# Neonatologist Performed Echocardiography: Assessment of PDA

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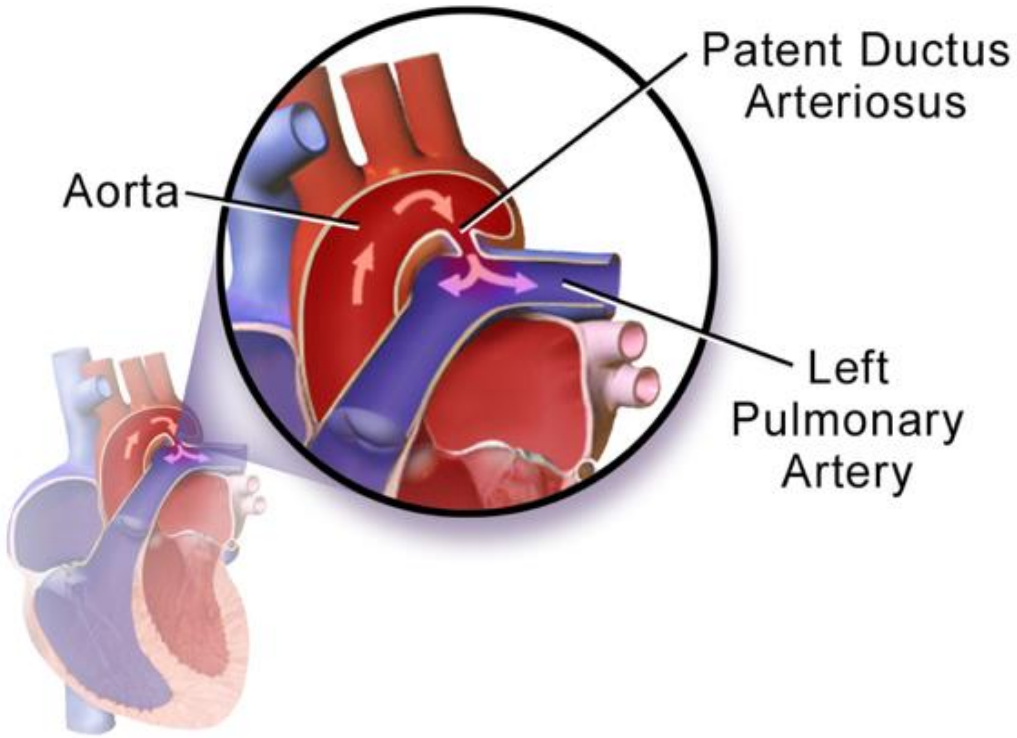
European School of Neonatology

