WEANING, TRIAL OFF & DECANNULATION

VA – VV ECMO

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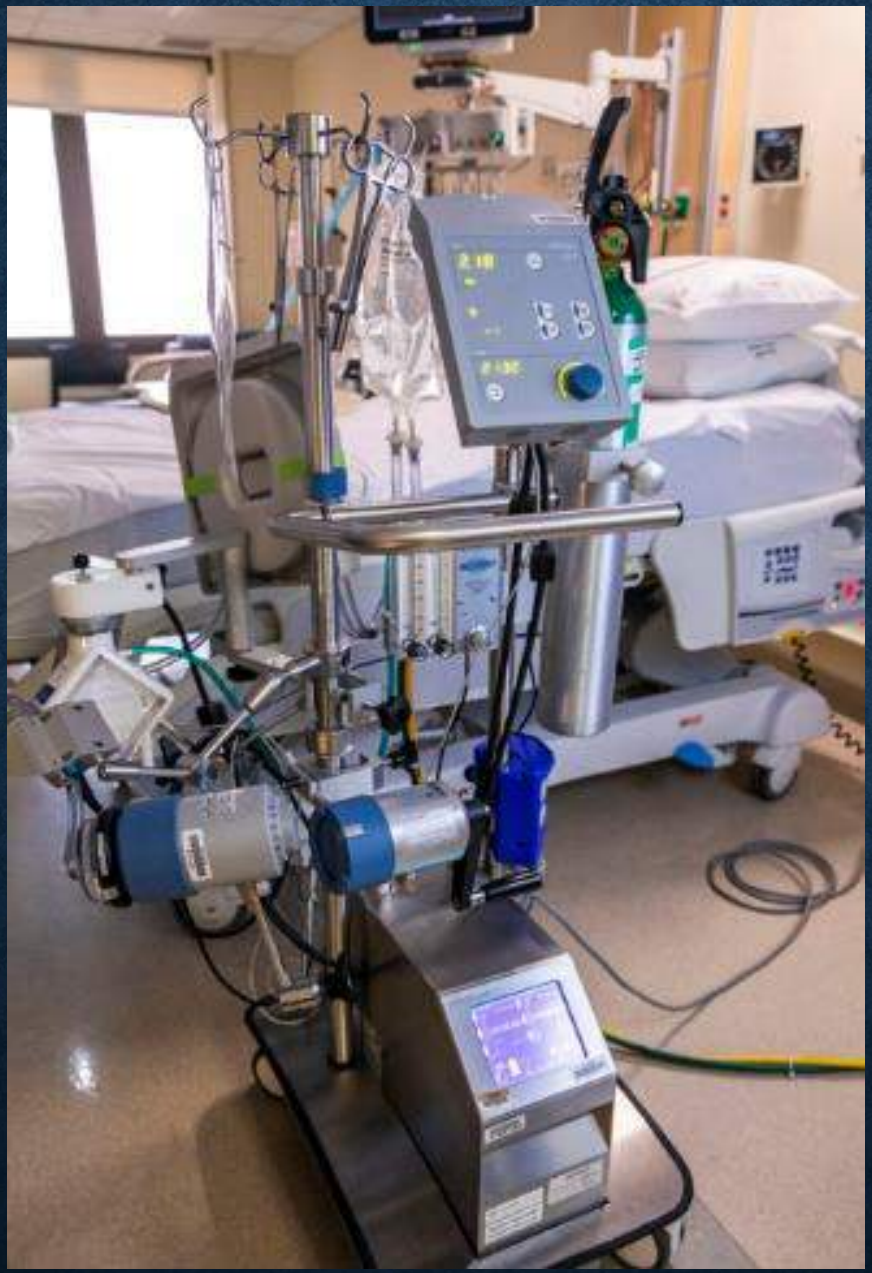

Vasques et al. Critical Care (2019) 23:316
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Critical Care

EDITORIAL Open Access

How I wean patients from veno-venous extra-corporeal membrane oxygenation

Francesco Vasques[1], Federica Romitti[2], Luciano Gattinoni[2†] and Luigi Camporota[1*†]

Perspective

Weaning from veno-arterial extra-corporeal membrane oxygenation: which strategy to use?

Sofia Ortuno[1], Clément Delmas[2], Jean-Luc Diehl[1], Clotilde Bailleul[1], Aymeric Lancelot[1], Mahassen Naili[3], Bernard Cholley[4], Romain Pirracchio[4], Nadia Aissaoui[1,5]

Intensive Care Med
DOI 10.1007/s00134-015-3663-y

WHAT'S NEW IN INTENSIVE CARE

Nadia Aissaoui
Aly El-Banayosy
Alain Combes

How to wean a patient from veno-arterial extracorporeal membrane oxygenation

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How I wean patients from veno-venous extra-corporeal membrane oxygenation

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OBJECTIVES

- What is weaning & Trial off
- Criteria for weaning & Trial off
- Weaning protocols
- Trial off protocols
- Criteria for Decannulation
- Protocols for decannuation

TABLE 85.3 The "SAVE" Score for Pre-ECMO Prediction of Survival at 30 Days After Initiation of VA ECMO for Cardiac Failure

Parameter	Score
ACUTE CARDIOGENIC SHOCK DIAGNOSIS GROUP (SELECT ONE OR MORE)	
Myocarditis	3
Refractory VT/VF	2
Post heart or lung transplantation	3
Congenital heart disease	−3
Other diagnoses leading to cardiogenic shock requiring VA ECMO	0
AGE (YEARS)	
18-38	7
39-52	4
53-62	3
≥63	0
WEIGHT (kg)	
≤65	1
65-89	2
≥90	0
ACUTE PRE-ECMO ORGAN FAILURES (SELECT ONE OR MORE IF REQUIRED)	
Liver failure*	−3
Central nervous system dysfunction†	−3
Renal failure‡	−3
Chronic renal failure§	−6
DURATION OF INTUBATION PRIOR TO INITIATION OF ECMO (h)	
≤10	0
11-29	−2
≥30	−4
Peak inspiratory pressure ≤ 20 cm H_2O	3
Pre-ECMO cardiac arrest	−2
Diastolic blood pressure before ECMO ≥ 40 mm Hg¶	3
Pulse pressure before ECMO ≤ 20 mm Hg¶	−2
HCO_3 before ECMO ≤ 15 mmol/L¶	−3
Constant value to add to all calculations of SAVE-score	−6
Total score	−35 to 17

Total SAVE-Score	Risk Class	Survival (%)
HOSPITAL SURVIVAL BY RISK CLASS		
>5	I	75
1-5	II	58
−4 to 0	III	42
−9 to −5	IV	30
≤−10	V	18

TABLE 85.2 The "RESP" Score for Pre-ECMO Prediction of Survival at 30 Days After Initiation of VV ECMO for Respiratory Failure

PARAMETER		Score
AGE, YEARS		
18-49		0
50-59		−2
≥60		−3
Immunocompromised status*		−2
MECHANICAL VENTILATION PRIOR TO INITIATION OF ECMO		
<48 h		3
48 h to 7 days		1
>7 days		0
ACUTE RESPIRATORY DIAGNOSIS GROUP (SELECT ONLY ONE)		
Viral pneumonia		3
Bacterial pneumonia		3
Asthma		11
Trauma and burn		3
Aspiration pneumonitis		5
Other acute respiratory diagnoses		1
Nonrespiratory and chronic respiratory diagnoses		0
Central nervous system dysfunction†		−7
Acute associated (nonpulmonary) infection‡		−3
Neuromuscular blockade agents before ECMO		1
Nitric oxide use before ECMO		−1
Bicarbonate infusion before ECMO		−2
Cardiac arrest before ECMO		−2
$PaCO_2$, mm Hg		
<75		0
≥75		−1
PEAK INSPIRATORY PRESSURE, cm H_2O		
<42		0
≥42		−1
Total score		−22 to 15
Total RESP Score	**Risk Class**	**Survival**
HOSPITAL SURVIVAL BY RISK CLASS		
≥6	I	92%
3-5	II	76%
−1 to 2	III	57%
−5 to −2	IV	33%
≤−6	V	18%

WEANING

- Weaning –
  - a slow decrease in pump flow or gas flow or FiO2 of ECMO over hours to days in an effort to take away mechanical heart/lung support from the patient.
- Trial off –
  - To disconnect patient from the ECMO for few hours to a day without removing cannula

WEANING
General Comments – VA ECLS

- NOT promoted for initial 24 hours

  [helpful for patient to recover from pre-ECLS hypoxia]
- Weaning NOT continued if inotrope doses need increasing beyond "tolerance" levels
- Weaning, if all parameters stable, can progress –
- Weaning usually slower
- Assess "arterial waveform" – reflects cardiac contractile function
- Gradually switching ventilatory parameters to 'normal' settings
- Monitor ACT closely & keep within 'new range'
- Monitor blood gases and lactate closely

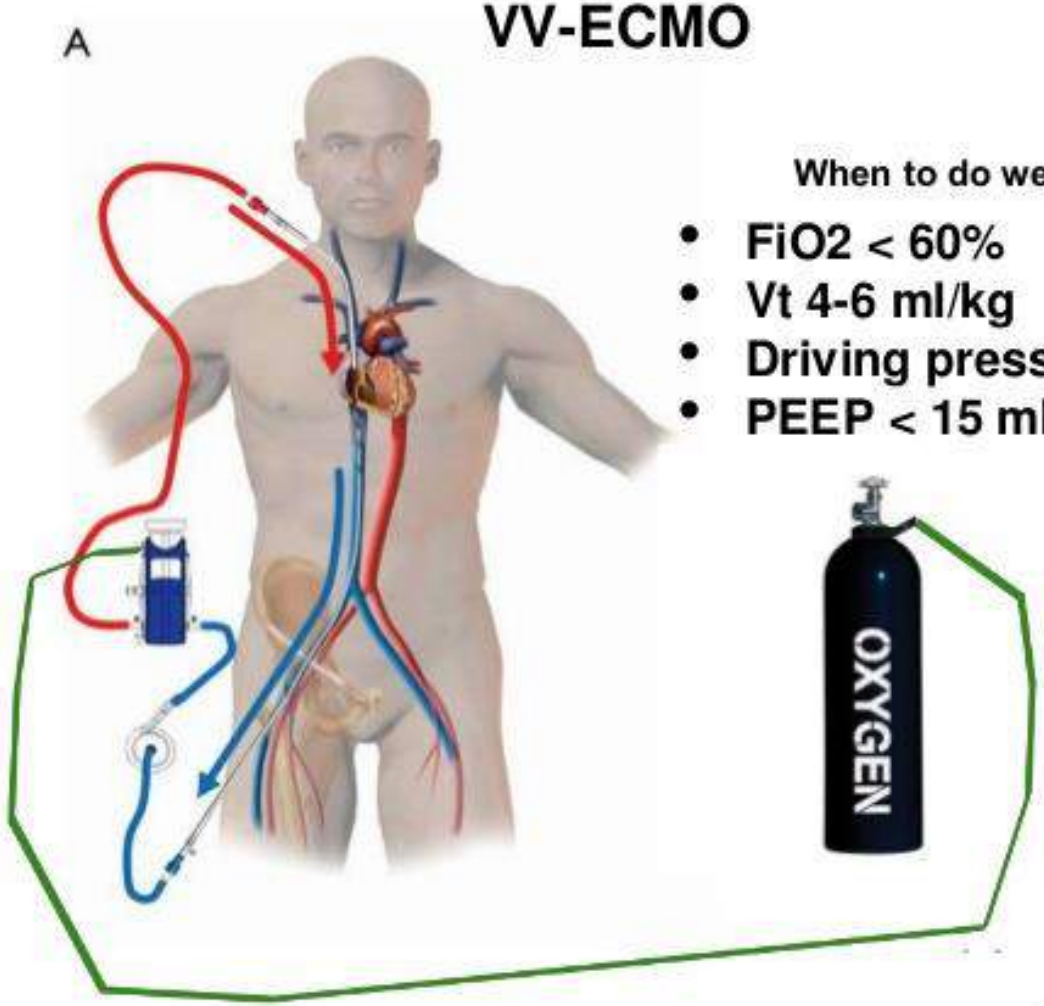
VENTILATORY MANAGEMENT

'Weaning ECLS'

