Connection of a Renal Replacement Therapy or Plasmapheresis Device to the ECMO Circuit

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In patients under extracorporeal membrane oxygenation (ECMO) support requiring renal replacement therapy or plasmapheresis, connecting such extracorporeal therapy device to the ECMO circuit provides many advantages compared with central venous catheterization. However, high pressures of the ECMO circuit limit the usefulness of this technique. We propose a new approach to connect extracorporeal therapy lines to the ECMO circuit. Inlet line is connected to the oxygenator, and outlet line is connected either to the femoral artery antegrade perfusion cannula in case of venoarterial ECMO or to the lateral vent of the return cannula in case of venovenous ECMO. We report the successful management of 21 patients using this connection, with much longer hemofilter average lifetime than previously reported. *ASAIO Journal* 2017; XX:00–00.

Key Words: extracorporeal membrane oxygenation, renal replacement therapy, plasmapheresis

Patients on extracorporeal membrane oxygenation (ECMO) frequently require renal replacement therapy[1] and sometimes plasmapheresis. Separate vascular access is the most used approach for such extracorporeal therapies (ECTs), but with the risk of complications related to percutaneous catheterization. Moreover, peripheral cannulation of ECMO limits central venous accesses for ECT. The alternative is to insert a full ECT device in parallel to the ECMO circuit. This technique was easily performed in pediatric patients with low flows of both ECT and ECMO.[2] However, in adults, this technique is restricted by the elevated pressures of the ECMO circuit, particularly at high blood flows,[3] leading to ECT failure. Moreover, the exact site where the ECT device has to be connected to the ECMO circuit is not yet standardized.[4]

We evaluated the feasibility and efficiency of a new approach of ECT in patients under ECMO support by connecting the ECT outlet line to the distal arterial perfusion cannula for venoarterial (VA) ECMO or to the venous return cannula for venovenous (VV) ECMO.

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Technique

After institutional review board approval (no. CCML-2016-5), all patients on ECMO who needed ECT from December 2015 to June 2016 were identified.

Venous return jugular cannulas in VV ECMO and arterial cannulas in VA ECMO were 23 cm long, 17 or 19 Fr cannulas, with a lateral Luer-Lock connector. In VV ECMO, we added a 25 cm PVC line and a Q-Syte bidirectional valve (BD Worldwide; Franklin Lakes, NJ, USA) to the lateral vent of the venous return cannula. In VA ECMO, the distal perfusion cannula was a 6 Fr Radifocus Introducer (Terumo; Hatagaya, Japan) linked to the arterial cannula with a 25 cm PVC line and an additional three-way tap.

The ECT device could then be connected to the ECMO circuit for the duration of the treatment. The ECT inlet line was in all cases connected to the ECMO oxygenator. In VV ECMO, the ECT outlet line was connected to the bidirectional valve (**Figure 1**), whereas in VA ECMO, the outlet line was connected to the 3-way tap on the distal perfusion cannula (**Figure 2**).

Extracorporeal therapy was performed using Prismaflex or AK 200 devices (Gambro-Hospal; Meysieu, France). Blood flow comprised between 200 and 300 ml/min. The upper pressure alarm limit was 350 mm Hg on the outlet line of both ECT devices. Duration of plasmapheresis or hemodialysis sessions was 4 hours, and maximal recommended lifetime of the hemofilter during hemofiltration was 72 hours. Unfractioned heparin was used for anticoagulation, with a targeted anti-Xa between 0.2 and 0.4 IU/ml. Measures were recorded 1 hour after beginning ECT.

Twenty-one patients under ECMO support had ECT with connection to the circuit using our technique. Features of the patients are reported in Table 1. The average VA ECMO, VV ECMO, and ECT blood flows were 3.76 ± 0.86 L/min, 4.10 ± 0.83 L/min, and 234.0 ± 31.6 mL/min, respectively. The average lifetime of the hemofilter was 57.5 ± 24.0 hours. In 10 patients, the hemofilter reached its recommended duration time (72 hours). No ECT was interrupted for excessive circuit pressure. In all cases, serum urea decreased when renal replacement therapy was achieved. No severe complication, such as circuit disconnection, hemorrhage, air embolism, hemolysis with free bilirubinemia above 30 mmol/L, blood pressure drop at ECT initiation, or lower limb ischemia occurred during the study period.

