

active vasculitis, on the basis of three arguments: (1) immunosuppressive medications increase the risk of infection regardless of ESRD; (2) rates of death should take into consideration duration of follow up; (3) comparison of causes of death between ESRD and non-ESRD patients should take into account the state of disease activity.

The goal of maintenance immunosuppressive therapy in patients in remission is to decrease the risk of relapse. Decisions regarding maintenance therapy must consider the relative risks and benefits of such therapy (risk/benefit ratio). Considering that the incidence of relapse was significantly lower after ESRD (0.08 episodes/person-year) compared with the same patients before ESRD (0.2 episodes/person-year, $P=0.0012$), there is little potential benefit of maintenance immunosuppression after ESRD.

In describing the major causes of death in the ESRD population, our goal was to highlight the frequency of infections, especially among immunosuppressed patients. Although active vasculitis was a major cause of death in the first month after diagnosis, infection accounted for 50% of deaths beyond then. Not surprisingly, infections were more frequent among patients receiving immunosuppressants compared with those who were not (1.94 vs 1.03 episodes/person-year, $P<0.0001$). In aggregate, the high rate of serious infections coupled with the low rate of relapse suggest that ESRD patients without active vasculitis are more likely to suffer from severe or fatal infections than relapsing disease. Therefore, the risk/benefit ratio does not support the routine use of maintenance immunosuppression therapy in antineutrophil cytoplasmic autoantibody small vessel vasculitis patients on chronic dialysis.

1. Chen M, Zhao M-H. Antineutrophil cytoplasmic autoantibody associated vasculitis on chronic dialysis. *Kidney Int* 2010; **77**: 468.
2. Lionaki S, Hogan SL, Jennette CE *et al*. The clinical course of ANCA small-vessel vasculitis on chronic dialysis. *Kidney Int* 2009; **76**: 644–651.

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CRRT in series with extracorporeal membrane oxygenation in pediatric patients

To the Editor: We read with great interest the article by Santiago *et al.*¹ describing an institutional method of performing continuous renal replacement therapy (CRRT), using a dedicated machine in series with extracorporeal membrane oxygenation (ECMO) in pediatric patients. We previously described the same method with some important differences,² and subsequently evaluated the technical and

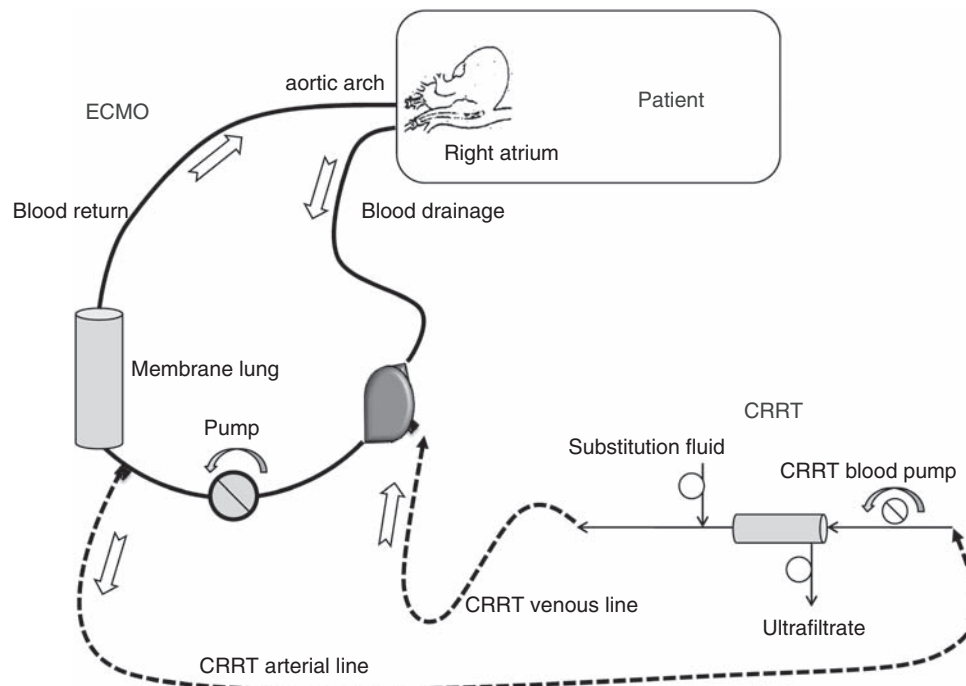


Figure 1 | Schematic representation of continuous hemofiltration circuit in parallel and countercurrent to cardiopulmonary circuit. CRRT, continuous renal replacement therapy; ECMO, extracorporeal membrane oxygenation.