With successful weaning of ECLS, assisted ventilation parameters altered to 'normal' settings

↓ECLS flows ⟶ ↑rate + ↓PEEP + ↑PIP

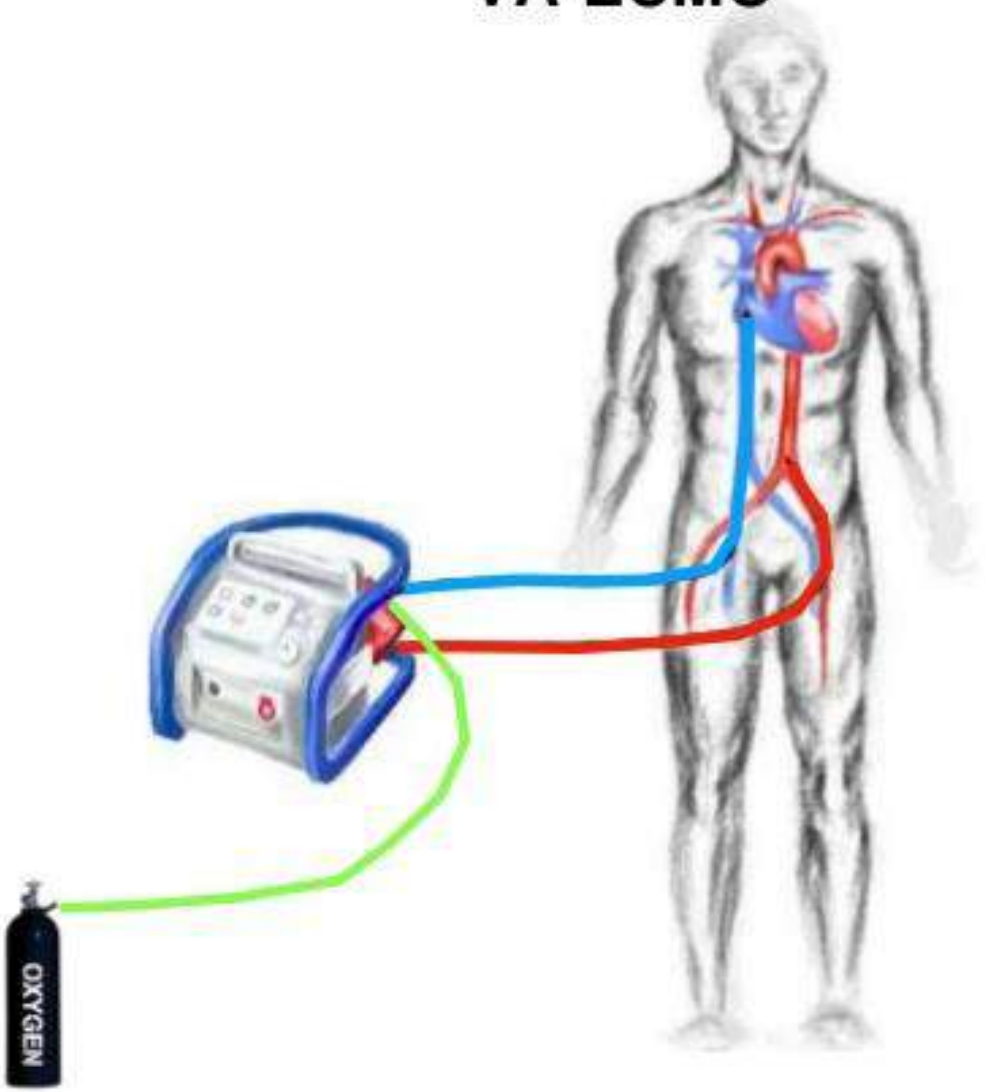
VV-ECMO



When to do wean trial …

- FiO2 < 60%
- Vt 4-6 ml/kg
- Driving pressure < 15 mbar
- PEEP < 15 mbar

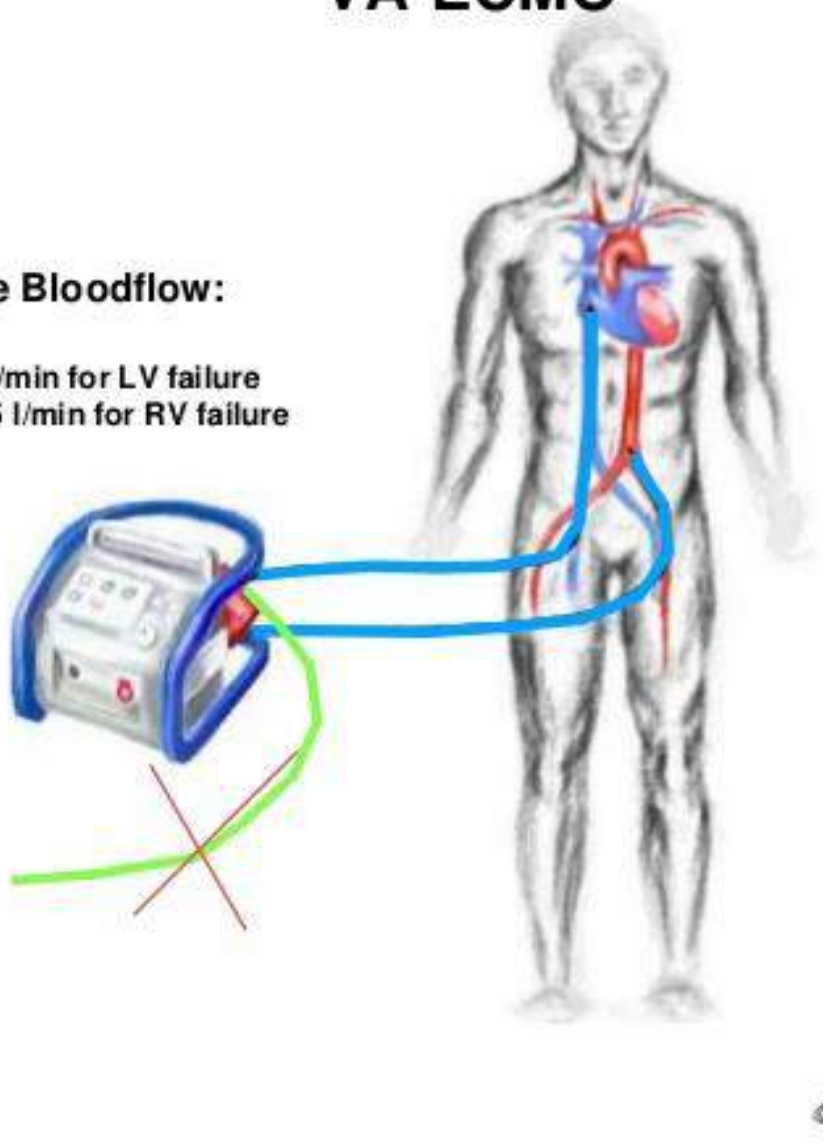
VA-ECMO



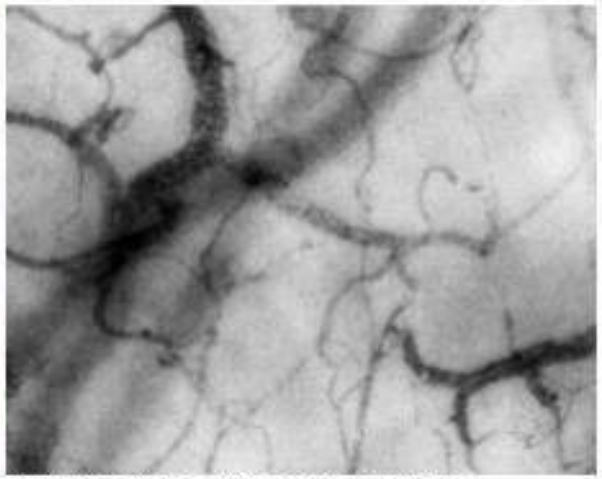
VA-ECMO

Decrease Bloodflow:

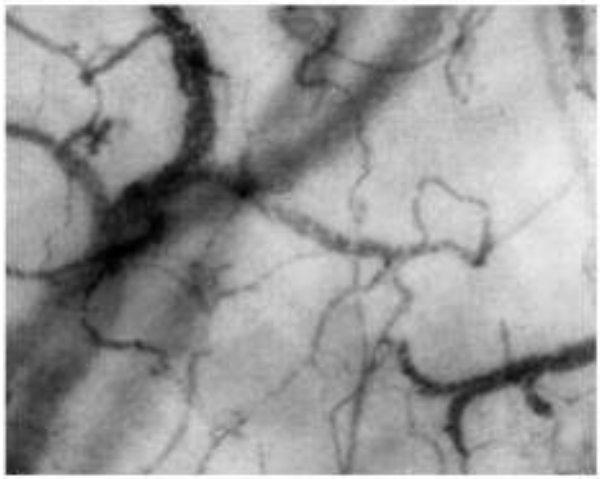
Approx. 1 l/min for LV failure
Approx. 0.5 l/min for RV failure



Patient with cardiac recovery, ECMO blood flow 50%

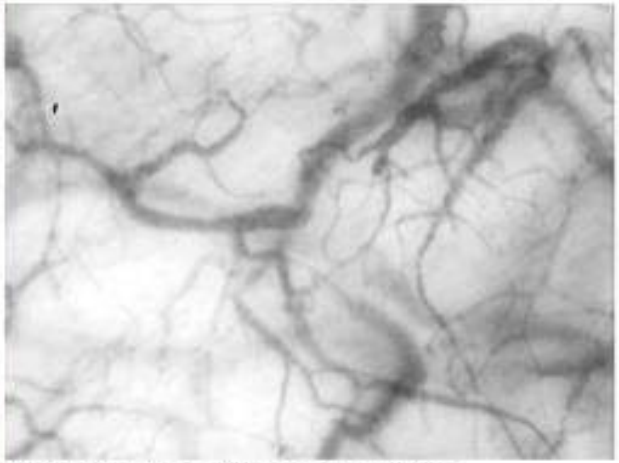


ECMO Bloodflow 6.1 l/min
MAP 77 mmHg

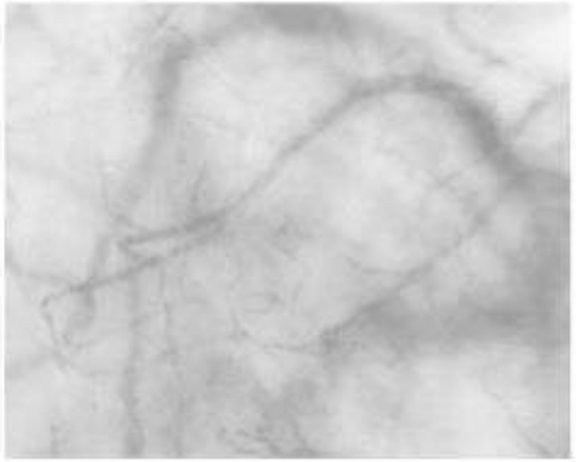


ECMO Bloodflow 3 l/min
MAP 74 mmHg

Patient with cardiac recovery, ECMO blood flow 50%

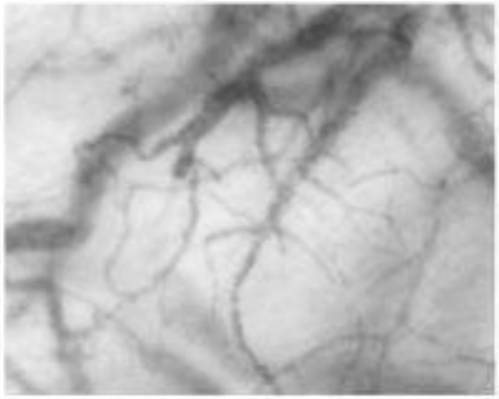


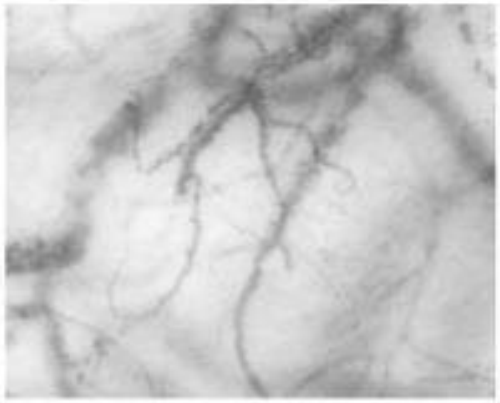
ECMO Bloodflow 5.0 l/min
MAP 75 mmHg



ECMO Bloodflow 2.2 l/min
MAP 70 mmHg

Patient WITHOUT cardiac recovery, ECMO blood flow 50%





ECMO Bloodflow 4.5 l/min
MAP 65 mmHg

ECMO Bloodflow 2.1 l/min
MAP 45 mmHg

Conclusion from these studies:

During weaning of vaECMO, there is a poor coherence between macrocirculation and microcirculation.