Comment

The major interest of connecting ECT to an ECMO circuit is to avoid complications related to central venous catheter placement. Moreover, iterative undetected blood flow reductions related to catheter have been reported, with a shorten hemofilter lifetime.[5]

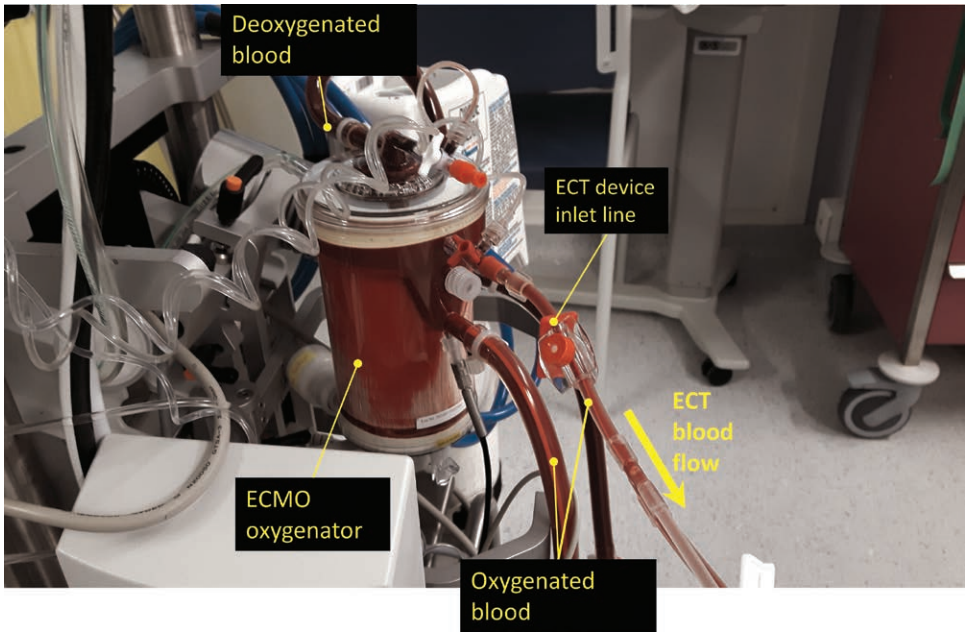

Figure 1. Connection of the extracorporeal therapy inlet line to the extracorporeal oxygenator. Connection after the membrane is mandatory to provide oxygenated blood to the most distal point of the extracorporeal membrane oxygenation (ECMO) circuit and then avoid shunt.

Some authors previously described different possibilities for ECT connection to the ECMO circuit. The most used is to connect both inlet and outlet lines between the pump and the oxygenator (alternate connection site No. 1, **Figures 1 and 2**). However, the main limitation of this technique is the high circuit pressure when ECMO blood flow rises above 3 to 3.5 L/min, hindering the ECT outlet flow. In that case, the only way to perform ECT is to decrease the ECMO blood flow, which could not be tolerated by the patient.

Others described ECT outlet line connection to the ECMO prepump line decreased outlet pressure[6] (alternate connection site No. 2, **Figures 1 and 2**). However, the major issue of using

