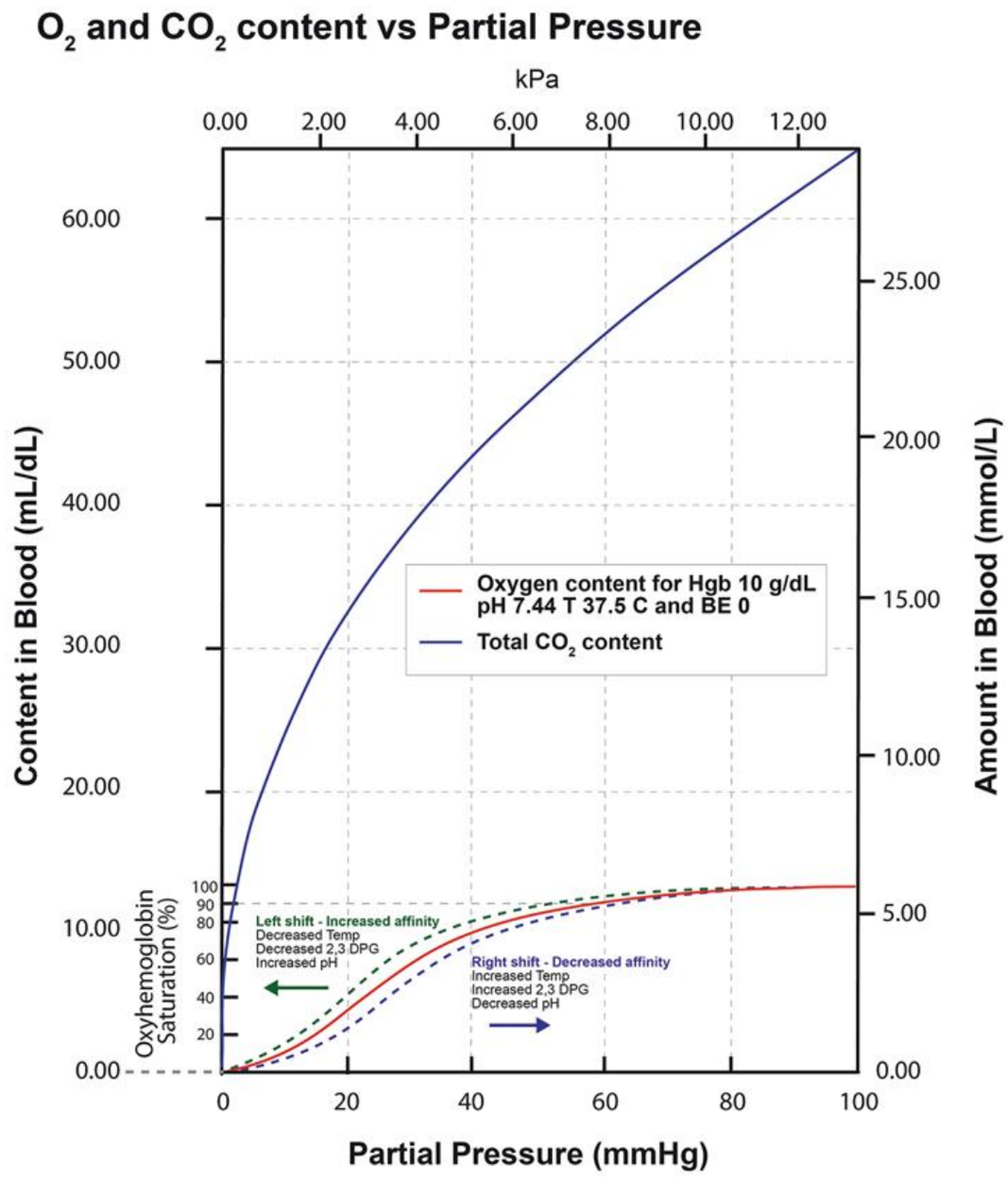
Meet The Expert

pCO_2= 60 mmHg
CO_2 content = 52 ml/100 ml blood

pCO_2= 80 mmHg
CO_2 content = 60 ml/100 ml blood

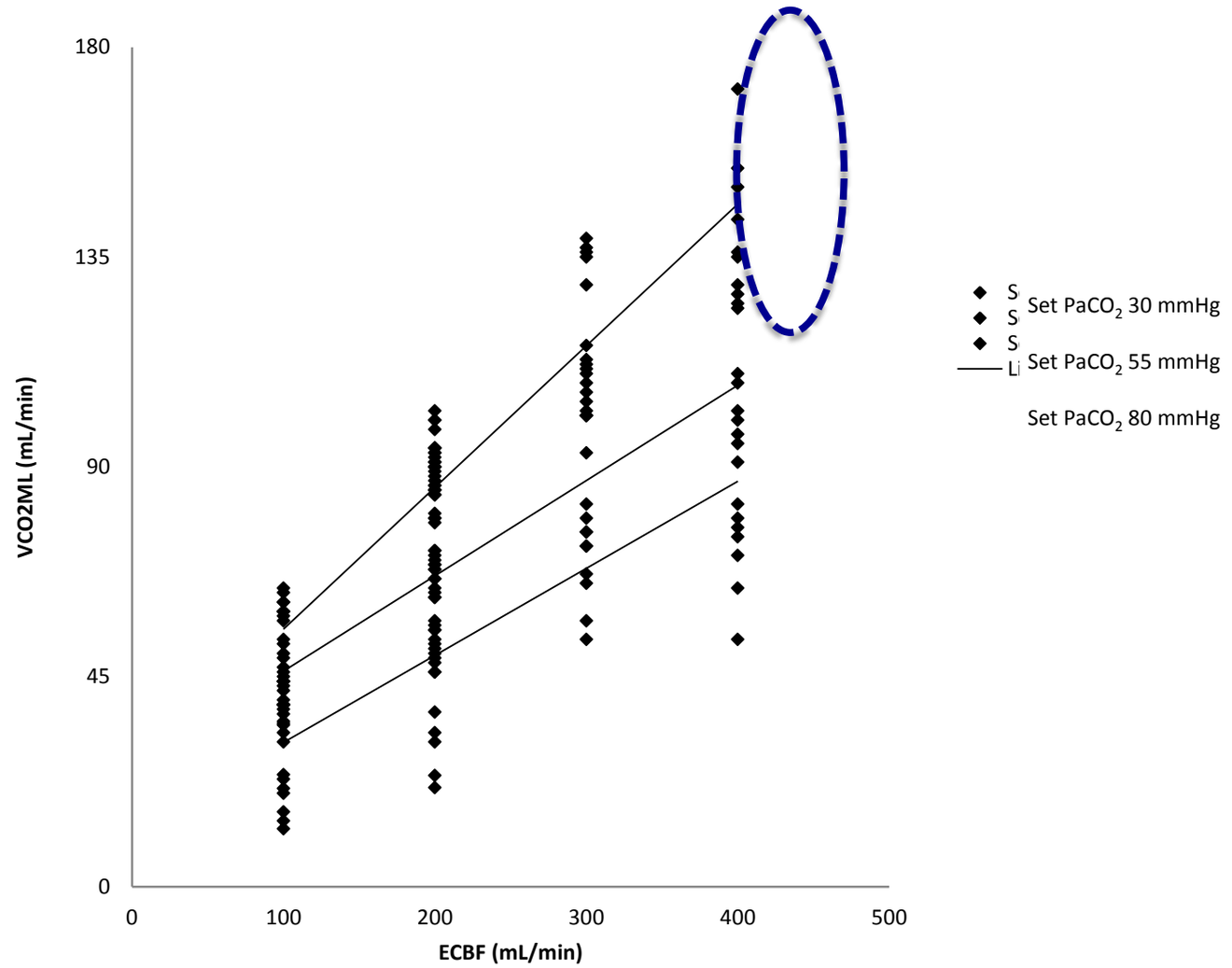
pCO_2= 90 mmHg
CO_2 content = 70 ml/100 ml blood

Qb = 400 ml/min	pCO_2 [mmHg]	CO_2 content [ml]
	60	208
	80	240
