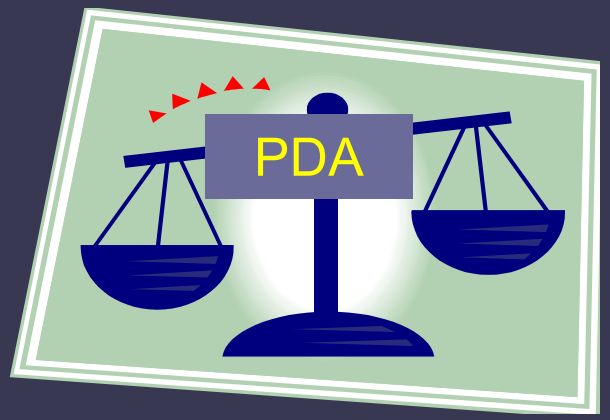
Pulmonary Pressure



Systemic Pressure

Clinical Controversies: Transitional Pulmonary Hypertension Management approaches

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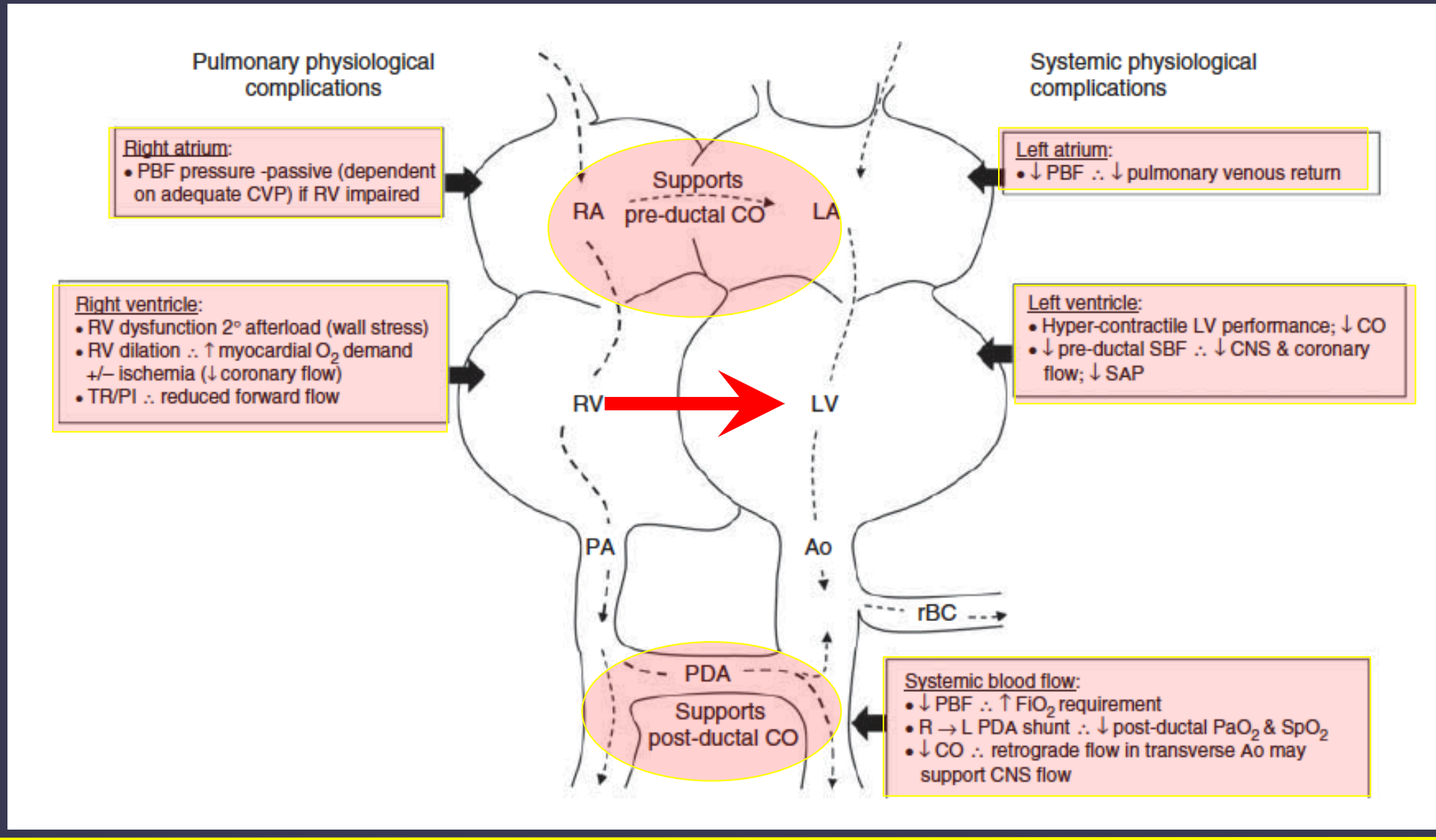
NeoHemodynamics 2018
May 3 – 4, 2018
Venue: Art Gallery of Ontario, Toronto, Canada

Persistent Pulmonary Hypertension of the Newborn (PPHN)

- Failure of normal pulmonary vascular relaxation and subsequent increased PBF at/after birth - often low PBF
- ?PAP – relative to systemic BP vs single number (>25mmHg)
- Clinically hypoxic respiratory failure, lability
- Multiple underlying elements interacting together to give a clinical phenotype
- Can affect both term and preterm infants

