Extracorporeal CO_2 removal with CRRT among patients with ARDS

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Case

- 62 year old, female was admitted to ICU due to increasing FiO_2 and vasopressor requirements, increasing lactate, and metabolic acidosis following an open laparotomy and colonic resection complication by bilateral femoral embolectomy

- BG: Previous vascular surgery for peripheral arterial/venous disease (lower limbs), AF – on apixaban and DM2

- Deteriorated on Day 2, NIV failure → I+V, on severe ARDS, VQ mismatch; on noradrenaline, vasopressin; oliguric with AKI 1; high abdominal pressures; generalized oedema (weigh gain ~ 16kg)

- Now Day 3 → increasing ventilation pressure parameters, FiO2 at 90%, paO_2 8.1 kPa $paCO_2$ 8.9 pH 7.1 with lactate of 6, now anuric with no changes with vasopressin requirements

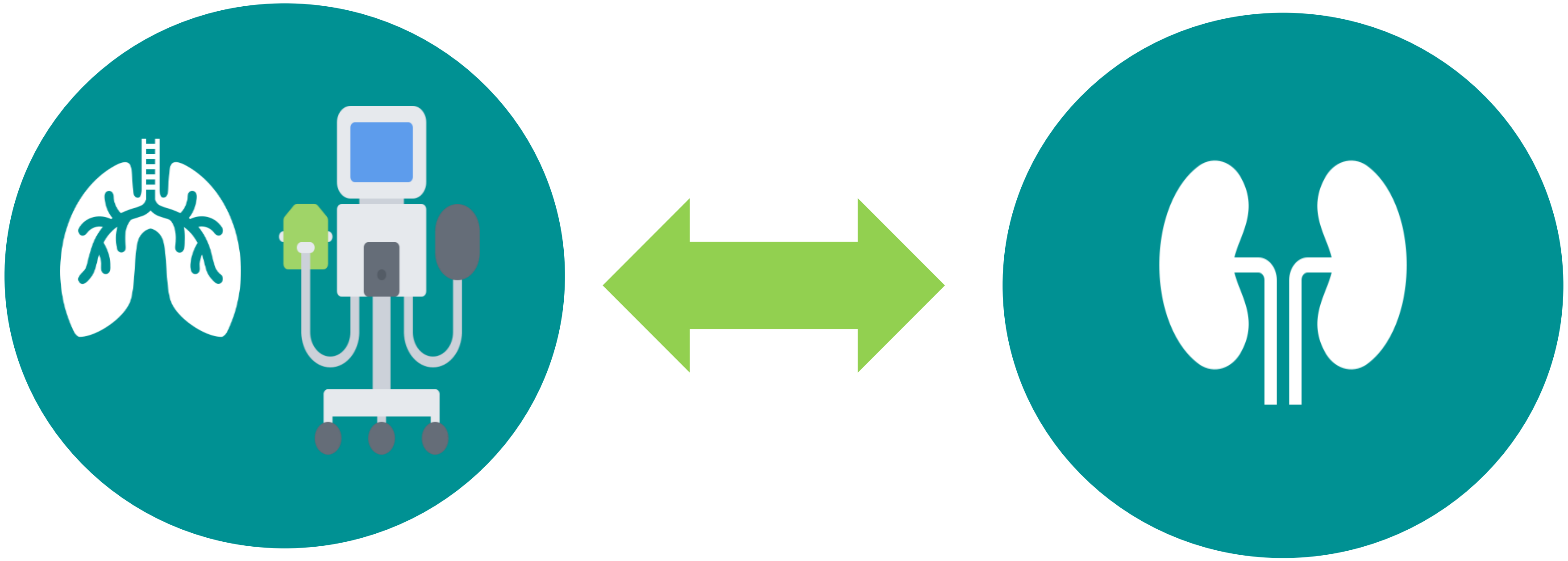
Background

- ARDS is a form of severe lung inflammation characterised by hypoxia, ↓compliance and bilateral infiltrates (Jacobs, 2020; Cappadona, 2023).
- Mortality is 27%, 32% and 45% for mild, moderate and severe, ARDS (Sedhai, et. al., 2024)
- Lung protective ventilation (LPV) has ↓mortality (Brower, et. Al, 2000) but it can lead to ↑$paCo_2$ with subsequent respiratory acidosis (Jacobs, 2020; Terragani et al, 2007; Alessandri, 2023).
- Driving pressure (ΔP) is strongly associated with survival (Amato, et al., 2015)

Lung and Kidney Crosstalk

Lung ✕ kidney injury ↑ mortality to 80% in ARDS
35-60% of them would require renal support