	90	280



Significant CO2 amount is contained in 400 ml/min of Blood

MORELLI et al. ICM 2017



Clinical Benefits

Avoid intubation when NIV fails

Facilitate protective ventilation

Duscio et al, CCM 2018

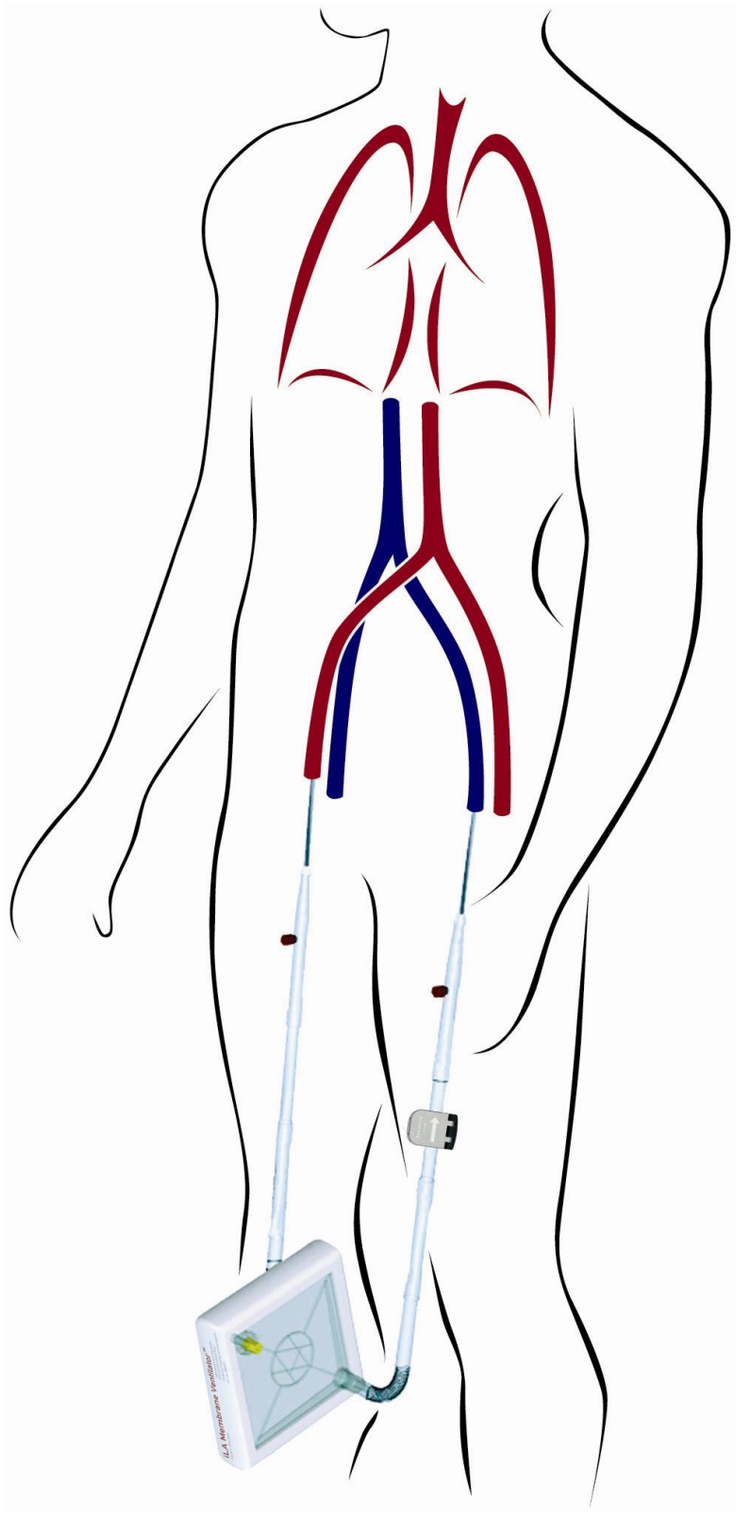
What is the role of ECCO$_2$R in the management of respiratory failure?

