

Mechanical Circulatory Support

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- ECLS : Extracorporeal Life Support
- ECMO : Extracorporeal Membrane Oxygenation
- VAD : Ventricular Assist Device
- ECPR : Extracorporeal Cardiopulmonary Resuscitation

Role of MCS

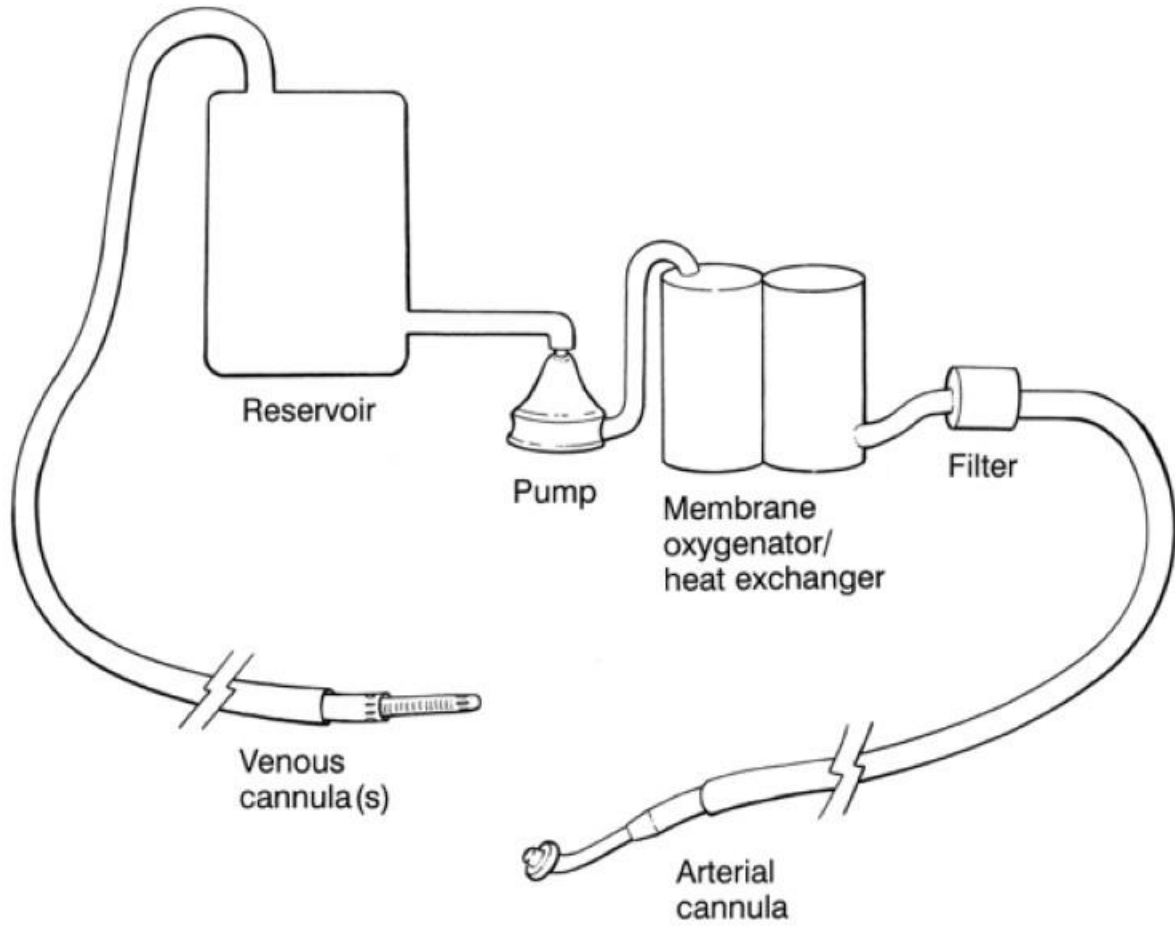
Bridge to Bridge (goal to transition to VAD)

Bridge to Recovery (reversible disease)