clinical efficacy of this system.^{3,4} In the last 3 years, we treated 15 patients with ECMO and CRRT. In contrast to the setup suggested by the authors, we connected the filter inlet of the CRRT machine after the ECMO pump, and the filter outlet was then returned to the ECMO circuit before the pump (into the reservoir, if present): The CRRT circuit, running counter-current to extracorporeal assistance, allows the blood to be infused into the venous ECMO section (where the patient is drained) and then to be aspirated from the arterial ECMO section (where blood returns to the patient) (Figure 1). In our opinion, there are several reasons to prefer this setup. First, ECMO connection lines are generally used for circuit pressure monitorization, and frequently one connection in the ECMO venous line and one in the arterial line remain available. Second, this might reduce blood flow resistance and turbulence after the centrifugal pump and improve reservoir drainage when a roller pump is present. Blood recirculation induced by this circuit setup is negligible, considering that the CRRT to ECMO blood flow ratio is never >0.1. The only requirement to take into consideration during roller extracorporeal assistance is to increase ECMO blood flow by the same amount as CRRT blood flow, to compensate the shunted circulation. Interestingly, during centrifugal ECMO, the flow is self-adjusted to the increased value, considering the additional pre-pump blood flow coming from the CRRT circuit and reduced resistances after the centrifuge due to blood aspiration into the dialysis machine.

1. Santiago MJ, Sánchez A, López-Herce J *et al.* The use of continuous renal replacement therapy in series with extracorporeal membrane oxygenation. *Kidney Int* 2009; **76**: 1289–1292.
2. Ricci Z, Polito A, Giorni C *et al.* Continuous hemofiltration dose calculation in a newborn patient with congenital heart disease and preoperative renal failure. *Int J Artif Organs* 2007; **30**: 258–261.
3. Ricci Z, Morelli S, Vitale V *et al.* Management of fluid balance in continuous renal replacement therapy: technical evaluation in the pediatric setting. *Int J Artif Organs* 2007; **30**: 896–901.
4. Ricci Z, Carotti A, Parisi F *et al.* Extracorporeal membrane oxygenation and high-dose continuous veno-venous hemodiafiltration in a young child as a successful bridge to heart transplant for management of combined heart and kidney failure: a case report. *Blood Purif* 2009; **29**: 23–26.

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The Authors Reply: After having read Dr Ricci *et al.*'s¹ comments about our article,² we would like to add some considerations.

The papers published by these authors are single-case descriptions that basically refer to the working of the continuous renal replacement therapy (CRRT). In these

papers no assessment of CRRT and extracorporeal membrane oxygenation (ECMO) working in-line was carried out.^{3,4} On the contrary, our study evaluates these characteristics *in vitro*, in an animal model as well as in children, through a clinical prospective study.²

Similar to our model, Ricci *et al.* connect the filter inlet of the CRRT machine after the ECMO pump, but the filter outlet is returned to the ECMO circuit before the pump (into the reservoir, if present). The authors suggest that this type of connection may have some advantages:

- (1) One connection in the ECMO venous line and one in the arterial line are available. However, this depends on the type of ECMO circuit used. In our type of circuit, the CRRT device is connected through a three-way luer lock connection that allows measurement of the pressure and the infusion of heparin simultaneously in the same line. This also makes the connection and withdrawal of the circuit easy at any time without causing any alteration in the ECMO function.
- (2) This might also reduce blood flow resistance and turbulence after the centrifugal pump and improve reservoir drainage when a roller pump is present. We are not aware of any study having measured the turbulence and resistance to blood flow or suction pressures in the reservoir after the connection of the CRRT to the ECMO circuit, but the effect is likely to be minimum because, as the authors say, the CRRT to ECMO blood flow ratio is never greater than 0.1.

So, what disadvantages might the connection that Dr Ricci *et al.* propose have? As the ECMO pump exerts a negative pressure in the reservoir and/or the circuit, which could be transmitted to the CRRT device and could cause errors in the outlet pressure, as well as decrease in the filter pressure and transmembrane pressure, important information regarding the state of the filter could be lost.

In conclusion, connecting the CRRT device to the ECMO circuit improves the handling of the CRRT device. Probably there is no unique method to connect these devices, and each institution must assess and decide on which method to adopt depending on the circuit and machine they use.

1. Ricci Z, Ronco C, Picardo S. CRRT in series with extracorporeal membrane oxygenation in pediatric patients. *Kid Int* 2010; **77**: 469–470.
2. Santiago MJ, Sánchez A, López-Herce J *et al.* The use of continuous renal replacement therapy in series with extracorporeal membrane oxygenation. *Kidney Int* 2009; **76**: 1289–1292.
3. Ricci Z, Polito A, Giorni C *et al.* Continuous hemofiltration dose calculation in a newborn patient with congenital heart disease and preoperative renal failure. *Int J Artif Organs* 2007; **30**: 258–261.
4. Ricci Z, Morelli S, Vitale V *et al.* Management of fluid balance in continuous renal replacement therapy: technical evaluation in the pediatric setting. *Int J Artif Organs* 2007; **30**: 896–901.

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