Does $ECCO_2R$ in COPD patients prevent endotracheal intubation?

What about intermittent ECCO$_2$R?

$ECCO_2R$:
arterio-venous or veno-venous device?

iLA Membrane Ventilator®



Blood flow rate: 100–1500 mL/min

Membrane oxygenator surface area: 1.3 m^2

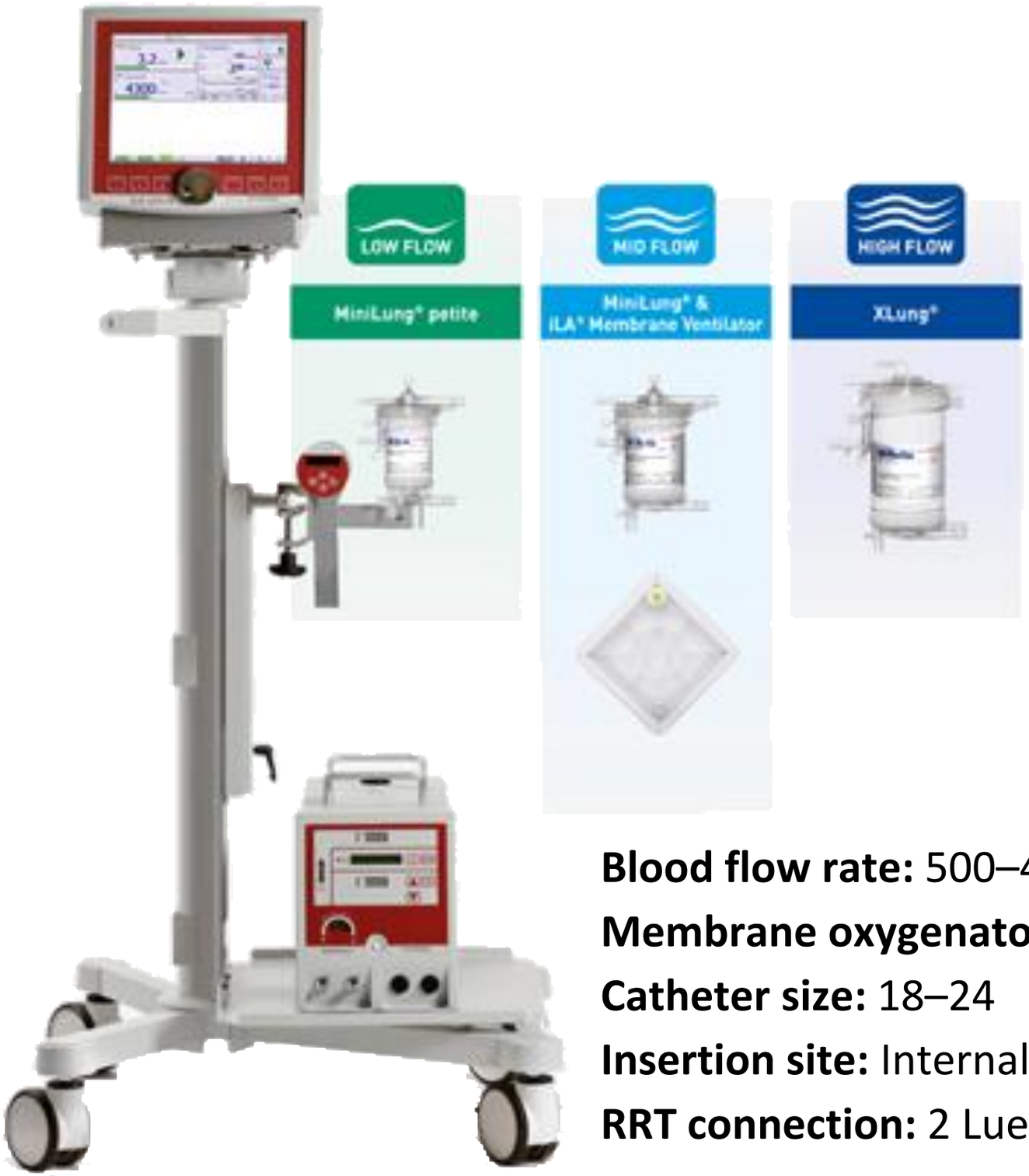
Catheter size: 13–21

Insertion site: femoral artery/vein

RRT connection: 2 Luer lock connectors in post-membrane limb

Fresenius/Xenios, Heilbronn, Germany

iLA activve®



Blood flow rate: 500–4500 mL/min

Membrane oxygenator surface area: 1.3 m^2

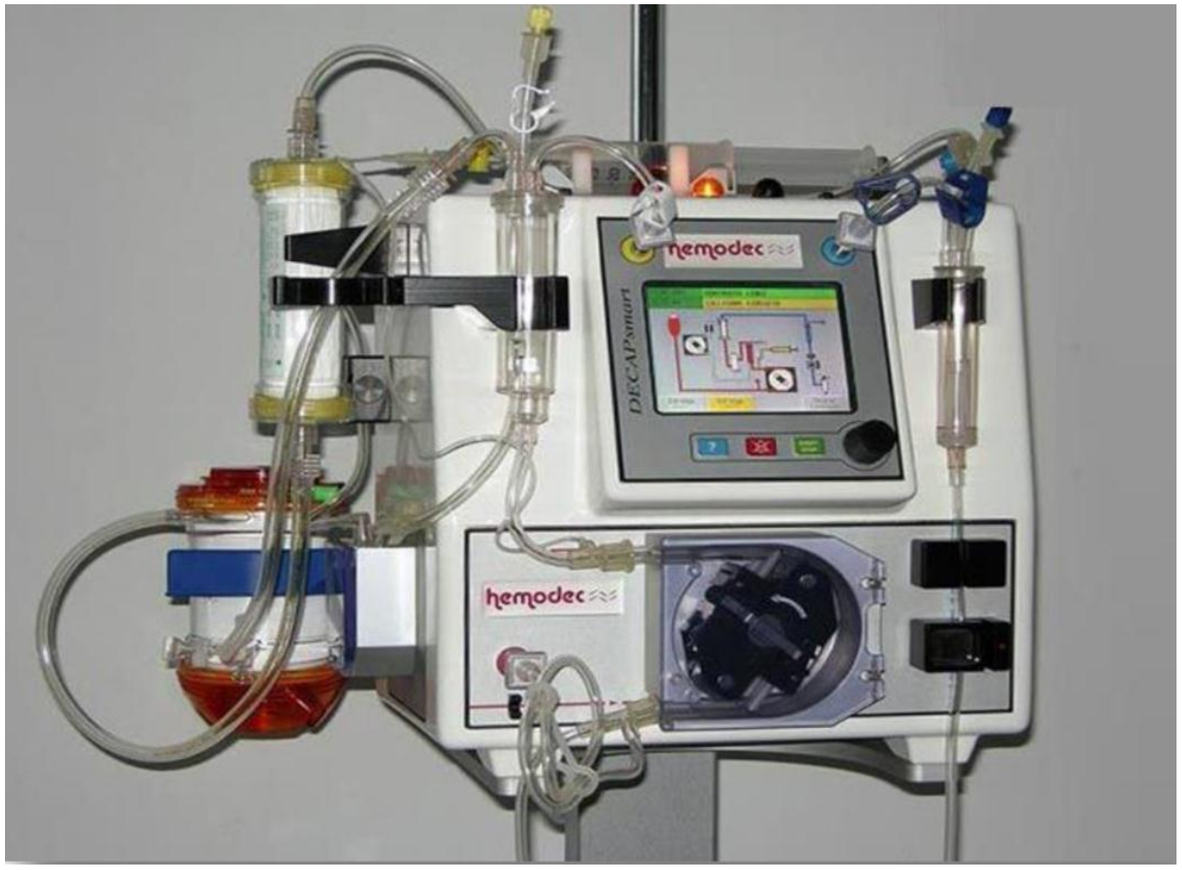
Catheter size: 18–24

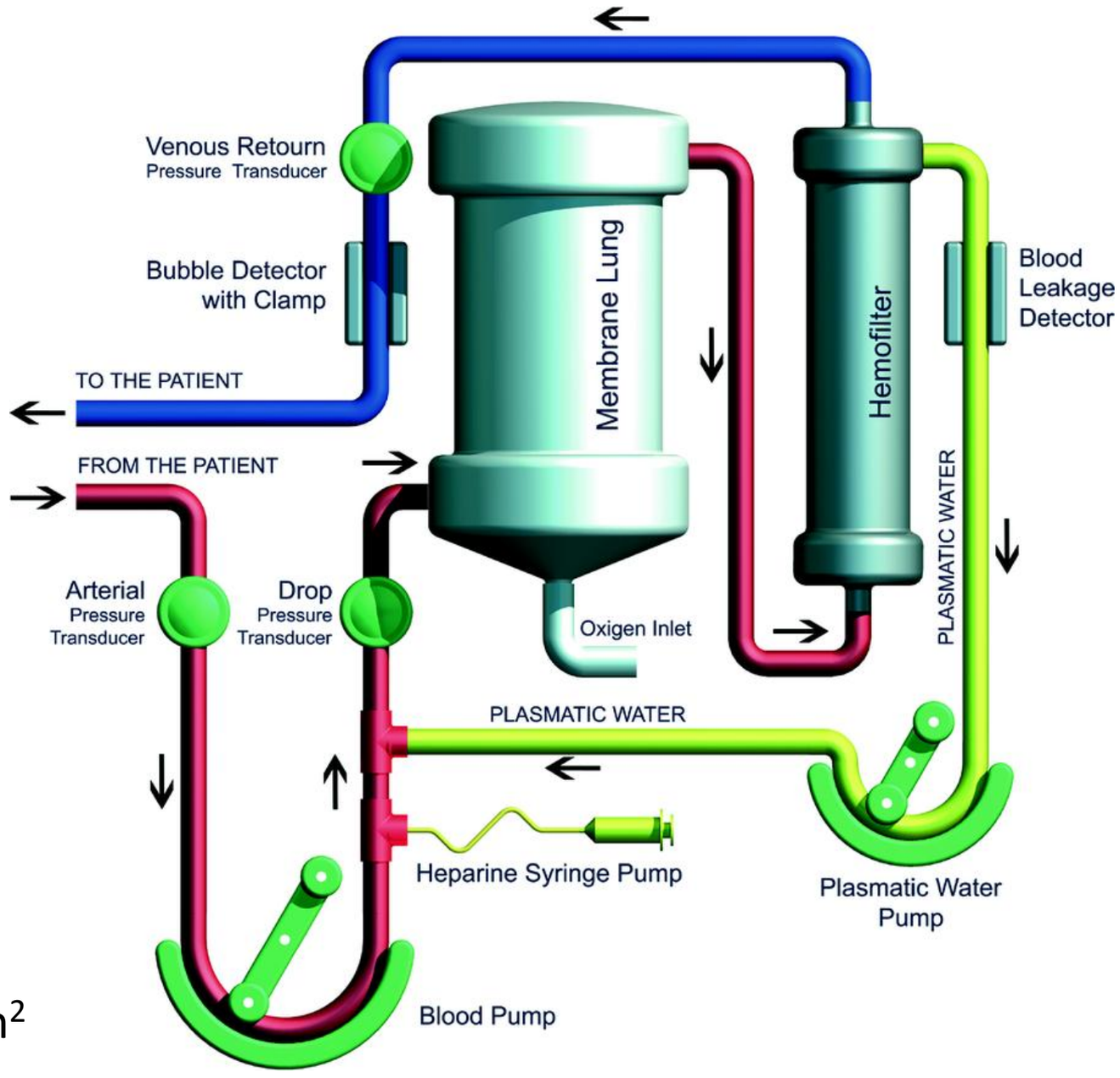
