1st UDINE ECMO meeting
18-19, December 2015

ECMO for Kids

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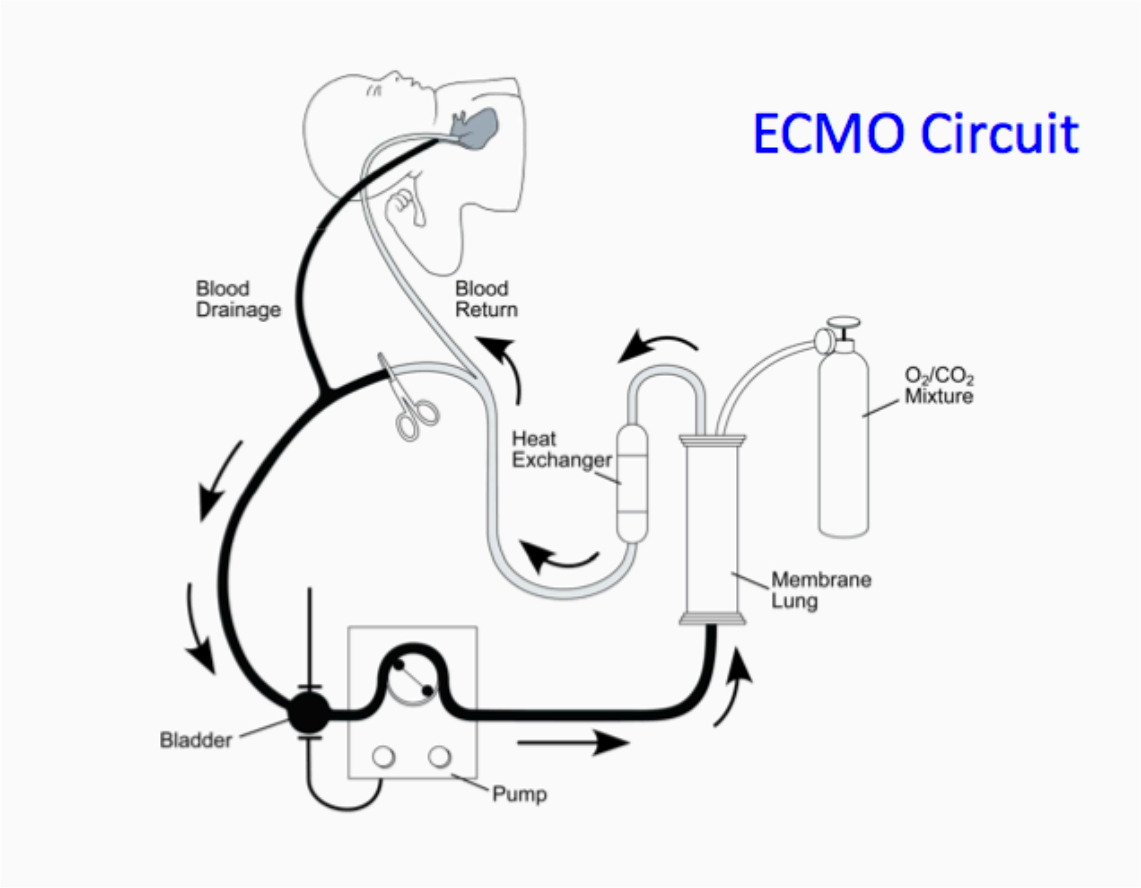
Extracorporeal Membrane Oxygenation

Cardiopulmonary Bypass to support function of Heart & Lungs



ECMO Uses

- Cardio-respiratory Support Modality
- Does not Treat Primary illness

- Best suited to those:
  - Reversible Cardiac or Respiratory Illness
  - Good prognosis
  - Amenable to Heart or Lung transplantation

- Failed Conventional Therapies

ECMO Current indications

- Cardiac ECMO
  - Primary Cardiac Disease with failure (i.e myocarditis)
  - Congenital heart disease (post cardiotomy)
  - Bridge to VAD/ HeartTransplant
  - ECMO-CPR: as an adjunct to CPR
  - Sepsis
  - Cardiorespiratory support for interventional procedures (i.e PDA stenting, balloon dilation)
- Respiratory ECMO
  - Diaphragmatic Hernia
  - Meconium aspiration
  - Respiratory failure from other disease (Cystic fibrosis)