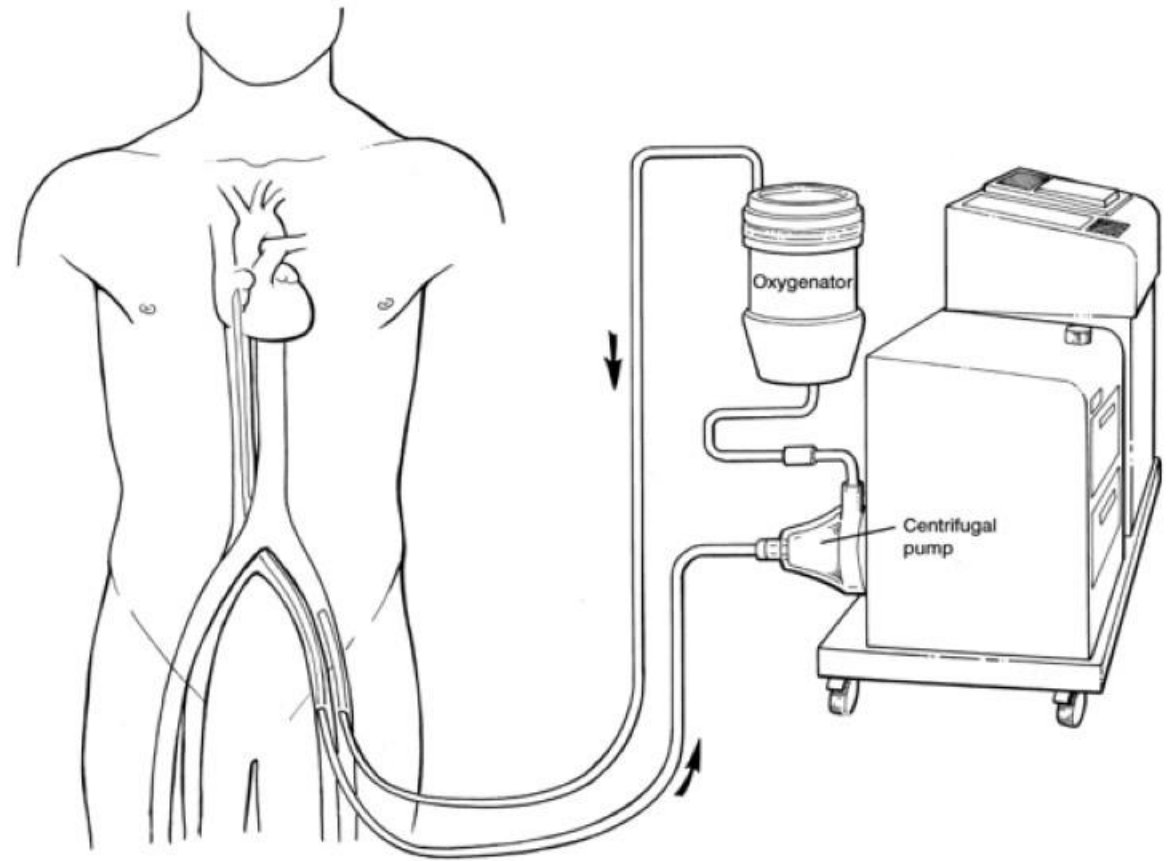
Bridge to transplantation

Bridge to Decision (providing time for recovery, diagnosis, or determination of candidacy for alternative support)

CPB



ECMO



CPB vs. ECMO		
Major Differences	CPB	ECMO
Open reservoir	Yes	No
Heparin (ACT)	>600	180
Autotransfusion	Yes	No
Arterial Filter	Yes	No
Patient	Asleep	Awake
Environment	OR, Hours	ICU, Days

CPB (Cardiopulmonary bypass)

ECMO (extracorporeal membrane oxygenator)