Echocardiography and microcirculatory monitoring seem to correlate

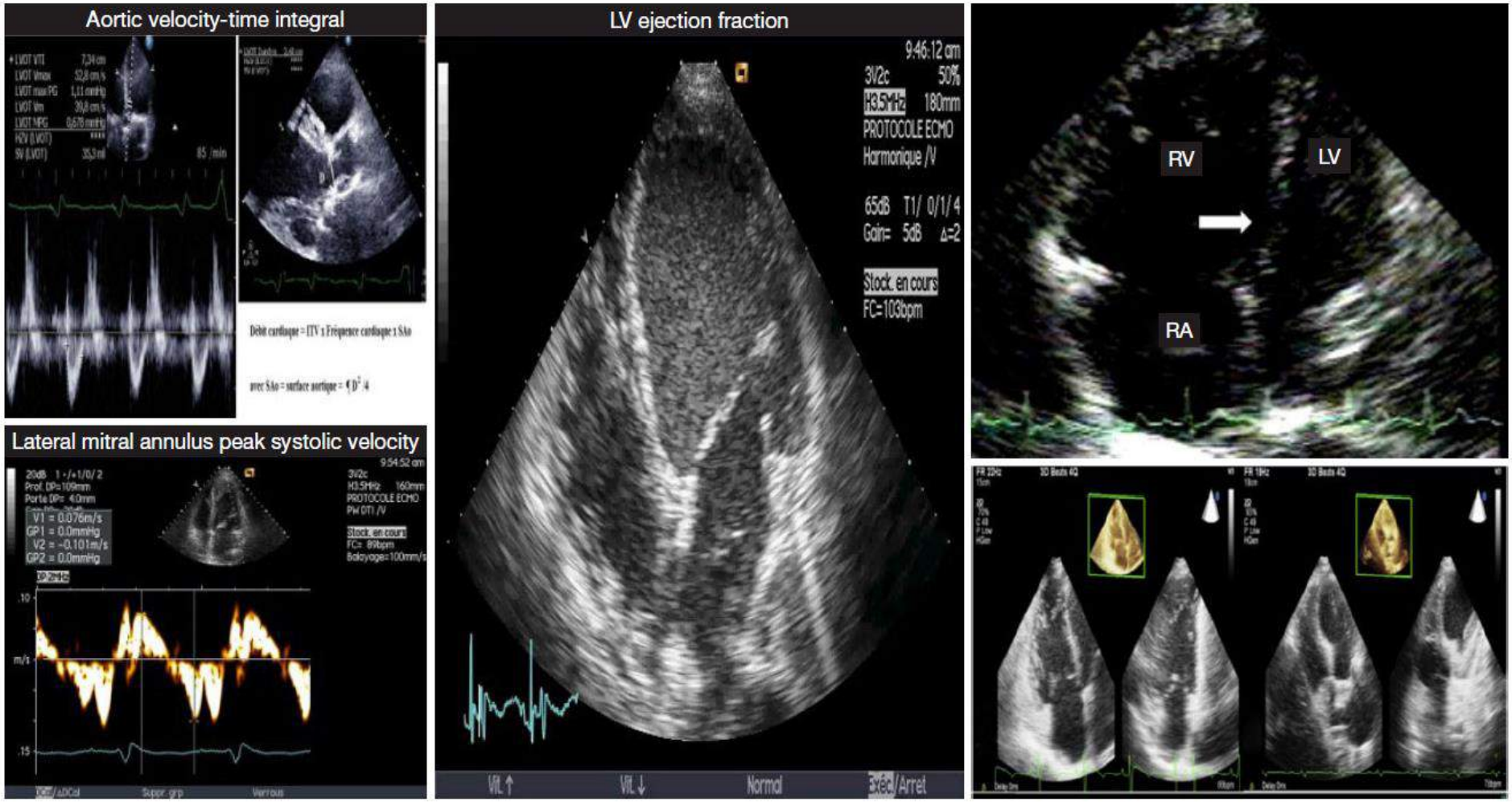


Figure 1 Useful echocardiographic parameters. LV, left ventricle; RV, right ventricle; RA, right atrium.

Table 1 Studies reporting main predictors of successfully weaning from VA ECMO

Study/authors	Numbers of patients	Weaning ratio	Categories	Parameters	Cutoff
Aissaoui *et al*., 2011	51	20/51	Clinical	Pulse pressure	>52±12 mmHg
			TTE	Aortic velocity-time integral	>10 cm
				LVEF	>20–25%
				Lateral mitral annulus peak systolic velocity	>6 cm/s
Cavarocchi *et al*., 2013	21	6/21	TEE	LV and RV function	Qualitative
Pappalardo *et al*., 2015	42	18/42	Clinical	Pulse pressure	>59 mmHg
Li *et al*., 2015	123	69/123	Biological	Lactate at baseline	<9.4±4.2 mmol/L; >0.55±0.4 mmol/L
				Lactate clearance at H6-H12	
Huang *et al*., 2018	46	38/46	TTE	RVEF	<24.6%

VA ECMO, veno-arterial extracorporeal membrane oxygenation; TTE, transthoracic echocardiography; TEE, transesophageal echography; LV, left ventricle; RV, right ventricular; EDV, end-diastolic volume; ESV, end-systolic volume; EF, ejection fraction.

WEANING PARAMETERS

WHEN TO TRIAL OFF – VA ECMO

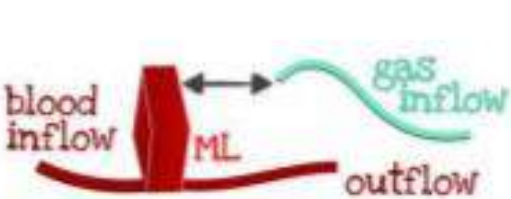
- Cardiac function slowly begins to improve
- Flows begins to fall
- Eventually good gases & tissue perfusion on minimal ECMO suuport
- Improved LV function
- Minimal inotropic support & ventilator support
- PA Pressures less than half systemic
- **Special case (bleeding, sepsis, “window”)**

WEANING PARAMETERS FOR VA ECMO

- Increased pulsatility – Increased pulse pressure > 20
- Improved Mean arterial prresure > 70 in adult
- Echo evidence –
  - Improved LV contractibility
  - Decreased MR, minimal MR
  - VTI of > 10 cm
  - TDSa of > 6 cm
- Improved tissue perfusion – SVO2 > 70
- PH > 7.35

weaning the ECMO patient

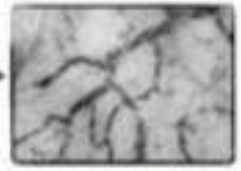
veno-venous ECMO
do not decrease blood flow
Set sweep gas flow off at reasonable MV setting
maintain for couple of hours (practical: overnight)



veno-arterial ECMO
do NOT decrease gas flow
Set reasonable MV setting
decrease Blood Flow for 5-15 min
~1 l/min for LV failure
~0.5 l/min for RV failure
do NOT solely rely on macrohemodynamic parameters Use echo or microcirculation

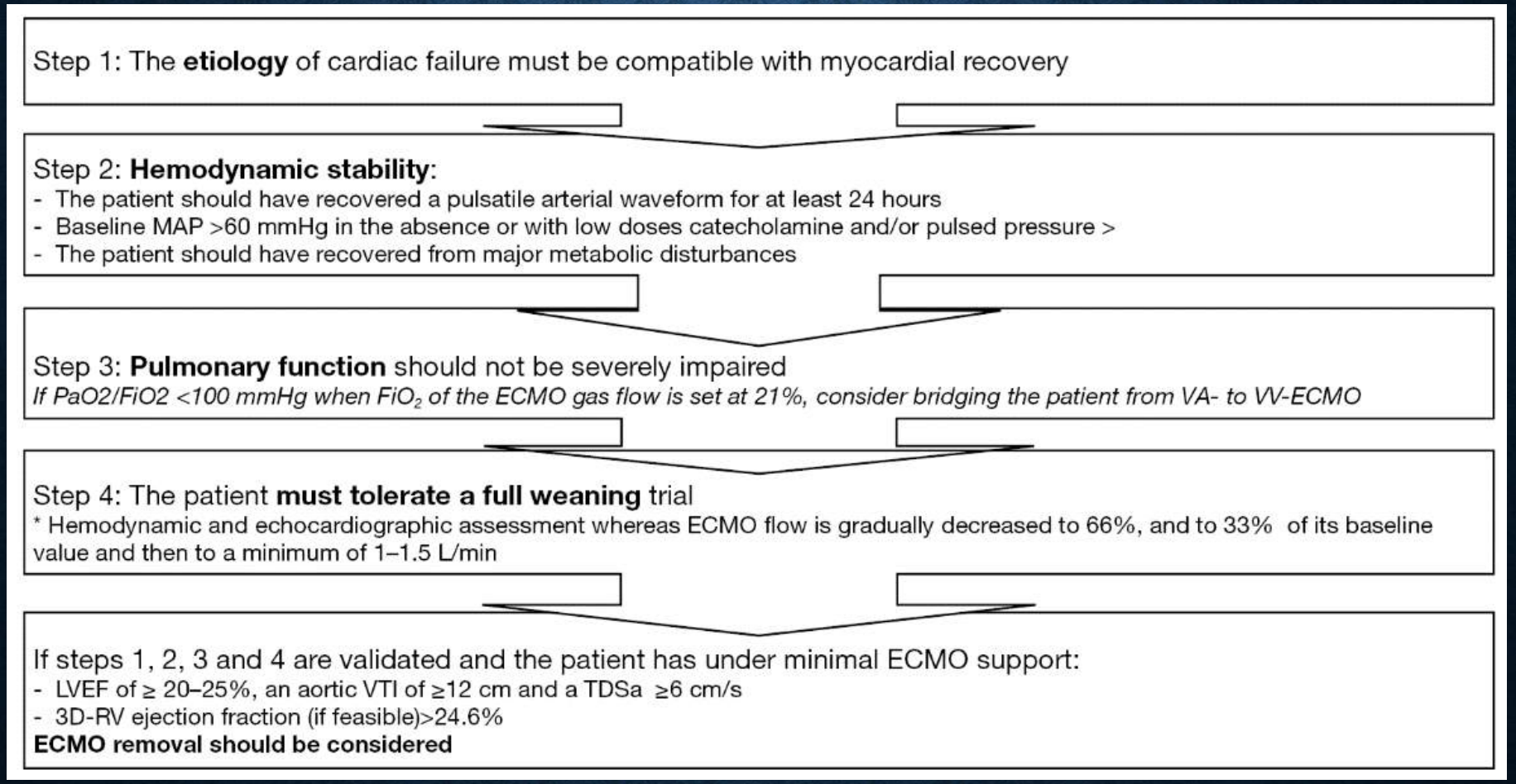
decrease RMP ↓

VTI ≥10 cm
LVEF ›20-25%
TDSa ≥6 cm/s
Aissaoui et al. ICM
bit.ly/weanpredict



ifad based on @ecmophile talk #BEACH2018 #IFAD2018
graphics @FOAMecmo on behalf of @Fluid_Academy