Increased PVR
Affects ALL cardiac chambers

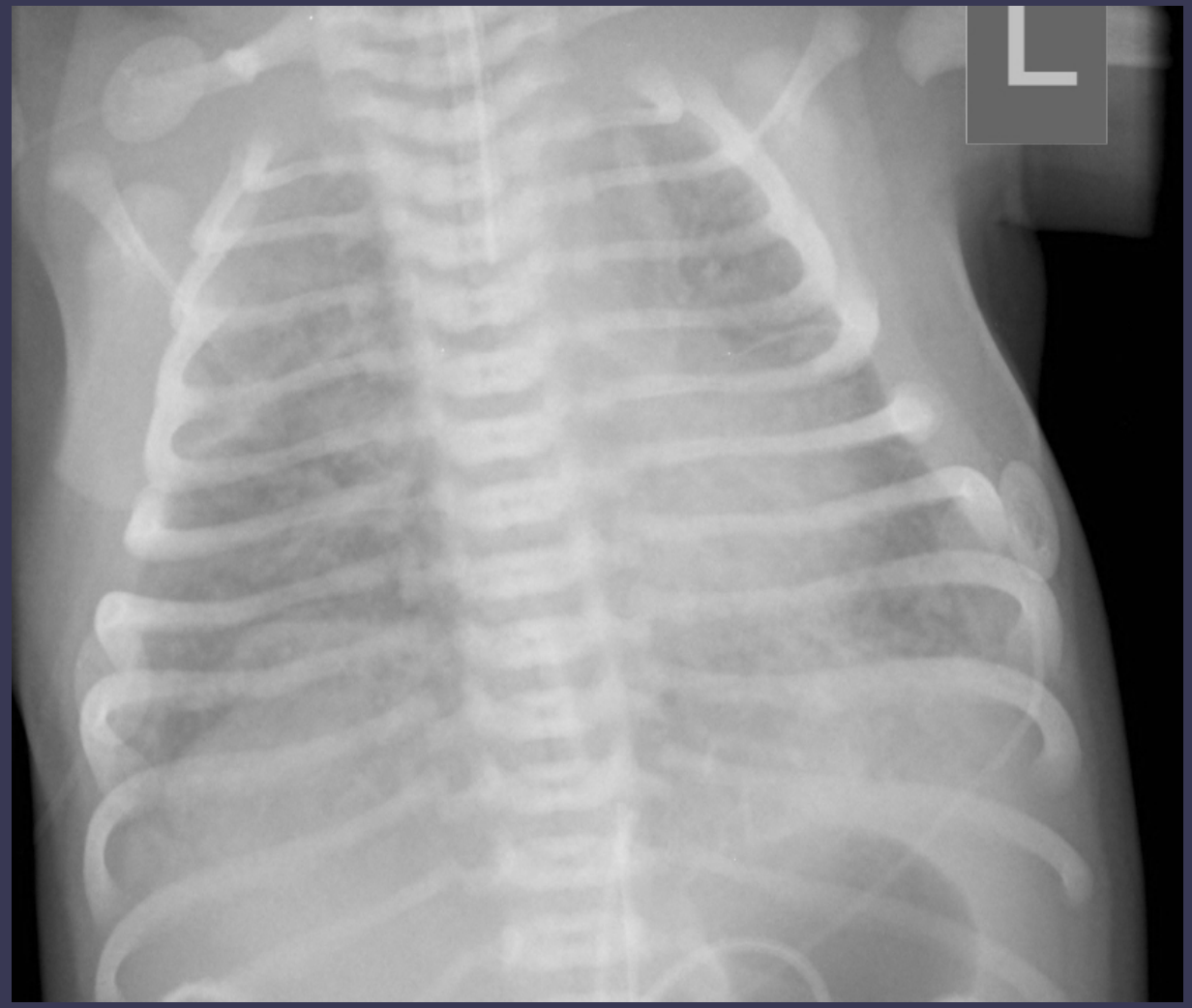


Giesinger, McNamara et al 2017

Case History

- Normal pregnancy
- Vaginal delivery at 2 am
- Term infant 3.7 kg
- Thick meconium stained liquor
- Apgar scores 3 & 8 Normal cord pH
- Meconium suctioned from below cords, IPPV
- FIO2 90%+ to maintain saturation >90% by 15 minutes

