ECMO

Neurological Complications

BACKGROUND

The Extracorporeal Life Support Organization (ELSO) registry collect information on the outcomes and complications with ECMO. There is limited information on seizures, ICH/IVH, infarcts, and brain death in this population. Per the database, the rate of occurrence of neurological injury is largely unchanged despite advances in circuitry and management.

2005—2010: 20% had “some” neurological complication in neonates

1990-2017: ICH occurred in 2-21% of adults, stroke in 1-33% of adults

The quantification of neurological complication burden is difficult due to the voluntary and retrospective nature of reporting as well as a lack of consensus on neuromonitoring.

EPIDEMIOLOGY

Overall, the (pre-COVID) incidence of neurological complications on ECMO was approximately 7.1%, with some studies citing up to 19%:

- ICH: up to 19%
- Brain death: up to 20%
- Stroke: up to 5%
- Seizures: up to 4%

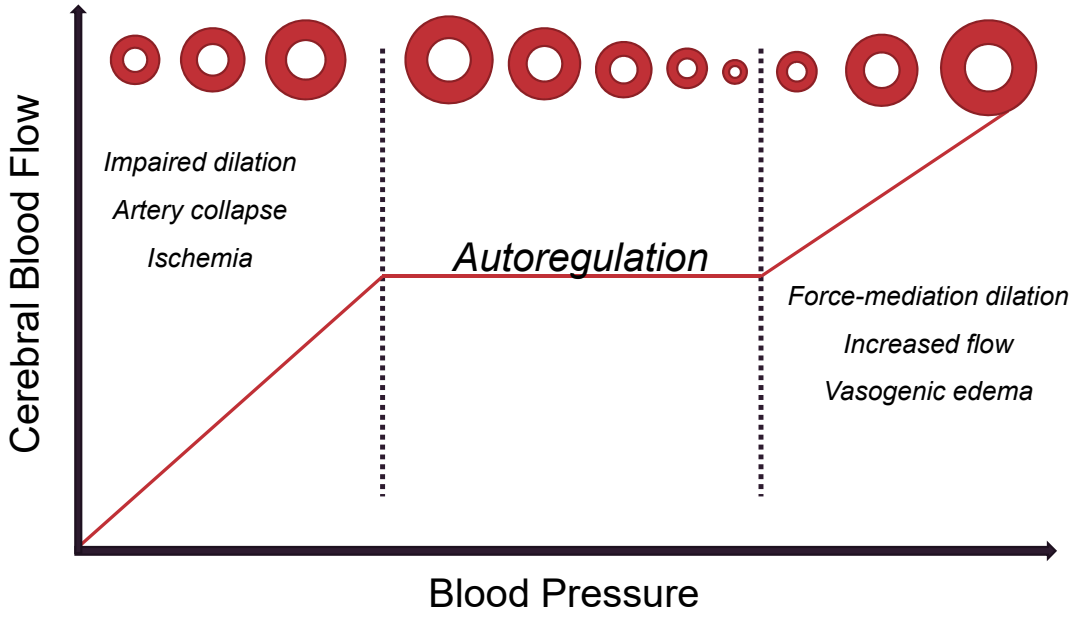
The impact of COVID in this population is unclear at this time.

In-hospital mortality is higher for those with neurological injury, approximately 75% vs 37% (no neurological injury).

CBF on ECMO

ECMO can lead to changes in cerebral blood flow due to vasospasm, severe acidosis, low CO_2 states, hypo/hyper-tension, and reperfusion injury. Hypercapnia leads to cerebral vasodilation while hypocapnia promotes cerebral vasoconstriction. Rapid declines in $PaCO_2$ have also been associated with CNS injury.

Cerebral autoregulation is tightly controlled as it maintains steady cerebral blood flow across a wide range of pressures. This is achieved through dilation and constriction of cerebral vessels in response to fluctuations in MAP. Disruption of this autoregulation may lead to ischemia, hemorrhage, or edema.


Cerebral Blood Flow
Impaired dilation
Artery collapse
Ischemia
Autoregulation
Force-mediation dilation
Increased flow
Vasogenic edema
Blood Pressure

RISK FACTORS

Risk factors for neurological injury include:

Pre-ECMO	ECMO-related	VA vs VV ECMO
• Severe hypoxemia and acidosis • Refractory hypotension • High lactate • Cardiac arrest • Need for CRRT	• Cannulae/circuits are prothrombotic • Thrombocytopenia (platelets consumed in circuit) • Anticoagulation (used for circuit) • Reperfusion injury	• VA: arterial emboli • VV: differential hypoxia (lower PaO_2 in upper limbs)

TYPES OF COMPLICATIONS

The neurological complications of ECMO can include, but are not limited to:

- Embolic strokes
- Ischemic strokes
- Hypoxic-ischemic encephalopathy
- Intracranial hemorrhages
- Subarachnoid hemorrhages
- Intraventricular hemorrhages
- Seizures
- Cerebral edema
- *Critical Illness myopathy*
- *Neuropathies*
- *Delirium*
- *Vocal cord paralysis (prolonged intubation*)

Some of these complications are due to prolonged critical illness (italicized) while others are more specific to the prothrombotic and anticoagulated state of ECMO patients.

Hemorrhagic complications are one of the more common adverse events and carry a high mortality rate (80-90%). Risk factors for intracerebral hemorrhage include longer duration of ECMO, higher activated clotting times (TEG ACT), pre-admission antithrombotic therapy, and lower platelets counts. Those with small bleed can continue on ECMO and ECMO circuits can be run without anticoagulation, although there is greater risk of the circuit clotting.

Ischemic complications can be caused by clots from the prothrombotic circuit but may also be related to hypotension or septic emboli. Carotid cannulation has the highest risk of ischemic stroke due to positioning. Optimizing hemodynamics through adequate pump flows and help minimize risk of clot formation regardless of cannula positioning.

Cerebral edema can result from intracranial pathology or from metabolic derangements. Ischemia and hypoxic-ischemic insults can lead to cytoxic edema, while intracranial hemorrhages lead to surrounding vasogenic edema. Hypercarbia can lead to cerebral hyperperfusion secondary to cerebral vasodilation via perivascular extracellular pH changes. Other metabolic derangements, such as a rapidly dropping sodium, may also lead to diffuse cerebral edema.

Seizures are a less common complications than ischemia or hemorrhages and most of the data is from the pediatric population. Seizures occur in 18-23% of neonates and children on ECMO with 61% electrographic status and 83% exclusively electrographic status. The presence of seizures has been found to decrease survival to discharge. Due to the risk for seizures, the ACNS does recommend EEG monitoring in paralyzed patients.

Brain death can be the result of the complications listed above but is mostly seen in ECMO-assisted CPR due to devastating hypoxic-ischemic injury secondary to prolonged hypoxia. The diagnosis of brain death while on ECMO requires normothermia, normal pH, no medications that may interfere with respiratory drive or that could cloud neurological exam. The apnea test is still performed with the oxygenator on the circuit capped or decreasing the sweep speed to 0.5-1L/min. The $PaCO_2$ is trended while monitoring for spontaneous breaths as in the typical apnea test.