

# Apnea test for brain death diagnosis in a patient on extracorporeal membrane oxygenation

## Abstract

**Background:** Apnea test in most countries is a fundamental part in Brain Death (BD) diagnosis. In patients receiving extracorporeal membrane oxygenation support apnea test remains challenging and controversial.

**Case:** We report the case of a 40 year old man receiving veno-venous Extracorporeal Membrane Oxygenation (ECMO) as a respiratory support presenting signs of brain death. Decreasing ECMO flow and gas sweep flow while the patients lungs were kept on a Continuous Positive Airway Pressure (CPAP) during the apnea test allowed the PaCO<sub>2</sub> to increase without decreasing of PaO<sub>2</sub>.

**Discussion:** In order to diagnose BD apnea test must be accomplished in some countries. Carbon dioxide removal by the ECMO membrane makes CO<sub>2</sub> rise very difficult. Sweep gas decrease on ECMO can make CO<sub>2</sub> rise possible but exposes patients to hypoxemia. Decreasing gas flow on the oxygenator and concomitantly inflating the lungs on a 100% oxygen CPAP allowed us to perform apnea test safely.

**Conclusion:** With the technique described apnea test can be safely assessed without exposing patients to hypoxemia.

**Keywords:** Brain death, Apnea test, Extracorporeal membrane oxygenation, Sweep gas

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**Abbreviations:** BD, Brain Death; ECMO, Extracorporeal Membrane Oxygenation; CPAP, Continuous Positive Airway Pressure; GCS, Glasgow Coma Scale

## Introduction

Extracorporeal membrane oxygenation (ECMO) is increasingly used as a means of extra corporeal support to a wide variety of patients. The Extracorporeal Life Support Organisation reported that 21% of patients undergoing extracorporeal CPR were brain dead.<sup>1</sup> Due to carbon dioxide removal via the oxygenator membrane apnea test remains controversial and challenging in patients on ECMO in the lack of published guidelines.<sup>2</sup>

## Case report

A 40 year old male has been admitted to our Intensive Care Unit for respiratory failure due to suspected Guillan Barre Syndrome and concomitant interstitial pneumonia. The patient rapidly developed severe Acute Respiratory Distress Syndrome. A veno-venous ECMO with a femoral-jugular access was placed to assist oxygenation on day 3. On ECMO day 2 bilateral mydriasis associated with diabetes insipidus were reported. A brain CT scan was performed and revealed massive cerebral hemorrhage. Sedation was stopped for neurological assessment. Neurological examination revealed bilateral mydriasis, Glasgow Coma Scale Score (GCS)=3T, absence of brainstem reflexes, electro encephalographic silence. During neurological examination body temperature was 36.5°C, mean arterial pressure was > 80mm Hg, heart rate was 80bpm and a nor epinephrine infusion of 0.12 mcg/kg/h was administered. No acid base and electrolyte disturbances were present. ECMO parameters were 4 L/min blood flow, 8L/min Oxygen flow with a FiO<sub>2</sub> of 0.7. Ventilator settings were TV 650ml, Respiratory Rate 14/min, FiO<sub>2</sub> 0.7, P<sub>plateau</sub> 30cm H<sub>2</sub>O, Peep 10cm H<sub>2</sub>O. In order to assess brain death diagnosis also an apnea test had to be performed.

During the apnea test patient was kept on a Continuous Positive Airway Pressure (CPAP) of 10cm H<sub>2</sub>O on 100% oxygen via a T-piece to sustain oxygenation.<sup>3</sup> ECMO blood flow was decreased to 2L/min and gas flow sweep was reduced to 0.5L/min with a FiO<sub>2</sub> of 1.0. In line CO<sub>2</sub> monitoring was performed during the procedure and blood gases were drawn at baseline and when EtCO<sub>2</sub> was >60mm Hg. The apnea test lasted 6 minutes to obtain a PaCO<sub>2</sub> level on blood gas analysis of 64.2mm Hg. Sat O<sub>2</sub> remained reliably stable >90% during the procedure and light hypoxemia developed during the course of the 6 minutes apnea test. (PaO<sub>2</sub> 159 mmHg → 80 mmHg). We closely observed the patient's chest movements, the CO<sub>2</sub> tracing and the ventilator flow for any spontaneous breathing effort.

## Discussion

Clinical assessment of brain death in Italy is made on several criteria according to current Law (Legge 29 Dic 1993n°578/D.M. 22 Ago 1994 n° 582/D.M.S. 11 Apr 2008). Cerebral death is defined as irreversible loss of known etiology of the functions of the whole brain, including the brainstem, associated with loss of electro encephalographic activity.

According to Italian law apnea test is a fundamental requisite in the diagnosis of brain death and cannot be substituted by any other test unless it is not possible to adequately perform apnea test. A positive apnea test is defined by the absence of respiratory activity at a PaCO<sub>2</sub> ≥60mm Hg. The pre requisites for a valid test are the presence of norm tension, absence of blood gas and electrolytes disturbances. There are no published guidelines for diagnosing brain death in patients with veno-venous ECMO support. Performing an apnea test in such patients can be challenging and physicians have considered it too difficult to perform<sup>4</sup> in a retrospective review in adult treated with ECMO at Mayo Clinic (2002-2010) found that loss of all brain stem reflexes was identified in three cases (3/87, 3.4%); the apnea test was not performed since it was deemed "difficult," leading to withdrawal of ECMO and intensive care.

When a patient is disconnected from the ventilator to perform the apnea test, poorly oxygenated blood returning from the lungs to the left heart side can cause hypoxemia. Reduction of sweep gas flow on the oxygenator can worsen hypoxemia in the above conditions before we can appreciate a valid CO<sub>2</sub> rise for the diagnosis of brain death. The authors propose a simple and reliable method to safely guarantee oxygenation and CO<sub>2</sub> increase according to the recommendations made by.<sup>4,5</sup> The authors proposed an approach based on continuous lung insufflation at a FiO<sub>2</sub> 1.0 with 10cm H<sub>2</sub>O CPAP and the lowest possible oxygenator weep flow to maintain an oxygen saturation ≥90% with no addition of CO<sub>2</sub> on the oxygenator circuit. After eucapnia (35–40mm Hg) is confirmed with arterial blood gas, apnea is confirmed by absence of respiratory activity when an absolute PaCO<sub>2</sub> > 60mm Hg is achieved. The authors were able to perform safely the apnea test with the current methodology.

According to the Italian Law (Legge 29 Dic 1993 n° 578/D.M. 22 Ago 1994 n° 582/D.M.S. 11 Apr 2008) in the case apnea test cannot be safely performed a blood flow test must be performed to confirm brain death. Absence of intra cranial blood flow can be assessed by means of CT angiography, digital angiography or transcranial doppler. In the first two cases the procedure might be hazardous because the potential organ donor must be transferred on ECMO to the radiology ward. In the case of transcranial doppler assessment 2 recordings are needed: one at baseline which demonstrates flow and a second which demonstrates absence of flow; it is not standard practice to perform transcranial doppler in all neurologic patients at baseline.

## Conclusion

In Italy apnea testing is fundamental for brain death diagnosis but is challenging in patient on ECMO. World wide it is not employed consistently on ECMO patients due to the lack of standardized and universal procedures. Timely brain death diagnosis is important

for families, ICU organization and for possible organ donation. We describe a simple, safe and accurate method of apnea testing in presumed brain dead patients during ECMO in the lack of published guidelines.

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