Case History
CXR



Management

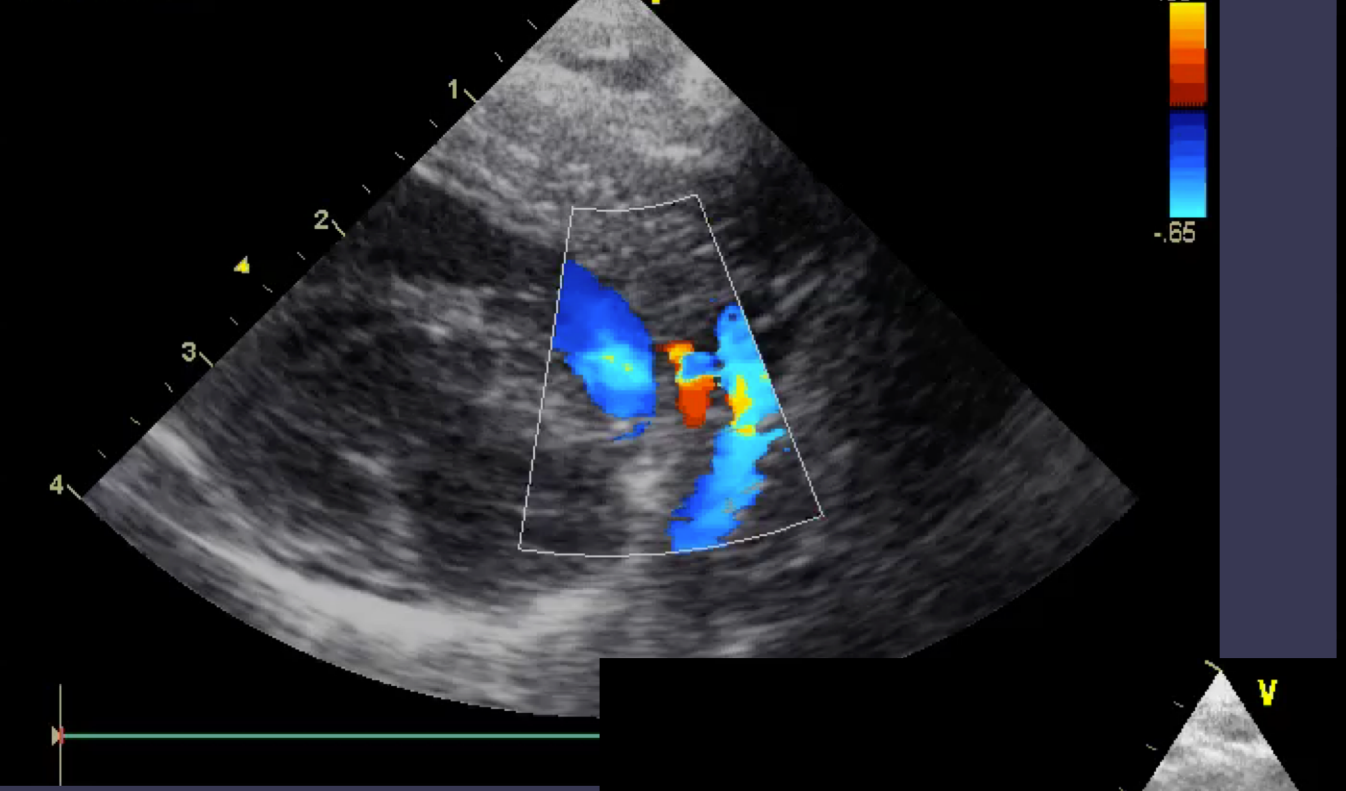
- Placed on conventional ventilation initially but quickly changed to HFOV
- MAP & Amplitude adjusted to ABG
- Mean blood pressure 42 mmHg
- By 60 minutes – still requiring 90% FIO2 to saturate >90%
- 3am , 1 hr old
- No pediatric cardiologist in sight!

