MEMBRANE SUPPORTED LIQUID-LIQUID OXYGENATION: A NOVEL APPROACH IN ECLS THERAPIES

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Background

Chronic respiratory diseases are the third most frequent cause of death worldwide. The gold standard end-stage therapy is lung transplantation. However, the limited availability of transplantable organs led to an increased research effort in artificial lung systems. Current artificial lung systems use hollow fibre membrane-based oxygenators with limited gas-transfer. Historic oxygenators using a direct liquid-gas or liquid-liquid interface outperformed today's hollow-fibre technology in terms of gas transfer. However, these approaches were no longer pursued due to complications of embolization by gas or liquid particle formation in the bloodstream. The herein presented approach of a membrane-supported liquid-liquid oxygenator combines today's hollow-fibre technology with the historic liquid-liquid approach to achieve a stable interface without risk of embolization with the advantages of a higher gas transfer and the decrease of blood contacting membrane surface.

The concept of membrane-supported liquid-liquid oxygenation is sketched in Figure 1 (right) and compared to a conventional polymethylpenten-membrane (PMP).

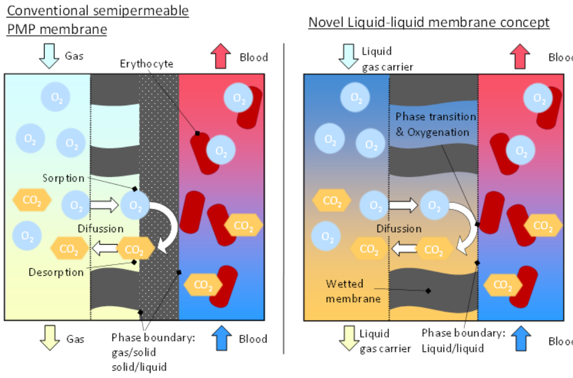

Figure 1:Conventional semipermeable PMP membrane (left(compared to the novel liquid-liquid mambrane concept

Methods

Literature was analyzed regarding a suitable perfluorocarbon fluid for the presented approach of a membrane-supported liquid-liquid oxygenator. The candidate fluids were tested primarily for hemocompatibility. The interface interaction between blood and fluid was analyzed using a Nitsch cell test. Transmembrane pressure was investigated for stable operation in conventional polypropylene fibers as used in the proof-of-principle oxygenator. Based on these results, a proof-of-principle oxygenator was manufactured, tested in vitro for gas transfer and checked for droplet formation in the blood.

Results

Perfluoro-n-hexane was chosen as a hemocompatible carrier fluid for the presented liquid-liquid approach. The Nitsch cell test revealed a stable interface between blood and fluid at Reynolds numbers 285 and 368 with a maximum initial gas transfer of 0.151 $mmol_{O2}\ min^{-1}$ and 0.848 $mmol_{CO2}\ min^{-1}$, respectively. A transmembrane pressure of 5 kPa was determined for stable operation in the proof-of-principle oxygenator with O_2 and CO_2 total gas transfers measured after 10 minutes to be 1.83 $mmol_{O2}$ and 1.34 $mmol_{CO2}$, respectively. In the proof-of-principle, no Perfluoro-n-hexane droplets were identified in the blood after the experiment.

Conclusion

This study demonstrates proof-of-principle of a new membrane-supported liquid-liquid oxygenator. Gas transfer efficiency results were comparable to conventional hollow-fibre technology, while no indication of droplet formation was found. Considering that a non-optimal conventional membrane was utilized for this approach, this is a promising finding indicating that with a more suitable membrane material, the liquid-liquid approach is safe and could exceed hollow-fibre technology by a large margin with respect to gas transfer efficiency.