Insertion site: Internal jugular vein/femoral vein

RRT connection: 2 Luer lock connectors in post-membrane limb

Fresenius/Xenios, Heilbronn, Germany

Decap Smart®





Blood flow rate: 200–500 mL/min

Membrane oxygenator surface area: 1.35–1.8 m^2

Catheter size: 13

Insertion site: Internal jugular vein/femoral vein

RRT connection: alone or in series with HD hardware (Diapact, Omni)

B. Braun Avitum, Melsungen, Germany (previously: Hemodec, Salerno, Italy)

ProLUNG®

Blood flow rate: 450 mL/min

Membrane oxygenator surface area: 1.8 m^2

Catheter size: 13.5

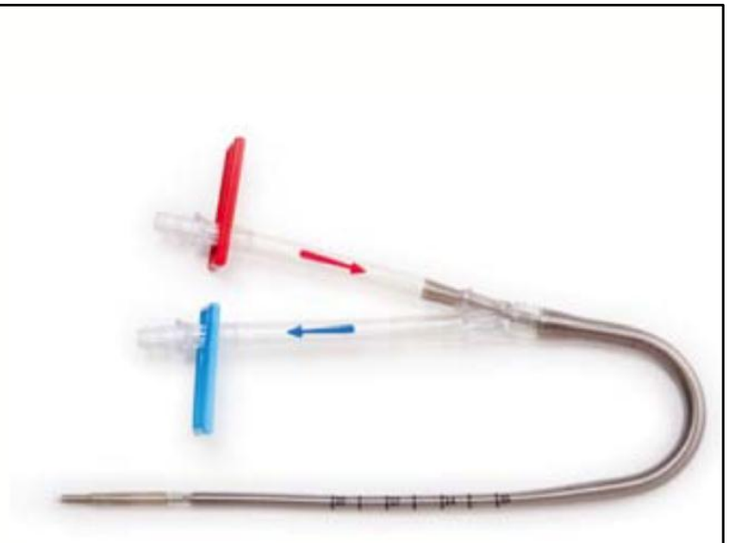
Insertion site: Internal jugular vein/femoral vein

RRT connection: officially none

Estor SpA, Pero, Italy

Hemolung®

Cartridge



Catheter

Blood flow rate: 350–550 mL/min

Membrane oxygenator surface area: 0.67 m^2

Catheter size: 15–21

Insertion site: Internal jugular vein/femoral vein

RRT connection: officially none by the manufacturer

Alung Technologies, Pittsburgh, USA

Prismalung®

Blood flow rate: <450 mL/min

Membrane oxygenator surface area: 0.32 m^2

Catheter size: 13–14

Insertion site: Internal jugular vein

RRT connection: First extracorporeal lung specifically designed for in-line attachment to existing HD hardware (PRISMAFLEX)