Courtesy of Velia Marta Antonini


Step 1: The **etiology** of cardiac failure must be compatible with myocardial recovery
Step 2: **Hemodynamic stability**:
- The patient should have recovered a pulsatile arterial waveform for at least 24 hours
- Baseline MAP >60 mmHg in the absence or with low doses catecholamine and/or pulsed pressure >
- The patient should have recovered from major metabolic disturbances
Step 3: **Pulmonary function** should not be severely impaired
If PaO2/FiO2 <100 mmHg when FiO_2 of the ECMO gas flow is set at 21%, consider bridging the patient from VA- to VV-ECMO
Step 4: The patient **must tolerate a full weaning** trial
* Hemodynamic and echocardiographic assessment whereas ECMO flow is gradually decreased to 66%, and to 33% of its baseline value and then to a minimum of 1–1.5 L/min
If steps 1, 2, 3 and 4 are validated and the patient has under minimal ECMO support:
- LVEF of ≥ 20–25%, an aortic VTI of ≥12 cm and a TDSa ≥6 cm/s
- 3D-RV ejection fraction (if feasible)>24.6%
ECMO removal should be considered

Step 1: The etiology of cardiac failure must be compatible with myocardial recovery

Step 2: Hemodynamic stability

- The patient should have recovered a pulsatile arterial waveform for at least 24 hours
- Baseline MAP > 60 mmHg in the absence or with low doses catecholamine and/or pulsed pressure
- The patient should have recovered from major metabolic disturbances

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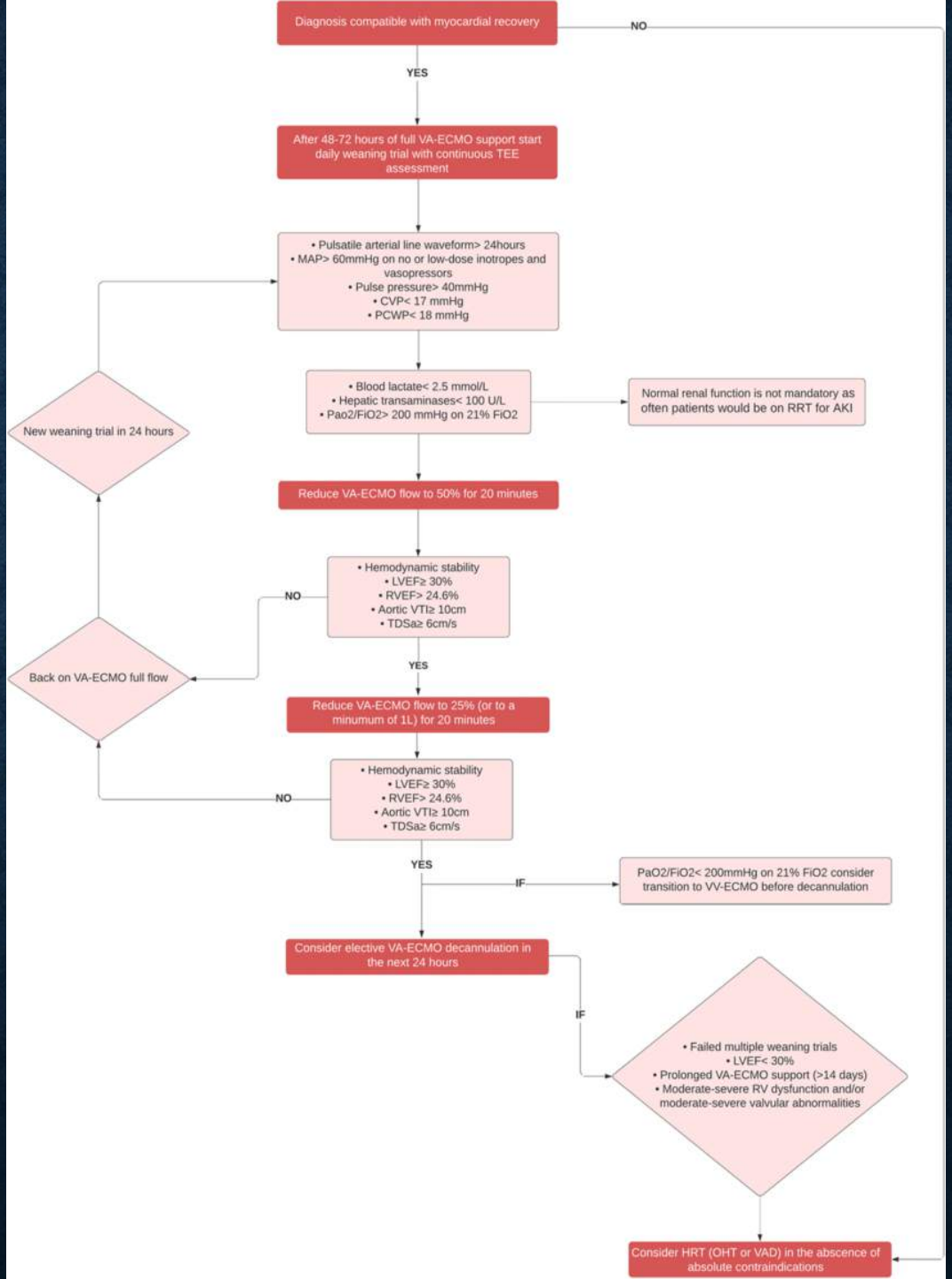
Hemodynamic and echocardiographic assessment whereas ECMO flow is gradually decreased to 66%, and to 33% of its baseline value and then to a minimum of 1—1.5 L/min

If **steps 1, 2, 3 and 4** are validated and the patient has under minimal ECMO support:

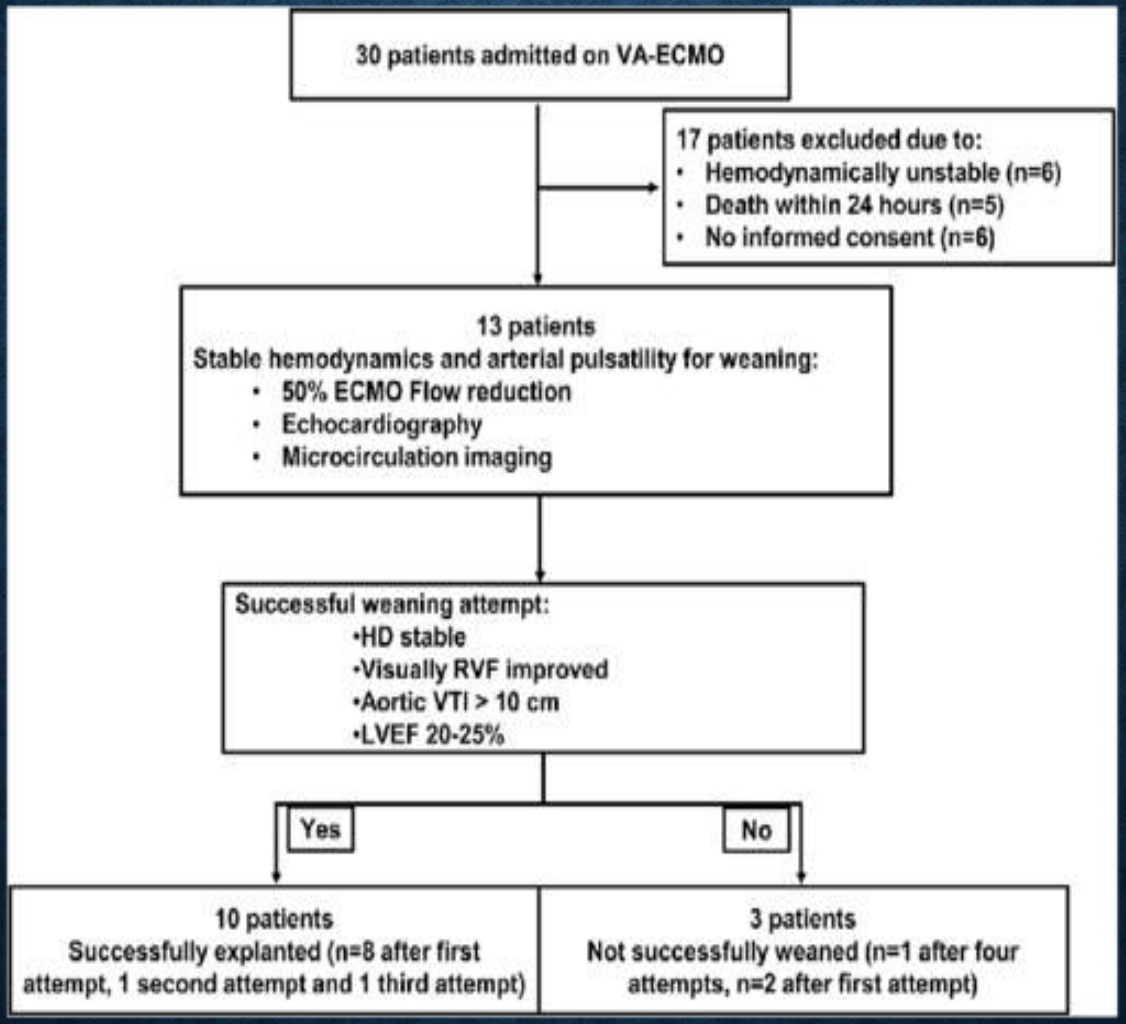
- LVEF of ≥ 20—25%, an aortic VTI of ≥ 10 cm and a TDSa ≥ 6 cm/s
- or CI > 2.4 L/min/m^2, PCWP < 18 mmHg and CVP < 18 mmHg
- 3D-RV ejection fraction (if feasible) > 24.6%

-> ECMO removal should be considered


Diagnosis compatible with myocardial recovery
NO
YES
After 48-72 hours of full VA-ECMO support start daily weaning trial with continuous TEE assessment
• Pulsatile arterial line waveform> 24hours
• MAP> 60mmHg on no or low-dose inotropes and vasopressors
• Pulse pressure> 40mmHg
• CVP< 17 mmHg
• PCWP< 18 mmHg
• Blood lactate< 2.5 mmol/L
• Hepatic transaminases< 100 U/L
• Pao2/FiO2> 200 mmHg on 21% FiO2
Normal renal function is not mandatory as often patients would be on RRT for AKI
New weaning trial in 24 hours
Reduce VA-ECMO flow to 50% for 20 minutes
• Hemodynamic stability
• LVEF≥ 30%
• RVEF> 24.6%
• Aortic VTI≥ 10cm
• TDSa≥ 6cm/s
NO
Back on VA-ECMO full flow
YES
Reduce VA-ECMO flow to 25% (or to a minumum of 1L) for 20 minutes
• Hemodynamic stability
• LVEF≥ 30%
• RVEF> 24.6%
• Aortic VTI≥ 10cm
• TDSa≥ 6cm/s
NO
YES
IF
PaO2/FiO2< 200mmHg on 21% FiO2 consider transition to VV-ECMO before decannulation
Consider elective VA-ECMO decannulation in the next 24 hours
IF
• Failed multiple weaning trials
• LVEF< 30%
• Prolonged VA-ECMO support (>14 days)
• Moderate-severe RV dysfunction and/or moderate-severe valvular abnormalities
Consider HRT (OHT or VAD) in the abscence of absolute contraindications

ECMO Weaning Protocol

- ICU
  - ECMO flow down to 1-1.5 L/min for 5 min
  - Assess CVP, PAP, CO
  - TTE to assess LV, RV function
- OR
  - 3000-5000 U heparin
  - ECMO flow down to 1 L/min
  - Assess CVP, PAP, CO
  - TEE to assess LV, RV function, septal position
- Explant ECMO if appropriate