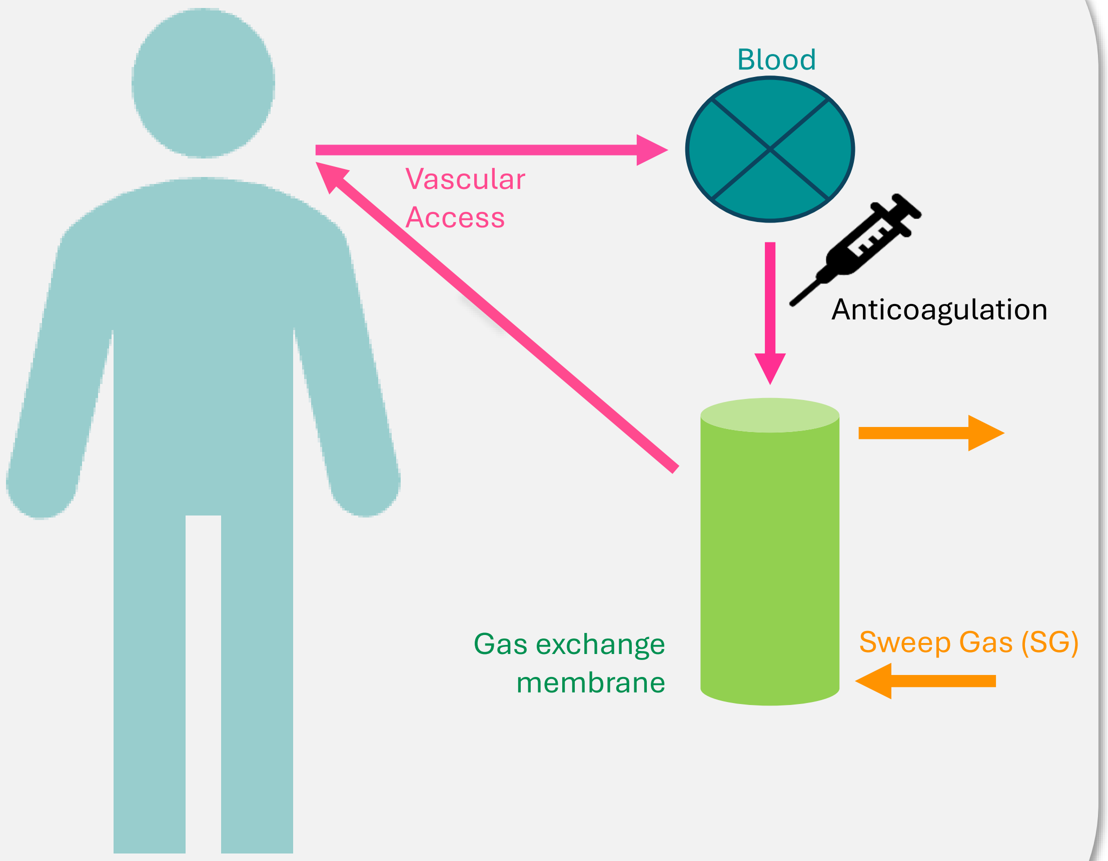
(Uchino, 2005; van den Akker, 2013; Husain-Syed, 2016)



(Redant, 2021; Quintard, 2014)

Extracorporeal Carbon dioxide removal ($ECCO_2R$) is a low-flow CO_2 elimination system which aims to facilitate LPV among critically ill patients with ARDS.

