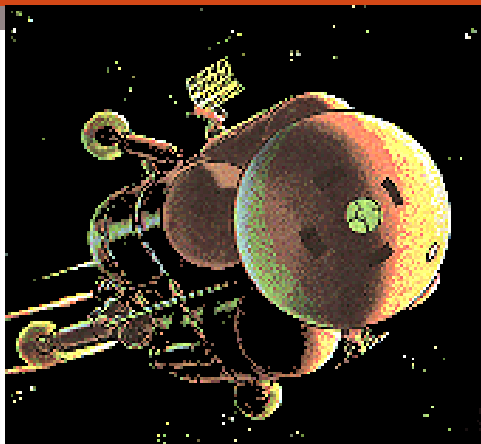


ECMO RETRIEVAL

(Extracorporeal Membrane Oxygenation)



Multi-organ failure secondary to
Acute Mitral Regurgitation



Dr Ajintha Pathmanathan

Anaesthetics Fellow

Dr Paul Forrest

Head of Cardiac Anaesthesia & Perfusion, RPAH

Dr Ken Harrison

Cardiac Anaesthetic and Retrieval Consultant, Careflight



Rationale for ECMO retrieval..

ECMO = *Extracorporeal membrane oxygenation...*
aka... artificial heart lung machine

Patients who are at the limit of conventional Rx for severe respiratory or cardiac failure may benefit from ECMO..

..these patients are also at significant risk of deteriorating if transported conventionally



