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Mechanical Thrombectomy in Acute Ischemic Stroke Patients under Venoarterial Extracorporeal Membrane Oxygenation

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SUMMARY

Use of venoarterial extracorporeal membrane oxygenation (VA-ECMO) in adult to treat refractory cardiogenic shock has increased in recent years, and ischemic stroke is the most frequent VA-ECMO-induced cerebrovascular complication. No adult case of mechanical thrombectomy (MT) has been reported. We describe herein two adult patients on VA-ECMO with acute ischemic stroke, successfully treated with MT, and discuss feasibility and safety of such procedure.

BACKGROUND

Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is used to provide circulatory support in patients with refractory cardiogenic shock^{1 2}. Ischemic stroke is among the most frequent complications occurring in VA-ECMO-treated patients³⁻⁵. Due to the increased risk of secondary hemorrhagic transformation, the need for curative anticoagulation, and the ECMO-related hemostasis disorders, thrombolysis for acute ischemic stroke in patients on ECMO is theoretically contra-indicated, and has never been reported so far in an adult patient. We describe herein two adult patients from our tertiary care center, with acute ischemic stroke occurring while on VA-ECMO support, successfully treated by mechanical thrombectomy (MT).

CASES PRESENTATION

The first case was a 51-year-old man with a history of ischemic dilated cardiomyopathy admitted to the intensive care unit (ICU) for cardiogenic shock. Despite optimal medical treatment, his condition worsened and a femoro-femoral VA-ECMO was implanted in the left groin under local anesthesia. Five days after VA-ECMO implantation, he presented a sudden right hemiplegia with aphasia with an initial national institute of health stroke scale (NIHSS) of 18. CT-angiography (CTA) was performed, since ECMO is an MRI-incompatible device, and showed left middle cerebral artery (MCA) M1 segment occlusion. MT was urgently performed via a right femoral artery access, using a Solitaire stent retriever (Medtronic, Irvine, CA). Time to groin puncture was 4 hours, with a successful result. Modified Thrombolysis In Cerebral Infarction (mTICI) score was at 3 at the end of the procedure. Brain CT scan performed 24h after recanalization showed no sign of hemorrhagic transformation. Patient's cardiac condition progressively improved, and VA-ECMO was removed on day 9. Ten day after the ischemic stroke, he was discharged from the ICU and transferred in the cardiology department. At this time, he only presented a slight aphasia, with a Rankin score of 1. One year later he had normal neurological examination with a Rankin score of 0.

The second case was a 35 year-old man, who was admitted for cardiogenic shock complicating acute myocardial infarction. Coronary angiography showed proximal left anterior descending artery occlusion, that was successfully stented. At the end of the procedure, he developed refractory cardiogenic shock requiring implantation of a peripheral, left femoro-femoral ECMO, and a sudden left hemiplegia with an

initial NIHSS of 24. CTA showed distal right MCA occlusion. After multidisciplinary team discussion, MT was performed via the right femoral artery, using a Solitaire stent retriever. Time to groin puncture was 6.5 hours, with a successful result (Figure 1; A, B). mTICI score was at 3 at the end of the procedure. Brain CT performed 24h after recanalization showed no sign of hemorrhagic transformation, but a right hemispheric swelling with midline shift and obstruction of the right lateral ventricle (Figure 1; C). A right decompressive craniectomy was performed 72 hours after MT because of persistent coma and radiological worsened (Figure 1; D). Patient's cardiac condition progressively improved, and VA-ECMO was removed on day 5. Due to delayed awakening, a tracheostomy was performed on day 15. Patient's neurological condition progressively improved, and cranioplasty was performed 3 months after craniectomy. The patient was finally weaned from his tracheostomy and transferred in a rehabilitation department. The patient was discharged home 2 years later; at that time his was walking without help and had a Rankin score of 2.

DISCUSSION

These cases illustrate the feasibility of performing MT on ECMO in adult patients⁶.

ECMO circuit is either in a VA or in a veno-venous (VV) configuration. It consists of a centrifugal pump, which provides a continuous flow in the circuit, and a membrane oxygenator that allow oxygenation and decarboxylation of the blood. In VA-ECMO, the circuit includes an inflow cannula which drains blood from the venous system, and an outflow cannula which delivers the warmed oxygenated blood back into the arterial system (Figure 2, A) in order to restore a circulatory flow in refractory cardiogenic shock and cardiac arrest. Intra-aortic balloon pump (IABP) is often added within the femoral artery in these patients (Figure 2, B) to protect against hydrostatic pulmonary edema⁷, or to improve coronary bypass graft flow and cardiac function in refractory postoperative cardiogenic shock^{8,9}. It reduces left ventricular afterload, improves coronary perfusion, and provide pulsatile blood flow.