ECMO Circuit Components

1. cannula
2. Blood Pump
3. Membrane Lung (oxygenator)
4. Tubing

5. Heat exchanger
6. Monitors
7. alarms

ECMO mode

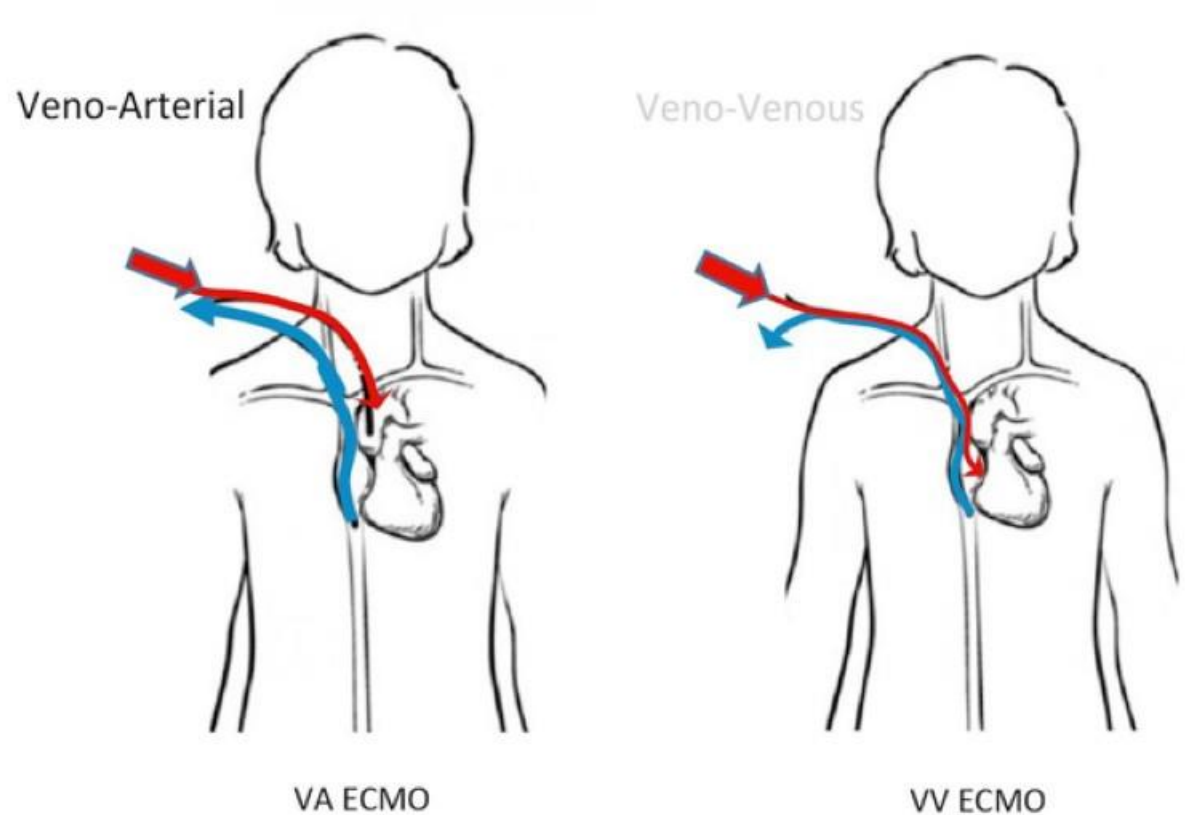
VV : venovenous mode

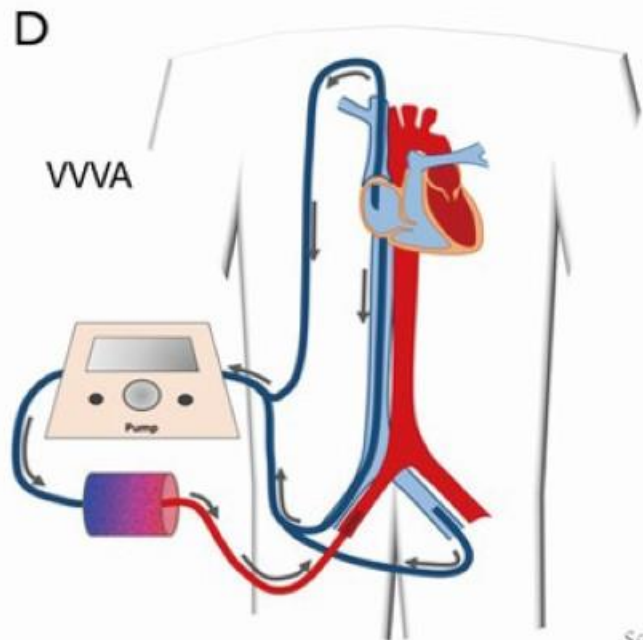
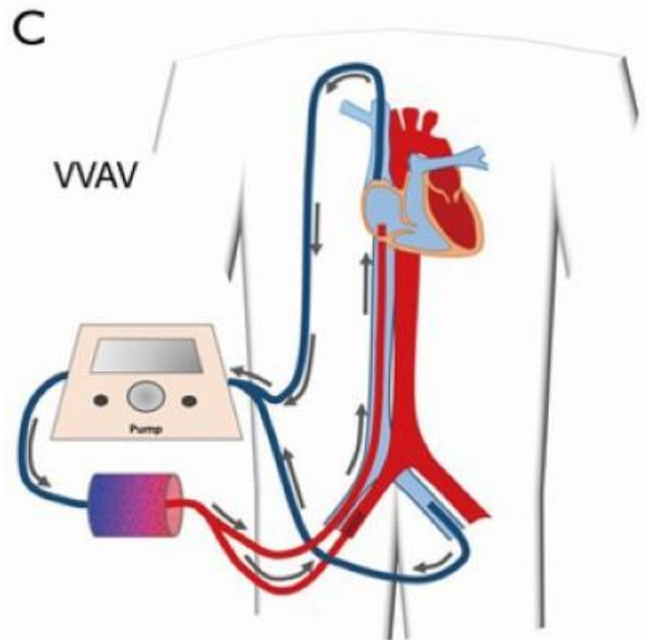
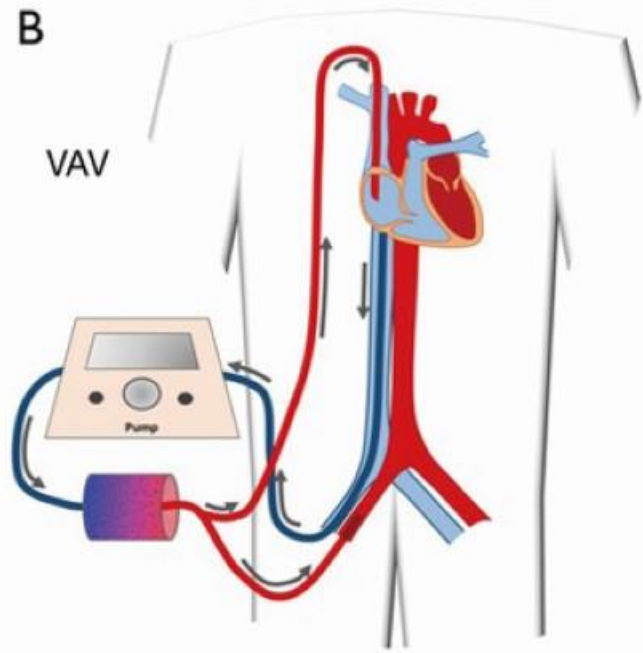