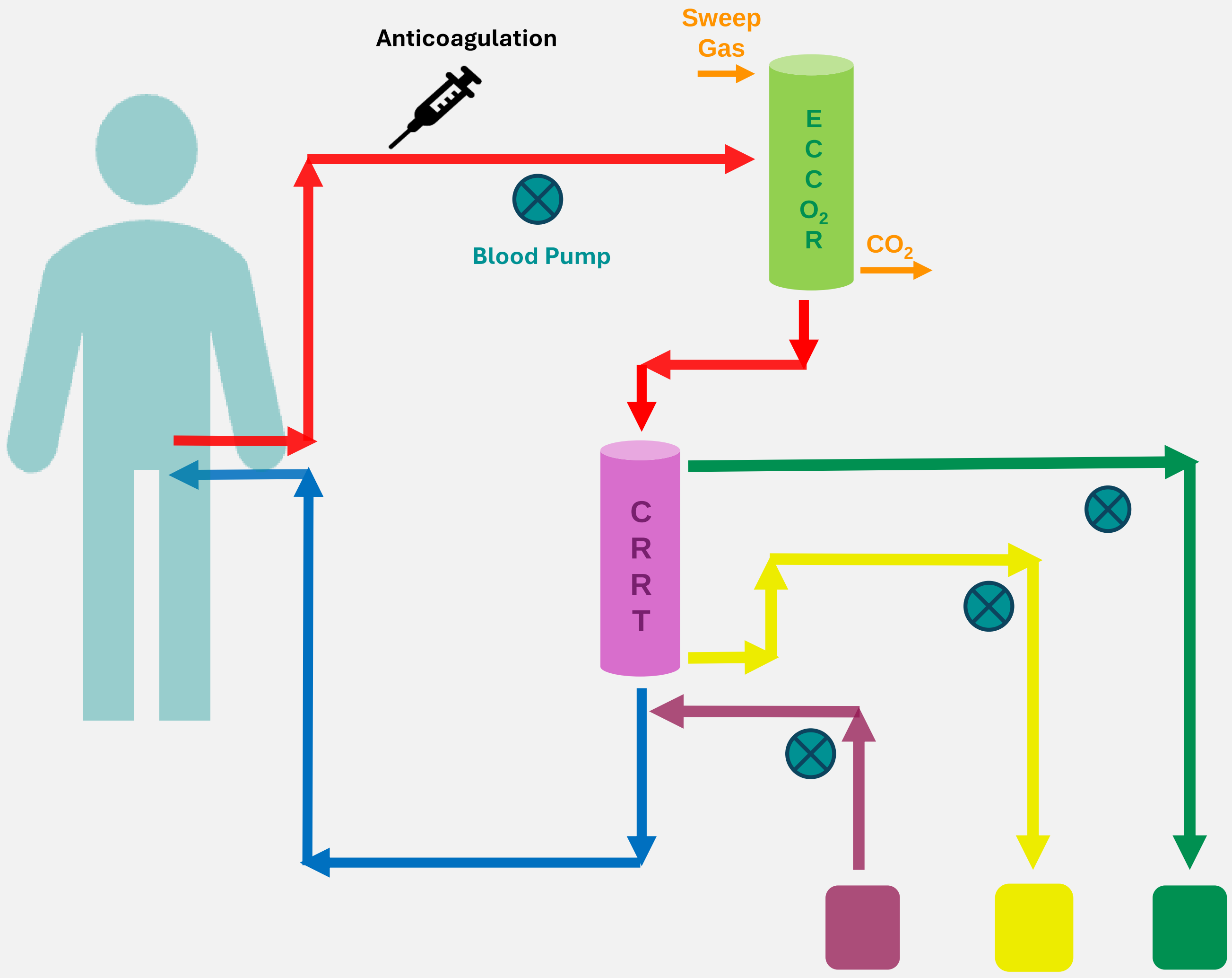
(Combes, 2020; Schmidt, 2018; Cappadona, 2023)



$ECCO_2R$ + CRRT Schematic diagram

$ECCO_2R$ + CRRT

can ↓ risk by ↓CO_2 facilitating ultraprotective ventilation (UPV) – reduction of VT to 3-4 mL/Kg PBW and plateau Pressure (PPlat) ≤25 cm H2O while simultaneously providing renal replacement therapy (Alessandri, 2023).



$ECCO_2R$ + CRRT Schematic diagram

Evidence Review

Is it **feasible**? Is it **Safe**? Is it **Cost-effective**? How does it affect the **ventilation values** of the patients? Does this treatment affect the **ICU LOS**? Does it affect the **MV days**? How does it affect **patient outcomes**?

Evidence Review

Study Profile	Intervention	Significant Results	Conclusions
Forster et al, 2013 Non-randomised proof-for-concept study N= 10 ventilated patients with ARDS + AKI with ongoing CRRT	Hollow fibre gas exchanger was added to CRRT circuit	✓ Mean ↓$paCo_2$ by 2.3 kPa after 4 hours with simultaneous ↑ pH ✓ Hemodynamic improvement with average ↓ of vasopressors by 65% average in 24 hours	$ECCO_2R$ +CRRT is safe and feasible. It significantly ↓CO_2 with rapid correction of arterial pH. This could be a potential addition to treatment of ARDS

Evidence Review

Study Profile	Intervention	Significant Results	Conclusions
Allardet-Servent et al, 2015 Prospective human observational N= 11 patients with ARDS and AKI 2 or 3	Membrane gas exchanger was inserted within the CRRT circuit; patients were placed with VC MV and reduced TV in stages	✓ PEEP level, respiratory compliance – unaltered and stable ✓ ↑ rate of CO2 elimination by lung after TV reduction ✓ Co_2 removal upstream > downstream ✓ ↑Pre and post dilution, ↑ fluid removal ✓ ↑HR, 20% ↑MAP and CO after 20 min ↓noradrenaline requirement ✓ No patient/circuit related complications	Combining $ECCO_2R$+CRRT is safe and allows efficient blood purification with enhanced LPV