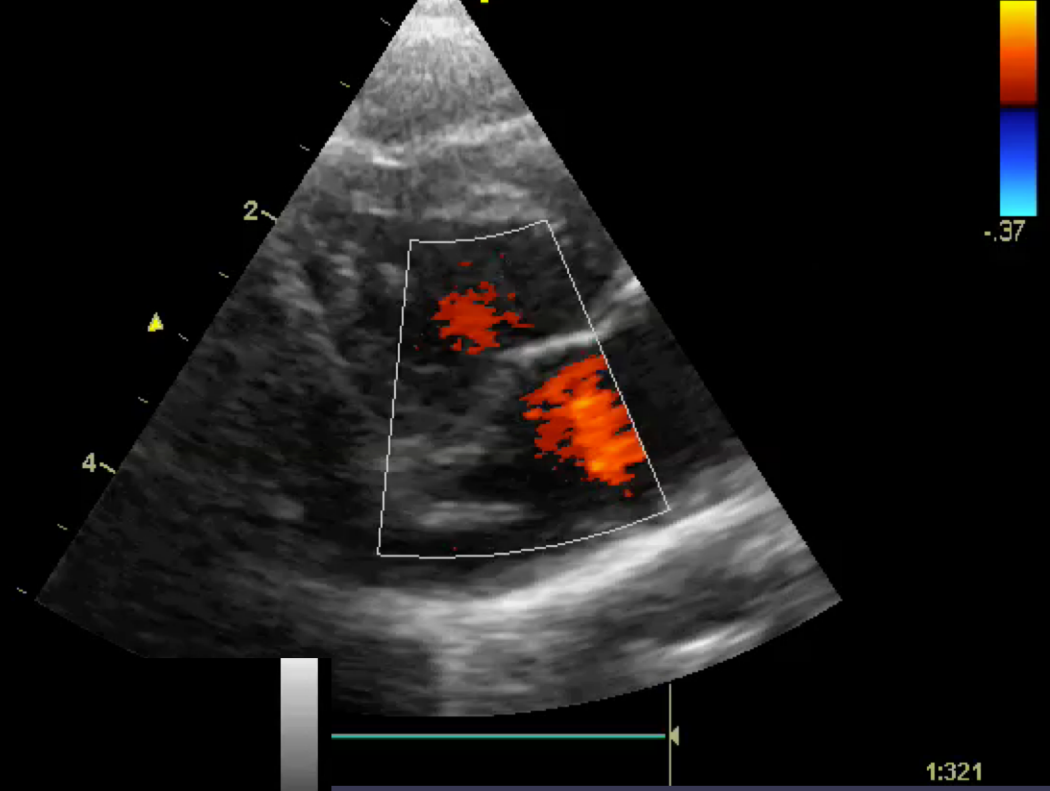
Management

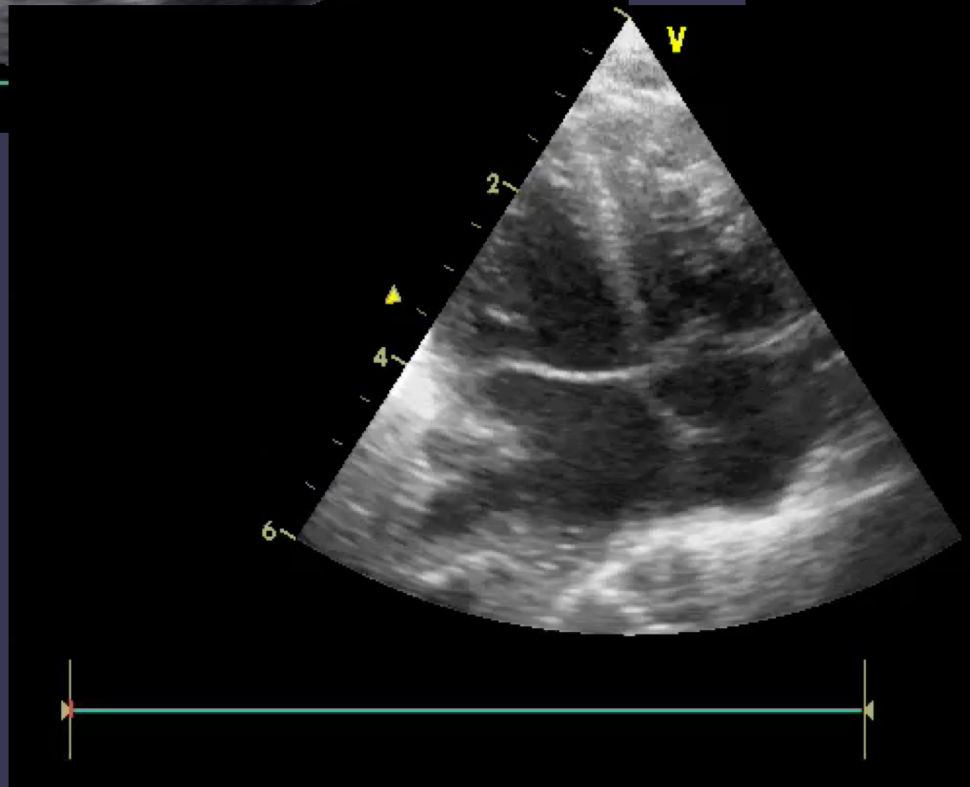
Commence PPHN treatment
- Volume
- Inotrope
- Vasodilator

Escalation of care
Days in NICU

Perform a CPU
(Clinician performed US)
to gain more information
and decide on treatment







Normal structural heart (confirmed later)
Good filling & contractility
Small PDA Left to right
No TI/evidence of raised pulmonary pressure

Not all infants with high FIO_2 have PPHN

- Management:
  - No iNO
  - No inotropes
  - No volume
- Optimised HFOV
- Rapid improvement next 4 hrs
- Extubated at 15 hrs of age
- Discharged from the nursery Day 2

PPHN
Understand underlying elements

- Respiratory effects on PVR
- Systemic blood pressure
- Pulmonary pressures high? > SystemicBP
- Impaired cardiac function/filling - asphyxia
- PDA open or closed, shunt direction
- Right ventricular function/impingement
- Left ventricular impairment*
- Combination of these elements will define clinical presentation and treatment requirements

Evans & Kluckow Arch Dis Child 1998, Skinner et al Pediatric Cardiology 1996

Classical treatment approach - stepwise

- Oxygen, pO_2 – Target higher levels
- Carbon dioxide, pH – target lower pCO_2
- Acid base balance - optimize
- Optimize respiratory management – CMV/HFOV, lung recruitment/surfactant
- Inotrope/pressor – dopamine, epinepherine, norepinephrine, vasopressin
- Pulmonary vasodilators– iNO, sildenafil, milrinone, use oxygenation index (OI)
- Sedation/muscle relaxation?

Refractory = unresponsive to classical treatment (30% in some series)

- Wrong diagnosis – Primary Respiratory vs CVS
- Wrong physiology – underlying elements
- Wrong treatment (leads on from above)
- Treatment too late (iNO start times/OI threshold) – lung injured
- Treatment too long – missed weaning cues
- Physiology has transitioned (CVS to Respiratory)
- Biochemical/Molecular resistance – refractory to iNO ?Milrinone instead

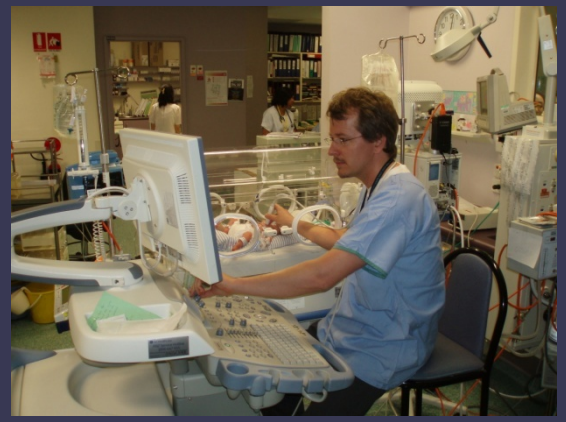
Clinician Performed Ultrasound (CPU)