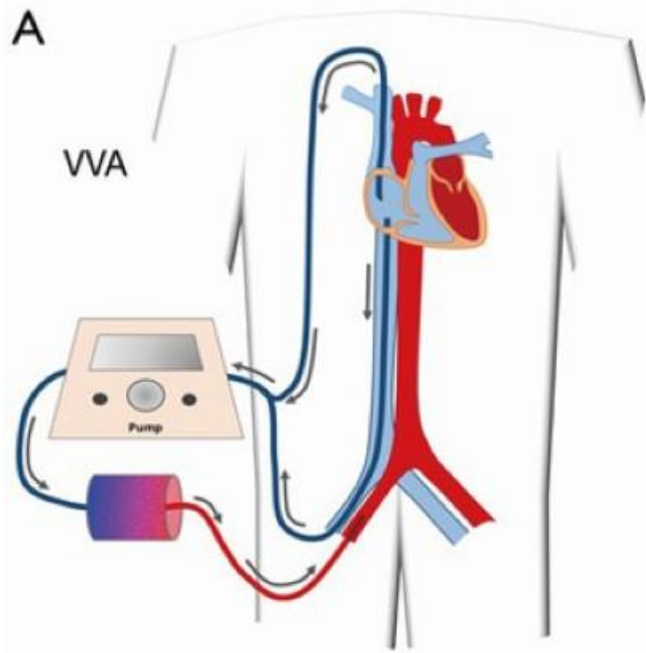
- Only respiratory support

VA : venoarterial mode

- Both circulatory and respiratory support
- Totally or partially

VVA / VAV /





Hybrid extracorporeal
membrane oxygenation
doi: 10.21037/jtd.2018.03.84

VV ECMO

Neonatal and pediatric respiratory Dz.

