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A double catheter approach for extracorporeal CO_2 removal integrated within a continuous renal replacement circuit

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After the avian flu epidemic in 2009, oxygenation-improving techniques such as extracorporeal membrane oxygenation (ECMO) and extracorporeal CO_2 removal ($ECCO_2R$) gained momentum considerably.[1] $ECCO_2R$ systems in particular earned increasing clinical appeal as adjuvant therapy of the acute respiratory distress syndrome (ARDS) and chronic obstructive pulmonary disease (COPD). $ECCO_2R$ allowed safe application of ultra-protective ventilation in ARDS and improved $PaCO_2$, pH, and minute ventilation in COPD patients.[2] The basic physiological concept of $ECCO_2R$ was already elaborated in the late seventies.[3] Since then, technical progress has made giant steps evolving from spontaneous arterio-venous to pump-driven veno-venous $ECCO_2R$, and finally, the embedding of $ECCO_2R$ within a continuous renal replacement therapy (CRRT) circuit.[4]

Blood flow is an important factor that may limit optimal CRRT-$ECCO_2R$ use. Some patients require a blood flow of 450 mL/min in order to achieve significant CO_2 removal to assure a pH above 7.2.[5] In many cases, such high blood flow can only be maintained for 24 h,[6] even when up to 16 Fr double lumen catheters are used. These large-bore catheters are also mostly armored and expensive. The amount of removed CO_2 dramatically declines when blood flow decreases to 300–350 mL/min. CO_2 elimination then becomes more dependent upon sweep gas flow rather than blood flow.[7]

In the intensive care unit of the Brugmann University Hospital, we developed a novel and cost-saving approach that enables to run $ECCO_2R$ integrated within a CRRT circuit at a 450 mL/min blood flow for 48 h to 72 h. Briefly, two double-lumen catheters were inserted in a jugular vein and in a femoral vein respectively. Both catheters were 13 Fr sized and 25 cm long (GamCath®, Gambro, Lund, Sweden). Adapting a similar approach as for veno-venous ECMO,[8] blood was extracted from the CRRT-$ECCO_2R$ system via the femoral catheter and, after decarboxylation, reinfused through the cephalic catheter. The lumina of the double-lumen catheters were linked by a y-adapter to create a single blood line without loss of blood flow. Compared with the single catheter approach, access pressures measured in the Prismaflex® (Baxter, Illinois, ISA), were reduced by 40%, which allowed, as previously reported in case studies, an almost 40% increase in blood flow.[7] Some centers have used this double catheter technique on specific occasions and only when a single approach was found to be ineffective. The true originality of our approach lies in the systematic implementation of the double catheter technique in all CRRT-$ECCO_2R$-treated patients. Significant improvements in the pressure regimen and circuit rheology permitted to run CRRT-$ECCO_2R$ for at least 48 h and, in the majority of cases, for up to 72 h.

No increased incidence of bleeding or catheter-related infection was observed

with this double catheter approach. Of importance is that diluted citrate anticoagulation should be avoided when performing CRRT-ECCO$_2$R with the Prismaflex® device. A blood flow of 450 mL/min will dramatically increase citrate flow. This may cause an unwarranted increase in transmembrane pressure and a more pronounced pressure drop which promotes filter clogging and compromises filter lifespan.[9] Moreover, an increased citrate flow can enhance the risk of citrate intoxication.[10] Unfractionated heparin therefore is the preferred anticoagulation approach. It remains to be determined whether concentrated citrate could be an acceptable surrogate.[11]

In conclusion, a double catheter approach to integrate ECCO$_2$R within a CRRT circuit guarantees optimal and prolonged removal of CO_2. Our experience in more than 50 treated patients learns that the technique is safe and cost-effective.

Conflict of Interests

The authors declare to have no competing interest.

REFERENCES

1. Twigg S, Gibbon GJ, Perris T. The use of extracorporeal carbon dioxide removal in the management of life-threatening bronchospasm due to influenza infection. Anaesth Intensive Care 2008; 36: 579-81.
2. Winiszewski H, Aptel F, Belon F, Belin N, Chaignat C, Patry C, *et al.* Daily use of extracorporeal CO(2) removal in a critical care unit: indications and results. J Intensive Care 2018; 6: 36.
3. Gattinoni L, Kolobow T, Tomlinson T, White D, Pierce J. Control of intermittent positive pressure breathing (IPPB) by extracorporeal removal of carbon dioxide. Br J Anaesth 1978; 50: 753-8.
4. Trahanas JM, Lynch WR, Bartlett RH. Extracorporeal Support for Chronic Obstructive Pulmonary Disease: A Bright Future. J Intensive Care Med 2017; 32: 411-20.
5. Karagiannidis C, Strassmann S, Brodie D, Ritter P, Larsson A, Borchardt R, *et al.* Impact of membrane lung surface area and blood flow on extracorporeal CO_2 removal during severe respiratory acidosis. Intensive Care Med Exp 2017; 5: 34.
6. Forster C, Schriewer J, John S, Eckardt KU, Willam C. Low-flow CO_2 removal integrated into a renal-replacement circuit can reduce acidosis and decrease vasopressor requirements. Crit Care 2013; 17: R154.
7. de Villiers Hugo J, Sharma AS, Ahmed U, Weerwind PW. Quantification of Carbon Dioxide Removal at Low Sweep Gas and Blood Flows. J Extra Corpor Technol 2017; 49: 257-61.
8. Frenckner B, Broman M, Broomé M. Position of draining venous cannula in extracorporeal membrane oxygenation for respiratory and respiratory/circulatory support in adult patients. Crit Care 2018; 22: 163.
9. Sharma AS, Weerwind PW, Bekers O, Wouters EM, Maessen JG. Carbon dioxide dialysis in a swine model utilizing systemic and regional anticoagulation. Intensive Care Med Exp 2016; 4: 2.
10. Honore PM, De Bels D, Preseau T, Redant S, Spapen HD. Citrate: How to Get Started and What, When, and How to Monitor? J Transl Int Med 2018; 6: 115-27.
11. Jacobs R, Honore PM, Hendrickx I, Spapen HD. Regional Citrate Anticoagulation for Continuous Renal Replacement Therapy: All Citrates Are Not Created Equal! Blood Purif 2016; 42: 219-20.

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