

"Primum non nocere"
First, do no harm!
- Hippocrates

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Critical Care Cardiac Patient

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Cardiac Surgery Patient Evolution

- Not just CABG -----but High risk CABG
- Complex valve procedures
- VAD
- Percutaneous complex procedures
- ECMO
- Heart Transplant
- Sicker population
- Robotic and "minimally invasive options"

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Mechanical ventilation Cardiac Patient

- Higher risk over all !!!!
 - Intubation: trauma, Medications
 - Neurological: Delirium, sedatives
 - Pneumonia
 - Volotrauma: Risk of Ventilator induce injury
- Benefits:
 - PEEP ???
- FIO2 / Oxygenation paradigm
- Cardiac surgery
 - Low incidence of ARDS
 - Quickly adapt to hemodynamic changes
 - Short Intubation time !!!!

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Ventilator Induced Lung Injury

- FIO2
- Lung volumes /overdistension
- High pressures
- Driving pressure

Volutrauma	• Overdistension
Atelectrauma	• Repeated recruitment and collapse
Bio trauma	• Inflammatory mediators
Barotrauma	• High-pressure induced lung damage
Oxygen toxic effect	• FIO2

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Risk of Intubation
Complex cardiac Patient

- Hypotension
 - Medications: Rapid sequence, avoid vasodilators
 - Ketamine
 - Paralytics
 - Lack of autonomic reserve
 - Decrease preload
- Trauma (bleeding)
- Arrhythmias: acidosis and hypoxemia
- Autonomic response
 - Pulmonary vasoconstriction

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Effects of Positive Pressure (CPAP / PEEP)

Good for the Left ventricle

Lung:

- Decrease extra-vascular lung water
- Decrease work of breathing

Preload:

- Decrease venous return
- Increase PVR
- Decrease hypoxemic vasoconstriction

Afterload:

- Increase intrathoracic pressure
- Increase transmural pressure


Heart:

- Decrease O₂ demand
- Increase O₂ delivery



Bad for the Right ventricle

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What do I need ??? Mechanical ventilation or PEEP




- Corrects hypoxemia and hypercapnia
- Corrects acidosis
- Decreases oxygen consumption
- Delivery of Medications (nitric oxide, prostacyclins etc ...)
- Aloud to give deep sedation

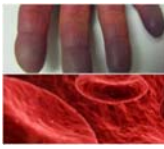
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Oxygen




- Hypoxemia: tissue
 - **DO₂ vs CaO₂**
- Alveolar hypoxia causes :
 - Decrease Nitric Oxide production
 - Pulmonary vasoconstriction
Inc PVR ----Decrease RVSV
 - High FIO₂ (>50%)
 - Increase Free radicals that lead to coronary vasoconstriction and cardiac necrosis
 - Hyperoxia post arrest (PaO₂ > 300)increase mortality






Balance FIO₂ and PEEP !!!




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Complications of Mechanical Ventilation




				
Complications related to Intubation	Mechanical complications related to presence of ETT	Ventilator induced lung injury	Complications related to Oxygen	Infectious complications of mechanical ventilation

Medications: sedatives, paralytics, etc..., immobility, deconditioning, etc...






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What do I Need???




Gas Exchange ??
Positive pressure ???

Access to airways !!!

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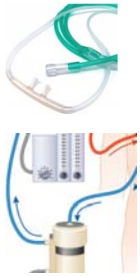
How to improve gas exchange ? Oxygenation and or Ventilation



Mechanical ventilation ??

- Do I need ETT ??
 - Protect airway
 - Deliver meds: INO...
- Do I need PEEP?? Or CPAP!!
- Do I need sedation?

Or just Add O₂ and Remove CO₂





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How to improve gas exchange ?? Oxygenation and or Ventilation

AVOID OR MINIMIZE MV

- Full ECMO (no MV): total ECMO support
 - Extubate while on ECMO
 - No lung contribution
- MV + ECMO: Reduce MV injury (ARDS)
 - Minimize Airway pressures and volumes
 - Use ECMO to remove CO₂ and some oxygenation
- BIPAP + ECMO: (Provides PEEP- Lung expansion)
- HFNC + ECCO₂R: Pulmonary fibrosis
- Only ECCO₂R (Low oxygen needs) : Asthma, COPD, cystic fibrosis


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Respiratory Dialysis in addition to Mechanical Ventilation Post Lung Transplant





Respiratory Dialysis in addition to NRBM Small Cannula

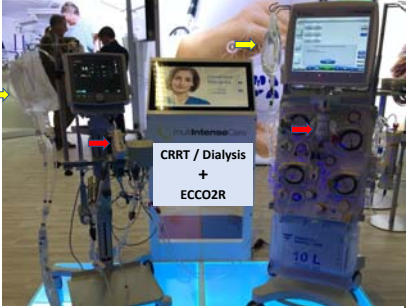


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Hemodialysis Respiratory dialysis !!!