The ESN is a project by the European Society for Paediatric Research

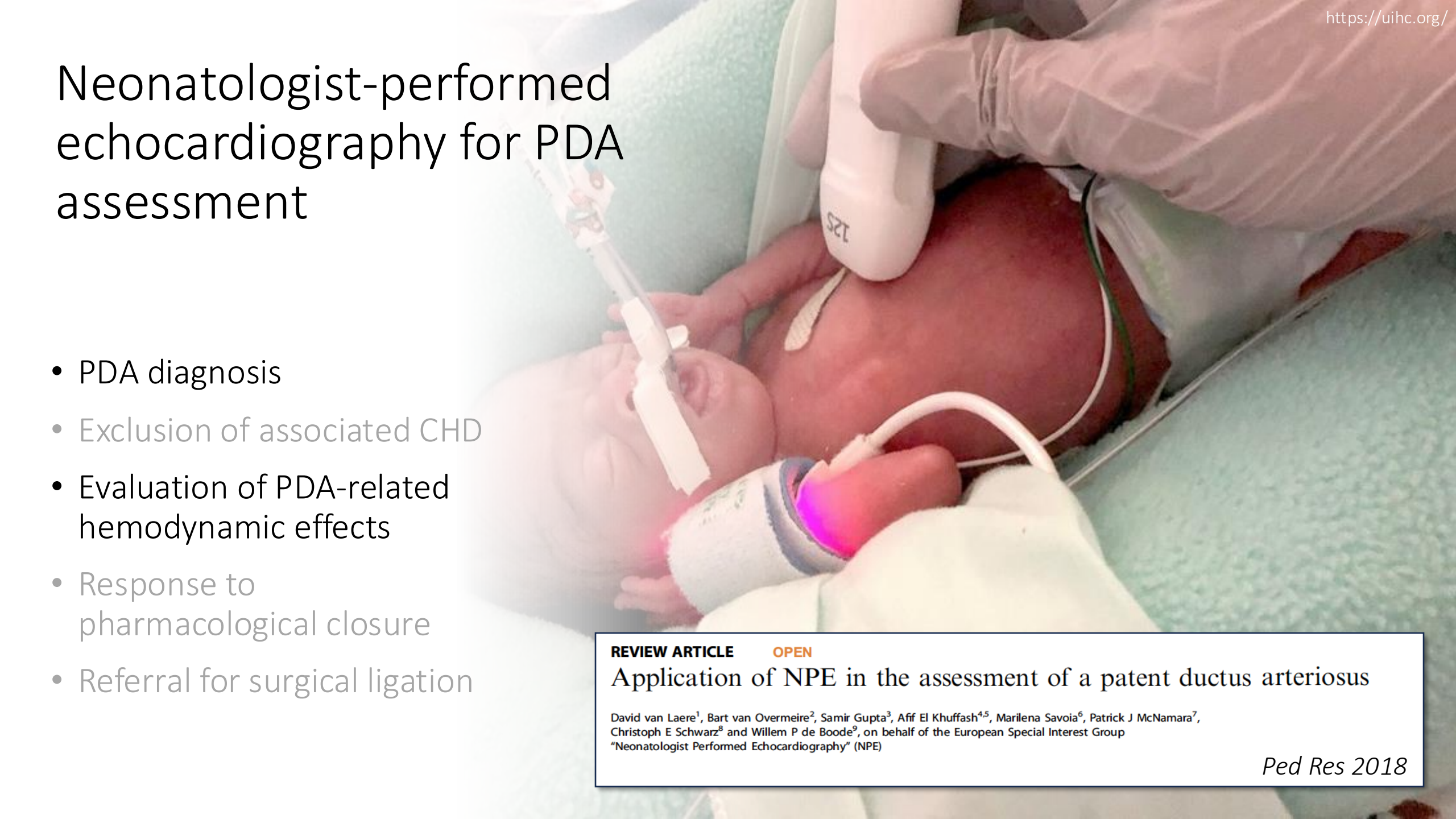
# Patent ductus arteriosus (PDA)




- Prevalence inversely related to GA and BW
- Spontaneous closure within the first 72h:
  - 90% at 30-36 wks
  - 10-20% at 24-28 wks
- Potentially related comorbities (IVH, pulmonary haemorrhage, prolonged mechanical ventilation, BPD, NEC, renal failure...)
- Lack of consensus on hsPDA definition and management

# Neonatologist-performed echocardiography for PDA assessment

- PDA diagnosis
- Exclusion of associated CHD
- Evaluation of PDA-related hemodynamic effects
- Response to pharmacological closure
- Referral for surgical ligation



REVIEW ARTICLE OPEN

Application of NPE in the assessment of a patent ductus arteriosus

David van Laere[1], Bart van Overmeire[2], Samir Gupta[3], Afif El Khuffash[4,5], Marilena Savoia[6], Patrick J McNamara[7], Christoph E Schwarz[8] and Willem P de Boode[9], on behalf of the European Special Interest Group "Neonatologist Performed Echocardiography" (NPE)

