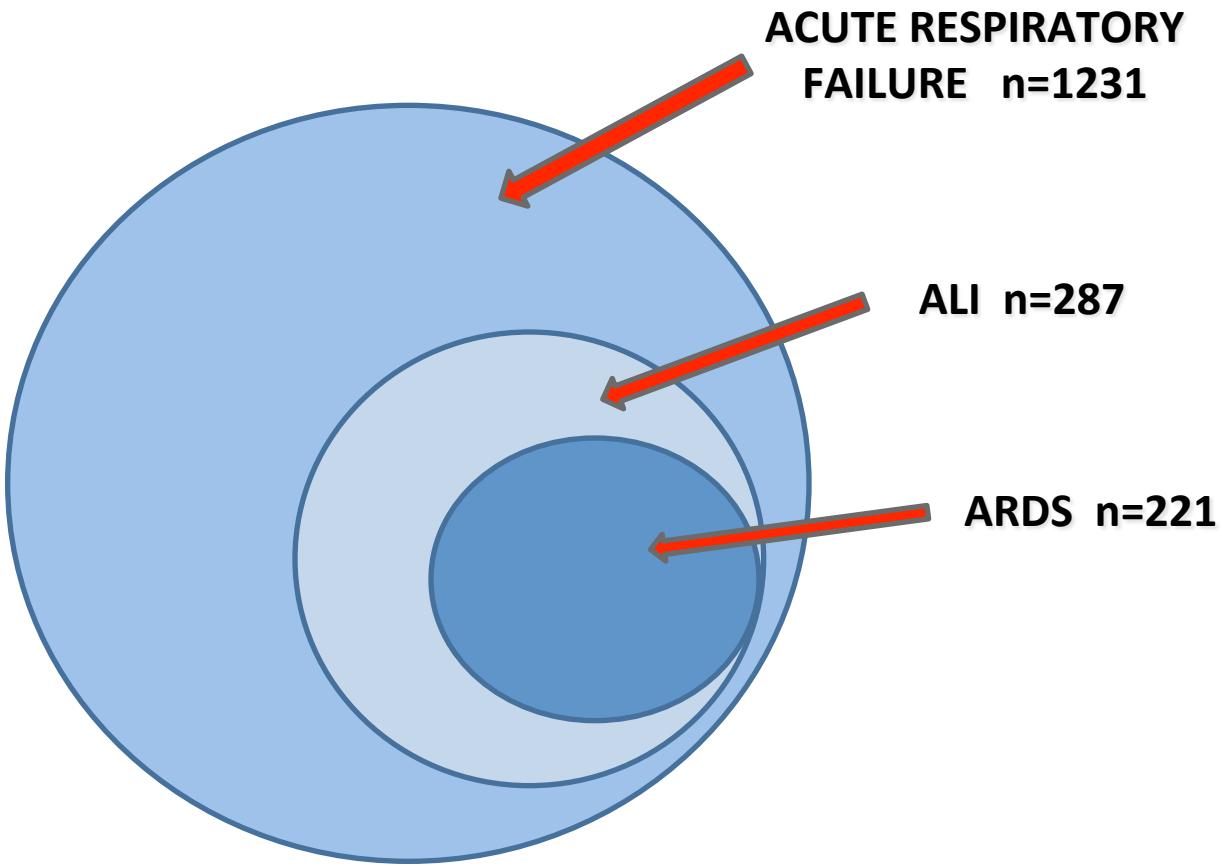
'Broken Lungs'

Cait P. Searl

Consultant Cardiothoracic Anaesthetist / Intensivist

Luhr et al, *Am J Respir Care Med* 1999; **159**:1849



Does the actual diagnosis matter?

Exacerbations of COAD – optimal mode of ventilation?