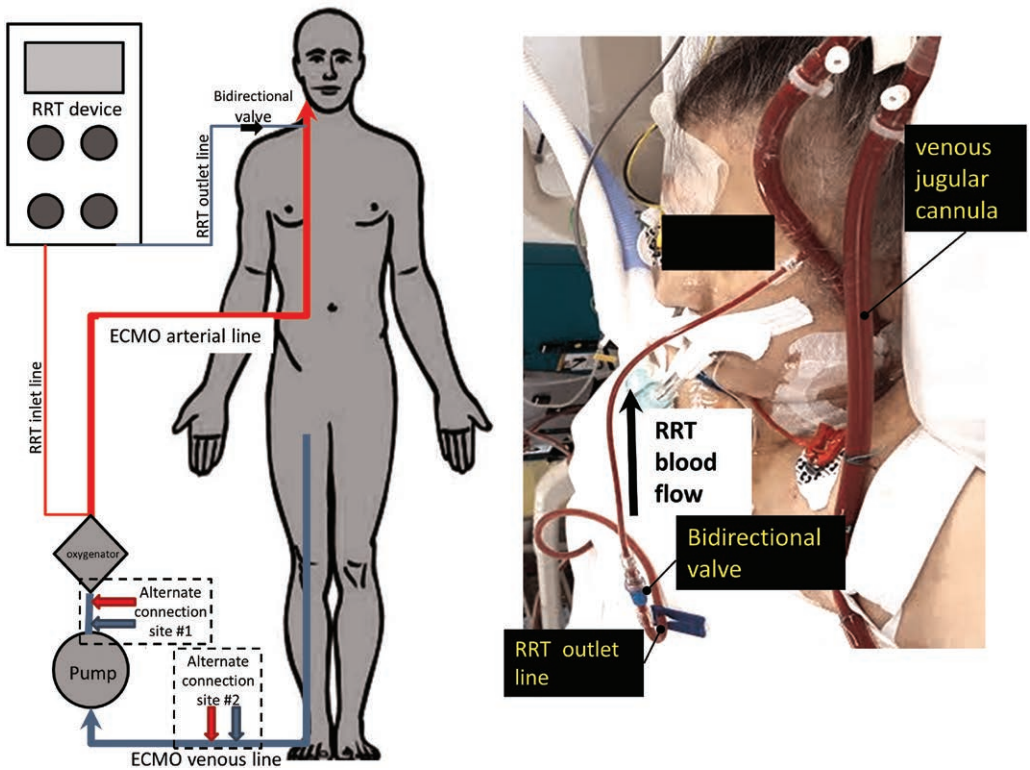

Figure 2. Connection of the extracorporeal therapy outlet line to the venovenous extracorporeal membrane oxygenation (ECMO) return cannula. Oxygenated blood is reinjected in the jugular return cannula through a bidirectional valve and a short PVC line.

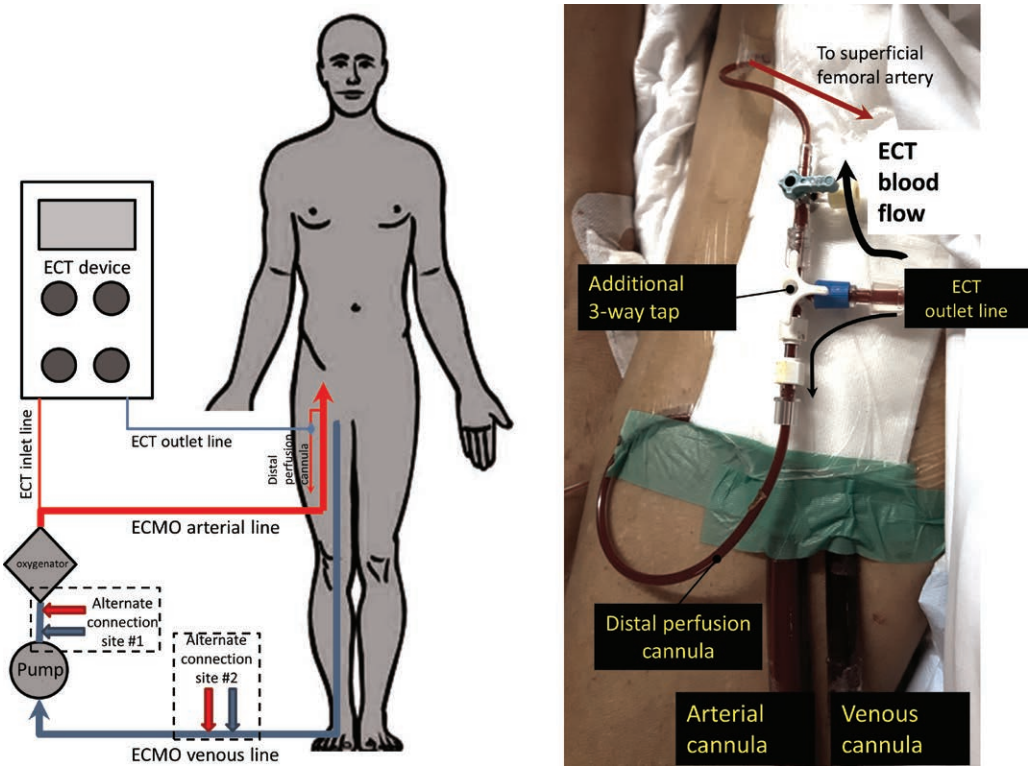

Figure 3. Connection of the extracorporeal therapy outlet line to the distal perfusion cannula in venoarterial extracorporeal membrane oxygenation (ECMO). Oxygenated blood is reinjected through an open 3 way tap, both in the antegrade and possibly in the retrograde direction. The retrograde reinjection occurs only if the pressure through the introducer exceeds the pressure in the distal part of the ECMO circuit.

the prepump line for any connection is a high risk of air entrapment in this negative-pressure part of the circuit. Moreover, pressure variations are high in this part of the ECMO circuit and could cause ECT iterative dysfunctions. Thus, a recently published work in adults using this technique reported a much lesser hemofilter duration time (22 hours) than we noticed.[3]