- **Background on ECMO**

- Case

- Retrieval Logistics

- Physiology & Equipment

- Retrieval Issues

- Key Learning Points

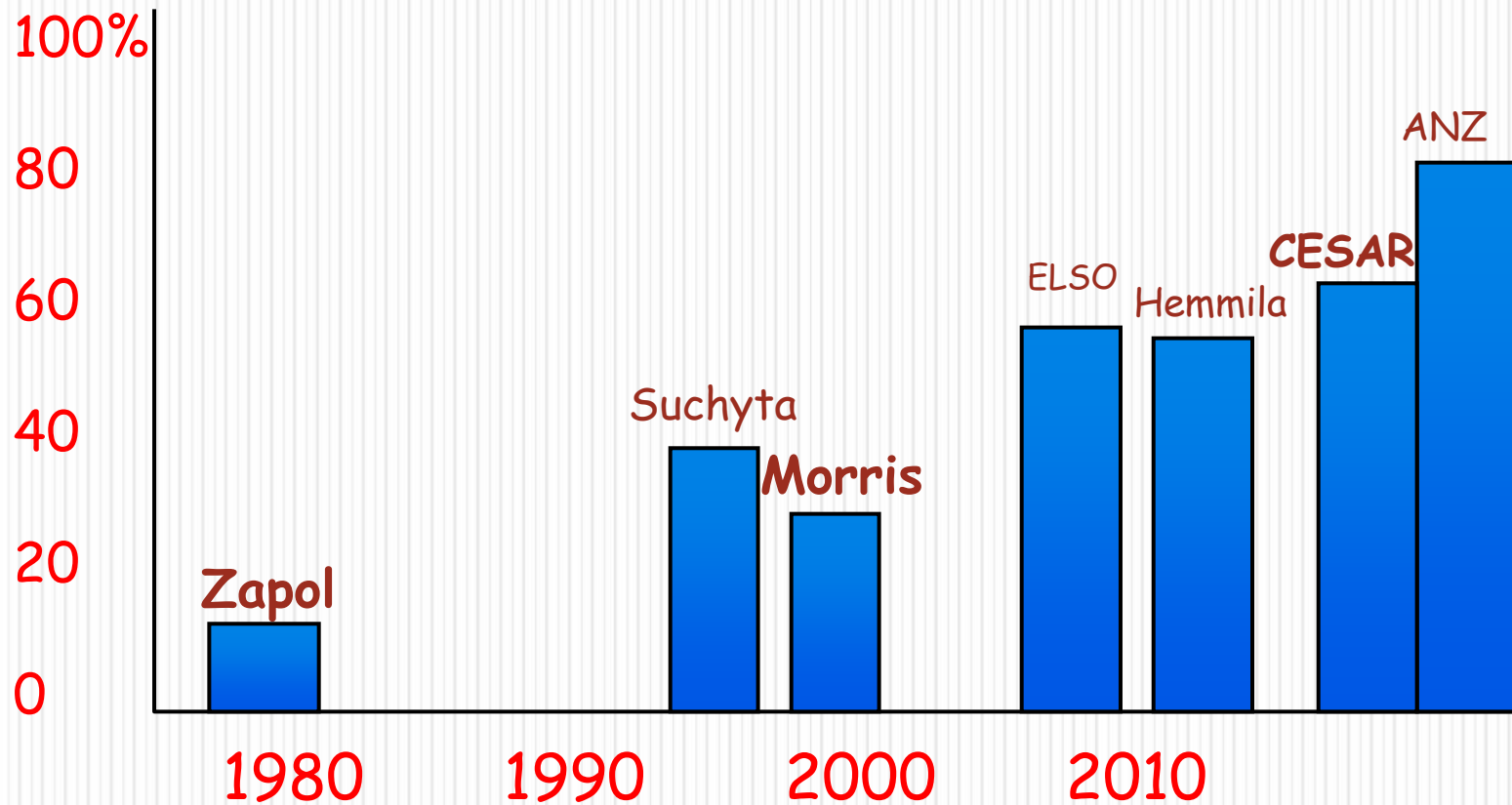


A little bit of history...

- 1972 - first reported clinical use
- Zapol et al (1976)
 - Conventional vs ECMO. Survival in 15%
- CESAR
 - Oxford Trials Group (UK)
 - RCT with 180 patients
 - ECMO vs Conventional Support
 - Death / Severe disability
 - ECMO: 37%
 - Conventional Rx: 53% $p < 0.05$
- ANZ
 - Australian & New Zealand ECMO Influenza Investigators
 - Winter 2009, Observational study
 - 68 patients, 33% needed ECMO and of these 80% weaned successfully



Survival: *ECMO for severe respiratory failure*



Severe ARDS: *NSW vs. ELSO vs. CESAR..*

	<i>age</i>	<i>PaO2/FiO2</i>	<i>ALI score</i>	<i>survival</i>
NSW <i>(n=39)</i>	34	57	3.7	87%
ELSO <i>(n=600)</i>	37	57	-	50%
CESAR <i>(n=68)</i>	40	76	3.5	63%



NSW ECMO Retrieval Service 2007-2010

Indication	Survival to discharge	%
respiratory (veno-venous)	34/39	87
cardiac (veno-arterial)	3/4	75
all	36/43	84

NSW	43
interstate	1
international	4
died prior to ECMO	2



Birth of NSW ECMO Retrieval Service ...

- **January 2008**

- RPAH and St. Vincent's Hospital agreed to share referrals for ECMO support
- providing a cardiac surgical / perfusion team to the referring hospital...

- **April/Mar 2009**

- NSW Health Department allocated funding for capital and recurrent costs of running service
- Funding for 10 patients / year

- **May 2009**

- NSW ECMO Retrieval Service launched..





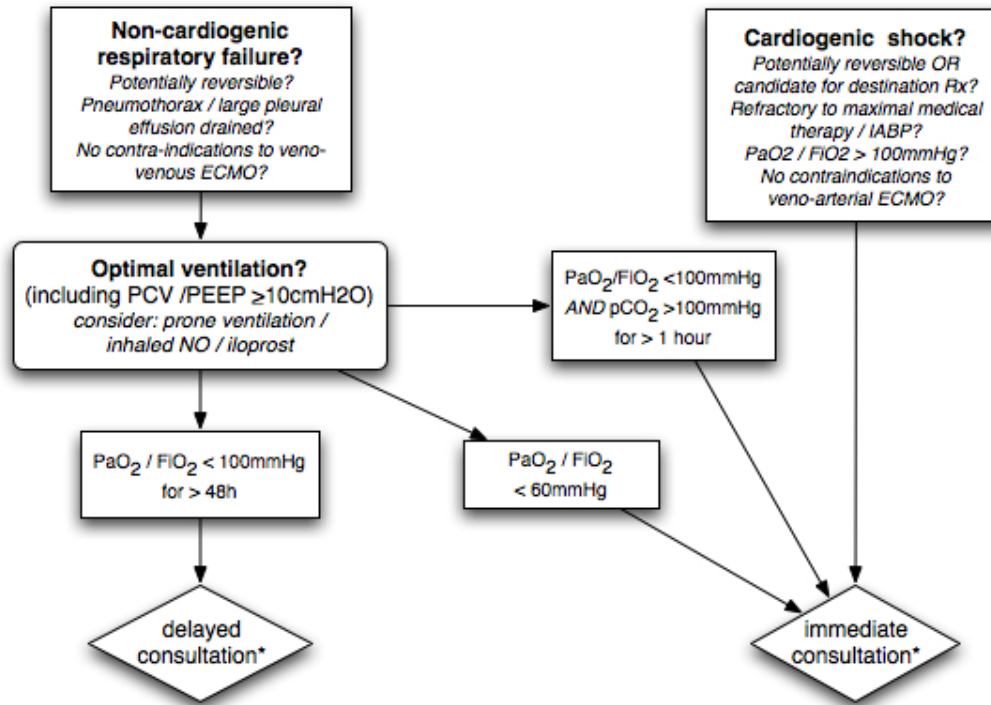
- Background on ECMO retrieval
- Cases
- **Retrieval Logistics**
- Physiology & Equipment
- Retrieval Issues
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Indications for ECMO retrieval