Neonatal respiratory assist

Congenital diaphragmatic hernia

Meconium aspiration syndrome

Airway obstruction

Surfactant Dysfunction

Pediatric respiratory assist

Acute respiratory failure

Status asthmaticus

Mediastinal masses

Pulmonary hemorrhage

Perioperative support for airway surgery

Burns

Respiratory support of patients with CHD

Indication

All eligible neonates and children who are failing to respond to more conventional medical therapies.

Table 19-1. A comparison of the most common conditions requiring ECLS support among neonates and children.

Neonatal		Pediatric	
CDH	(30%)	Viral Pneumonia	(20%)
MAS	(25%)	Non-ARDS, Respiratory failure	(20%)
PPHN	(20%)	Bacterial Pneumonia	(8%)
Sepsis	(5%)	ARDS	(6%)
RDS/Pneumonia	(1.5%)	Aspiration Pneumonia	(1%)
Other	(18.5%)	Other	(45%)

CDH=Congenital diaphragmatic hernia, MAS=Meconium Aspiration Syndrome; PPHN=Persistent Pulmonary Hypertension; RDS=Respiratory Distress Syndrome; ARDS=Acute Respiratory Distress Syndrome

Contraindication

Few absolute contraindication

Large intracranial bleed with mass effect
Cardiac arrest without adequate CPR

Irreversible underlying pathology

Greater than two weeks of high pressure ventilation

Pulmonary hypertension and chronic lung disease

Chronic multi-organ dysfunction

Incurable malignancy

VV cannulation

Neonate : VV is almost always via double lumen cannula (VVDL)

- VVDL percutaneous technique
- VVDL semi-open technique

Children : two-vessel cannulation, or VVDL

- internal jugular vein, femoral vein,
- Iliac vein?

Complications

- Cannulation complications
 - Low rates reported with ultrasound/fluoroscopy
- Equipment component failure
- Bleeding
 - Minor: cannulation site, surgical sites
 - Major: intracerebral
- Hemolysis

VV ECMO weaning

Sweep gas

Mechanical ventilator setting change

PaO₂ about 60~80mmHg

PaCO₂ about 40~60mmHg

VV ECMO outcome?

Comorbid conditions

Duration of pre-ECMO mechanical ventilation (>2wks?)

ECMO support duration (<2wks?)

VV ECMO Complications

Table 25-1. Mechanical and patient-related complications on ECMO support.

Complications	
Thrombotic Clots (oxygenator, hemofilter, bridge, bladder)	Mechanical oxygenator failure, raceway rupture, other tubing rupture, pump malfunction, heat exchange malfunction, air in circuit, cracks in connectors, cannula related issues
Hemorrhagic	Intracranial hemorrhage, gastrointestinal hemorrhage, cannulation site bleeding, surgical site bleeding, hemolysis, disseminated intravascular coagulation, pulmonary hemorrhage
Cardiopulmonary	Cardiopulmonary resuscitation required, cardiac arrhythmia, hypertension, tamponade (blood, serous, air)
Pulmonary	Pneumothorax, hemothorax
Neurologic	Brain death, seizures, infarction, intracranial hemorrhage
Metabolic Related	Hypoglycemia, hyperglycemia, hyperbilirubinemia, metabolic acidosis
Infections	
Renal failure	

VA ECMO

VA ECMO indication

1. Cardiac surgery and catheterization
 - a) pre-operative stabilization
 - b) Failure to wean from CPB
 - c) Elective support during high risk catheter procedures
 - d) Low cardiac output in the post-operative period
2. cardio-circulatory failure due to various etiologies
 - a) Cardiogenic : myocardial failure due to myocarditis, cardiomyopathy, intractable arrhythmia
 - b) Distributive : sepsis, anaphylaxis
 - c) Obstructive : pulmonary hypertension, pulmonary embolus.
3. In-hospital cardiac arrest not responsive to conventional CPR, with rapid availability of specialist ECMO team

VA ECMO contraindications

- Cardiopulmonary ECLS is inappropriate if;
 - a) the condition is irreversible and/or,
 - b) there is no timely, reasonable Tx option and/or,
 - c) high likelihood of poor neurological outcome.