Evidence Review

Study Profile	Intervention	Significant Results	Conclusions
Newich et al, 2019 Multicentre observational, pilot N= 20 patients ventilated with PC mode receiving RRT	Application of $ECCO_2R$ to CRRT	✓ 78% received UPV after 8H and 82% after 24 hours ✓ ↓$PaCo_2$ ↑pH ✓ ↓TV ↓driving pressure (ΔP) ✓ No complications r/t procedure noted	$ECCO_2R$+ CRRT can correct respiratory acidosis and ↓ ventilation requirements in hypercapnic patients with coexisting renal failure

Evidence Review

Study Profile	Intervention	Significant Results	Conclusions
Consales et al, 2022 **CICERO Study** Retrospective observational N= 22 with mild to moderate ARDS or aeCOPD + AKI ≤ 2	Application of $ECCO_2R$ + CRRT with heparin infusion as anticoagulation	✓ 6/17 extubated, 12/17 LPV in 24 H; ✓ 1 NIV → SV, 4/5 (aeCOPD) NIV failure ✓ ↓$PaCo_2$ ↑pH ✓ ↓PPlat, ↓TV and improved p/f ratio ✓ 21/22 recovered from AKI, with ↑ diuresis in 48-72 hours ✓ N=4 tracheostomy (18.2%) ✓ N=4 died during the study; 2 after the treatment (total = 6) ✓ N=4 blood transfusion	$ECCO_2R$+ CRRT can ↓ ventilation pressures while providing adequate RRT. It can facilitate LPV, and can be used to avoid IMV among aeCOPD or facilitate extubation.

Evidence Review

Study Profile	Intervention	Significant Results	Conclusions
Alessandri et al, 2023 Retrospective multicentre observational N= 27 with ARDS and AKI 3	Ventilation of VC Mode, $ECCO_2R$ + CRRT and gradual ↓TV to 4ml/kg PBW, BF 186-393 ml/min SG 9-11min/L heparin infusion	✓ $PaCo_2$ remained stable despite ↓TV ✓ No change in oxygenation ✓ ↓ Plasma creatinine ✓ No patient-related and circuit related adverse effects	$ECCO_2R$ + CRRT is effective in facilitating UPV while maintaining effective renal support among patients with COVID 19-induced ARDS and AKI.

Summary of Findings

- Ventilation values improvement i.e. ↓TV and ↓driving pressure (ΔP), stable oxygenation, improved p/f ratio – (Nenwich 2019, Consales 2022, Allardet-Servent 2015)
- Reduction/stability of $PaCo_2$ (Forster 2013, Allardet-Servent 2015, Nenwich 2019, Consales 2022, Alessandri 2023)
- Haemodynamic and Biochemical improvement (Forster 2013, Allardet-Servent 2015)
- Rise and stability of pH (Forster 2013, Nenwich 2019)
- Minimal/No circuit or patient complications (Allardet-Servent 2015, Nenwich 2019, Alessandri 2023)

Limitations

- The majority of the evidence currently -> observational/retrospective in nature
- Small, heterogenous population (ie phase and severity of ARDS, patient characteristics, one study included aeCOPD)
- Varying ventilation strategies (depending on the preference of physicians)
- No follow-up – unable to comment of the long-term effects of the combined treatment (most of the studies only looked at upto 72 hours)
- Mostly single centre

Conclusions

- Evidence is limited to support the practice
- Extracorporeal CO_2 removal + CRRT can **improve respiratory acidosis** among patients with ARDS.
- It can **facilitate ultraprotective ventilation** among patients with ARDS, preventing potential ventilator-induced lung injury complications while effectively providing RRT.

Implications to Nursing Practice

- ✓Adding gas exchanger in current local CRRT circuit may only require minimal training due to its simplicity
- ✓It does not require additional access for patients who are already receiving CRRT.
- ✓Highly practicable for non-specialized areas that are already providing CRRT
- ✓This is can provide a rescue therapy for ARDS who may be candidate for and/or waiting for ECMO.

Call for Future Studies

Is it **feasible**? Is it **Safe**? Is it **Cost-effective**? How does it affect the **ventilation values** of the patients? Does this treatment affect the **ICU LOS**? Does it affect the **MV days**? How does it affect **patient mortality**?

Questions?

Thank you!

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