- Acute cardio/pulmonary disease must be reversible
- 80% predicted mortality with “conventional therapy”
- Ability to achieve “normal” quality of life following ECMO
- No major co-existing deficits
- Patients with above who are at significant risk of deteriorating if transported conventionally



INDICATIONS FOR ECMO REFERRAL



* Call the Medical Retrieval Unit: 1800 65 0004

Absolute contraindications to all forms of ECMO

- * Significant pre-existing co-morbidity, such as irreversible neurological condition, cirrhosis with ascites, encephalopathy, history of variceal bleeding, active malignancy with predicted limited survival, AIDS.

Relative contraindications to all forms of ECMO

- * Age > 65
- * Multiple trauma with uncontrolled haemorrhage
- * Multiple organ failure

Absolute contraindications to veno-venous ECMO (for respiratory failure)

- * Severe pulmonary hypertension (mPAP > 50mmHg)
- * Severe right or left heart failure (EF < 25%)
- * Cardiac arrest

Relative contraindications to veno-venous ECMO

- * High pressure, high FiO₂ IPPV for > 1 week

Absolute contraindications to veno-arterial ECMO (for cardiac failure)

- * Severe aortic valve regurgitation
- * Aortic dissection

Relative contraindications to veno-arterial ECMO

- * Severe peripheral vascular disease



Contraindications for Adult ECMO

All forms of ECMO

- Age (>60yo)
- Terminal malignancy
- Graft vs host disease
- Irreversible lung disease or cardiac disease
- Severe brain injury
- Body size >120kg

Absolute contra-indications to veno-arterial ECMO

- Aortic dissection
- Severe aortic regurgitation

Absolute contra-indication to veno-venous ECMO

- Severe heart failure
- Severe pulmonary hypertension



ECMO transportation process

- 1 Peripheral hospital team refers patient to ECMO team at receiving centre
- 2 ECMO team makes decision to establish patient on ECMO prior to their transfer to receiving centre
- 3 Retrieval of patient is coordinated by the Statewide Medical Retrieval Unit
- 4 ECMO team and equipment travel to peripheral hospital
- 5 ECMO team establish patient on ECMO
- 6 Retrieval team (critical care physician and paramedic) are deployed to retrieve patient
- 7 Patient is loaded into pre-configured helicopter or road Multi-Purpose Vehicle
- 8 Patient is transported to receiving hospital



ECMO retrieval team

ECMO team:

*Cardiac surgeon + medical perfusionist
+/- perfusion technician*

+

Retrieval team:

Retrieval doctor + paramedic/nurse



- Background on ECMO retrieval

- **Case**

- Retrieval Logistics
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42yo male from New Caledonia...

- 5 day history of worsening sepsis...
 - On day of retrieval acute deterioration with development of cardiogenic shock, severe pulmonary edema and respiratory failure
 - High inotrope requirements: noradrenaline 3mg/hr, adrenaline 5mg/hr, dobutamine
 - Difficult ventilation: VCV (Vt 550, RR 15, FiO2 100%)
 - Acute renal failure on CVVHDF



- Echocardiogram showed severe mitral regurgitation
- Diagnosis: Acute mitral regurgitation secondary to infective endocarditis
- Non-survivable pathology without surgery
 - No cardiothoracic surgical facilities in Noumea
- ECMO retrieval team called