ECMO for Circulatory Support

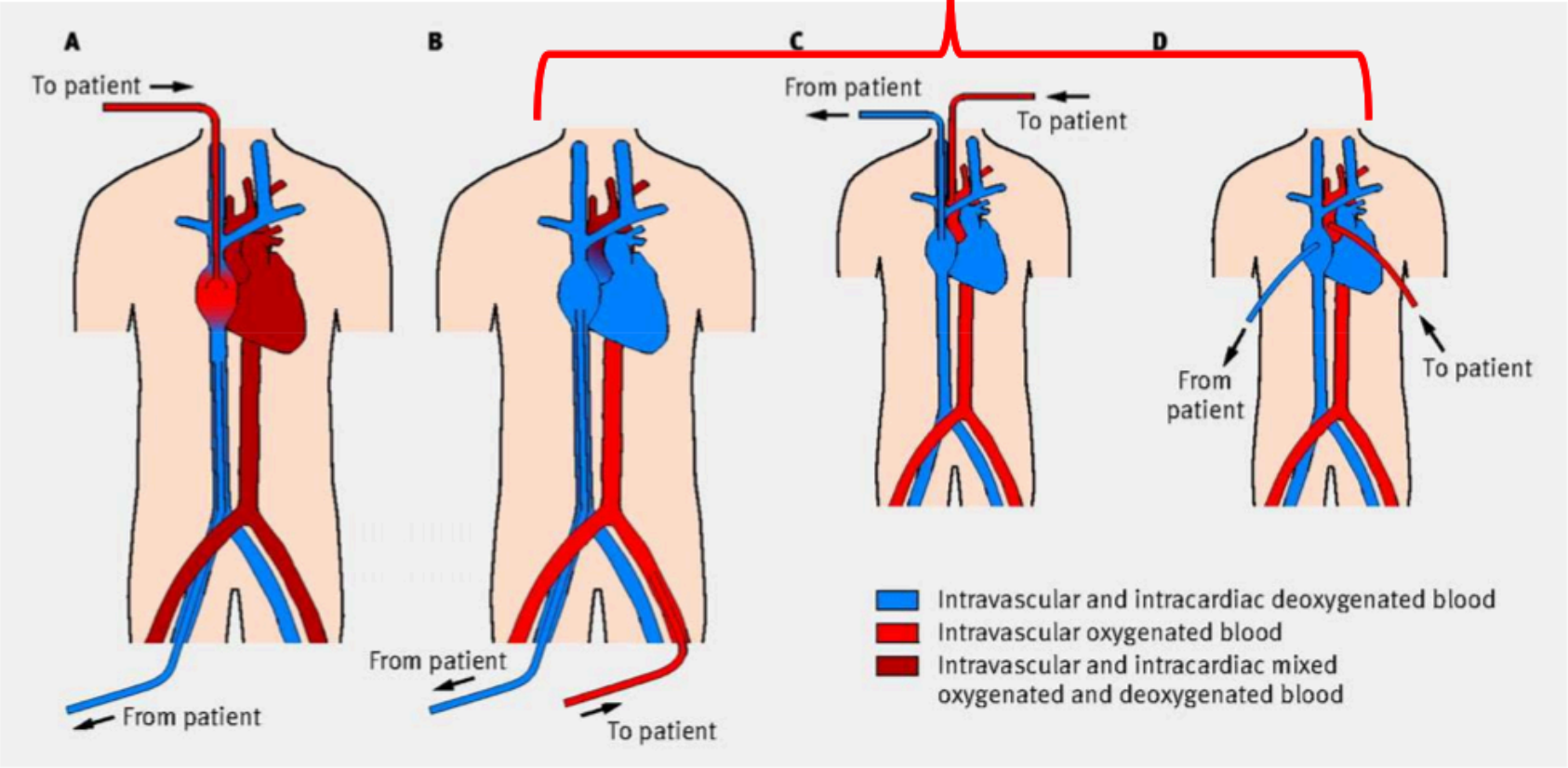
Contraindications

- Poor prognosis for Primary Disease
  - MOF
  - Irreversible or inoperable disease
- Prior neurological injury or CNS bleeding
- Prematurity < 34 WG; size < 1.8 kg
- Inaccessible vascular access (?)

VA & VV ECMO

VV -ECMO

VA ECMO



CV ECMO is mostly VA ECMO

Gaffney A M et al. BMJ 2010;341:bmj.c5317

ECMO for Circulatory Support

When to initiate VA ECMO

- Failed conventional therapy
  - Optimized preload
  - Reduce afterload
  - Enhance myocardial contraction

- Increasing Metabolic acidosis
- Decreased Urine output
- End organ dysfunction
- Approaching CPR

