Master track Medical Sensing and Stimulation

Innovative bedside method for monitoring cerebral perfusion in post-cardiac arrest patients on veno-arterial extracorporeal membrane oxygenation

Group 1; Isabelle Busman, Nienke Timmermans, Lieuwke Verkaar, Iris Visser

Abstract

Cerebral perfusion in patients on veno-arterial extracorporeal membrane oxygenation (VA-ECMO) after resuscitation from cardiac arrest needs to be monitored closely, as cerebral hypo- or hyperperfusion might lead to secondary brain injury. To date no adequate or reliable methods for continuous bedside monitoring of cerebral blood flow (CBF) exist. The goal is to propose an innovative, bedside method for monitoring cerebral perfusion. Global CBF can be calculated from the flow measured by thermodilution in the internal jugular vein. Since adequate global CBF does not guarantee adequate perfusion at the level of the microcirculation, the metabolic state of the brain is assessed by calculating a ratio between mixed venous-arterial CO2 difference and arterial-venous O2 content difference. This ratio distinguishes between aerobic and anaerobic metabolism and can be calculated from pO2, pCO2, pH, hemoglobin and temperature. pO2, pCO2 and pH are measured in the carotid artery and the internal jugular vein with intravascular sensors placed on a catheter. The arterial catheter will be advanced through the ECMO cannula, to avoid an extra arterial puncture. Further research is needed before this proposed method can be implemented to monitor cerebral perfusion in post-cardiac arrest patients on VA-ECMO.

Cerebral perfusion monitoring with a combination of transcranial Doppler and contrast enhanced ultrasound.

Group 2; Nicole de Kruijf, Stefan Lip, Leen Vanwinsen, Lisa Vulders

Abstract
For patients in the ICU in cardiogenic shock that receive extracorporeal membrane oxygenation (ECMO) treatment, it is important to perform accurate monitoring of cerebral perfusion in order to prevent neurological damage due to oxygen deficiency. A possible method to monitor cerebral perfusion is to use a combination of transcranial Doppler and contrast enhanced ultrasound (CEUS). By the use of transcranial Doppler, the blood flow in the internal carotid artery (ICA) and middle cerebral artery (MCA) can be determined. With CEUS the intensity of injected microbubbles can be measured in the ICA, MCA and the microcirculation, which results in three time intensity curves. By combining the flows found with Doppler and the parameters derived from the time intensity curves, the flow in the microcirculation can be determined. When the cerebral flow is found to be too high or too low, the ECMO settings can be adjusted in order to reach a sufficient cerebral perfusion and therefore minimize neurological damage.

Optimizing the cerebral perfusion pressure through continuous monitoring of the cerebral metabolism with arterial-venous O_2 and glucose difference measurement and intracranial pressure regulation with two-depth doppler.

Groep3; Jason van Duijn, Stefan van Haren, Jari de Rover, Hille Torenvlied

Abstract
Minimizing neurological damage is one of the most important goals in treating patients in the ICU after cardiac arrest. If the cerebral blood supply is not coherent with the cerebral metabolism this can cause ischemia, which causes neurological damage. However, there are currently no techniques available which can measure the cerebral blood supply accurately. It is important to make sure that the intracranial pressure stays within normal ranges, by measuring this with two-depth doppler. As an increase in cerebral metabolism leads to greater usage of glucose and oxygen, this can be seen as increased arterial-venous differences. Through recognition of decreasing trends of these differences in combination with EEG, it is possible to detect anaerobic metabolism and ischemia timely and therefore might lead to a better neurological outcome in these patients.

Prevention of brain injury in VA-ECMO patients by transcerebral thermodilution

Group 4; Cecil ten Cate, Véronique Gubbels, Lotte Hazeleger, Peter van 't Ooster

Abstract
In patients treated with VA-ECMO, brain injury is the most frequent complication affecting 8-50%. Brain injury can be a result of changes in intracranial pressure. It is important to find a method to help the physician adapt ECMO settings in such a way that brain injury is prevented. In our presentation we propose a method of transcerebral thermodilution combined with internal jugular blood analysis to measure several parameters related to cerebral blood flow, intracranial pressure and cerebral metabolism.

Ultrafast ultrasound localization microscopy to monitor cerebral in ICU patients receiving ECMO

Group 5; Cindel Albers, Ingrid de Bekker, Wibrich Boskma, Eva Groenendijk

Abstract
Background: Extracorporeal membrane oxygenation (ECMO) is a life-saving treatment for patients with severe cardiopulmonary failure. This technique is widely used on the intensive care unit (ICU) as a form of temporary cardiopulmonary bypass, to ensure perfusion of and oxygen delivery to the organs. However, the optimal selected rate of blood flow during ECMO is not decided upon yet, because it remains unsure how the perfusion of the organs change after resuscitation. This means that at one moment a selected blood flow can cause adequate perfusion of the organs and a couple of hours later this flow causes hypo- or hyperperfusion of the organs. The organ most sensitive to these changes is the brain. It would therefore help ICU staff if there was a way to non-invasively monitor cerebral perfusion and hence prevent hypo- and hyperperfusion.
Aim: The aim of this study is to conceptualize a new technique that can monitor cerebral perfusion in ICU patients receiving ECMO.
Proposed method: Ultrafast ultrasound localization microscopy (uULM) is a promising technique for measuring the cerebral perfusion on patients receiving ECMO on the ICU. uULM will be performed with a cap that fits perfectly around the head of the patient with two or three built-in ultrasound probes. A flowchart was created for future implementation of uULM for measuring cerebral perfusion on the ICU.
Discussion: Despite the fact this technique is promising for the future, further research is necessary before implementing this technique in a clinical setting. Some aspects that should be researched are how the microbubbles affect the functionality of the ECMO-pump, the possible interference of the ultrasound waves transmitted by different probes and what type of microbubbles have the best properties for uULM.

Real-time monitoring of cerebral perfusion and adjustment of ECMO flow after cardiac arrest

Group 6; Irene Heijink, Susanne Jelsma, Anne- Lynn Paalvast, Anna Schoonhoven, Maaike Wösten

Abstract
Currently, difficulties are considered in the flow settings of the venous-arterial extracorporeal membrane oxygenation (VA-ECMO). A new measurement method is desired to monitor the cerebral perfusion and oxygenation and to adjust the settings of the VA-ECMO according to the measurement. The proposed method is to measure the blood flow, SaO2 and PaO2 in the cerebral vasculature to determine the cerebral metabolic rate of oxygen (CMRO2) and the oxygen extraction fraction (O2EF). The measurement is performed with a robotic thread, which can be steered with magnetic navigation through the cerebral vasculature based on a 3D rotational angiogram of the brain. Although more research is needed before the method can be implemented in the clinic, the technique seems promising.

Oxi-OCTA for monitoring Retinal Blood Flow and Oxygen Saturation as a measure for Cerebral Blood Flow during ECMO.

Group 7; Deborah Hubers, Marit Nelissen, Myrthe Schoenmakers, Jacomine Tertoolen

Patients connected to ECMO often suffer neurological injuries. Therefore, it is beneficial to have a reliable method to monitor cerebral blood flow (CBF). It was concluded that a combination between oximetry and flowmetry would be best in this case. Literature review showed that the retina could be an alternative location for monitoring CBF, since retinal and cerebral blood flow are thought to be comparable. Techniques for measuring retinal blood flow and oxygen saturation were researched. The best option found is a combination of Hyper Spectral Imaging (HSI) and Optical Coherence Tomography Angiography (OCTA).