- Background on ECMO retrieval
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- **Physiology & Equipment**
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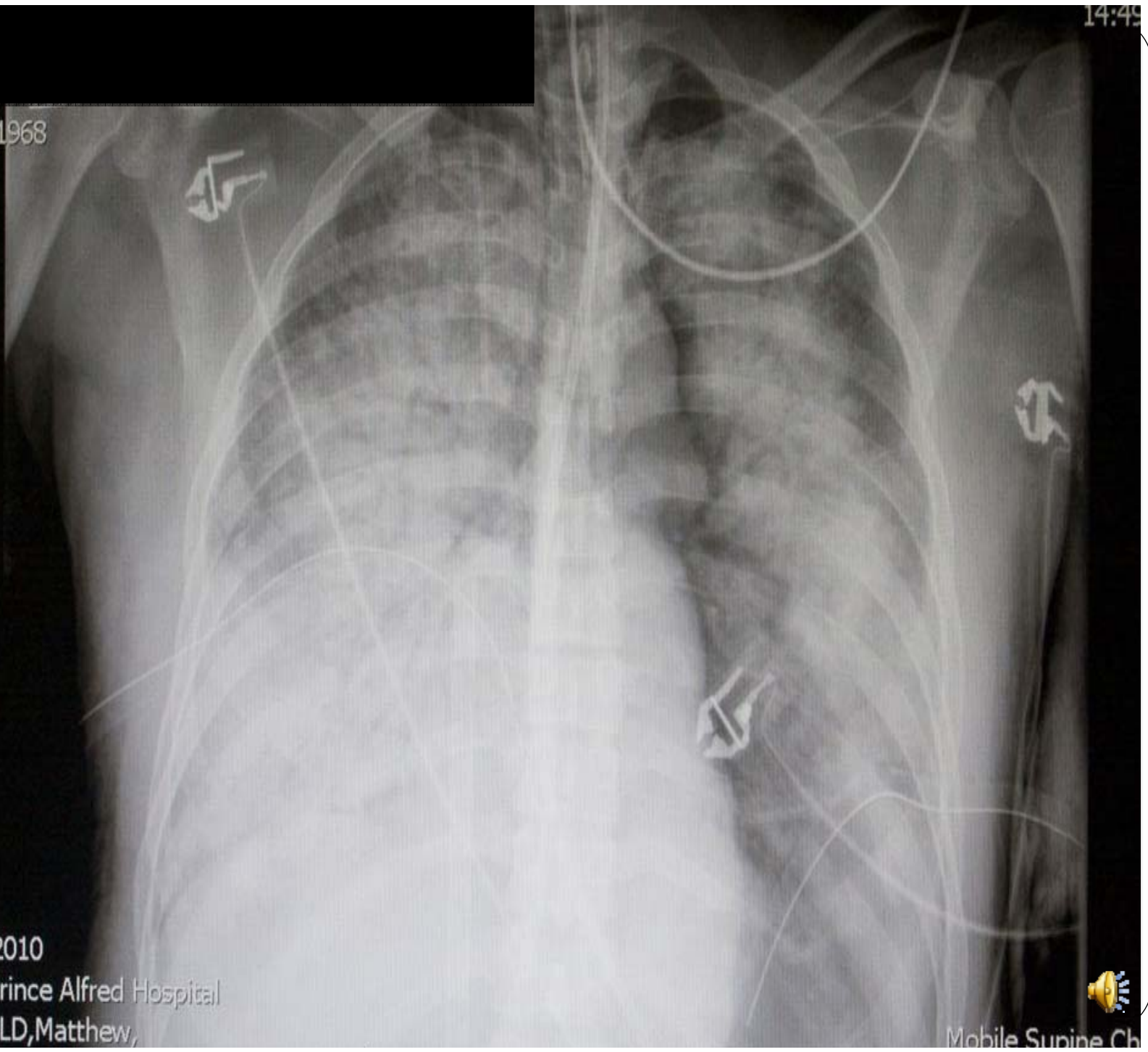
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05/06/2010
Royal Prince Alfred Hospital
BAYFIELD, Matthew,



Physiology of mitral regurgitation

- Acute MR causes sudden volume overload in left ventricle and left atrium
- Progression = increased LV volume and deterioration in contractile function = distal organ underperfusion and dysfunction
- Pressure & volume load in left atrium inhibits pulmonary drainage = acute severe respiratory failure and difficult ventilation