Focused

Monitor responses

Target treatment

Bedside



Refine clinical decisions

Real time

Understand physiology

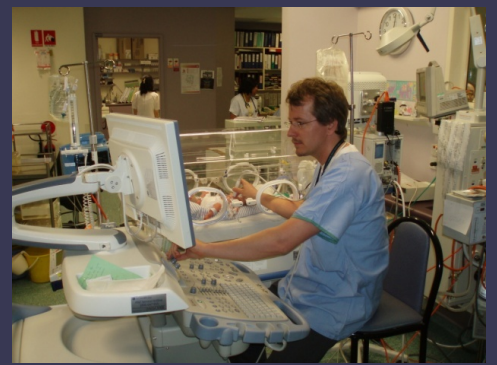
Serial

Function mainly

PPHN
Ultrasound assessment

- Exclude structural heart disease

- Measurement of pulmonary pressures
- Assessment of the ductus arteriosus/PFO
- Assessment of ventricular function & filling
- Measurement of cardiac output



PPHN – US assessment
Raised pulmonary pressures/RV

- Measures
  - Tricuspid incompetence
  - TPV/RVET ratio
  - RV function/TAPSE/RVOT velocities/RVO
  - Septal bowing
  - Decreased pulmonary venous return
  - Tissue doppler imaging (TDI)

PPHN – US assessment
PDA and PFO assessment

- Measures
  - PDA present
  - Shunt direction and proportion of right to left shunt
  - Estimate relative pulmonary vs systemic pressure
  - PFO present and shunt direction

PPHN – US assessment
Adequate LV function

- Measures
  - LVO
  - Contractility measures

- LV dysfunction often associated with PPHN, particularly if asphyxia related
- Increasing PBF with iNO may be contraindicated

Sehgal Acta Ped 2011, Giesinger, McNamara et al 2017

PPHN
Management decisions

- Which oxygen saturation to target?
- Pre/Post ductal SpO_2 – value of these?
- Role of oxygenation index(OI) – single number?
- Which pH/pCO_2 to target? Phase of illness
- Respiratory support – PVR/lung recruitment/NIV*
- Vasopressors vs inotropes – PDA shunt direction, RV/LV function, PVR vs SVR/BP*
- Pulmonary vasodilator choice in term and preterm infants with raised PVR, subgroups of term infants*.
- Sedation/Paralysis

PPHN
Management decisions

- Which oxygen saturation to target?
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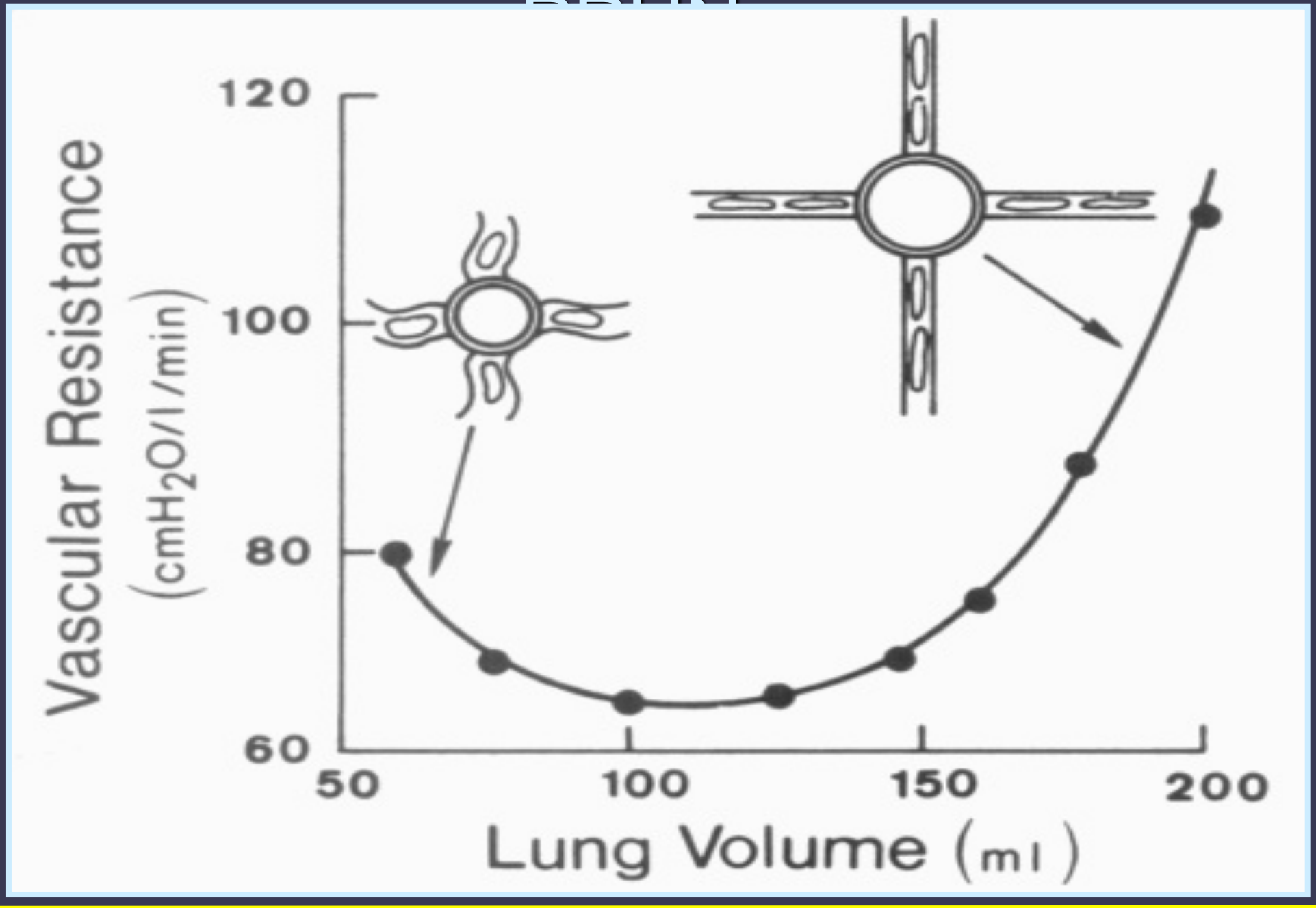