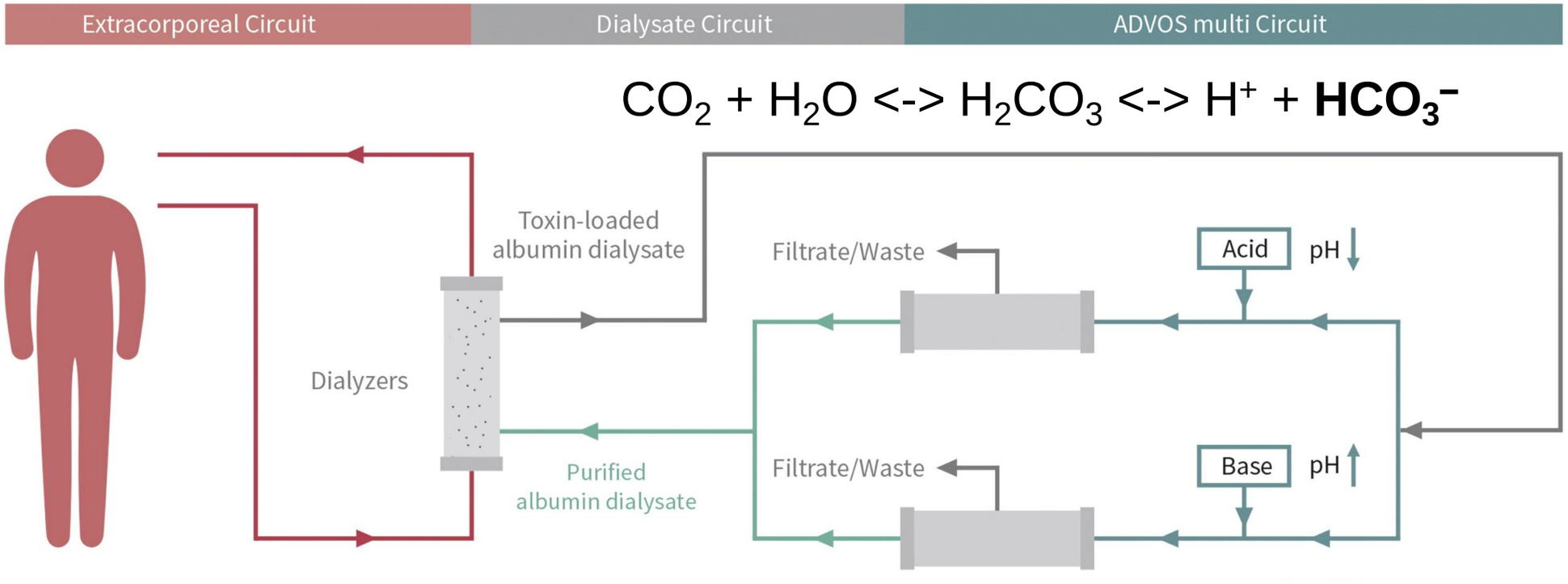
Gambro/Baxter, Unterschleissheim, Germany

Pump-Assisted Lung Protection (PALP)®

Blood flow rate: 200–2800 mL/min
Membrane oxygenator surface area: 0.98 m^2
Catheter size: 13–21
Insertion site: Internal jugular vein/femoral vein
RRT connection: officially none by the manufacturer