- Absolute contraindication
 - a) extremes of prematurity or low birth weight (<30wks, <1kg)
 - b) lethal chromosomal abnormalities (e.g., trisomy 13 or 18)
 - c) uncontrollable hemorrhage
 - d) irreversible brain damage

VA ECMO cannulation

Patient needs

Skill of the operator

Good decompression of the heart

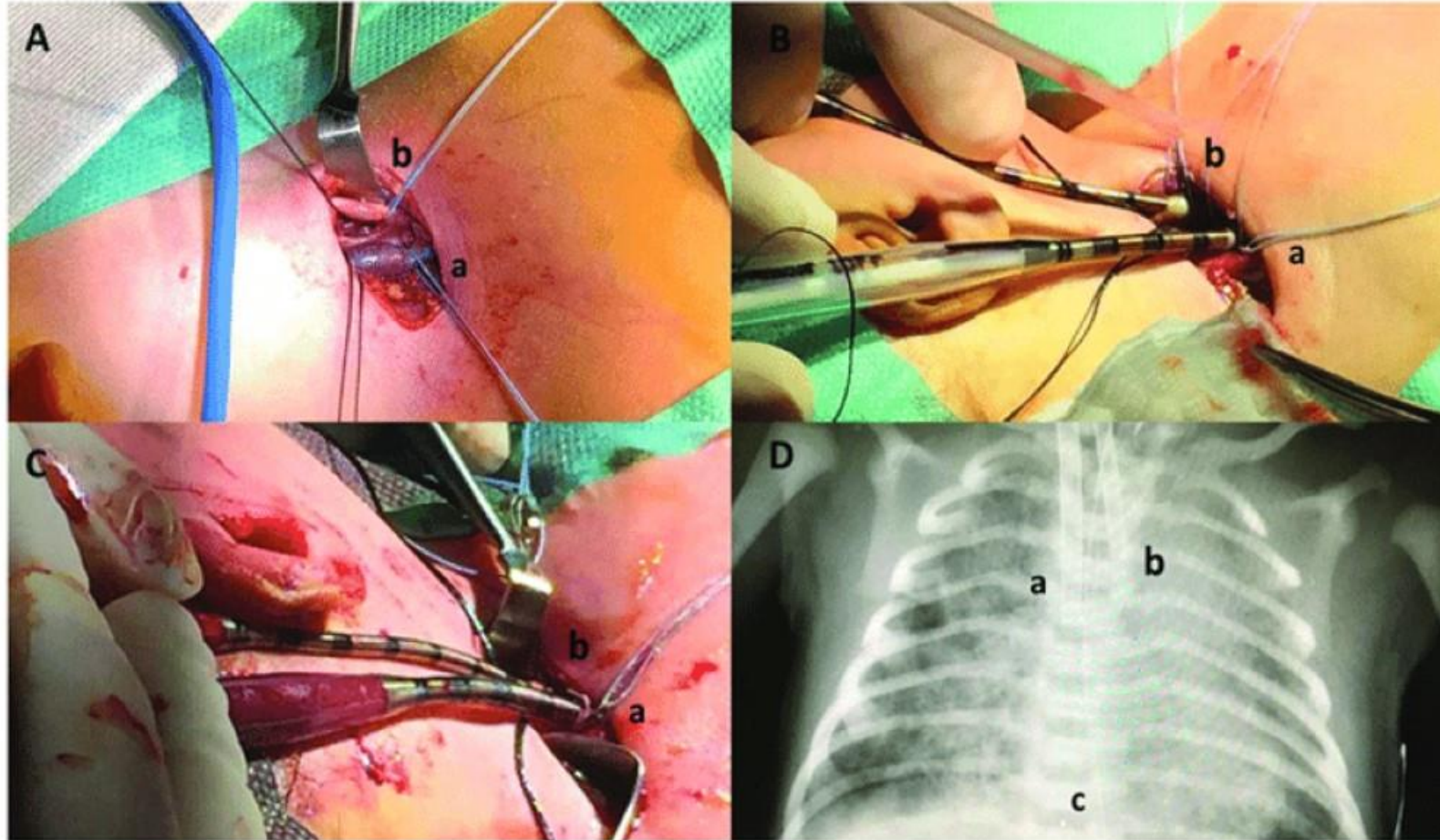
Strict asepsis

Maintenance of hemostasis

Prevention of polyneuropathy/ myopathy

Neck cannulation >> transthoracic cannulation...