Low Cardiac Output Sdr

VA ECMO Physiology

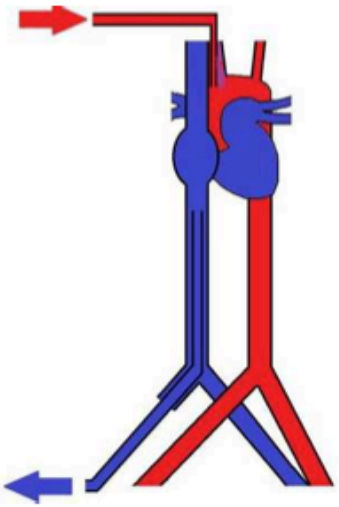
Right Ventricle

- Directly Drained
- ↓↓Preload
- ↓ Wall Stress

Left Ventricle

- Indirectly Drained
- ↓Preload (Bronchial)
- ↑Afterload
- ↓ Wall Stress

VA ECMO



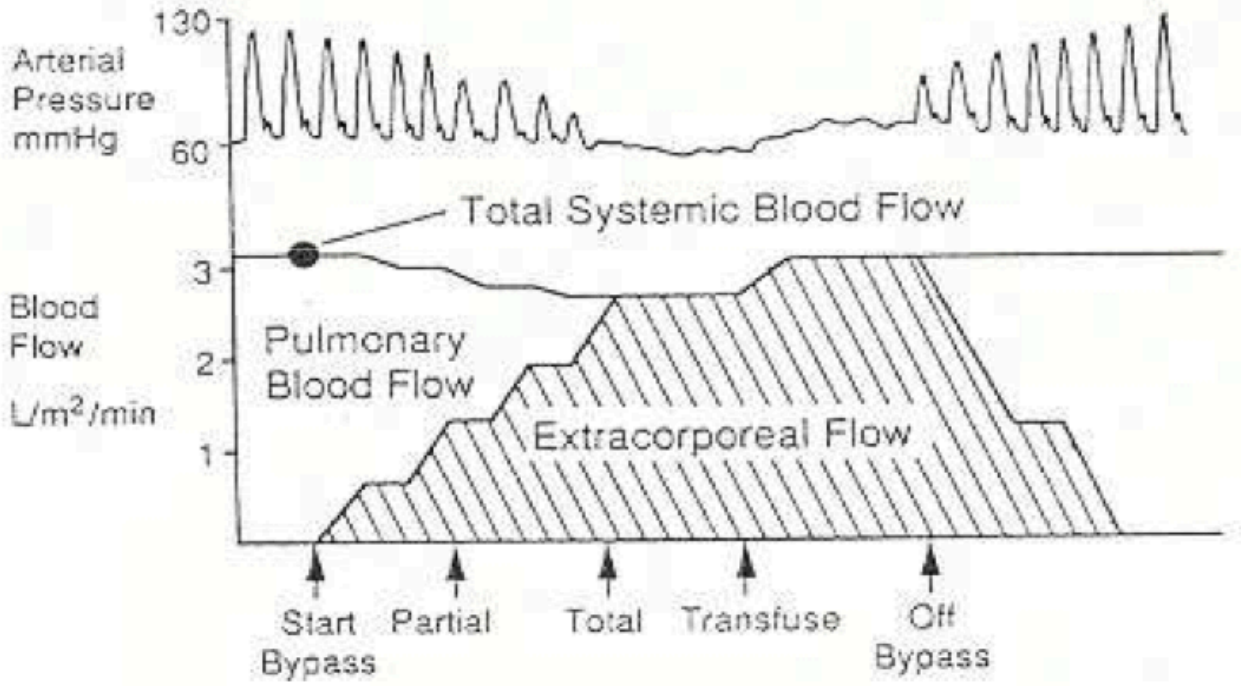
- ↑LVEDP
- ↑LA Pressure

- LV decompression may be required

Hsu S-J et al. www.intechopen.com

VA ECMO Physiology

↑ ECMO Drainage results in ↓ Ejection & Pulsatile Flow