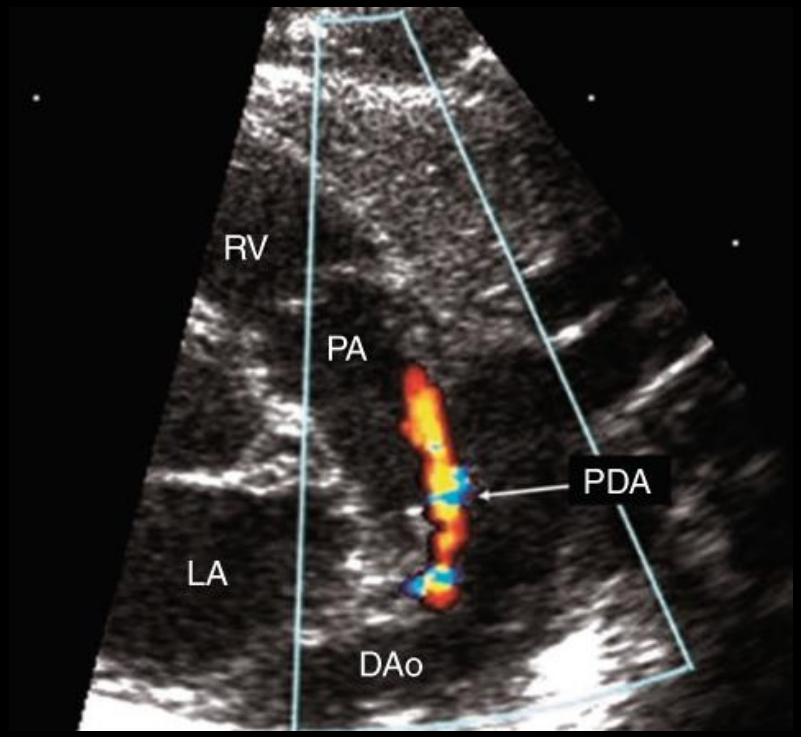
*Ped Res 2018*

Comprehensive appraisal of cardiac anatomy at the initial scan to exclude duct-dependent CHD

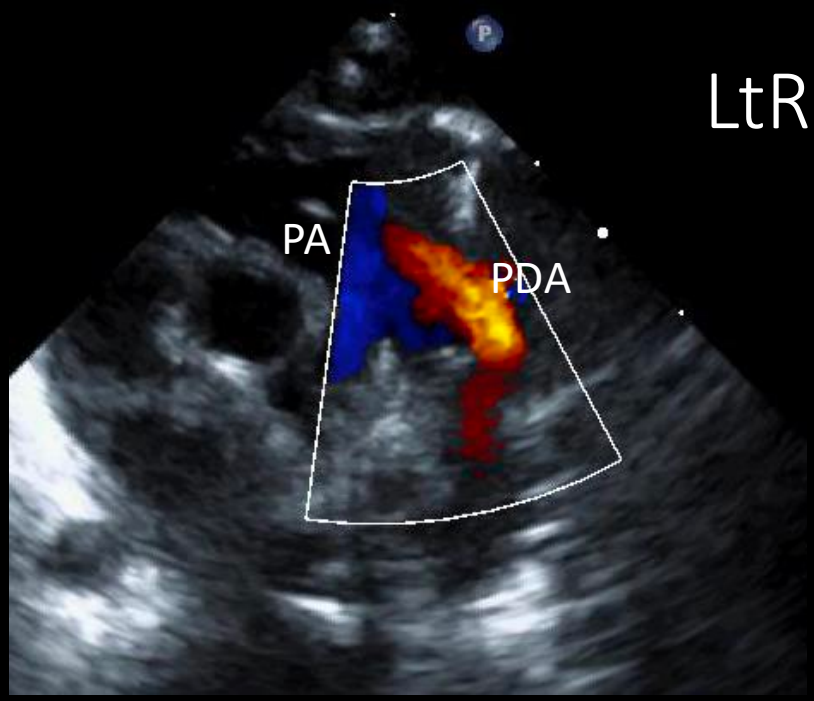
| Duct dependent pulmonary circulation | Duct dependent systemic circulation |
|---|---|
| Pulmonary Atresia with intact ventricular septum | Interrupted aortic arch |
| Pulmonary Atresia with VSD | Hypoplastic Left Heart syndrome |
| Pulmonary Atresia with single ventricle | Critical Aortic stenosis |
| Critical pulmonary stenosis | Critical coarctation of aorta |
| Severe Ebstein anomaly | |
| Rare TOF with critical RVOT obstruction | |
| **Admixture lesions** Transposition of great arteries with intact ventricular septum | |

VSD ventricular septal defect, TOF Tetrology of Fallot, RVOT right ventricular outflow tract