Maquet, Rastatt, Germany

Advanced Organ Support (ADVOS)®



Hepawash, Munich, Germany

Blood flow rate: 100–400 mL/min

Membrane oxygenator surface area: none

Catheter size: 13–14

Insertion site: Internal jugular vein/femoral vein

RRT connection: combined kidney, liver, lung support

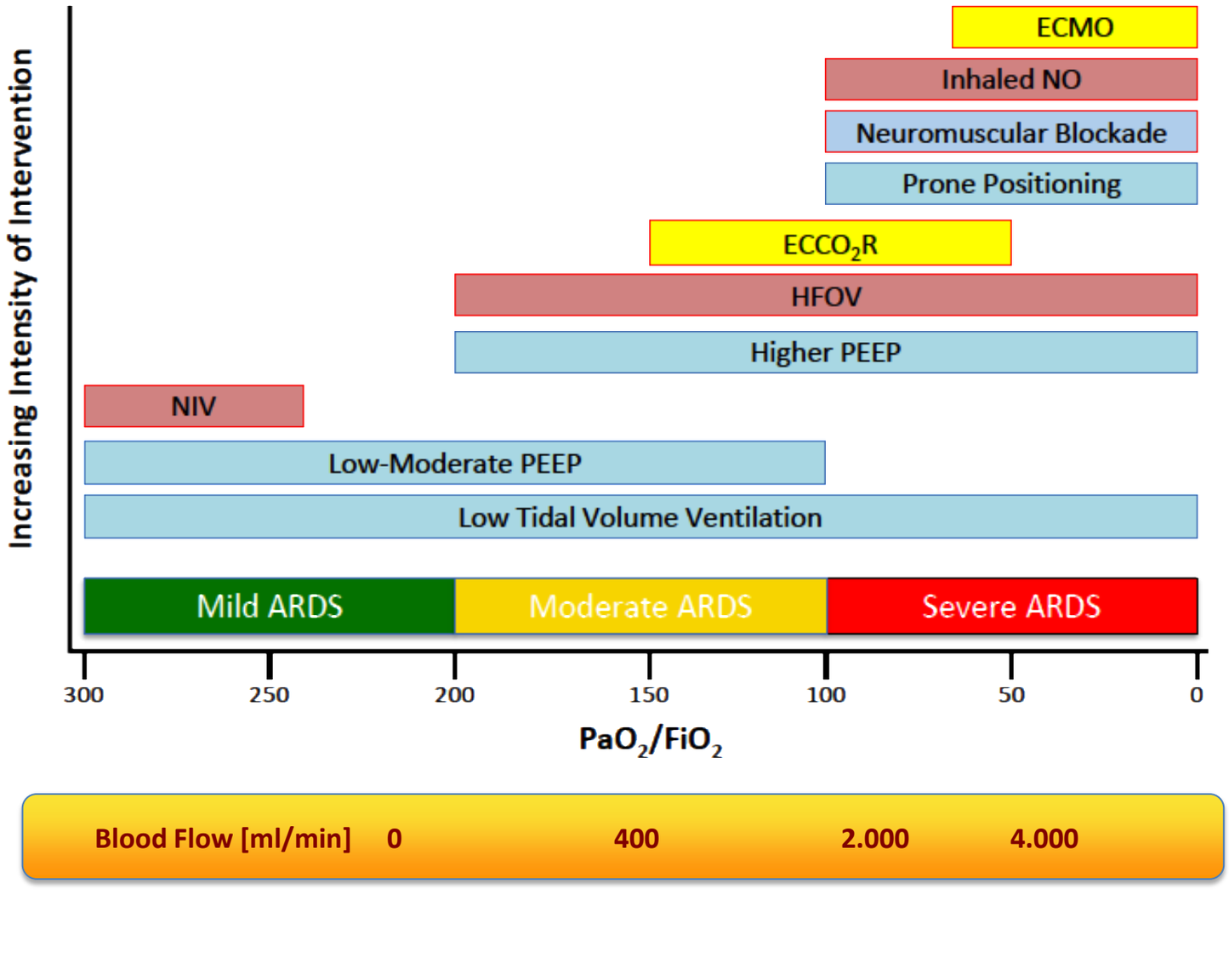
What is the role of ECCO$_2$R in the management of moderate ARDS?

A ventilation strategy using lower tidal volumes is associated with a lower risk for developing ARDS. ARDSnet strategy might not protect against tidal hyperinflation (when Pplat remains >28-30 cm H_2O)

Preventing VILI

Acute Respiratory Distress Syndrome

The Berlin Definition



MINI-INVASIVE ECCO2-R for PREVENTING VILI

Extracorporeal CO_2 removal may provide the physiologic prerequisites for controlling VENTILATOR INDUCED LUNG INJURY and to allow further reduction of Vt/Pplat/ΔP

Neto et al, JAMA 2012
Terragni e al, Curr Opin Crit Care, 2012
The ARDS Definition Taskforce. JAMA 2014
Duscio et al, CCM 2018

Should the efficiency of each device be an important consideration for clinicians?

Measurement of CO2 removal should be displayed for titration of therapy according to the quantity of CO2 removed

The efficiency of each device (ie, the quantity of CO2 removed per minute, adjusted to blood flow) determines the blood flow rate and hence the catheter size needed for adequate CO2 removal

Manufacturers and researchers should measure the efficiency of ECCO2R devices through the quantification of CO2 removed per minute and per 100 mL of blood flow under standardised clinical conditions.

A pratical application of minimal invasive approach…

Extracorporeal CO_2 Removal: The Minimally Invasive Approach, Theory, and Practice*

Eleonora Duscio, MD[1]; Francesco Cipulli, MD[1]; Francesco Vasques, MD[1]; Francesca Collino, MD[1]; Francesca Rapetti, MD[1]; Federica Romitti, MD[1]; Tim Behnemann, MS[1]; Julia Niewenhuys, MS[1]; Tommaso Tonetti, MD[1]; Iacopo Pasticci, MD[1]; Francesco Vassalli, MD[1]; Verena Reupke, DVM[2]; Onnen Moerer, MD[1]; Michael Quintel, MD[1]; Luciano Gattinoni, MD[1]

Duscio et al. as main result of their study demonstrated that a considerable amount of CO_2 **was removed by the ProLung system using only a minimally invasive cannulation** and a blood flow rate similar to that used in renal dialysis. Accepting a PaCO2 of 74 mm Hg and pH 7.3, they **were able to remove up to 138.8 mL/min** of CO_2. This allowed us to reduce total ventilation from 7.4 to 1.9 L/min with a corresponding reduction in mechanical power from 9.3 to 2.6 J/min with no detectable drawbacks"

This allowed us to reduce total ventilation from 7.4 to 1.9 L/min with a corresponding reduction in mechanical power from 9.3 to 2.6 J/min with no detectable drawbacks (Table 1).

Boyle et al, The Lancet 2018
Duscio et al, CCM 2018

What should we expect from a minimal invasive ECCO$_2$R device?