JB West Pulmonary Physiology Essentials, Giesinger, McNamara et al 2017

The ideal inotrope/pressor

- Support the systemic BP
- Enhance cardiac output and contractility
- Support the right ventricle – reduce afterload (PVR)

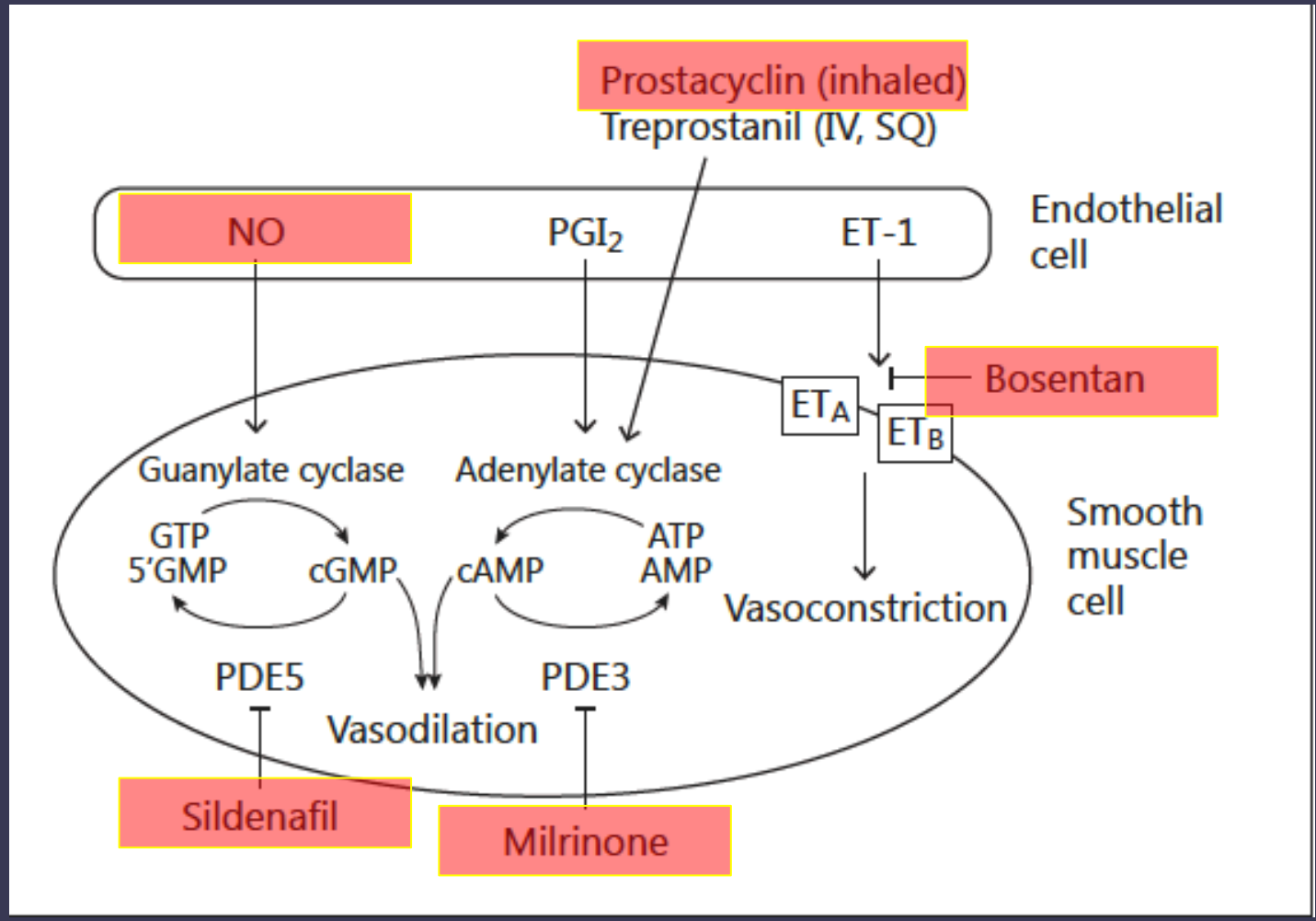
PPHN
Inotrope choice: PVR/SVR

	SV	SVR	PVR
Dopamine	↑	↑↑	↑↑↑
Noradrenaline	↑/≈	↑↑↑	↓/≈
Vasopressin	↓/≈	↑↑↑	↓
Dobutamine	↑↑	↓/≈	≈
Milrinone	↑↑	↓↓	↓↓
Adrenaline	↑↑↑	↑↑↑	↑↑