30 patients admitted on VA-ECMO
17 patients excluded due to:
• Hemodynamically unstable (n=6)
• Death within 24 hours (n=5)
• No informed consent (n=6)
13 patients
Stable hemodynamics and arterial pulsatility for weaning:
• 50% ECMO Flow reduction
• Echocardiography
• Microcirculation imaging
Successful weaning attempt:
•HD stable
•Visually RVF improved
•Aortic VTI > 10 cm
•LVEF 20-25%
Yes
No
10 patients
Successfully explanted (n=8 after first attempt, 1 second attempt and 1 third attempt)
3 patients
Not successfully weaned (n=1 after four attempts, n=2 after first attempt)

WEANING STRATEGY FOR VA ECMO

Not attempt to wean ECMO in the first 72 hours

↓

Renal and hepatic function should be restored

↓

Pulmonary **blood oxygenation** should not be compromised

↓

Hemodynamic stability on ECMO : MAP > 60 mmHg while no or low-dose vasoactive agents

↓

A **pulsatile arterial waveform** should be maintained for at least 24 hours

↓

The patient must **tolerate a full weaning trial** (MAP > 60 mmHg)

↓

Left and right ventricular echo parameters (VTI > 10cm, Sa > 6cm/s...) must be assessed at minimal ECMO flow

Conclusion:

In vvECMO:

- Do not decrease ECMO blood flow
- Set ECMO gasflow off at reasonable vent setting
- Maintain this for couple of hours (practical: overnight)

In vaECMO:

- Do not decrease ECMO gasflow
- Set reasonable vent setting
- Decrease ECMObloodflow to 0.5 - 1.0 liter/min for 5-15 min
- Do not solely rely on macrohemodynamic parameters
- Use echo or microcirculation

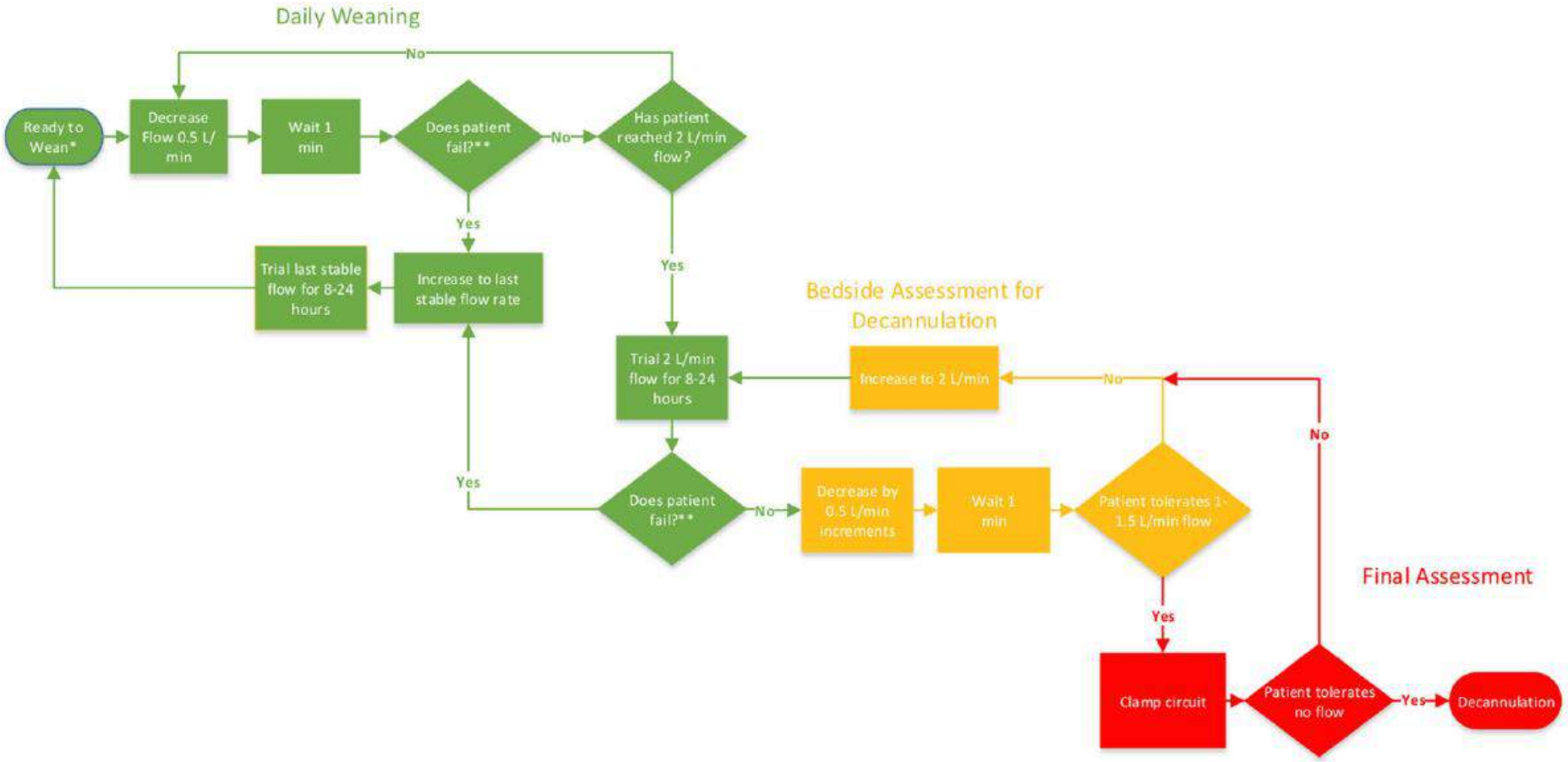


Fig. 1 VA-ECMO weaning process. *Criteria required to initiate weaning trial: (1) Phenotype is compatible with recovery (2) End-organ function is improving (3) Pa02/Fi02 > 100 (4) Vasopressors and intropes at low levels (norepinephrine ≤ 4 μg/min, dobutamine < 5 mcg/kg/min) **Any of the following criteria constitutes failure of a weaning trial: (1) MAP falls below 65–70 mmHg or decreases by more than 10 mmHg from baseline (2) Significant increase in intracardiac filling pressures (3) Deterioration in respiratory status

WEANING

VV ECMO weaning:

i. Circuit flow need not be reduced at any stage for weaning and therefore, no additional heparin is required

ii. Weaning VV ECMO is achieved by progressively reducing the Fresh Gas Flow to the oxygenator. An increase in lung ventilation is required to ensure adequate CO_2 clearance.

iii. In normal circumstances there is no requirement to wean the blender FiO_2 as part of the weaning process

iv. It is usual to observe the patient to be stable for 4-24 hours with the Fresh Gas Flow to the ECMO circuit at 0 L/min .

v. Echocardiography is not required

Table 2: Criteria or weaning trial

Cardiac

- Heart rate >120/min
- Systolic blood pressure > 90 mm Hg or pulse pressure > 40 mm Hg, mean arterial pressure > 70 mm Hg
- Central venous pressure <12 mm Hg
- Urine output > 0.5 cc/kg/hr (ARF case excluded)[4]
- IE (Inotropic equivalent) < 10
- Good tissue perfusion as revealed by blood lactate < 3 mol/L and SvO_2 > 65%
- X-ray chest improving
- 2D echo—improved EF > 40%

Respiratory

- CXR is improving
- Lung compliance improve: compliance >0.5 mL/kg
- ABG—on rest ventilator setting with moderate ECMO support
  - PaO_2 of >60 mm Hg
  - $PaCO_2$ of <50 mm Hg
  - pH > 7.35
- Successful 100% oxygen challenge test

Table 3: Assessment of weaning and trial off

Hemodynamic parameter

- Mean arterial pressure >70 mm Hg, pulse pressure >40
- Heart rate >60 and < 110. The heart rate should be maintained nearly to prior weaning. Any sudden change should be considered seriously.

Blood gas parameter

- pO_2—>60
- pCO_2—<45 sometimes up to 60 is accepted especially during long ECMO run if pH is maintained
- pH—>7.3
- SPO_2—>90%
- $EtCO_2$—35–40

Ventilator parameters

- Lung compliance—>0.5 cc/kg
- Peak inspiratory pressure > 30

Tissue perfusion

- Lactate level—20 or 4 mmol/L
- $ScvO_2$—70%
- Urine output—> 100 mL/hr

Weaning off VV-ECMO

- Increase ventilator support to a setting acceptable off VV-ECMO.
- Turn off the sweep gas but continue pump rate to maintain extracorporeal blood flow.
- Monitor systemic arterial oxygen saturation and pCO_2. If parameters remain adequate after one hour of ventilation at an acceptable setting with the sweep gas turned off, the patient is ready to come off VV-ECMO.
- Stop heparin infusion once the decision has been made to come off VV-ECMO. The circuit can be removed after 4 hours