Neck cannulation



Ligated vessels.
Separate incision
Gore-tex graft

Transthoracic cannulation

- Adequate extracorporeal flow
- Good decompression of the heart
- Strict asepsis

- Open sternum vs. closed sternum

- Venting
- Atrium distension -> pulmonary edema, pulmonary capillary rupture, pulmonary hemorrhage, death
- Site : RUPV, LA roof, LA appendage, LV apex via thoracotomy,

VA ECMO weaning

- Successful ECMO weaning?
 - Survival after discontinuation of ECMO without the need for reinitiation of mechanical support for the next 48 hours.
- When to attempt weaning
 - Depends on local factors : ICU
 - Depends on length of support : 2wks, VAD ?
 - Depends on indication for support
 - Primary myocardial dysfunction : no survival >4wks
 - Myocardial dysfunction after cardiac surgery : at least 48hours
 - Cardiac surgery with preexisting myocardial injuries : benefit from the longer support to recover
 - Postoperative events : resolution of the insult
 - Depends on team's perception of prognosis
 - Depends on capacity to go back on support

Predictors of successful weaning

- Myocardial recovery
 - Increasing pulse pressure
 - Increasing systolic pressure
 - Rising ETCO₂ (without shunt)
 - Improving function on echocardiography
- TTE
 - Under full flow : not predictor, as trend
 - Lower flow : predictor in adult with cardiogenic shock, cornerstone of most pediatric weaning protocol.

VA ECMO results

- Early survival outcomes
 - 51% in children, 41% in neonates (ELSO registry)
- Neurological outcome : 20% to 73% neurodevelopment problem in long term outcomes

VAD

Electromechanical device for assisting cardiac circulation, which is used either to partially or completely replace the function of a failing heart.

LVAD / RVAD / BiVAD / TAH

INTERMACS profile

Interagency Registry for Mechanically Assist Circulation Support

Profile-Level	Official Shorthand	Time frame for MCS support
INTERMACS Level 1	“Crash and burn”, critical cardiogenic shock	immediately – hours
INTERMACS Level 2	“Sliding fast” on inotropes	days to week
INTERMACS Level 3	“Stable” but continuous inotrope dependent	weeks
INTERMACS Level 4	“Frequent flyer”, resting symptoms, oral therapy at home	weeks to few months
INTERMACS Level 5	“Housebound” exertion intolerant, comfortable at rest	weeks to months
INTERMACS Level 6	“Walking wounded”, exertion limited	months
INTERMACS Level 7	Advanced class NYHA III	–

Potential contraindication for MCS

- Unclear or impaired neurological status
- Irreversible multi organ failure
- Sepsis / SIRS
- Malignancy
- Absent therapy compliance
- Aortic / pulmonary valve regurgitation more than mild
- Mechanical valves – esp. aortic valve
- Severe clotting disorder (DIC, HIT, factor deficiency ??)

VAD device

Table 1 FDA-approved Adult Durable Devices Included in INTERMACS

Type	Device
Durable devices	
Continuous flow	Thoratec HeartMate II HeartWare HVAD MicroMed DeBakey Child VAD
Pulsatile extracorporeal	Thoratec PVAD
Pulsatile intracorporeal	HeartMate IP HeartMate VE HeartMate XVE Thoratec IVAD NovaCor PC NovaCor PCq
Total artificial heart	SynCardia CardioWest

FDA, U.S. Food and Drug Administration; VAD, ventricular assist device.

Table 8 FDA-approved Devices—Pediatrics (<19 years)

Type	Device
Durable devices	
Continuous flow	Thoratec HeartMate II HeartWare HVAD
Pulsatile extracorporeal	Berlin Heart EXCOR
Total artificial heart	SynCardia CardioWest
Temporary devices	
Short-term devices	Abiomed AB5000 Thoratec CentriMag Tandem Heart Sorin Revolution Impella 2.5 Thoratec PediMag Maquet Rotaflow

ECMO vs. VAD		
Major Differences	ECMO	VAD
Duration of support	Days to weeks	Months to years
Oxygenator	Yes	No
Trauma to blood cells	Yes	Less
Mobilization	Yes/no	Yes
Exposure of blood to artificial surface	Some blood exposed to a large surface area	Some blood exposed to a relatively small surface area
Environment	ICU	General ward