Aim to balance

- Treatment of hypoxaemia
- Treatment of hypercapnia
- Unloading respiratory muscles
- Managing auto-PEEP
- Managing atelectasis

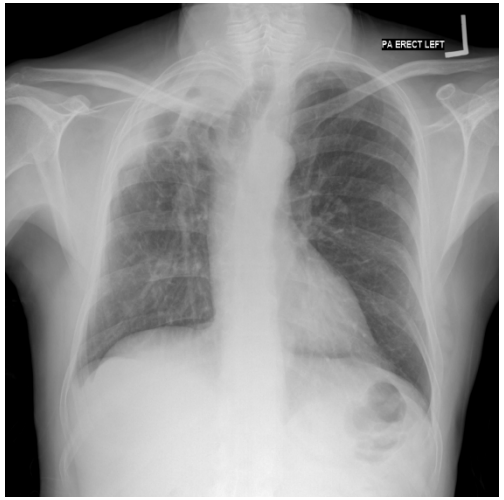
Normalisation of milieu

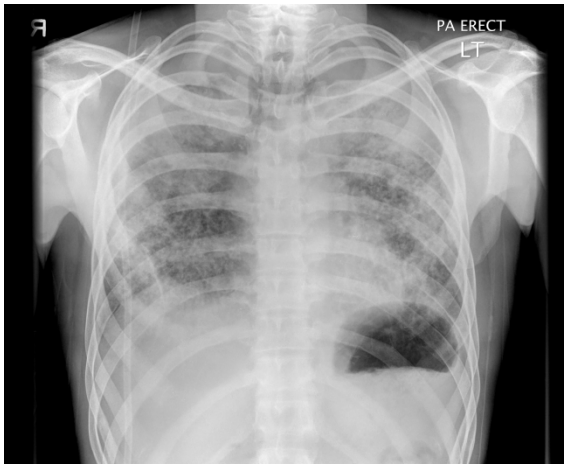
Target is normalising blood gases for that patient

Two principles of 'conventional' ventilation

1. Lung protection

2. Lung recruitment





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- ✓ Independent lung ventilation
- ✓ Maintaining spontaneous ventilation
- ✓ High frequency ventilation
- ✓ Continuous positioning therapy
- ✓ Prone positioning
- ✓ ECMO
- ✓ iNO

EVIDENCE ???

- ✓ Partial liquid ventilation
- ✓ Nebulised prostacyclin
- ✓ Surfactant
- ✓ Anti-inflammatory agents
- ✓ Anti-oxidants
- ✓ iLA
- ✓ i v salbutamol
- ✓ Carbon monoxide
- ✓ etc
- ✓ etc

Respiration

Combination of ventilation and perfusion

Separate out the ventilation (air in and out) component usually and treat just that.

Respiratory failure

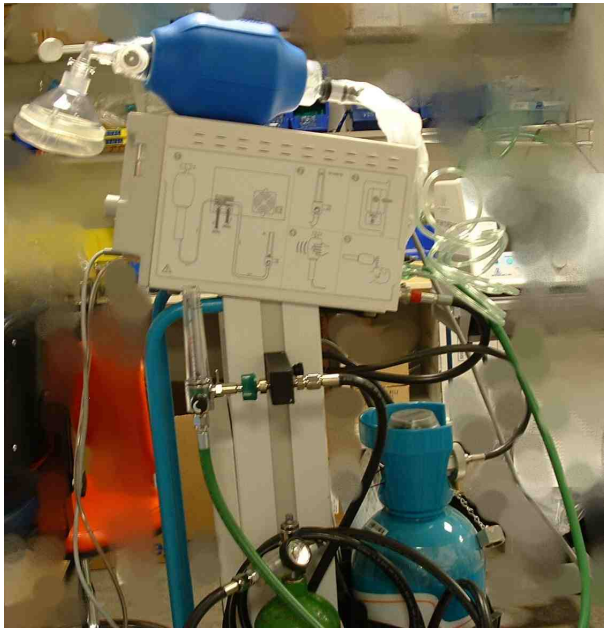
Components

1. Mechanical
2. Lack of functional lung tissue
3. Lack of blood supply

Respiratory Failure: Adjunctive treatment making ventilatory support more effective

- NO
- Inhaled epoprostenol

Improve ventilation- perfusion matching by dilating arterioles in ventilated alveoli



Respiratory Failure: Treatment recruiting functional but non-functioning lung

- Pronation
- HFOV

HFOV

- High frequency (3-15Hz) oscillation
- Ventilation (1-4 ml / kg)

Theoretically meets goals of protective ventilation and maintains constant lung recruitment.