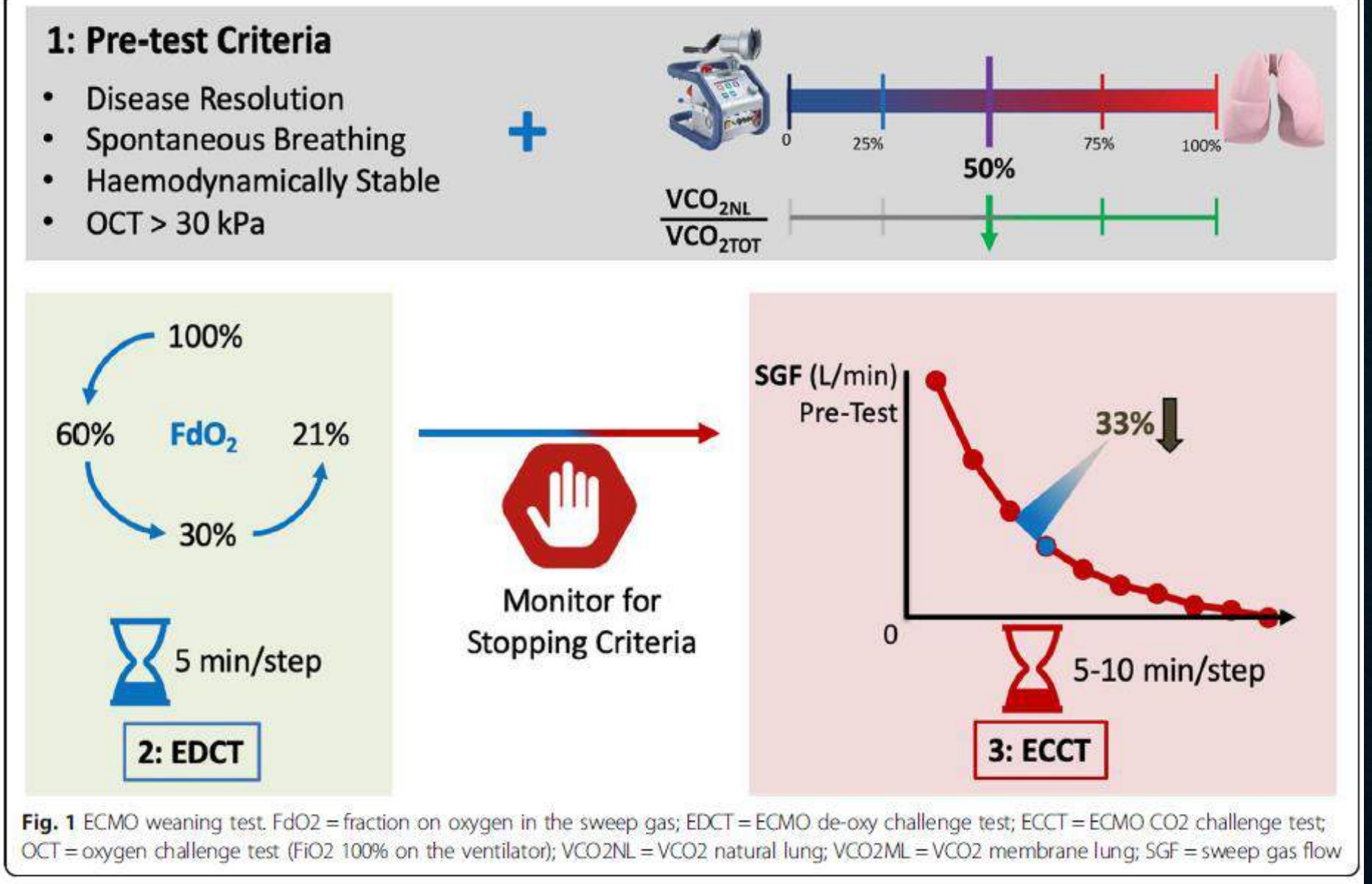
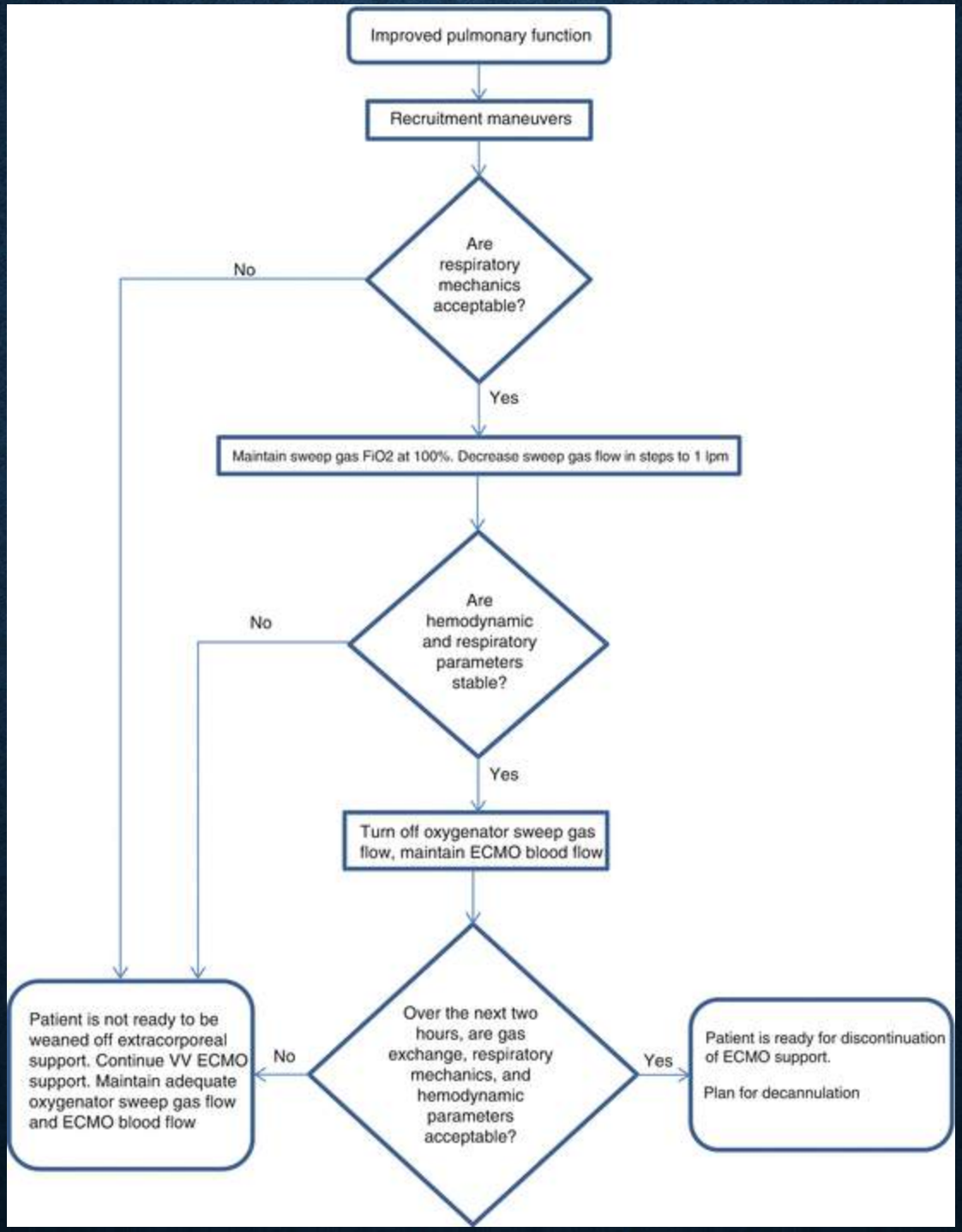


Fig. 1 ECMO weaning test. FdO2 = fraction on oxygen in the sweep gas; EDCT = ECMO de-oxy challenge test; ECCT = ECMO CO2 challenge test; OCT = oxygen challenge test (FiO2 100% on the ventilator); VCO2NL = VCO2 natural lung; VCO2ML = VCO2 membrane lung; SGF = sweep gas flow

	Weaning trial	Criteria for ECMO withdrawal
Venovenous ECMO	$F_{EC}O_2 = 21\%$	Pplat < 25 to 30 cmH_2O with TV around 6 ml/kg and PEEP < 12 cmH_2O
	Sweep gas flow 1 L/minute or stopped	and $PaO_2 > 70$ mmHg on $FiO_2 < 60\%$ or $PaO_2/FiO_2 > 200$ mmHg
	Duration: several hours	and pH > 7.3 with $PCO_2 < 50$ mmHg
		and no acute cor pulmonale
Arteriovenous ECMO	$F_{EC}O_2 = 21\%$	Pplat < 25 to 30 cmH_2O with TV around 6 ml/kg and PEEP < 12 cmH_2O
	Sweep gas flow 1 L/minute	and $PaO_2 > 70$ mmHg on $FiO_2 < 60\%$ or $PaO_2/FiO_2 > 200$ mmHg
	Reduce pump blood flow by steps of 0.5 L/minute	and pH > 7.3 with $PCO_2 < 50$ mmHg
	Duration: several hours	and no acute cor pulmonale
		without left ventricular failure:
		left ventricular ejection fraction > 25 to 30%
		velocity-time integral > 12 cm

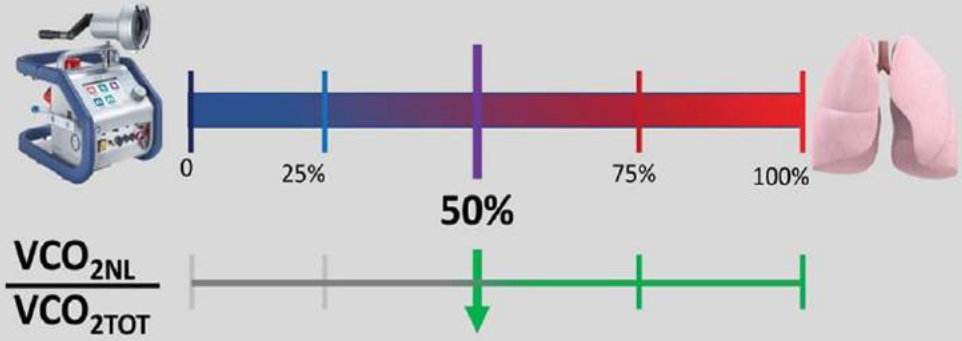
$F_{EC}O_2$, oxygen fraction delivered by the extracorporeal circuit; Pplat, plateau pressure; PEEP, positive end-expiratory pressure; TV, tidal volume.

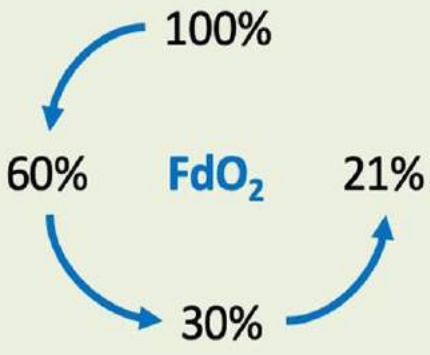

Improved pulmonary function
Recruitment maneuvers
Are respiratory mechanics acceptable?
No
Yes
Maintain sweep gas FiO2 at 100%. Decrease sweep gas flow in steps to 1 lpm
Are hemodynamic and respiratory parameters stable?
No
Yes
Turn off oxygenator sweep gas flow, maintain ECMO blood flow
Over the next two hours, are gas exchange, respiratory mechanics, and hemodynamic parameters acceptable?
No
Yes
Patient is not ready to be weaned off extracorporeal support. Continue VV ECMO support. Maintain adequate oxygenator sweep gas flow and ECMO blood flow
Patient is ready for discontinuation of ECMO support.
Plan for decannulation

1: Pre-test Criteria

- Disease Resolution
- Spontaneous Breathing
- Haemodynamically Stable
- OCT > 30 kPa