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CRRT / Dialysis + ECCO2R

Chen H. et al., (2014) Combination of extracorporeal Membrane oxygenation and continuous renal replacement therapy in critically ill patients: a systematic review, Critical Care 18:67: S:9

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ECCO2R vs MV

Like a mechanical ventilator, **ECCO2R** is not intended to treat the underlying disease but rather, is used to provide temporary respiratory support.




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Differences
Survival bias ?


ECMO

- Emphas
- High flo
- Comple
- High ris
- ARDS ar
- Survival








ECCO2R

- Emphasis on CO2 removal



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Qualitative comparison of complications			
Measure of Invasiveness	Intubation and MV	Partial ECCO ₂ R	Implication (>1% Incidence)
Blood Access	No	Yes	- Bleeding - Cannulation injury - Catheter dislocation/thrombosis
Endotracheal Intubation	Yes	No	- Laryngeal edema - Dysphagia / swallowing dysfunction
Negative Lung Tissue Impacts	Yes	No	- VAP - Barotrauma, volutrauma - Muscle fatigue / diaphragmatic muscle thinning
Sedation / Analgesics	Yes	No	- Neuromuscular impacts - Neuropsychiatric disorders
Quality of Life During Therapy			
Maintain Ability to Eat	No	Yes	- QOL / nutritional status reduced
Maintain Ability to Speak	No	Yes	- QOL / interaction with caregivers and family members reduced
Maintain Mobility	No	Yes	- Long-term rehabilitation impacts - pressure ulcers

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ECCO ₂ R Complications		Intubation- MV Complications	
Partial ECCO ₂ R (Veno-venous)		Invasive Mechanical Ventilation	
Complication	Rate	Complication	Rate
Major/minor bleeding	4.9%	Ventilator associated pneumonia	4%–48%
Intra-cerebral hemorrhage	0.1%	Barotrauma	3%
Cannulation injury	2.3%	Dysphagia / aspiration	50%
Thrombocytopenia	0.3%	Muscle fatigue or thinning	100%
HIT	0.3%	Cardiac dysfunction	6%–47%
DIC	0.1%	GI complications	50%
Circulatory failure	0.1%	Neuromuscular disorders	Varied by type
Pneumothorax	0.1%	Neuropsychiatric disorders	12%–52%
Hemolysis	0.1%	Pressure ulcers	20%
Catheter dislocation/thrombosis	1.5%	Pulmonary embolism	19%
Oxygenator malfunction	10.2%	Exposure keratopathy	57%
Circuit malfunction	0.5%	Endotracheal complications	4%–7%
Catheter related infection	None reported	Laryngeal edema or injury	11%–73%

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ECCO₂R / Respiratory Dialysis trials

• **p**rotective **v**entilation with **v**eno-**v**enous lung assist in **r**espiratory failure (**REST**) trial

- VV-ECCO₂R randomized control trial
- 1140 patients with ARDS to minimize VILI
 - Low PAP and low Volumes (6-7 ml/kg)
 - ECCO₂R (0.4 – 1 lt/min)
- UK National Institute Health Research
- 40 hospitals
- 2016 ongoing




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REST Trial

Primary Outcome Measures :All cause mortality (90 days after randomization)

Secondary Outcome Measures :

- Ventilator free days (28 days after randomization)
- Duration of MV
- Need for Extracorporeal Membrane Oxygenation (ECMO)
- Mortality rate (28 days, 6 months and 1 year)
- Quality of Life (6 months and 1 year)
- Adverse Event Rate (28 days)
- Health & Social Care Service costs (6 months and 1 year)
- Need for home oxygen (6 months and 1 year)
- PTSD (1 year)



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VENT-AVOID Trial

FDA approved to establish the safety and efficacy FDA pre-market approval (PMA)


RCT to validate the indication for its use in acute exacerbation of COPD.

VV-ECCO₂R randomized control trial

800 patients with COPD exacerbation as an adjunct or alternative to MV

U.S.- based, 40 hospitals, 2017


Safety and efficacy
Ventilator free days



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Respiratory dialysis

- ARDS
 - Minimize MV damage
- Bridge to transplant
 - Rehab potential
- COPD, Cystic fibrosis, severe asthma
 - Failed NIV
 - Persist despite MV
- Chronic Hypercapnea + ESRD
 - Intermittent vs Continuous ??
 - CO₂ Removal and ??? Oxygenation
- Economical considerations
- Chronicity vs Rescue
- ??Quality of life???



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