SV = stroke volume; SVR = systemic vascular resistance; PVR = pulmonary vascular resistance
↑ = increase; ↓ = decrease; ≈ = no effect

El-Khuffash 2018 adapted from Cox & Groves Acta Ped 2012

Vascular smooth muscle relaxation



Matching treatment to the individual pathophysiology

Diagnose & manage underlying disorder
- Specific treatments

Assess cardiac filling—under or over filled
- Volume if under filled
- Limit volume if overloaded

Sort out respiratory disease
- CXR, respiratory graphics, ABG
- Different ventilation modes

Look at blood pressure
- If low—inotropes, especially if cardiac dysfunction from hypoxia
- If OK, but oxygenation drops with BP drop—look at PDA—if open, systemic BP may need to be higher

Exclude structural heart disease
- Cardiologist if any concern

Look at cardiac output/ventricular function
- Inotropes if low cardiac output, poor function

Inotrope choice
Vasoconstricting vs. vasodilating—depends on myocardial function & peripheral resistance
- Dopamine followed by epinephrine if low BP and decreased afterload
- Dobutamine/Milrinone if high afterload and ventricular dysfunction

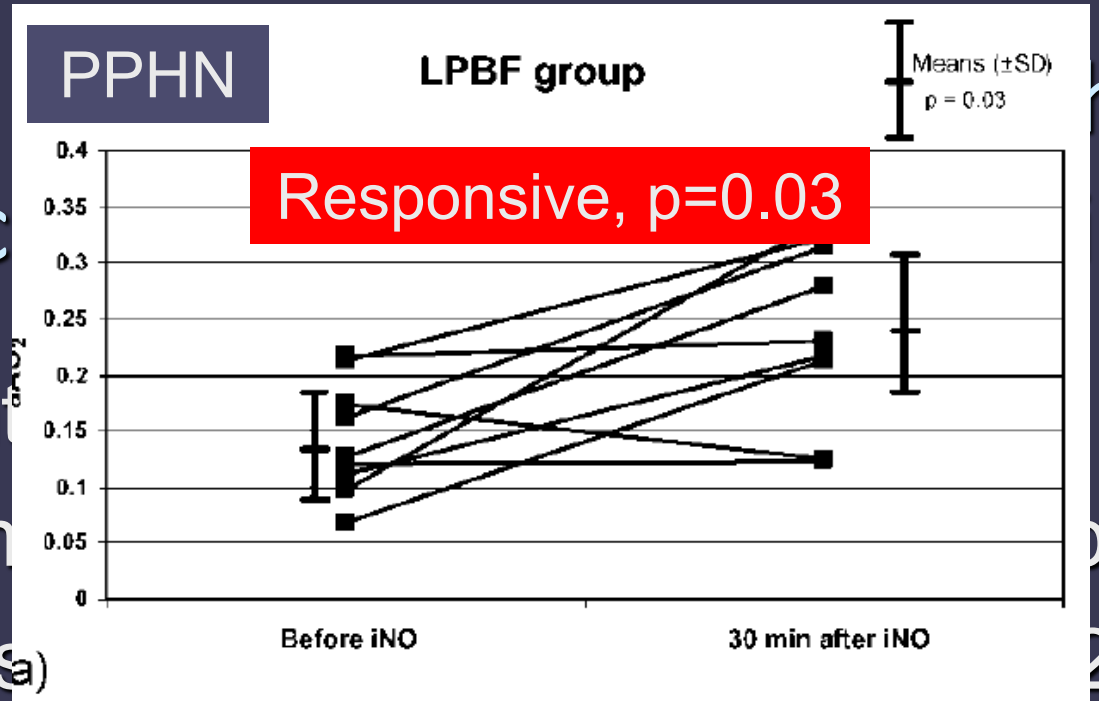
Need for pulmonary vasodilator
- Inhaled NO—ideal if lungs recruited
- Systemic vasodilator—risk of systemic hypotension

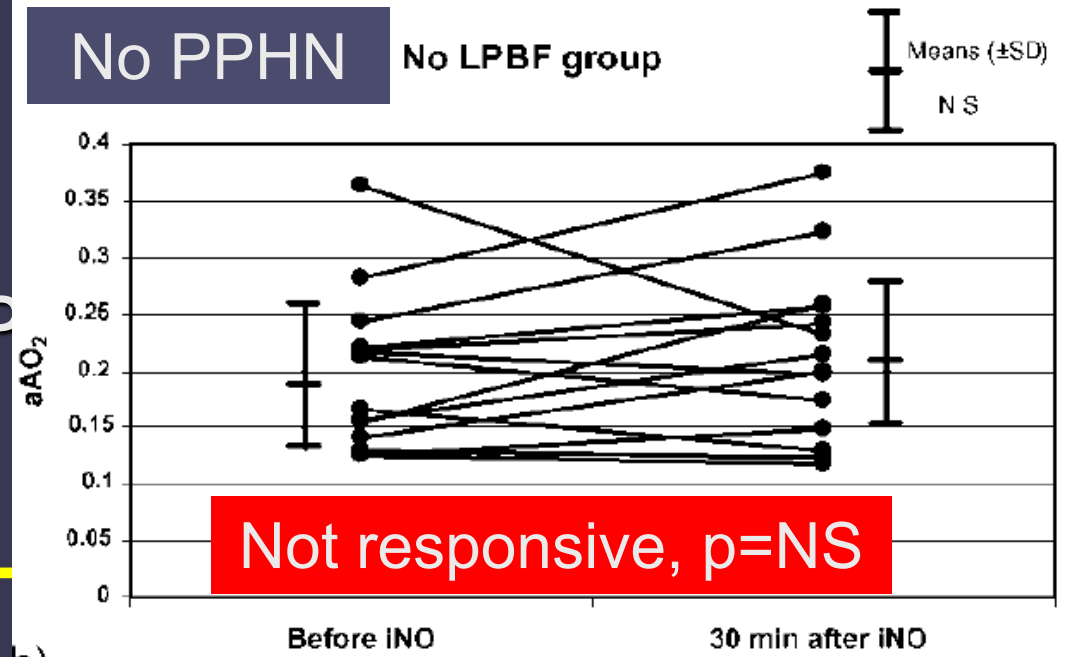
Review longitudinally and adjust according to response