In all cases of ECT device connection to the ECMO circuit, the most challenging is to manage excessive outlet pressure. Thus, we connected the outlet line to the most distal point of the ECMO circuit, where according to Poiseuille's law, pressure is the lowest. This part of the circuit corresponds to distal arterial perfusion cannula in VA ECMO or to venous return cannula in VV ECMO. The inlet line has to be connected to the oxygenator to provide oxygenated blood to the limb in VA ECMO and to avoid oxygenator shunt during VV ECMO. Our reported connection is safe for two main reasons. First, the embolic risk seems to be minimal with this technique because of the positive blood pressure of the ECMO circuit and the ECT device air detector. Second, blood flow through the distal perfusion cannula is at least equal to that would be observed without ECT, because backflow to the arterial cannula only occurs if its pressure is inferior to distal perfusion cannula pressure. Thus, no limb ischemia occurred in patients under VA ECMO support. The main risk of this technique is the ECT accidental disconnection, with subsequent severe bleeding. For this reason, we recommend ECT connection and disconnection under senior physician supervision. The main limitations are the need for a distal perfusion cannula when used in VA ECMO or very high ECMO blood flows (i.e., above 6 L/min) with subsequent high and difficultly predictable pressures. In that case, pressure measurement before connection is recommended.

Table 1. Patients Features

Variables	VA ECMO	VV ECMO
Age (years), mean±SD	53.4 ± 16.3	49.6 ± 11.4
Male gender, n (%)	9 (64.3)	1 (14.3)
SAPS 2,* mean±SD	52.2 ± 17.6	39.7 ± 8.7
Type of intensive care unit admission, n (%)	14 (100.0)	7 (100.0)
Heart surgery	3 (21.4)	0 (0.0)
Lung or heart transplant	6 (42.9)	5 (71.4)
Pulmonary endarterectomy	4 (28.6)	2 (28.6)
Medical	1 (7.1)	0 (0.0)
Renal replacement therapy indications, n (%)	12 (100.0)	4 (100.0)
Acute kidney injury	6 (50.0)	4 (100.0)
Fluid overload	3 (25.0)	0 (0.0)
Metabolic acidosis	2 (16.7)	0 (0.0)
Hyperkaliemia	1 (8.3)	0 (0.0)
Renal replacement therapy flow and pressures		
Blood flow, mL/min, mean±SD	241 ± 27	250 ± 40
Inlet pressure, mm Hg, mean±SD	75 ± 66	106 ± 100
Outlet pressure, mm Hg, mean±SD	290 ± 48	193 ± 41
Plasmapheresis indications, n_(%)	2 (14.3)	3 (42.9)
Acute humoral rejection	1 (50.0)	2 (66.7)
Pretransplant desensitization	1(50.0)	1 (33.3)
Plasmapheresis flow and pressures		
Plasmapheresis blood flow, mL/min, mean±SD	200 ± 0	208 ± 14
Inlet pressure, mm Hg, mean±SD	144 ± 67	78 ± 114
Outlet pressure, mm Hg, mean±SD	297 ± 39	151 ± 76

ECMO, extracorporeal membrane oxygenation; VA, venoarterial; VV, venovenous.

*The SAPS 2 was calculated from 17 variables at admission. Scores can range from 0 to 163, with higher scores indicating greater disease severity.

In conclusion, connecting an ECT device to the distal perfusion cannula during VA ECMO or to the venous return cannula during VV ECMO is simple, effective, and costless. Because high pressures management remains challenging, we suggest the present technique as first choice for ECT device connection in ECMO patients.

References

1. Schmidt M, Bailey M, Kelly J, et al: Impact of fluid balance on outcome of adult patients treated with extracorporeal membrane oxygenation. *Intensive Care Med* 40: 1256–1266, 2014.
2. Askenazi DJ, Selewski DT, Paden ML, et al: Renal replacement therapy in critically ill patients receiving extracorporeal membrane oxygenation. *Clin J Am Soc Nephrol* 7: 1328–1336, 2012.
3. de Tymowski C, Augustin P, Houissa H, et al.: CRRT connected to ECMO: managing high pressures. *ASAIO J* 63: 48–52, 2017.
4. Seczyńska B, Królikowski W, Nowak I, Jankowski M, Szułdrzyński K, Szczeklik W: Continuous renal replacement therapy during extracorporeal membrane oxygenation in patients treated in medical intensive care unit: technical considerations. *Ther Apher Dial* 18: 523–534, 2014.
5. Baldwin I, Bellomo R, Koch B: Blood flow reductions during continuous renal replacement therapy and circuit life. *Intensive Care Med* 30: 2074–2079, 2004.
6. Rubin S, Poncet A, Wynckel A, Baehrel B: How to perform a haemodialysis using the arterial and venous lines of an extracorporeal life support. Eur J Cardio-Thorac Surg Off J Eur Assoc Cardio-Thorac Surg 37: 967–968, 2010.