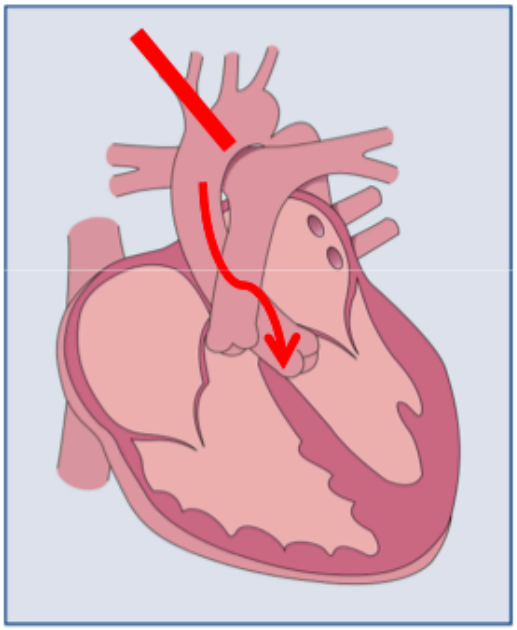


Cardiac Output = Q (ECMO) + Q (Native Flow)

Bartlett RH; ECMO 4th edition 2012: 21

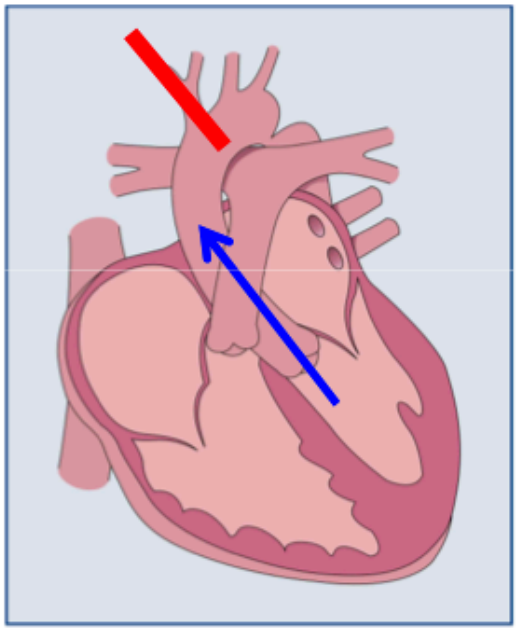
Coronary Blood Flow During ECMO

NO EJECTION FROM LV



Coronary Blood Flow is retrograde
Fully Saturated Blood From ECMO

LV EJECTION PRESENT



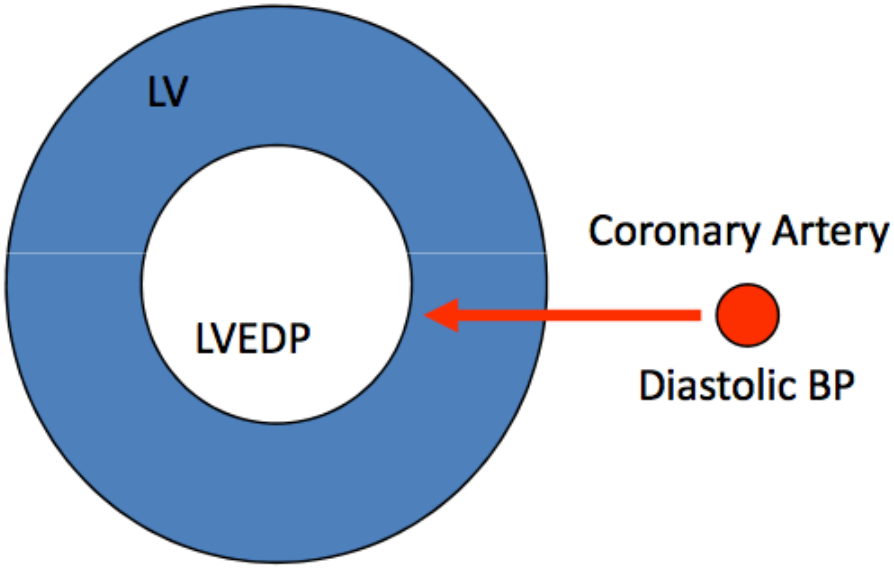
Coronary Blood is Antegrade
Desaturated Blood if ventilation is not provided