+

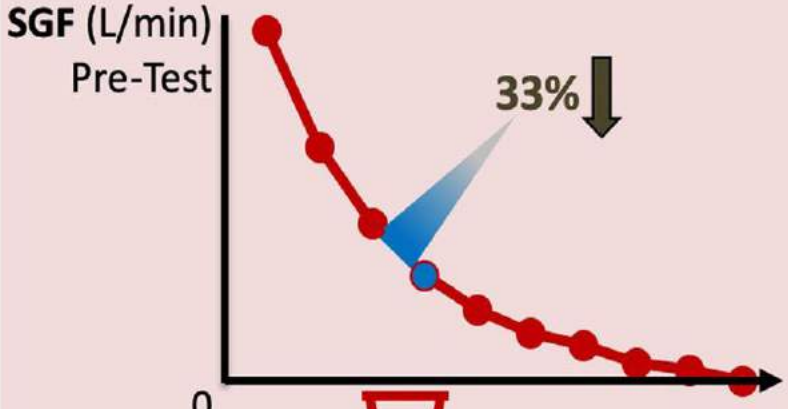




5 min/step

2: EDCT

Monitor for Stopping Criteria



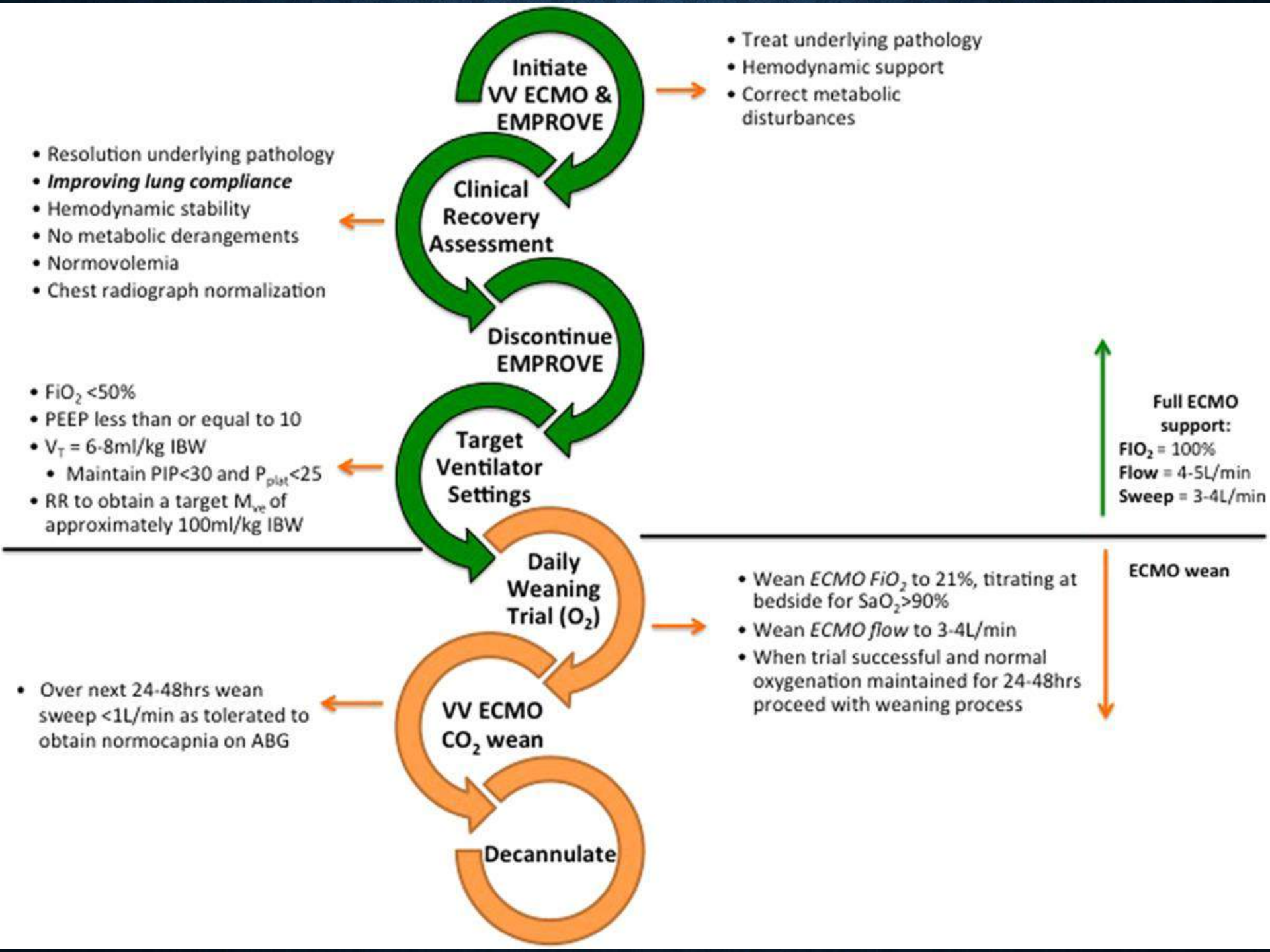
5-10 min/step

3: ECCT

WEANING ECMO[1,2,4,7]

- Decision made by consultants & CT surgeons

V-V	V-A
▪ Maintain ECMO flow rate ▪ Re-establish pt full ventilation ▪ Turn off 02 to oxygenator ▪ 6hr stability then decannulation	▪ Heparin so ACT >400 to decrease risk clotting ▪ Decrease pump flow 1litre while ventricular function assess by TOE ▪ Period of low flow ECMO before decannulation • Respiratory function is a concern: turn off gas flow (Only at circuit flows ≤1.5L/min) and assess oxygenation achieved using the ventilator exclusively. Note: in this situation the circuit flow acts as a right-to-left shunt. If adequate oxygenation and CO_2 removal can be maintained in the presence of this shunt it is likely that respiratory failure can be managed without ECMO. ▪ If 02 good & C02 managed by ventilation consider decannulation


Initiate VV ECMO & EMPROVE
• Treat underlying pathology
• Hemodynamic support
• Correct metabolic disturbances
Clinical Recovery Assessment
• Resolution underlying pathology
• Improving lung compliance
• Hemodynamic stability
• No metabolic derangements
• Normovolemia
• Chest radiograph normalization
Discontinue EMPROVE
Target Ventilator Settings
• FiO2 <50%
• PEEP less than or equal to 10
• VT = 6-8ml/kg IBW
• Maintain PIP<30 and Pplat<25
• RR to obtain a target Mve of approximately 100ml/kg IBW
Full ECMO support:
FIO2 = 100%
Flow = 4-5L/min
Sweep = 3-4L/min
Daily Weaning Trial (O2)
• Wean ECMO FiO2 to 21%, titrating at bedside for SaO2>90%
• Wean ECMO flow to 3-4L/min
• When trial successful and normal oxygenation maintained for 24-48hrs proceed with weaning process
ECMO wean
VV ECMO CO2 wean
• Over next 24-48hrs wean sweep <1L/min as tolerated to obtain normocapnia on ABG
Decannulate

WEANING PARAMETERS

VA ECLS	VV ECLS
Maintain $SvO_2 \geq 65\%$	Maintain O_2 Sats $\geq$ 85-90%
Wean for $SvO_2 \geq 70\%$	Wean for O_2 Sats $\geq$ 92%

TRIAL OFF

Trial OFF ECLS

- Method & Duration of trial off depends on type of support : VA vs VV
- Duration of Trial Off varies
  - Usually not to exceed 1-3 hours
- ECLS circuit flow increased to decrease clot formation

VA TRIAL OFF

- Clamp off
  - Venous Line
  - Bridge
  - Arterial Line
- Disconnect GREEN pipe + Increase flow
- Release clamps (ABV) every 10 min to flush the cannula
- ACT every 30 min
- Do not leave pump unattended
- Trial Off for 2 – 4 hrs

VA TRIAL OFF - MONITORING

- Draw ABG & SVO2 or lactate at 30 minutes, 90 mins & 180 mins during trial off
- Monitor MAP, Pulse pressire, pulse rate, saturation
- 2 D echo with color doppler before trial off after 1 hr & after 3 hrs
  - LV size
  - LVEF
  - Mitral regurgitation
  - VTI & TDSA

TRIAL OFF VV VS VA

VV

- Sweep gas off

VA

- Heparinise patient & circuit
- clamp off & clamp on
- sweep gas off
- flush cannulae Q10min
- Surgical decannulation

TRIAL OFF VA ECMO

- Call surgical team & plan
- Go back to pump till surgical team is ready

METHOD

VA ECMO

Step 1: once decide

- Up grade ventilator setting to moderate level
- Start small dose Inotrope if required

Step 2 :

- Wean the pump flow by 10 ml/kg/hr
- Continue to wean support until minimum flow

➢ After any change one should evaluate for 1 hour up to 3 hour

➢ Reduce the gas flow as proportional in blood flow

Minimum flows

Neonates 50 - 100 ml/min

Pediatric 100 - 200ml/min

Adults 500 - 1000 ml/min

Complication : sluggish flow , clots

Step 3 :

- Reduce the ECMO Fio2 to 60%
- Keep the patient on idle flow for around 2 hours

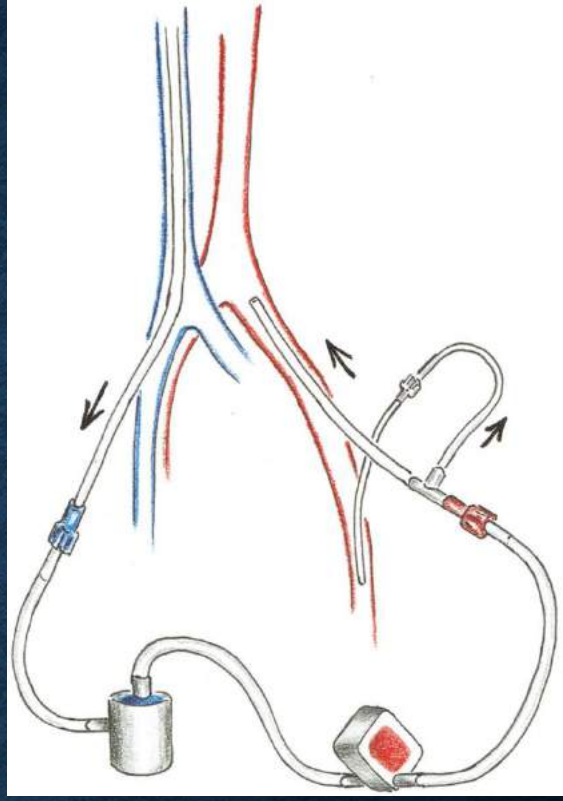
- Heparin / ACT should be maintained upper end of the ordered range
- Increased potential for circuit clot as blood will remain within the tubing for longer period of time

VV ECMO

Step 1 :

Decrease the flow to moderate

- Wean the pump flow by 20 ml/kg/hr
- Continue to wean support flow is reduced to ½ the ECMO flow



Step 2 :

Upgrade ventilator setting

- Once you come on half the flow, upgrade ventilator setting to moderate level
- Ventilator setting should be– maintain Spo2 of ~ 90%
- Fio2 decrease it to 40 %
- PEEP decrease to 6 – 8cmH20
- TV around 6 ml/kg
- Peak inspiratory pressure of < 30 cmH20

Minimum flows

Neonates 500 – 1000 ml/min

Pediatric 1 – 1.5 l/min

Adult 2.5 – 3 l/min

Step 3 :

Reduce Fio2 of ECMO

- Reduce Fio2 of ECMO till you reach Fio2 of 40 % on ECMO
- Maintain Spo2 of 90 %

Step 4 :

Decrease gas flow

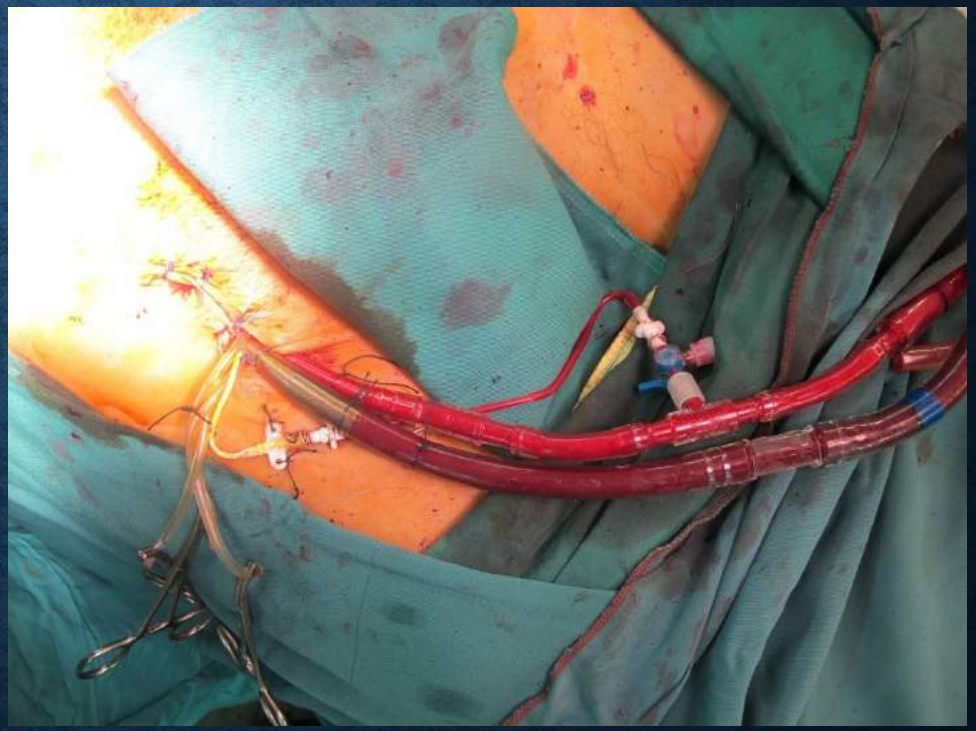
- Finally come down on gas flow .Reduce gas flow to maintain of 0.5 l/min in adults
- In pediatric to maintain flow of 0.3 l/min
- In neonates to maintain flow of 0.1 l/min
- Heparin / Act should be maintained or increased as pump flow is weaned (upper end of the ordered range)
- Increased potential for circuit clot as blood will remain within the tubing for longer period of time

MONITORING

- HgB
- SvO_2
- Lactate (unit dependant)
- Heart rate
- Urine output
  - CO_2
  - pO_2
- 2 D echo