Rath & Kluckow 2018

Ec … NO

- 70 infant…
- Random… …po
- Respons… …2
- MPBFV … …efined as LPBF
- 11/35 in … …HN), 24 had no low P…





…es et al Acta Paed 2004

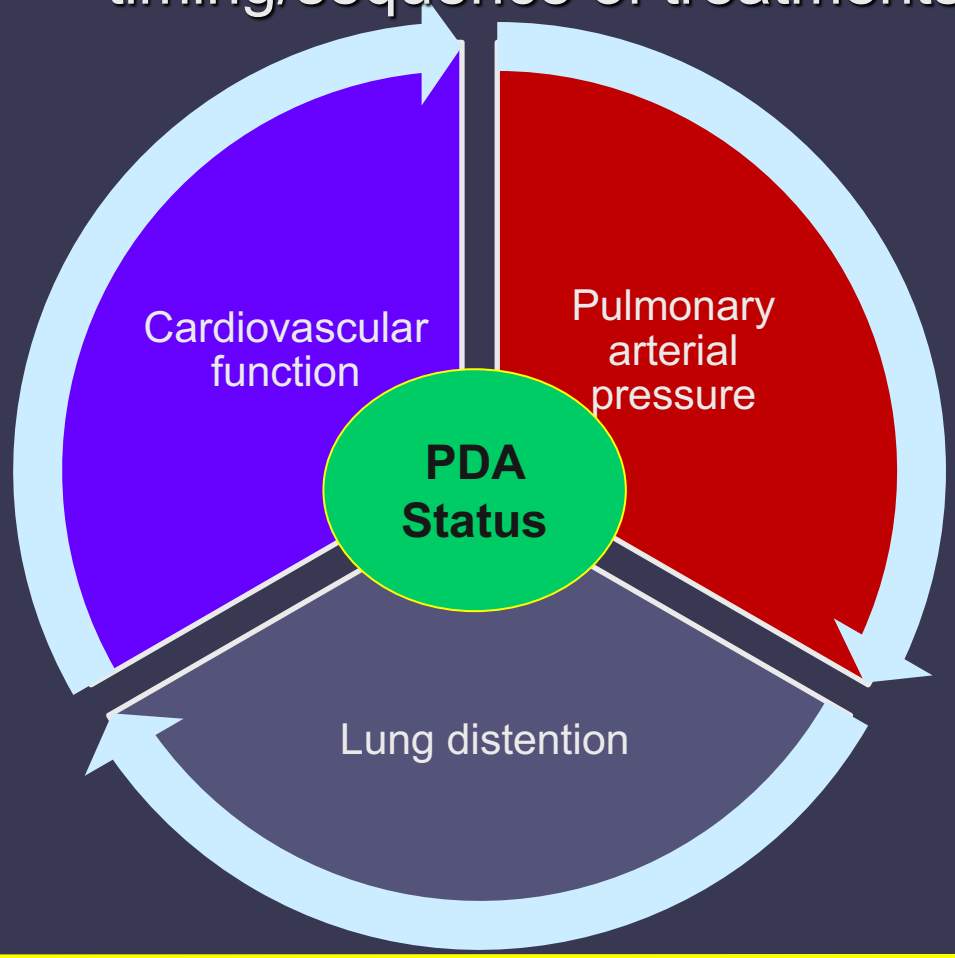
Use of cardiac ultrasound to guide treatment

- Retrospective cohort study over 2 epochs – before and after setup of a fECHO program
- 85 infants, 73%<29 wks
- In the epoch of more available US
  - 65% vs 36% had an US pre iNO
  - iNO was started earlier (1.8 vs 8hrs) and at a lower OI (31 vs 39)
- Survival similar but survivors overall had iNO started earlier

Cheng, Sehgal et al Acta Paed 2015

PPHN Management principles

Knowing underlying physiology can help determine timing/sequence of treatments



Modified from De Waal 2015

Conclusions

- Not all hypoxic respiratory failure is PPHN
- Deciding on logical treatment strategy requires understanding pathophysiology
- May lead to earlier targeted treatment (particularly iNO), better response rates
- Refractory PPHN may result from poorly targeted or delayed treatment
- Cardiac ultrasound is useful in assessment and treatment choices(including rule out CHD)

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