In VV-ECMO, the outflow cannula delivers oxygenated and decarboxylated blood to the vena cava and the right atrium (Figure 2, C), to insure a normal blood gas exchange during acute respiratory distress syndrome (ARDS) refractory to conventional therapy¹⁰.

Stroke occurs mainly during VA-ECMO^{3,11}, whereas cerebral hemorrhage is mostly observed during VV-ECMO¹². These complications have an important impact in terms of outcome.

In order to perform MT, the choice of the arterial vascular access to perform MT should be discussed with the bedside ECMO specialist in charge of the patient, depending on ECMO configuration. In our two cases, the femoral access opposite to the arterial inflow cannula was chosen, but transradial artery access is another option. As the patient receive continuous unfractionated heparin, it is mandatory to use vascular ultrasound during puncture to minimize complications. In both cases, no femoral IABP were implanted, but its presence should not contra-indicate MT, as the operator can perform the MT via transradial arteries. A particular situation, but rare in adult, is a VA-ECMO circuit configuration with outflow cannula delivering

blood back into the axillary artery (Figure 2, D). In this case, the operator should not access transradial artery ipsilateral to the outflow cannula. In VV-ECMO configuration, all arterial access can be approached without constraint.

Concerning the timing of MT, our cases mainly differ, regarding the onset of the VA-ECMO, in relation to the neurological event.

In the first case, the neurological symptoms occurred suddenly after 5 days of VA-ECMO support in an alert patient, allowing us to determine precisely the stroke onset time. Unfortunately, patients under VA-ECMO are too often on invasive mechanical ventilation and heavily sedated, thus compromising neurological examination and stroke onset time determination. Although some patients need sedations many VA-ECMO patients remain sedated for the sole reason that they are under VA-ECMO, mainly for safety reasons. Fortunately, the recent literature goes against this dogma^{13 14}, and patients are lightly sedated, or extubated when possible, giving the opportunity to have proper neurological evaluation.

For the second case, the timing was different: immediately after a coronary angiography, he presented sudden neurological symptoms suggestive of cerebral infarction, probably of cardioembolic origin, related to atherosclerotic material release out of vascular plaques in the setting of coronary angiography¹⁵. Due to the initial presentation with refractory cardiogenic shock, the first step was to restore respiratory and hemodynamic compromises using oro-tracheal intubation and mechanical ventilation, catecholamine infusion and VA-ECMO insertion. Even if it delayed the management of the stroke (6.5 hours were needed to perform this sequence, although all human and technical resources were available on site), the patient was finally transferred to the radiology department, where CT scan, CTA and MT were performed. For this latter case, the evolution differed from that of our first case mainly because the former had too late MT, complicated with brain infarction and brain swelling requiring hemicraniectomy. However, significant neurologic recovery was finally observed in this patient.

In both cases, the main point that was debated was about performing or not an MT: indeed, VA-ECMO usually requires continuous infusion of unfractionated heparin to avoid circuit thrombosis and/or thrombo-embolic events, which in our cases had to be counterbalanced with the risk of reperfusion syndrome occurrence with secondary hemorrhagic transformation after MT. Indeed, it is not known whether VA-ECMO increases the risk of MT-induced cerebral hemorrhage, and if we refer to the literature, the only published case of IAMT on ECMO has been reported by Sun *et al*¹⁶, in a 9-month-old infant under VA-ECMO, inserted for cardiovascular collapse after *parainfluenza* pulmonary infection associated with acute cor pulmonale. In this case report, the infant developed both left MCA and basilar artery occlusions. MT could only have been performed within the posterior circulation, with a successful result, and without secondary hemorrhagic transformation. Finally, poor clinical outcome was observed, due to a large intracerebral hemorrhage in the left MCA territory. Together, these three cases suggest MT safety under ECMO support, although further studies are needed to determine the precise risk of secondary hemorrhagic transformation after IAMT in this specific population.

LEARNING POINTS/TAKE HOME MESSAGES

- MT feasibility on ECMO
- Light sedation/extubation when possible in order to have proper neurological evaluation and stroke onset time determination.

FIGURES

Figure 1: Cerebral digital subtraction angiography of the right internal carotid artery in antero-posterior projection (second case) showing a right middle cerebral artery occlusion (white arrow) **(A)** before, and **(B)** after recanalization. **(C)** CT-scan performed at day 1 shows a large ischemic infarct despite recanalization, with a right hemispheric swelling, midline shift and collapsus of the right lateral ventricle. CT scan with volume rendering reconstruction **(D)** after the right decompressive craniectomy was performed.

Figure 2: ECMO circuits

(A) Femoro-femoral VA-ECMO circuit **(B)** Femoro-femoral VA-ECMO circuit with controlateral IAPB **(C)** Femoro-jugular VV-ECMO circuit **(D)** Femoro-axillary VA-ECMO circuit

ECMO; extracorporeal membrane oxygenation

VA; venoarterial

VV; venovenous

IAPB; Intra-aortic balloon pump

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