But...

Unproven benefits
Disadvantages

OSCAR ?

And...

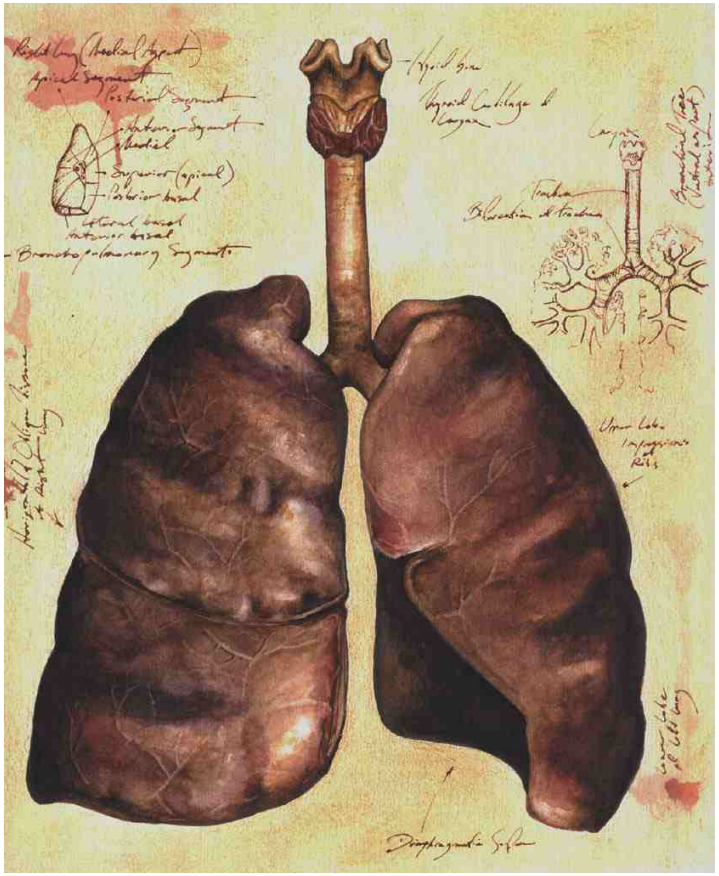
Hypercapnia is almost inevitable....

hypoxia may not improve

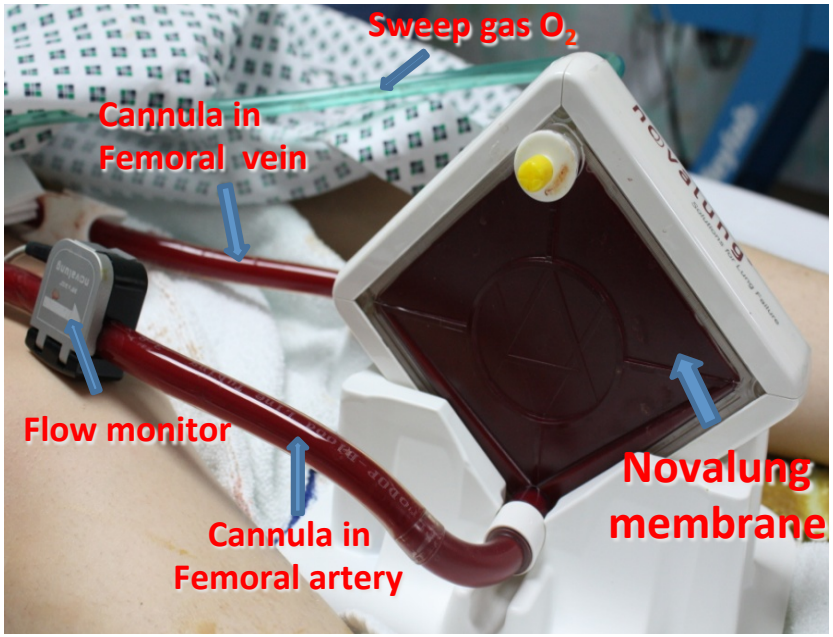
There may not be recruitable lung tissue