ECMO (extracorporeal membrane oxygenator)

VAD (ventricular assist device)

EXCOR pediatric components

Driving Units



Ikus
For all pump sizes



Excor mobile*
For 60 and 80 ml

Pumps

- 10 ml
- 15 ml
- 25 ml
- 30 ml
- 50 ml
- 60 ml
- 80 ml*



Cannula

- Arterial cannula
Diameter from 5/6 to 12 mm
- Atrial cannula
Diameter from 5/6 to 12 mm
- Apex cannula
Diameter from 5/6 to 12 mm



* Available only for adult patients

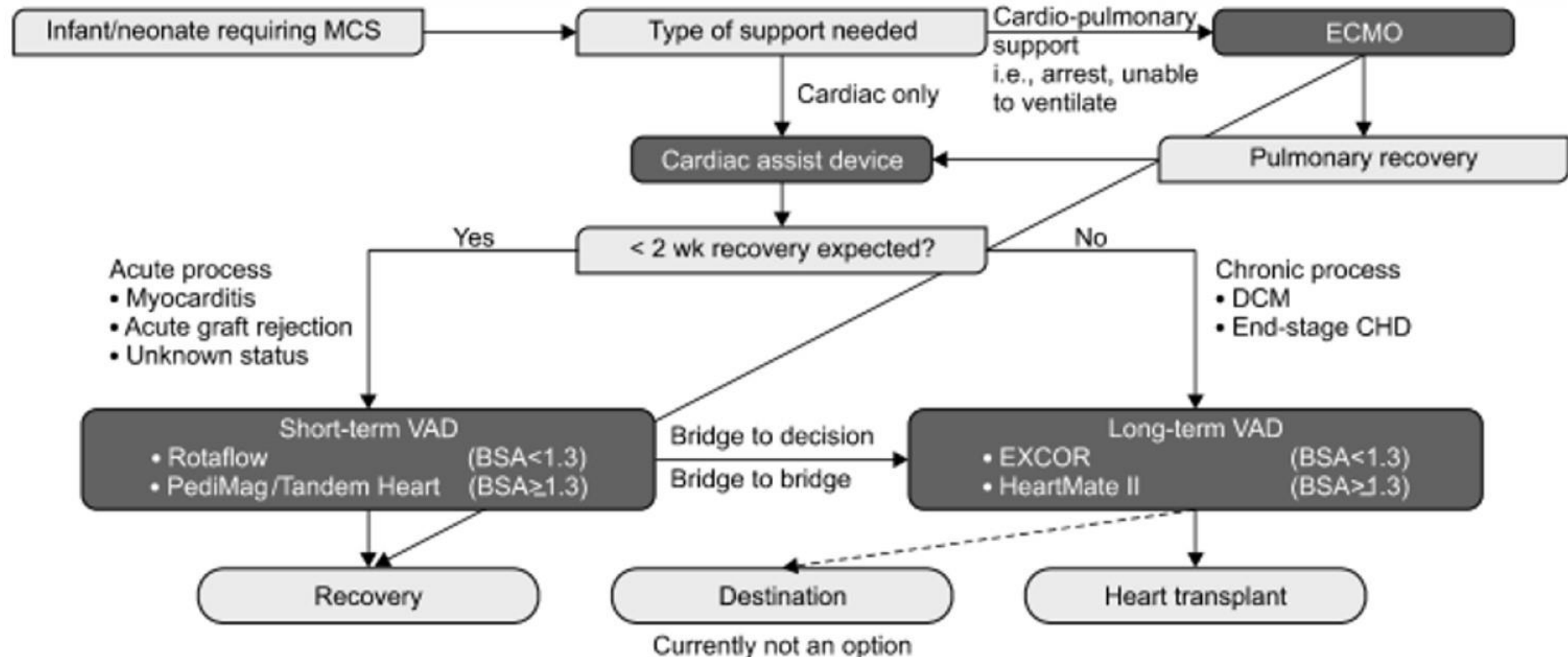


Fig. 1. Protocol for device selection; name of the devices used in the figure are authors' preference for each device type.

Thank for your attention

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