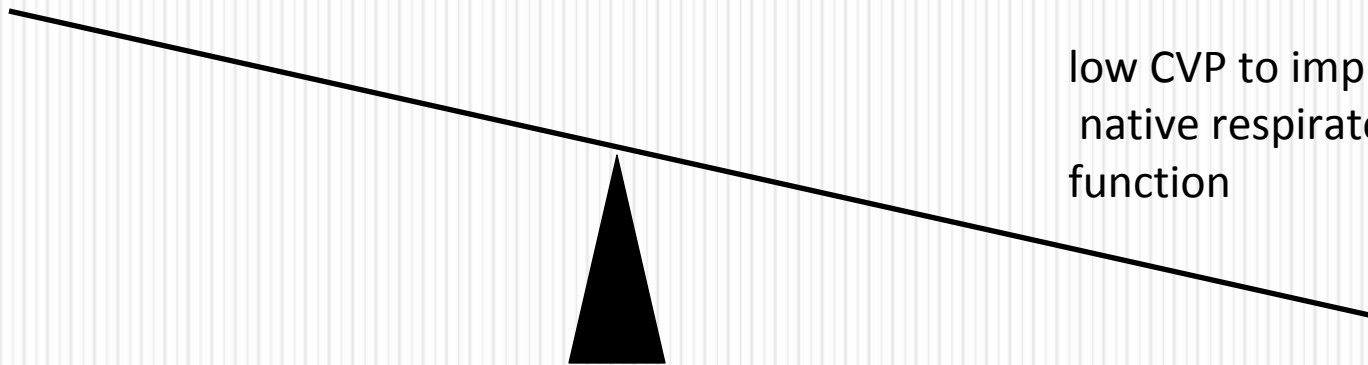
Principles of treatment

- Decrease afterload to increase forward flow
- Avoid tachycardia
- Cautious fluid filling



Achieving the right balance...

high CVP to
maintain
ECMO flow



low CVP to improve
native respiratory
function

Look for lowest CVP that will allow *adequate* oxygenation



Options for maintaining haemodynamics

- Cautious use of inotropes
- Avoid chronotropes
- Intra-aortic Balloon Pump
- Veno-arterial ECMO

Ventilating the ECMO patient...

- Ventilation strategy: minimal support (low minute ventilation) required to maintain alveolar patency
- May need to ventilate to supplement oxygenation
- V-A ECMO is capable of providing approx 80% oxygen requirements
- ARDS patients
- Due to low compliance may have high ventilatory requirements, thus efficiency of ventilator needs to be consider
- During our case we ran out of oxygen midflight
 - Consider ventilator used
 - Calculate oxygen requirements and take adequate amount





Types of ECMO...

- **Veno-arterial**
 - **Cardiac and respiratory support:**
 - Cardiac surgery
 - Cardiogenic shock
 - MI/myocarditis/drug overdose
 - Anaphylaxis
- **Veno-venous**
 - **Only for severe respiratory failure**
 - ARDS/pneumonia
 - Status asthmaticus
 - Smoke inhalation/aspiration



Veno - Arterial ECMO

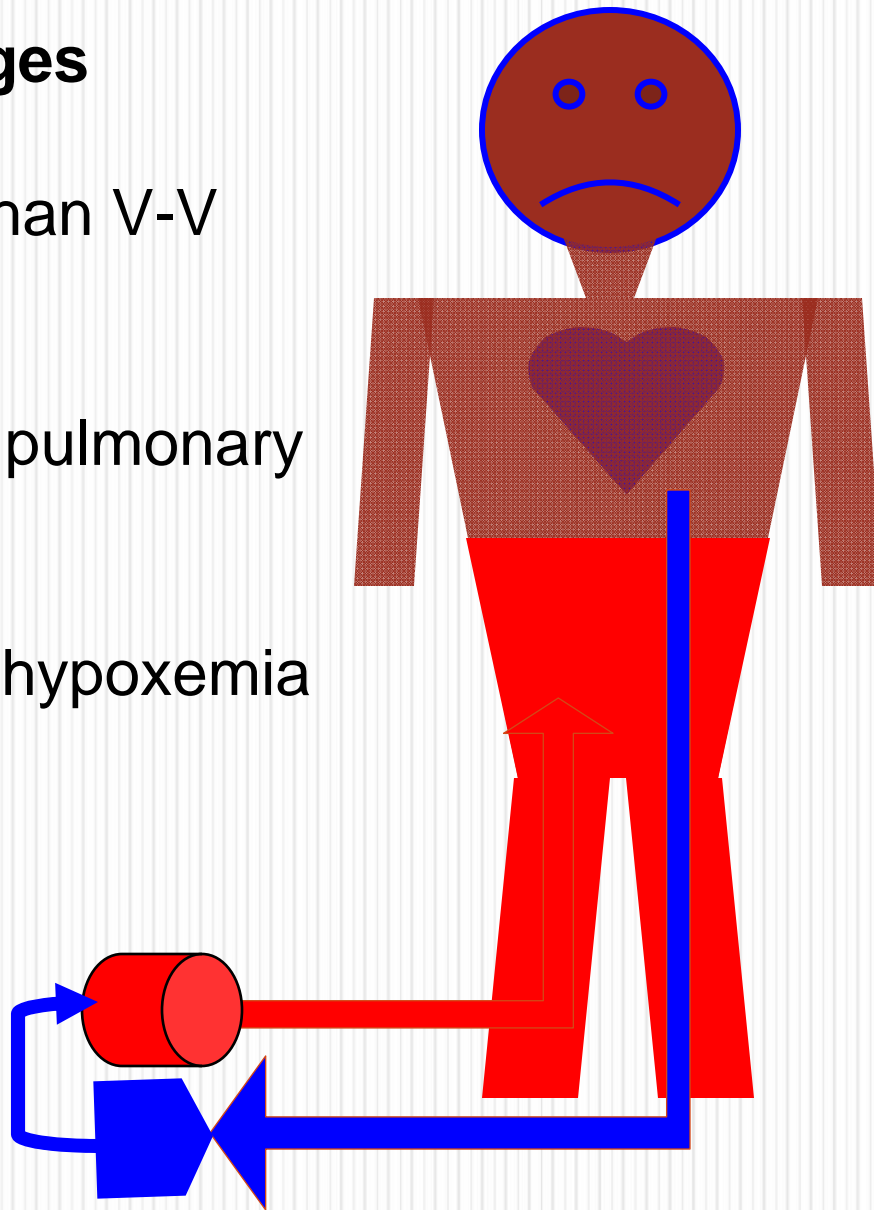
Advantages:

- Support to cardiac output in addition to native output
 - Providing 25-75% cardiac output
- Delivers higher level of oxygenation than V-V ECMO
- Efficient removal of CO₂ decreasing ventilatory requirements
 - Decreased barotrauma and volutrauma



Disadvantages

- Less safe than V-V ECMO
- Decreased pulmonary blood flow
- Differential hypoxemia



Complications

- Systemic anticoagulation
 - GI bleeding
 - Intracranial bleeding
- Exsanguination 2nd to circuit disruption
- Cannulation
 - Pneumothorax
 - **Vascular disruption**
 - Bleeding
 - **Systemic emboli**
 - **Distal Limb Ischemia**
 - Infection

- Day 1: Emergency Mitral Valve Repair. Dx Papillary Muscle Rupture secondary to Acute MI. Re-established on ECMO post-operatively
- Day 2 - 3: **Severe right lower limb ischemia.** Angiography and vascular surgery performed to re-establish flow. Unsuccessful. AKA performed.
- Two weeks later: Discharged to ward

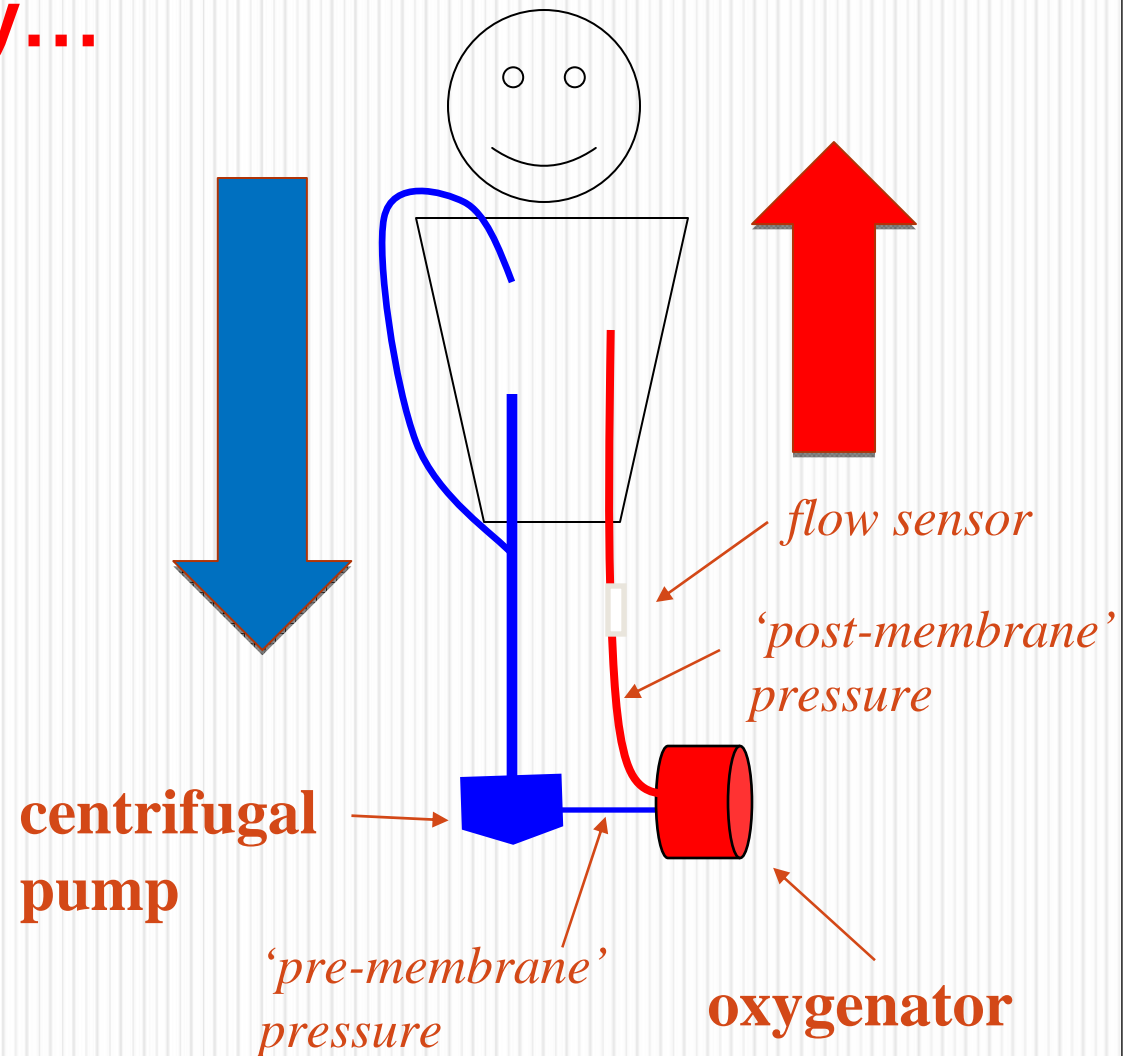


*August 2009; Griffith Base Hospital
First helicopter ECMO retrieval in NSW*



ECMO made easy...

1. Cannulae
2. Pump
3. Oxygenator
4. Circuit



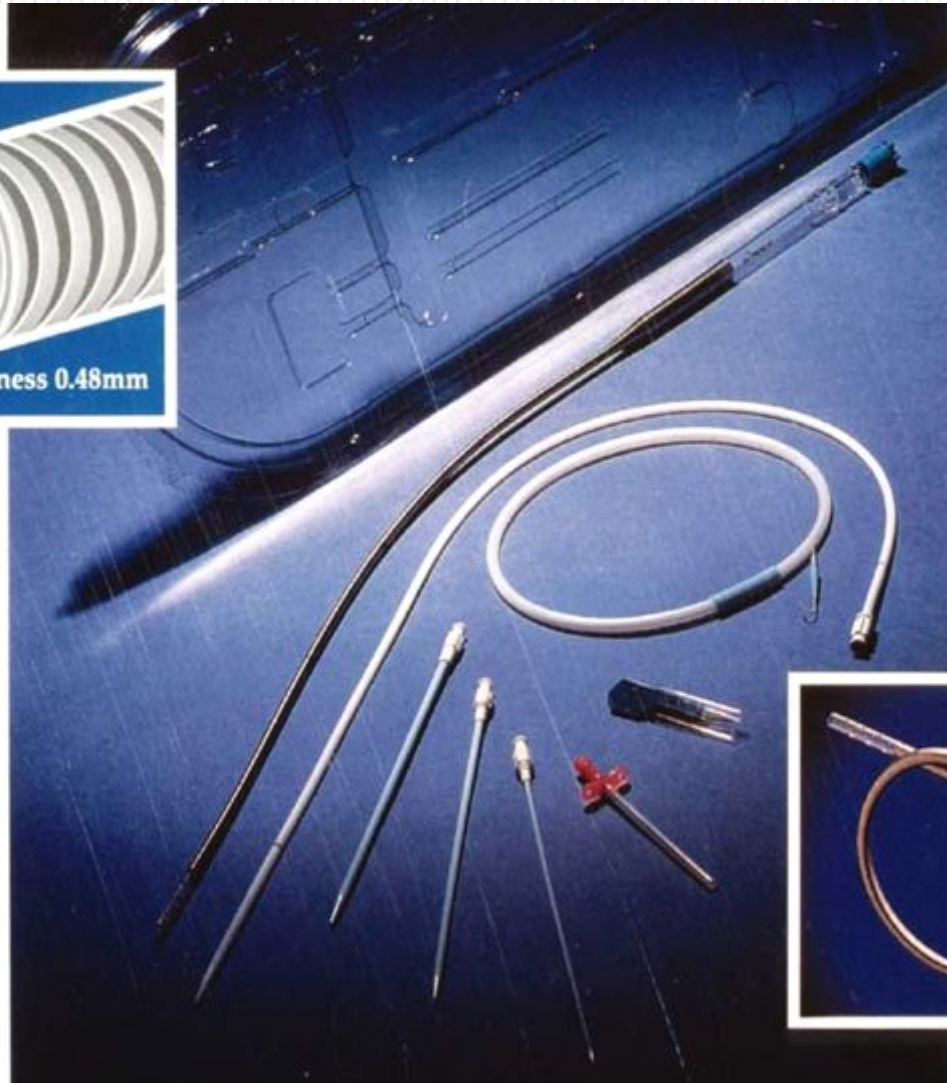
Cannulae: thin walled, percutaneous, high flow