Lung Replacement

- Temporary
  - NOVAlung
  - ECMO
- Semi-permanent
- Permanent
  - Transplant
  - Stem cell therapy
  - Biolung



NovaLung function



- High CO_2 gradient between blood and sweep gas allows diffusion across the membrane, allowing efficient CO_2 removal
- Oxygenation limited due to arterial inflow
- Low resistance to blood flow (7mmHg at 1.5l /minute) allowing the heart to be the pump for the device
- Heparin coated biocompatible surface

Two variables:

Sweep gas flow controls CO2 removal

Blood flow controls oxygenation

(MAP & cannula size)

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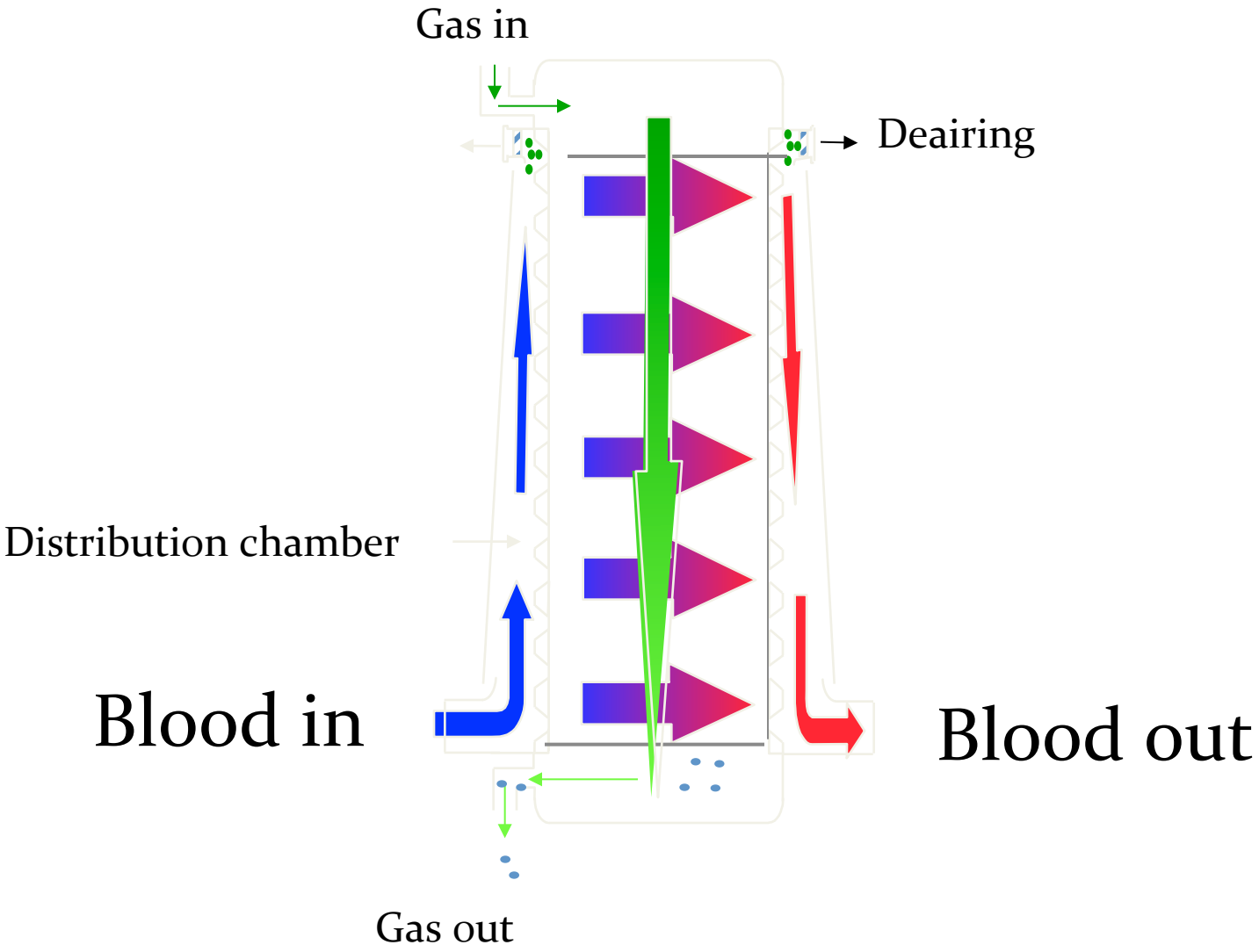
FUNCTION