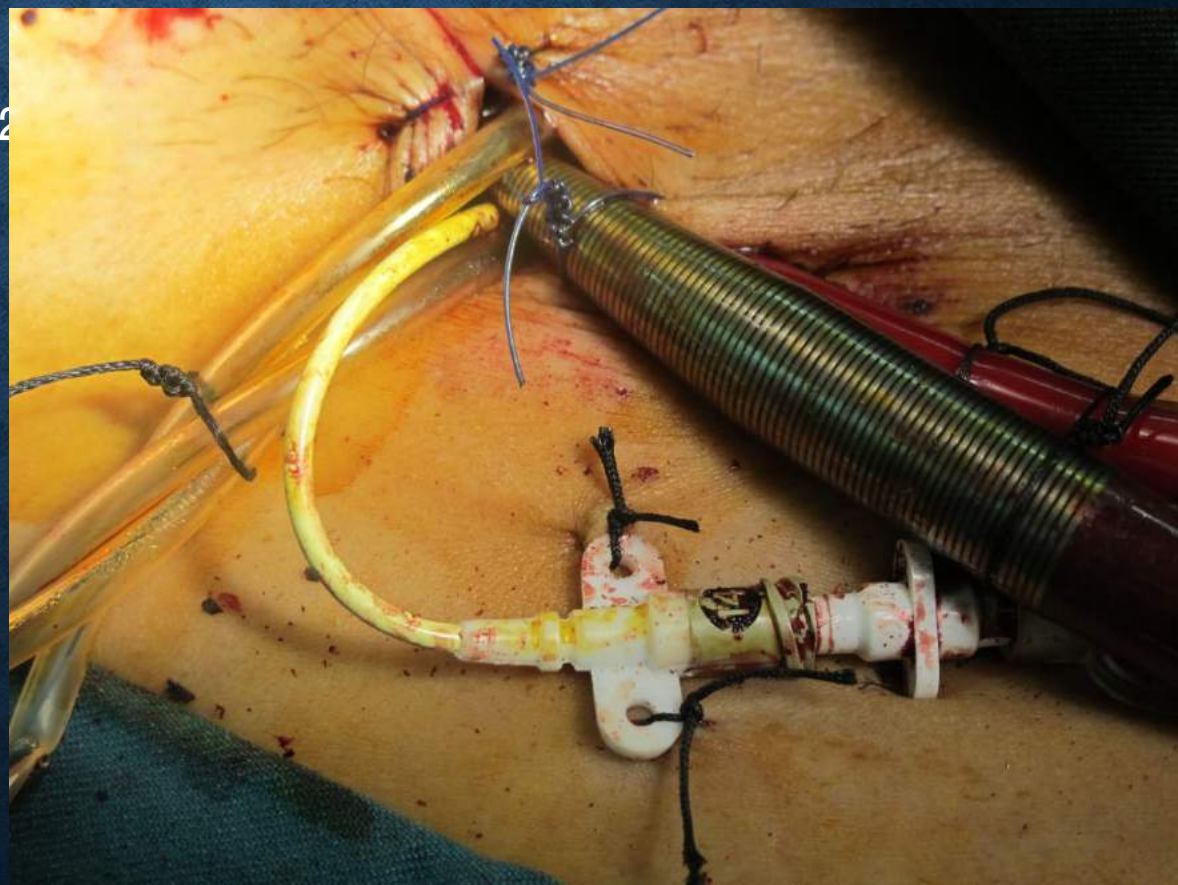
DECANNULATION

- Good gasses off ECMO
- Cardiovascular stability
- Assemble team
  - Co-ordinator
  - Specialist
  - Fellow



DECANNULATION

- Transfer all drugs to patient
- Anaesthesia
  - Ketamine
  - Atracurium
- Gown and gloves



DECANNULATION

- Clean skin with and cannula with Betadine
- Drape as for surgery
- Insert a single horizontal mattress suture around the cannula

DECANNULATION

- Cut all sutures
- Clamp off the circuit
- Assistant clamps the cnnula as close to the skin as possible
- Assistant pulls cannula as Surgeon ties the mattress suture

DECANNULATION

- Tip of cannula sent for culture
- Dry dressing
- Repeat procedure for other cannula
- Give Vancomycin

DECANNULATION VA

Most important

Dressing of Cannula

The most common mortality in ECMO is infection

Vascular lines are the most common sites for infection.

POST DECANNULATION

- CXR is mandatory
- Recheck bloods
  - ABG
  - Haematology
  - Biochemistry

QUESTIONS?

1)ECMO TRANSPORT

1) CLINICAL FACTORS IMPACTING DECISION FOR ECMO TRANSPORT
2) OTHER FACTORS IMPORTANT IN PLANNING FOR ECMO TRANSPORT
3) EQUIPMENT FOR ECMO TRANSPORT
4) SUPPLIES
5) BLOOD PRODUCTS
6) MEDICATIONS
7) VEHICLES

1) CLINICAL FACTORS IMPACTING DECISION FOR ECMO TRANSPORT

- ***Hospital to hospital /INTER-FACILITY:***
  - **Primary Transports**
  - **Secondary Transports**

- ***In hospital /INTRA-FACILITY***
  - **travel to radiology, the operating room, or the cath lab**

Interfacility Transport

- Primary Transports

  situation in which the Transport team is required to perform cannulation for ECMO support at the referring facility and then transport the patient to an ECMO center

- Secondary Transports

  situations in which the patient is already supported with ECMO at the referring facility and needs to be transported to another center

Clinical factors that impact a patient‘s candidacy for ECMO transport

1- criteria for any ECMO support

2-Criteria for interfacility transfer.

Geographic

- **Ground ambulance** feasible for distances ***approximately*** ***≤ 250 miles (400 km)***
- **Helicopter** feasible for distances ***approximately*** ***≤ 400 miles (650 km)***
- **Fixed wing aircraft** usually necessary for missions ***> 400 miles (650 km)***

Weather related

- The impact of the weather on the suitability of air transport for a given mission should **always be a pilot decision** with no input from medical team

Aircraft/Vehicle Availability and Capabilities

	Ground Ambulance	Helicopter	Fixed Wings Aircraft
Space for team and equipment	Sufficient (4-5 team members)	More limited (3-5 team members)	Variable (≥ 4 team members)
Noise	Relatively Little	Very loud	Loud
Distance range for reasonable transport times	Up to 400 km	Up to 650 km (depending on aircraft and weather)	Any distance
Weight Limitation	Unlimited	Limited (impacted by distance and weather)	Variable (depending on aircraft and conditions)
Loading and securing equipment and ECMO circuit/patient	Relatively easy	Relatively easy	Variable (depending on equipment and aircraft model)

Aircraft/Vehicle Availability and Capabilities

1) Any vehicle/aircraft must have appropriate electrical supply capability for ECMO and all other equipment for the duration of the mission
2) Climate control
3) Reliable oxygen supply (other than transport cylinders)
4) Suction
5) Compressed Air
6) Adequate Lighting
7) Adequate space for necessary team members and equipment

Personnel/Team Composition

1) Cannulating Physician
2) ECMO Physician
3) ECMO Specialist
4) Transport Nurse
5) Transport Respiratory Therapist

Cannulating Physician

- Primary responsibility is safe and proper placement of ECMO cannula(s)
- For neonatal/pediatric ECMO, this is typically a pediatric surgeon or pediatric cardiovascular surgeon
- For adult ECMO, this may be general surgeon, vascular surgeon, cardiovascular surgeon
- In some circumstances, ECMO team may choose to work with a surgeon and surgical team from the referring hospital if such collaboration facilitates timely patient transfer

ECMO Physician

- Must have substantial experience in management of ECMO patients
- On arrival at referring facility, promptly assesses patient and pertinent clinical data while ECMO Specialist and other team members prepare for cannulation or change to transport ECMO circuit.
- Decision
- Obtains informed consent for ECLS and for transport from next-of-kin
- Assumes and directs medical management of the patient during cannulation/change of ECMO circuit, and throughout the transport
  - Administration of heparin bolus at time of cannulation
  - Administration of any needed deep sedation/analgesia
  - Management of mechanical ventilation ,vasoactive infusions, etc

ECMO Specialist

- Primary responsibility for ensuring all equipment on checklist is functional and loaded at time of departure
- Primary responsibility for communication of blood product requirements with referring hospital staff prior to ECMO transport team's departure
- Primary responsibility for priming/preparation of transport ECMO circuit upon team's arrival at referring hospital
- Primary responsibility for management of ECMO

  circuit during all phases of transport
- Must possess extensive experience in ECMO circuit/patient management

Transport Nurse

- Administers medications, fluids, and blood products, and assists in patient assessment
- Primary responsibility for patient nursing care during all phases of transport
- To allow cross-tasking, it is strongly recommended that the transport nurse also has experience with ECMO patient/circuit management

Qualification of transportation staff

For the escorting physician, we assessed the following items (yes/no), based on DIVI recommendations [13, 14]:

1. Three years of clinical training in a field with intensive care tasks,
2. Six months verifiable full-time on an ICU,
3. Qualification as a pre-hospital emergency physician in the EMS according to local regulations,
4. Attending a 20-h course "intensive care transportation"

Due to the specific requirements of intensive care transports, the responsible paramedic also must have an additional qualification [13]. We assessed the following items (yes/no):

1. Professional qualification: paramedic
2. At least 3 years in an emergency service in a full-time or a time comparable to professional experience
3. Attending a 20-h course "intensive transport for emergency services personnel"

: mannequin preparation; percutaneous cannulation and starting ECMO; preparation for transportation; transportation; therapy in the department of intensive care.

EQUIPMENT FOR ECMO TRANSPORT

- A checklist should be completed before departure.
- The circuits and equipment utilized for mobile ECMO

EQUIPMENT FOR ECMO TRANSPORT

- A mobile ECMO system shall consist of the following minimum components:

1. Suitable blood pump, centrifugal or roller
2. Membrane oxygenator, appropriate for the patient size
3. Device(s) for heating and regulating circuit blood temperature (less critical for adult transports)
4. Medical gas tanks, regulators, hoses, connectors, flow meters, and blenders for provision and adjustment of blended sweep gas to the oxygenator
5. Venous and arterial pressure monitoring device(s), according to center-specific practices

EQUIPMENT FOR ECMO TRANSPORT

6. Point-of-care anticoagulation monitoring equipment (e.g., Activated Clotting Time)

7. Emergency pump or manual control menchanism in the event of primary pump failure or power failure

8. Uninterruptable power source(s) capable of meeting the electrical power needs of all equipment during transfer between vehicles and in the event of vehicle power source failure.

9. Portable ultrasound machine, if not provided by the referring facility.

EQUIPMENT FOR ECMO TRANSPORT

- Mobile ECMO personnel must be familiar with the voltage, current, and power requirements of all equipment. Checklists should include this information for rapid reference prior to and throughout the patient transfer

EQUIPMENT FOR ECMO TRANSPORT

Transport equipment, separate from the ECMO system, shall include:

1. Patient ventilator, appropriate for the patient's size and clinical needs
2. Point-of-care device for monitoring blood gases, electrolytes, glucose, hemoglobin

EQUIPMENT FOR ECMO TRANSPORT

4. **Medication and fluid infusion pumps**
   - i. Backup components of critical items must be available
   - ii. Patient/ECMO transport stretcher

EQUIPMENT FOR ECMO TRANSPORT

- Patient. The stretcher will enable the safe movement of the patient, in compliance with accepted patient transport standards.


MAQUET
Life Support Systems
ANSPORT
Back

- Supplies
- Bloodproducts
- Medications

- **If cannulation is intended at the referring center, all necessary instrument sets shall be either carried or made available from the referring facility:**
  1. **Cannulation surgical set / vascular surgery set**
  2. **Head lamp(s)**
  3. **Electrical cautery system**
  4. **Additional suction set-up for dedicated surgical use**
  5. **Operating room back table, kick bucket, tray tables, etc**
  6. **Optional bedside ultrasound device for assistance with cannulation**

MEDICATIONS

Medications will vary with team preference and formulary inventory, and will require case-by-case tailoring to the patient's needs.

VEHICLES

A. **Potential complications during transport between hospital and ambulance, and ambulance and aircraft**

1. **Sudden vertical or horizontal movement, altering patient position**
2. **Cannula movement, affecting surgical site integrity or cannula tip position**
3. **Circuit kinking, compression, or catching**
4. **Equipment movement or trauma**

B. ***The use of roller pumps for ECMO transport is not recommended.***

C. ***Additional features of vehicle or aircraft in addition to standard ACLS and safety requirement***

QUESTIONS?