Coronary Perfusion on ECMO

Myocardial Perfusion = Coronary Diastolic pressure – LVEDP

Myocardial Ischemia

- ↑ LVEDV
- ↑ After-load
- ↑ LVEDP

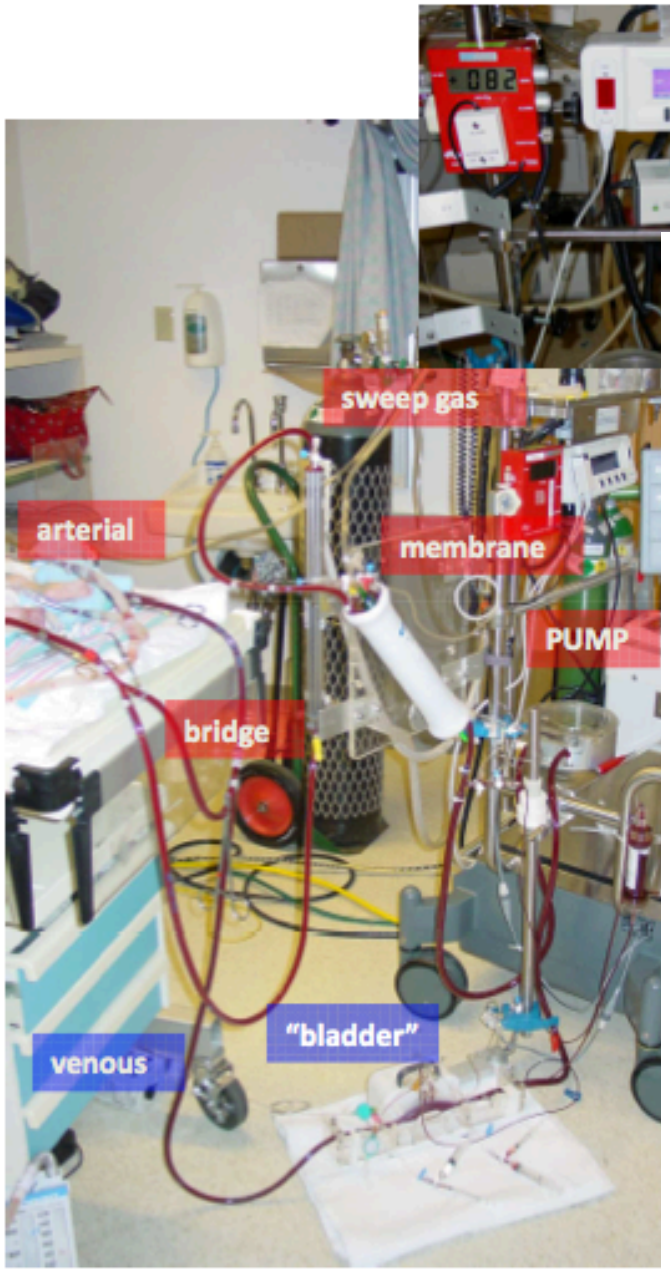


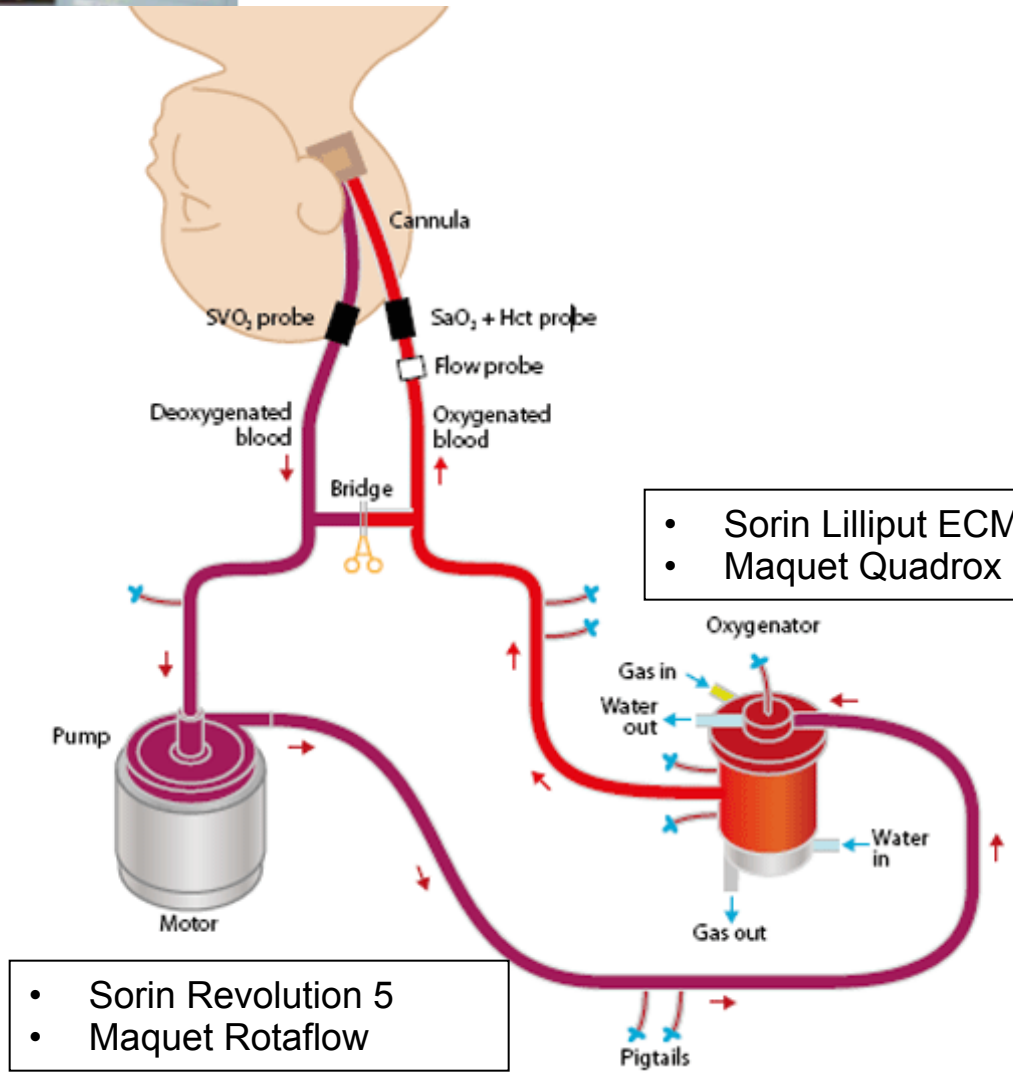
- ↓ Coronary flow May impair Myocardial Recovery

ECMO

- Cannula
- Reservoir
- Pump
- Oxygenator
- Heat Exchan
- Monitors
- Hemofiltratio

ECMO Circuit





- Sorin Lilliput ECMO
- Maquet Quadrox Ped

- Sorin Revolution 5
- Maquet Rotaflow

ECMO for Circulatory Support

the first hour after VA ECMO initiation

- Is Flow adequate?
- Physical Exam/ Pulsatile /MAP
- Lactate/ INVOS Monitoring/ ABG Acid Base balance
- Urine output
- Is gas exchange adequate?
- Is the patient bleeding?
- Diagnosis: ECHO/Catheter assessment?
- Limbs perfusion?
- Left heart decompression?

Patient management on VA ECMO

Pediatric care

- ECMO Flow - end organ function
- Lung rest
- Sedation ± paralysis
- Infection prophilaxis
- HB about 10 g/dl; plt about 80.000/dl
- CNS monitoring (INVOS/Brain US)
- Nutrition (parenteral and enteral)
- Skin care and joint mobility
- Anticoagulation protocol

PADUA ECMO ANTICOAGULATION PROTOCOL

Anticoagulation protocol (infusion of iv heparin 6 hours after implant, 10-15 UI/kg/hr)

Parameters	Goal of values
PTT	50-55 sec
Platlets	> 30 x10.9/L
AT III	> 80%
ACT	≈200 sec