Gas in
Deairing
Distribution chamber
Blood in
Blood out
Gas out

Searl et al, 2010

Insertion	Pre pH	Post pH	Pre CO_2 kPa	Post CO_2 kPa	Pre P_{insp} cmH_2O	Post P_{insp} cmH_2O	Outcome
17 days	7.07	7.23	10	6.7	31/8	25/12	Dead
1 hour	7.10	7.38	13.4	6.0	32/10	24/8	Dead
4 hours	7.06	7.31	12.2	6.4	32/10	20/8	Alive
10 hours	6.94	7.31	15	5.7	35/12	24/10	Alive
12 hours	7.04	7.34	13.3	6.2	35/12	18/10	Alive

Novalung as bridge to transplant

43 yrs F

- lymphangioleiomyomatosis (LAMM)
- increasing problems due to pneumothoraces
- developed hypercapnia with a progressive respiratory acidosis

Novalung as bridge to transplant

Immediate improvement was produced with a correction in pH from 7.19 to 7.4

and Pco_2 from 15 to 8.5 kPa.

Not an Oxygenator

when used as designed…

ECMO

Caesar trial etc…

Basically extended CPB

Blood drained from body

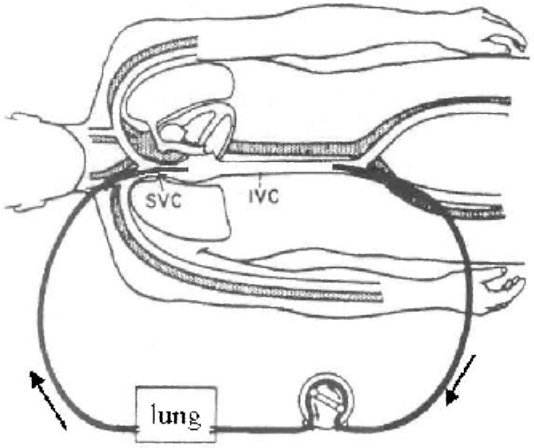
Blood circulated through an oxygenator (can be membrane diffusor or bubble)