Wall Thickness 0.48mm

Thin wall cannulae with high inside-to-outside diameter ratios notably improve flow rates. Pressure drops are *lowest size-for-size* of any cannulae.¹

1. In Vitro test data on file at Bio-Medicus, Inc.

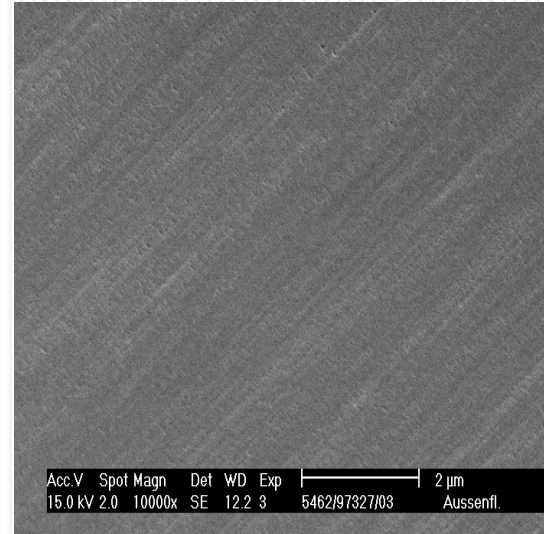


Centrifugal pumps...

- extremely robust
- low potential for haemolysis
- not height dependant
- potential for passage of air bubbles, esp on slowing pump



Diffusion Membrane Oxygenators



- Less haemolysis
- No plasma leakage
- *Much* more durable



Circuits Surface modification

- Have undergone surface modifications...
 - Reduces requirement for heparin
 - Reduces platelet dysfunction
 - Reduces systemic inflammatory response



Modern ECMO...

- Life of therapy
- Reduced level of supervision required
- Reduced requirement for heparinisation
- Low incidence of haemolysis





Maquet "Cardiohelp™,"



- Background on ECMO retrieval
- Case
- Retrieval Logistics
- Physiology
- **Retrieval Issues**
- Key Learning Points



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Critical events during transfer

- **Procedure related**
 - Cardiac tamponade post ECMO establishment
- **Patient related**
 - Ongoing hypotension – managed with inotropes
 - Difficult ventilation secondary to severe pulmonary edema
- **Equipment related**
 - Inadequate oxygen supplies
 - Inefficient ventilator used
- **Team related**
 - Protracted mission and fatigue management



Timelines

Patient Number	Task to Departure Time lag	Duration of Mission(hr:mm)	Stablisation Duration(hr:mm)	Booking to Tasking Time lag
1	0:10	5:50	0:45	4:01
2	2:20	5:55	1:35	0:59
3	1:00	6:55	4:05	6:29
4	1:45	7:45	1:20	14:07
5	0:30	10:30	1:35	3:27
6	0:10	4:55	3:15	4:19
7	2:45	8:30	1:30	6:15
8	5:20	10:15	1:05	2:21
9	0:10	9:50	1:30	5:46
10	1:05	5:25	1:40	4:49
11	0:15	11:15	2:10	8:02
12	3:20	8:25	1:55	3:59
13	5:55	11:15	1:20	1:55
14	0:00	6:45	1:10	4:35
15	0:00	8:50	1:20	5:38
16	0:00	5:20	0:50	7:31
17	2:00	10:15	2:20	0:50



Fatigue management...

- Retrieval team advised at 16:00
- Departed Sydney: 20:00
- Arrived at patient: 0:00
- Departed referring site: 05:30
- Diverted to Brisbane midflight for Oxygen and fuel
- Arrived in Sydney: 15:00
- Duration of mission approx 22hrs



Safety of ECMO retrieval

- 4 critical events
 - 2 equipment-related
 - Battery failure – hand pump until vehicle power available
 - Air in line (3-way tap opened) – pump stopped; aspirated; restarted
 - 2 patient-related
 - SVT – anti-arrhythmics / Mg²⁺ / DCCV
 - Hypotension – vasoactive drug commenced





Key learning points

- ECMO should be considered in patients with potentially reversible , severe respiratory and/or cardiac failure that is refractory to maximal conventional therapy
- A centralised ECMO retrieval process allowing standardisation of referral indications, mission planning, staffing, and equipment
- Specialised and adequately trained staff





Thank you...



Questions...

Emails:

Ajintha Pathmanathan
jin_001@hotmail.com

Paul Forrest
forrest4@bigpond.net.au

Ken Harrison
Ken.harrison@careflight.org