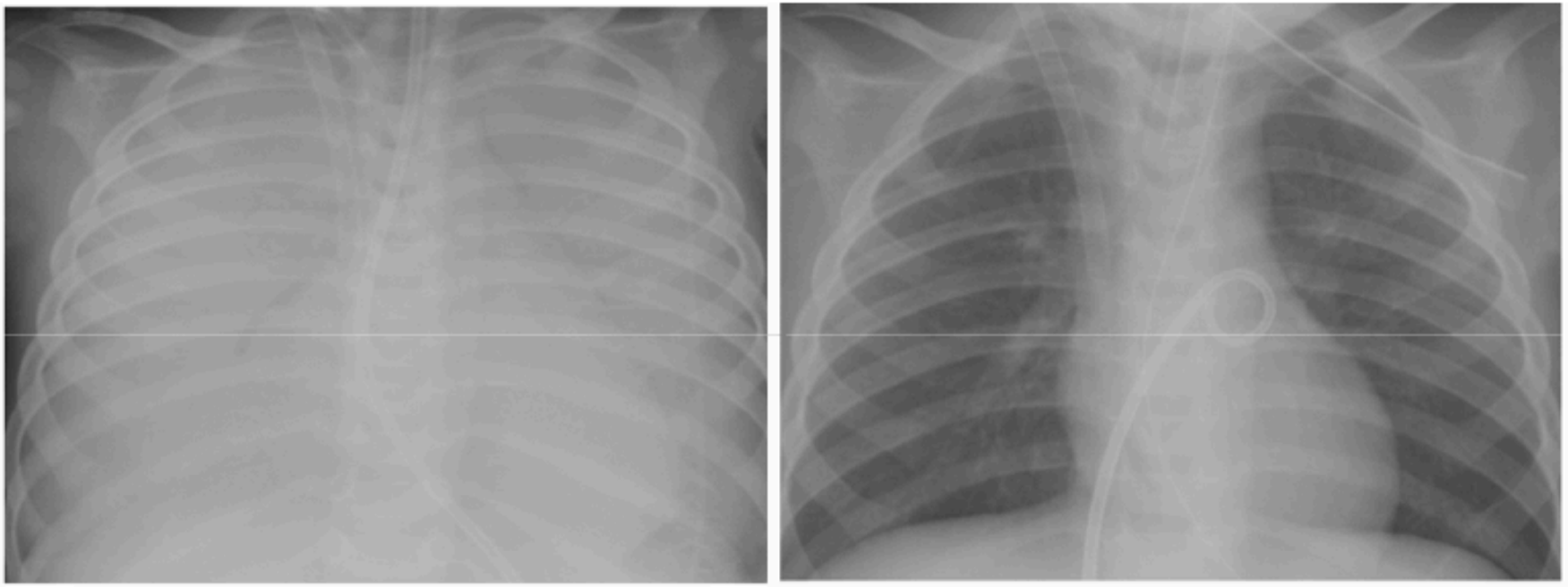
If bleeding

Parameters	Goal of values
PTT	40-45 sec
Platlets	Transfusion if <30 x10.9/L
AT III	> 80%
ACT	160-180 sec

Surveillance protocol

Parameters	Surveillance time	If Bleeding
PT-PTT-INR-AT III- FDP-fibrinogen	Every 6 hours/day	same
Count of platlets	Once a day	Re-control after transfusion
ROTEM/aggregometry	Once a week	On bleeding

Techniques for LV Decompression on ECMO



Salvin J et al. ELSO Red Book. 2013

ECMO experience
University of Padova

- Since 1991, ECMO for neonatal and pediatric patients
- About 15-20 pediatric ECMO/year (+80 adults)
- Either Respiratory and Cardiac
- Pediatric VAD center

ECMO Hub Center

in North-Eastern Italy

Analysis of our recent experience

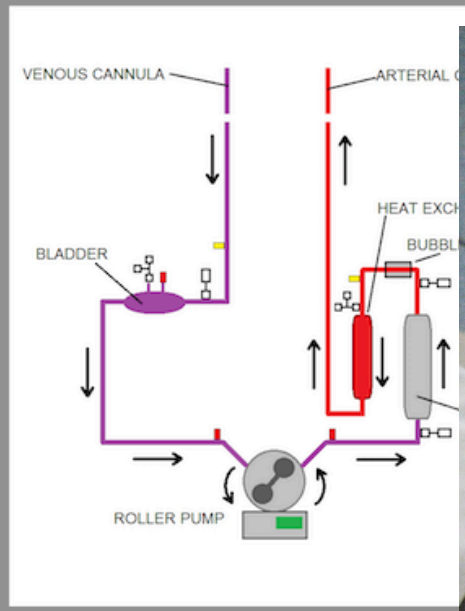
- Retrospective study
- Single center experience
- Period: January 2001-January 2014
- Approved by our Local Hospital Ethical Committee
- All patients gave consent to partecipate to the study

