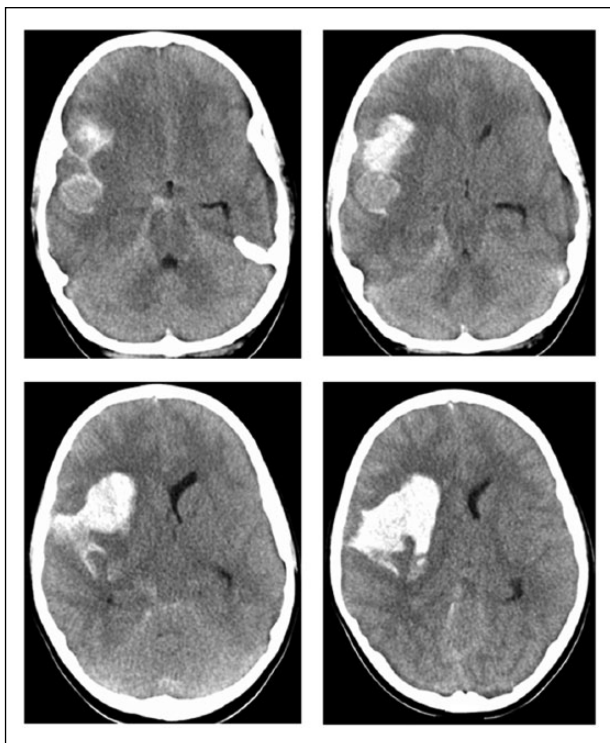
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**Figure 1.** Cranial computer tomography scan upon admission to our hospital: extended right-sided fronto-temporal hemorrhage co-terminous to a middle cerebral artery-communicating giant aneurysm.

but immediate postoperative angiography showed a territorial stroke due to loss of MCA perfusion distal to the clips. The patient was admitted to the pediatric intensive care unit for further monitoring and treatment. She had an otherwise uncomplicated early postoperative course under standard neuroprotective therapy, consisting of a cerebral perfusion pressure above 60 mmHg, strict normothermia, a partial pressure of arterial carbon dioxide ( $\text{PaCO}_2$ ) of 33 to 37 mmHg and osmotherapy with hyperosmolar sodium chloride. On day 4 after the craniotomy, she became septic, with a full systemic inflammatory response syndrome score, a maximum procalcitonin level of 21.4 ng/ml and a growth of *Staphylococcus aureus* in the blood culture treated with vancomycin. Sepsis-induced myocardial dysfunction with arrhythmias and poor biventricular contractility led to a catecholamine refractory shock. Due to rapid deterioration and inadequate cerebral perfusion pressure (CPP), the decision for the initiation of V-A ECMO support was made. Central cannulation ensued; a 14 Fr arterial cannula was placed into the ascending aorta and a 24 Fr venous cannula into the right atrium. The central site for cannulation was chosen to provide the best flow to the injured head without impairing the cerebral venous drainage. The ECMO set-up consisted of a 3/8" hepa-

rin-coated circuit and a Quadrox Ped BE 3000 oxygenator with a Rotaflow centrifugal pump (Maquet, Hirrlingen, Germany). The system's total priming volume was 500 ml; no heparin was given to the patient or into the circuit at ECMO initiation. Further anticoagulation was maintained using a heparin infusion, titrated to an activated partial thromboplastin time (aPTT) of 45-55 seconds. The median aPTT was 45 (34-55) seconds with a mean heparin dose of 13 units per kg bodyweight per hour for the ECMO run. As per routine, the central venous saturation ( $\text{CvO}_2$ ) was maintained above 60%, the regional cerebral oxygen saturation ( $\text{rSO}_2$ ) measured by near-infrared spectroscopy (NIRS) above 60% and the partial pressure of arterial oxygen ( $\text{PaO}_2$ ) was kept above 95 mmHg. The arrhythmias were treated with an amiodarone infusion and overridden with atrio-ventricular sequential pacing. With an initial V-A ECMO blood flow rate of 2.0 L/min (Cardiac Index 1.88 L/min/ $\text{m}^2$ ), the patient's CPP,  $\text{CvO}_2$ ,  $\text{rSO}_2$ ,  $\text{PaO}_2$  and  $\text{PaCO}_2$  remained in the targeted ranges. Subsequently, the serum lactate value dropped from 101 to 28 mg/dL within the first 24 hours. After significant improvement of cardiac function, the blood flow rate was constantly weaned to a minimum of 0.7 L/min (Cardiac Index 0.66 L/min/ $\text{m}^2$ ) over 4 hours without increasing the heparin dose and the cannulas were removed 5 days after the initiation of V-A ECMO support. During the ECMO run, the maximum values for D-dimer and free hemoglobin were 22.4 mg/L and 219 mg/L, respectively. Four weeks after admission, the girl was transferred to the pediatric rehabilitation center. Three months after the collapse, she had a very satisfactory neurologic recovery with normal cognitive function, but moderate left proximal hemiparesis without cranial nerve involvement. She is able to walk without any support and successfully attends her former school class.

## Discussion

In adults, ECMO support in patients with an intracranial hemorrhage is controversial and relatively contraindicated as the required anticoagulation for ECMO puts the patient at risk for progression of the hemorrhage and potentially aggravates outcome. However, successful ECMO treatment for respiratory failure in adult patients with traumatic brain injury and intracranial hemorrhage after spontaneous aneurysmatic rupture has been reported.<sup>4-7</sup> Most of these runs were performed in the veno-venous mode and both with and without systemic anticoagulation. To the best of our knowledge, this is the first report on the use of V-A ECMO for the treatment of circulatory failure in a (pediatric) patient early after craniotomy for intracranial aneurysmatic hemorrhage.

In this case, systemic anticoagulation during ECMO was performed using a heparin infusion. To minimize the risk of further intracranial bleeding, a low aPTT target range of 45–55 seconds was chosen. As confirmed by a median aPTT of 45 seconds during the V-A ECMO run, significantly less heparin effect was achieved than traditionally reported or recommended.<sup>8,9</sup> Comparable to patients with bleeding on ECMO after pediatric heart surgery, a reduction in anticoagulation was not associated with clotting complications.<sup>10</sup> Furthermore, ECMO facilitated the maintenance of the standard brain protective therapy, with the additional benefit of a significant reduction in inotropic support for poor cardiac function and concomitant arrhythmias. In severe sepsis, a reduced cardiac output due to poor contractility is commonly seen in children, whereas adults usually present it earlier in a hyperdynamic state.<sup>11</sup> This may explain the higher recovery rate in pediatric patients requiring ECMO treatment for sepsis, especially with central cannulation.<sup>12–14</sup>

In summary, we present the case of a pediatric patient with extended intracranial hemorrhage who was successfully treated with V-A ECMO for post-operative sepsis-induced cardiac failure. Central cannulation to provide good blood flow to the injured brain's penumbra without impairing the cerebral venous drainage and a modified anticoagulation management to minimize the risk of significant intracranial re-bleeding allowed an uncomplicated ECMO course with good neurological recovery of the patient.

### Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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