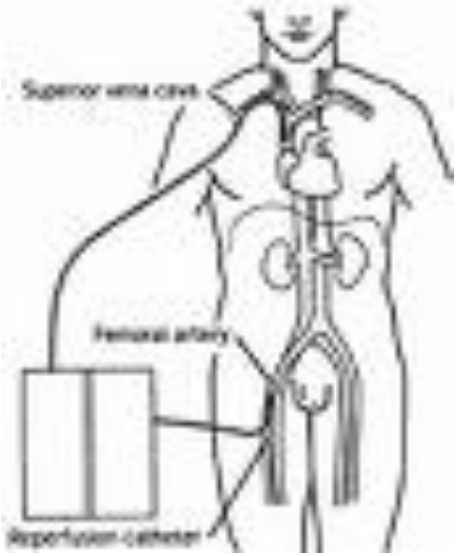
Pumped back to body

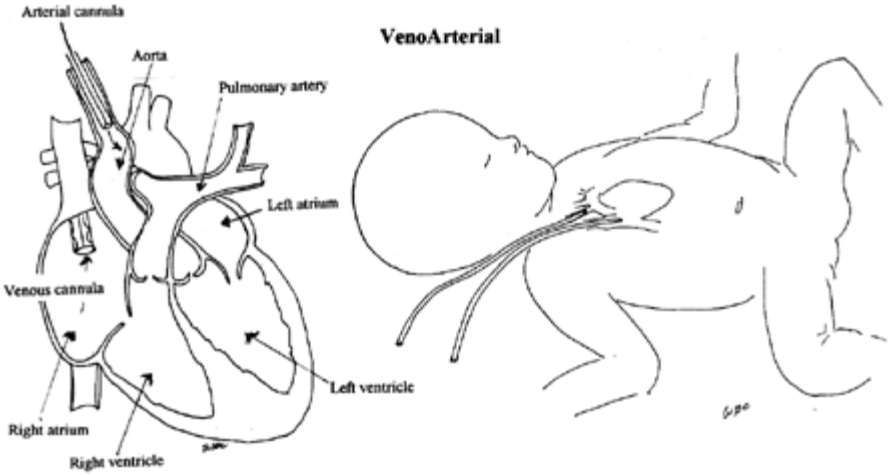
ECMO

VV ECMO

VA ECMO







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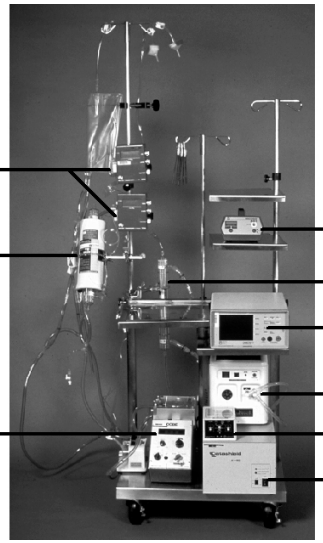
ECMO