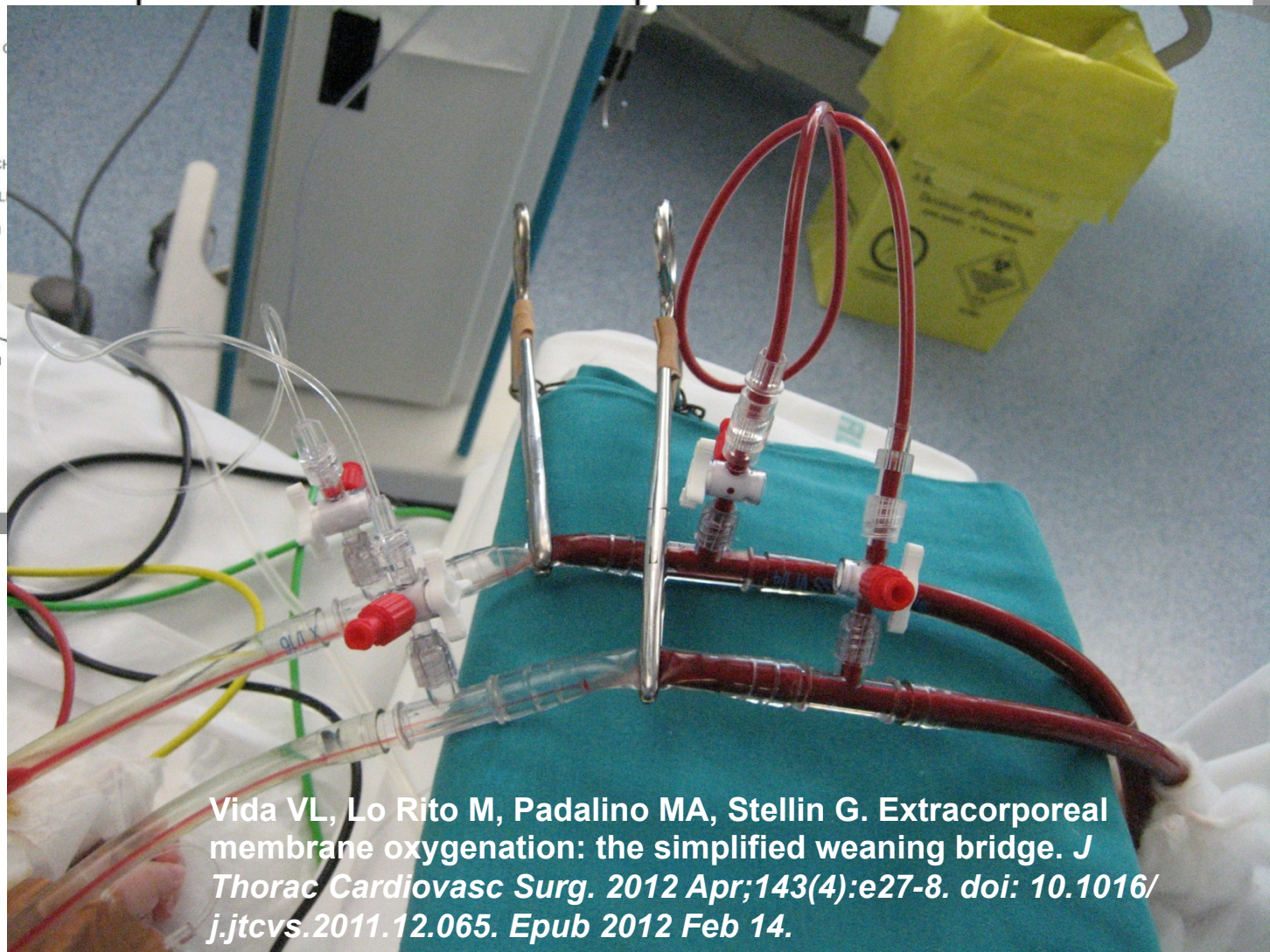
PADOVA ECMO ORGANIZATION #1

- Scheme of personnel involved:

#1 ECMO preparation and deployment	**#2 post-implant ECMO management and control in ICU**	**#3 ECMO dismantling**
Pediatric cardiac surgeon on call, ready for any emergency	ICU nurse **re-trained** annually	Pediatric cardiac surgeon on call, ready for any emergency
Perfusionist on call, ready for any emergency	Pediatric cardiac surgeon on call	Perfusionist on call, ready for any emergency
Scrub-nurse on call, ready for any emergency	Resident in hospital	Scrub-nurse, ready for any emergency
	Perfusionist on call, checking ECMO circuit every day	

PADOVA ECMO ORGANIZATION #2





Vida VL, Lo Rito M, Padalino MA, Stellin G. Extracorporeal membrane oxygenation: the simplified weaning bridge. *J Thorac Cardiovasc Surg. 2012 Apr;143(4):e27-8. doi: 10.1016/ j.jtcvs.2011.12.065. Epub 2012 Feb 14.*

Results (1)

	Total	Survivors	Not-survivors	
			Not-weaned	Not-discharged
Patients	**121**	**37 (30.5)**	**53 (43.8)**	**31 (25.6)**
ECMO runs (total, n)	**128**	**37 (28.9)**	**53 (41.4)**	**38 (29.7)**
Second ECMO run (n, %)	7 (5.5)	1 (2.7)	5 (9.4)	1 (2.6)
Median ECMO run (days, IQR)	7 (4-15)	5 (4-7)	12 (4-19)	6 (3.25-11.5)
CPR-E (n, %)	49 (38.3)	13 (35.1)	21 (39.6)	15 (39.5)
PC-E (n, %)	50 (39.1)	16 (43.2)	19 (35.8)	15 (39.5)
E-E (n, %)	29 (22.6)	8 (21.6)	13 (24.5)	8 (21)
ECMO implanted close to OR (n, %)	105 (82)	28 (75.7)	47 (88.7)	30 (78.9)
Venous-Arterial ECMO (n, %)	128 (100)	37 (100)	53 (100)	38 (100)
Central cannulation (n, %)	90 (70.3)	24 (64.9)	37 (69.8)	29 (76.3)
Other pathologies (n pts, %)	7 (5.8)	3 (8.1)	4 (7.5)	0
Hemolytic uremic syndrome	2 (28.6)	2 (66.7)	0	0
Hemophagocytic syndrome	2 (28.6)	1 (33.3)	1 (25)	0
Congenital nephrotic syndrome	1 (14.3)	0	1 (25)	0
Vasculitis	1 (14.3)	0	1 (25)	0
Diaphragmatic hernia	1 (14.3)	0	1 (25)	0
Previous cardiac surgery (n pts, %)	77 (63.6)	23 (62.2)	36 (67.9)	18 (58.1)

Multivariate analysis results.