WHAT SHOULD WE ASK TO A MINI-INVASIVE ECCO2-R SYSTEM ?

A) PERFORMANT CO_2 REMOVAL CAPABILITY

A) PROLONGED SET DURATION, MEMBRANE BIOCOMPATIBILITY

B) VCO_2 MONITORING

C) REDUCED PRIMING VOLUME

A) MINI- INVASIVITY

B) REDUCED COOLING OF PATIENT BLOOD

C) AUTOMATED GAS SWEEP FLOW

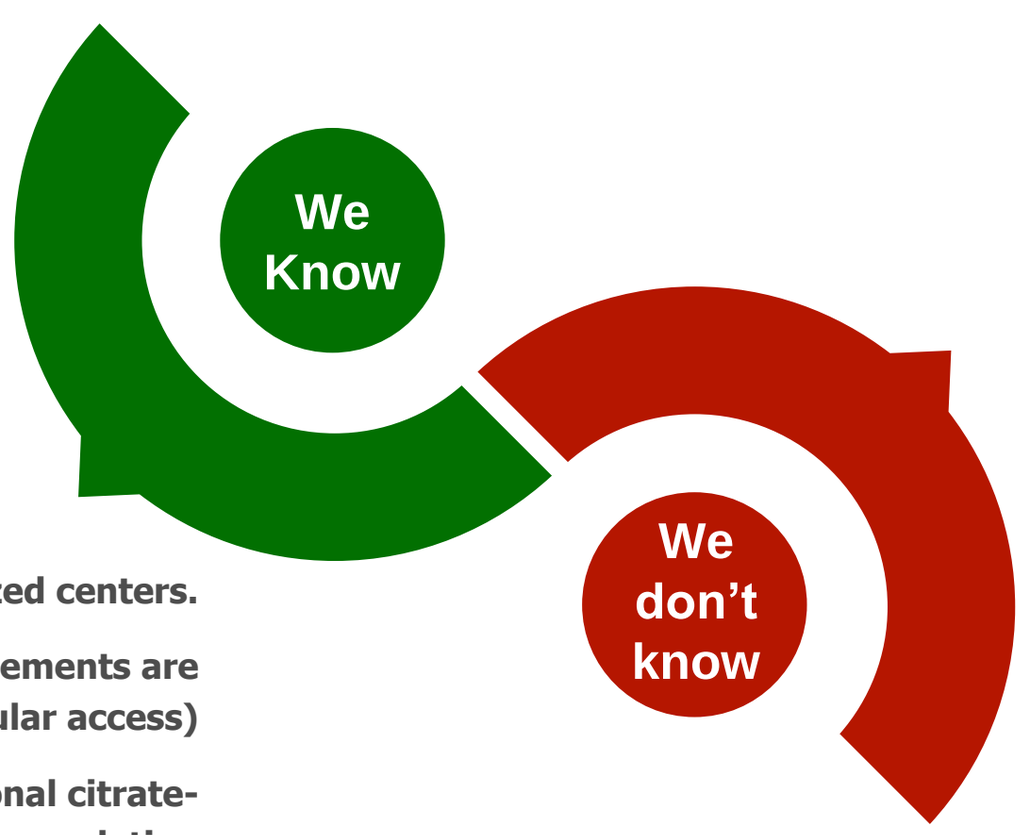
LF-ECCO2-R SYSTEM	ARTIFICIAL LUNG (MEMBRANE)	ARTIFICIAL LUNG (SURFACE mq)	TECHNOLOGY	VCO2 MONITORING
BELLCO – ABYLCAP (MEDTRONIC)	POLYMETHYLPENTENE	**0.67**	Peristaltic Pump Catheter ≤ 14 Fr	**NO**
BAXTER – PRISMALUNG	POLYMETHYLPENTENE	**0.35**	Peristaltic Pump Catheter ≤ 14 Fr	**NO**
ALUNG - HEMOLUNG	POLYMETHYLPENTENE	**0.59**	Centrifugal Pump Catheter ≥ 15.5 Fr	**YES**
BBRAUN - DECAP	POLYPROPILENE POLYMETHYLPENTENE	**1.35 1.81**	Peristaltic Pump Catheter ≤ 14 Fr	**NO**
ESTOR - PROLUNG	POLYMETHYLPENTENE	**1.81**	Peristaltic Pump Catheter ≤ 14 Fr	**YES**

What should we use integrated systems?

Integrated systems

About 35% to 60% of the patients undergoing respiratory therapies need renal-replacement therapies

Adding a membrane oxygenator within a CRRT circuit, in patients presenting with both ARDS and AKI, is safe and provides efficient extracorporeal Co2 removal with a reduction of PaCo2 by 21%



Applicable in non specialized centers.

No additional catheter placements are needed (unique vascular access)

Possibility to run regional citrate-calcium anticoagulation

Adequate anticoagulation and citrate dosing requirements at desired Qb (400 ml/min)

Qb achievable considering Artificial Lung + Hemofilter in line

Volume Control

if is possible to guarantee a $VCO_2 \approx 100$ ml/min

The strategy for Dialysate Liquid/Reinfusate (Lactate as buffer = septic shock; Bicarbonate as buffer = CO2)

Forster C, et al. Crit Care. 2013
Ilardet-Servent J, et al. Crit Care Med. 2015