Blood drained from body

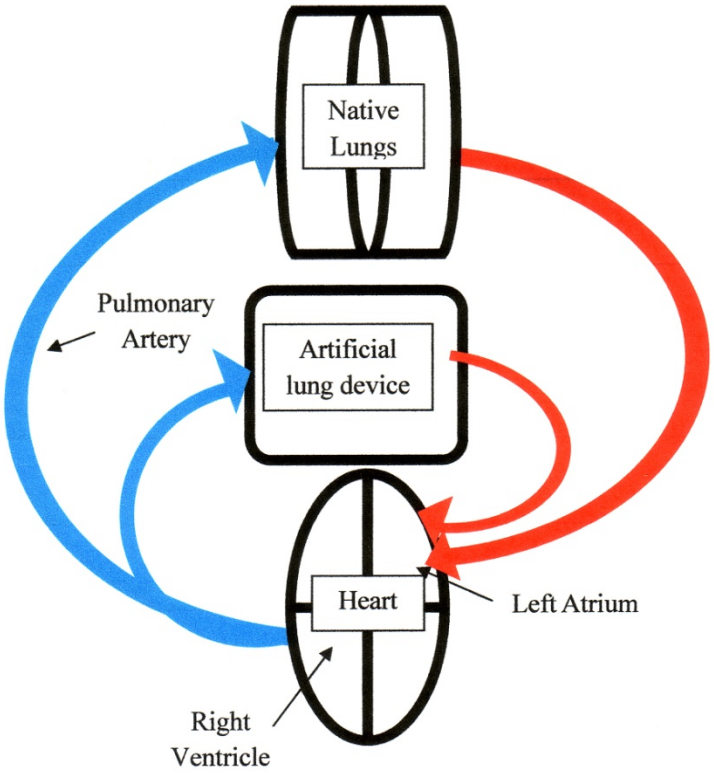
Passed through Oxygenator



Blood pumped back to Body


OUTLET
INLET

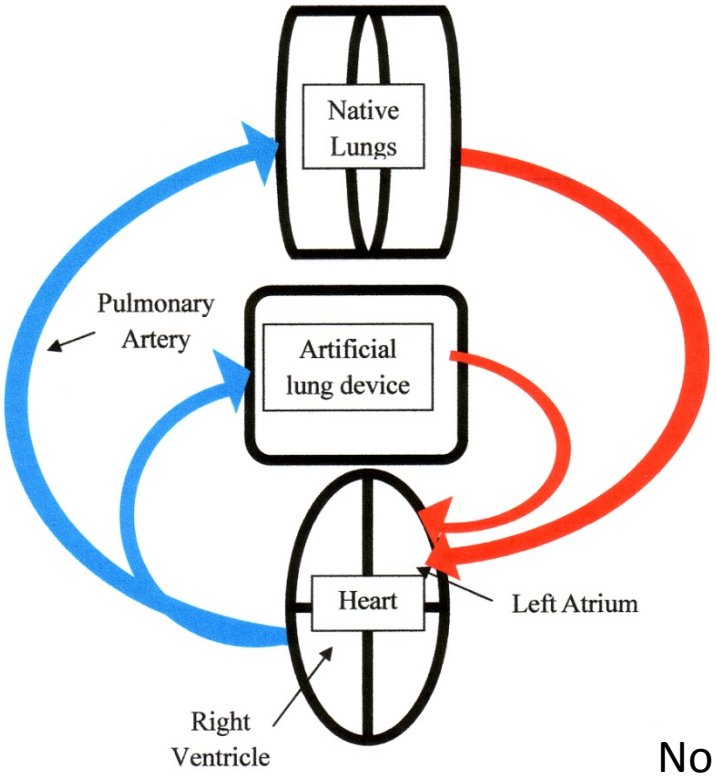
In parallel



Allows oxygenation as receives deoxygenated blood

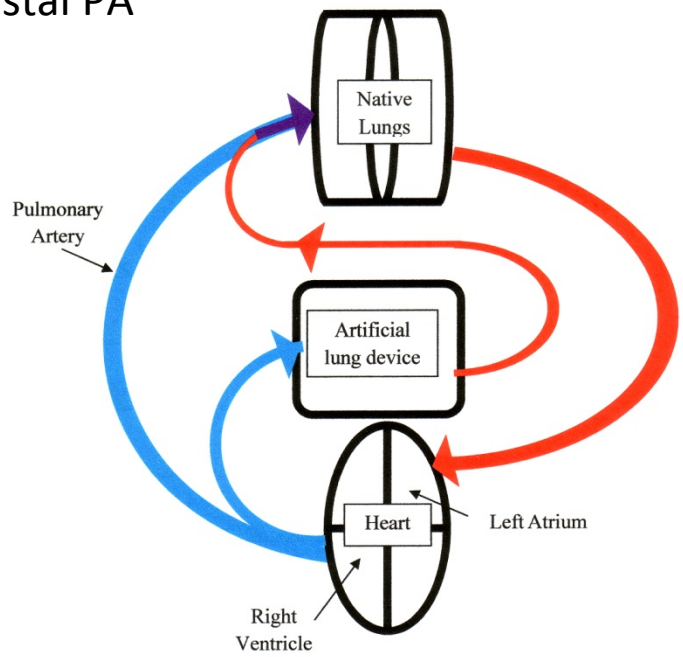
Novalung x 2 plumbed from pulmonary artery and back to Left atria

In parallel, low resistance so receives most blood



No sieving out of thrombi

In series – i.e. plugged between prox. and distal PA



Biolung

- Under development
- No long term rejection problems
- Would need long term anticaogulation (similar to mechanical heart valves)

- May take over from lung transplantation as a long term solution to chronic respiratory failure in conditions like COAD

Tissue Engineering?

Lung units consisting of pulmonary epithelium and vascular endothelium

If can build bone marrow and tracheas, why not lungs?

My approach at the moment

- Maximise protective ventilation using adjuncts if appropriate; if hypoxic try oscillator
- Elevated CO_2 – use NOVAlung first
- Continuing hypoxia – use VV ECMO

BUT MUST BE POTENTIALLY REVERSIBLE & NOT JUST EXTENDING DYING