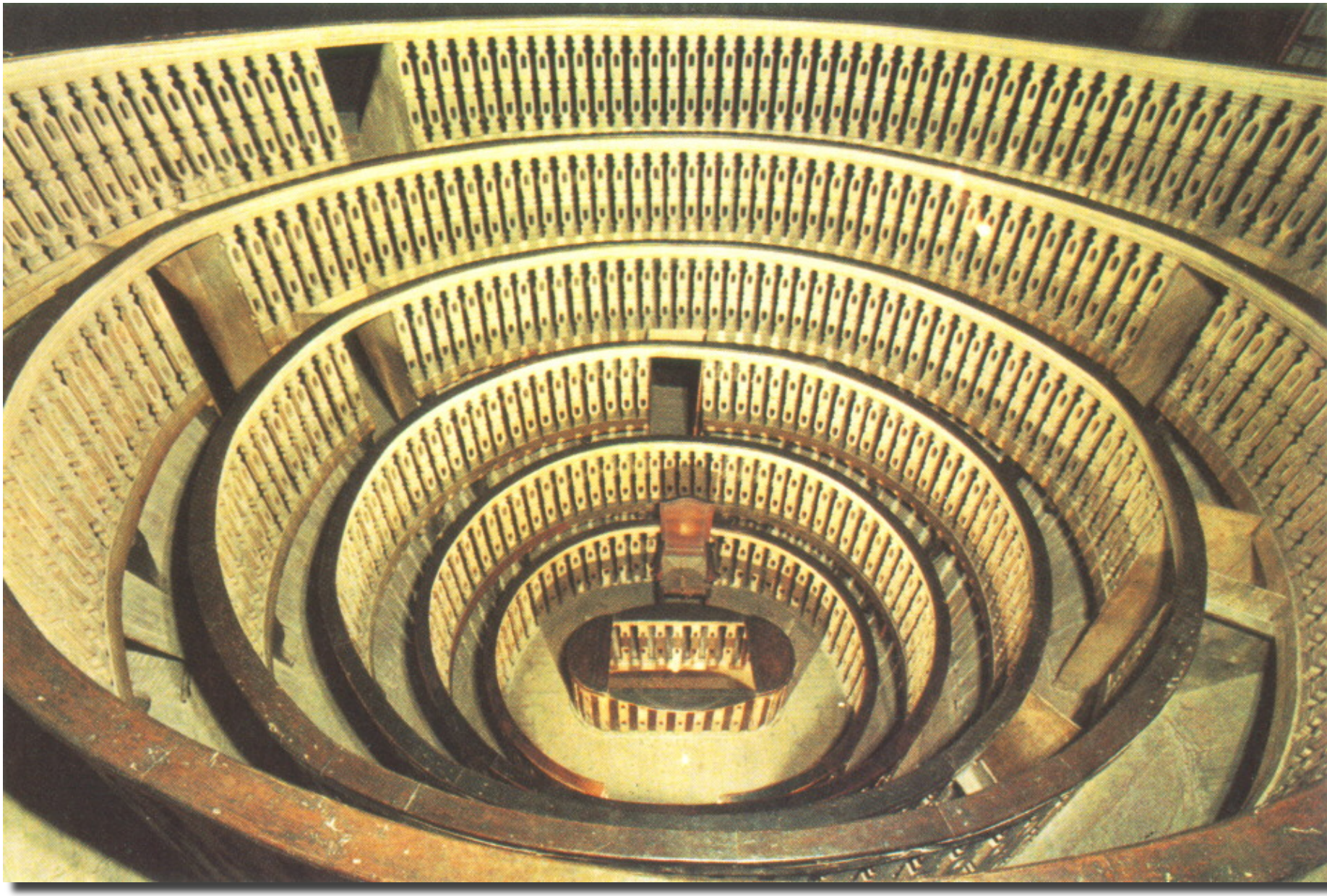
ECMO WEANING		
VARIABLES	**P**	**OR (95% CI)**
ECMO run (days)	0.0295	1.049 (1.005-1.095)
Surgical bleeding	0.0109	3.260 (1.313-8.096)
TE* complications	0.0260	7.477 (1.271-43.970)
Hemorrhagic complications	0.0123	8.807 (1.604-48.373)
30-DAY SURVIVAL		
VARIABLES	**P**	**OR (95% CI)**
ECMO run (days)	0.0333	1.054 (1.004-1.106)
CVA	0.0348	3.516 (1.094-11.298)

Padova-ECMO model VS ELSO (Extracorporeal Life Support Organization) registry (either Cardiac or E-CPR) in neonatal and pediatric age groups, in the same era (January 2014)

NEONATAL	TOTAL		WEANED		P	30-Day SURVIVAL		p
	Padova ECMO	ELSO	Padova ECMO	ELSO		Padova ECMO	ELSO	
Cardiac	37 (35*)	5425	20 (54%)	3339 (61%)	0.35	10 (28.6%)	2206 (40%)	0.0923
E-CPR	10	980	3 (30%)	626 (63%)	**0.046**	1 (10%)	388 (39%)	0.0988
PEDIATRIC	**TOTAL**		**WEANED**		**P**	**30-Day SURVIVAL**		**p**
	Padova ECMO	**ELSO**	**Padova ECMO**	**ELSO**		**Padova ECMO**	**ELSO**	
Cardiac	39 (37*)	6874	25 (64.1%)	4443 (65%)	0.9447	15 (40.5%)	3388 (50%)	0.1775
E-CPR	42 (39*)	2071	27 (64.3%)	1123 (53%)	0.1949	13 (33.3%)	840 (40%)	0.2090

CONCLUSIONS

- In modern medicine, ECMO has become a fundamental but expensive rescue tool
- Our experience with an ECMO support with no dedicated ECMO team is satisfactory
- Outcomes in terms of Weaning and Survival are comparable to ELSO in the pediatric age.
- Neonatal Cardiac ECMO and E-CPR still have worse results.



"Il Bo" - The Anatomy Theatre of Girolamo Fabrici d' Acquapedente

"Il Bo"

The Anatomy Theatre of
Girolamo Fabrici d'Acquapedente

COST ANALYSIS

Three phases of ECMO run:

COSTS WITHOUT ECMO TEAM
Circuit cost
Costs ECMO deployment
Costs ECMO management (7 days)
Costs ECMO dismantling
€ 24.760,45 /ECMO
€ 3.169.337,60/129 ECMO

Summary of VA ECMO Physiology

- ↓ Preload
- ↓ Contractility
- ↑ Afterload
  - LA Hypertension and Pulmonary Edema
- Myocardial Ischemia
  - Increased LV EDP
- Coronary Blood Flow may be desaturated if LV ejection and ventilation is inadequate