# Echocardiographic views for PDA assessment

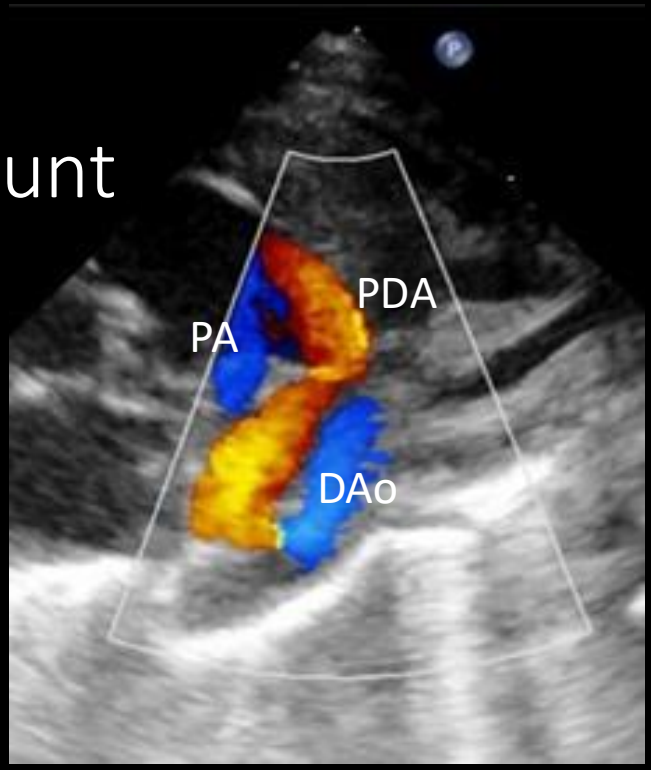



Parasternal short axis




High left parasternal short axis (”ductal view”)

LtR shunt



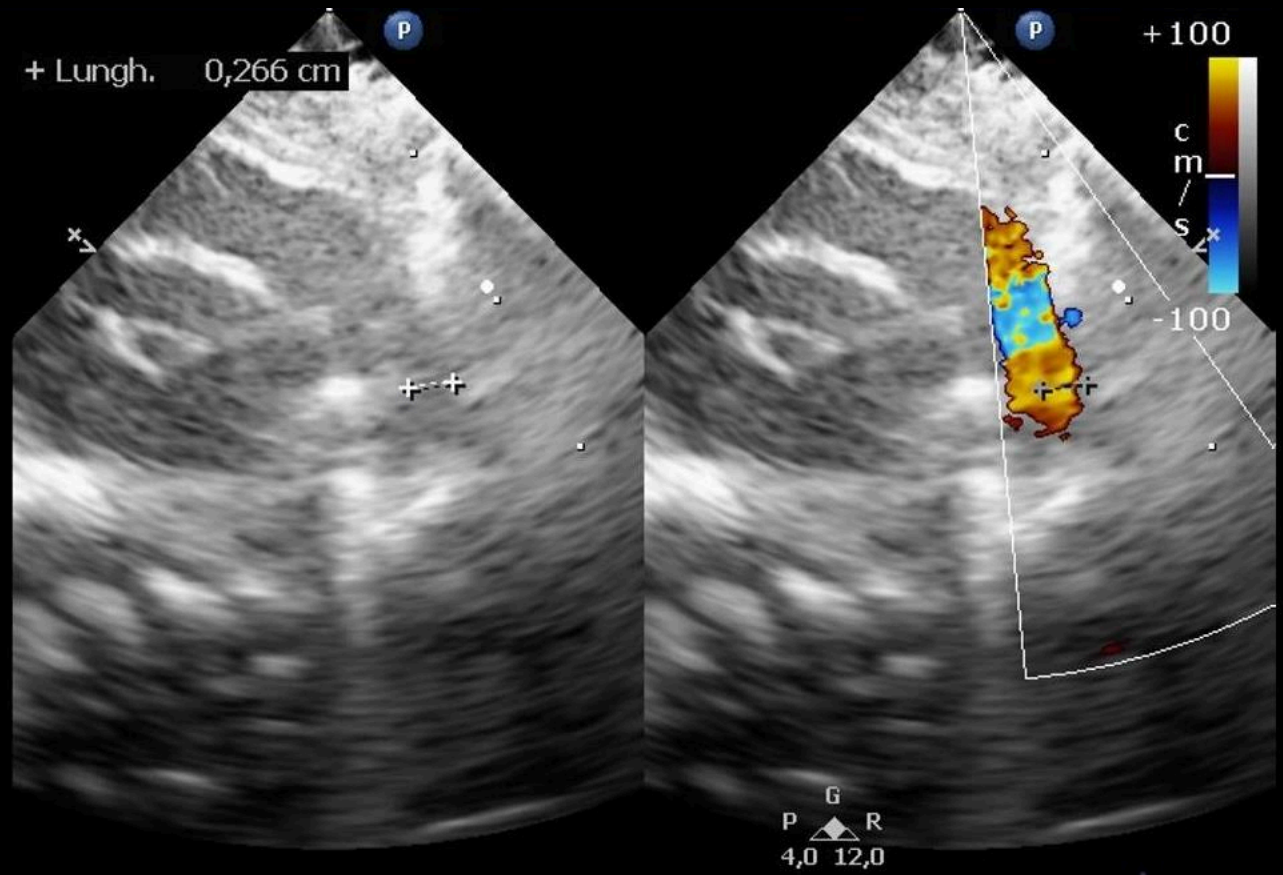

Sagittal suprasternal view

# Echocardiographic views for PDA assessment

RtL shunt

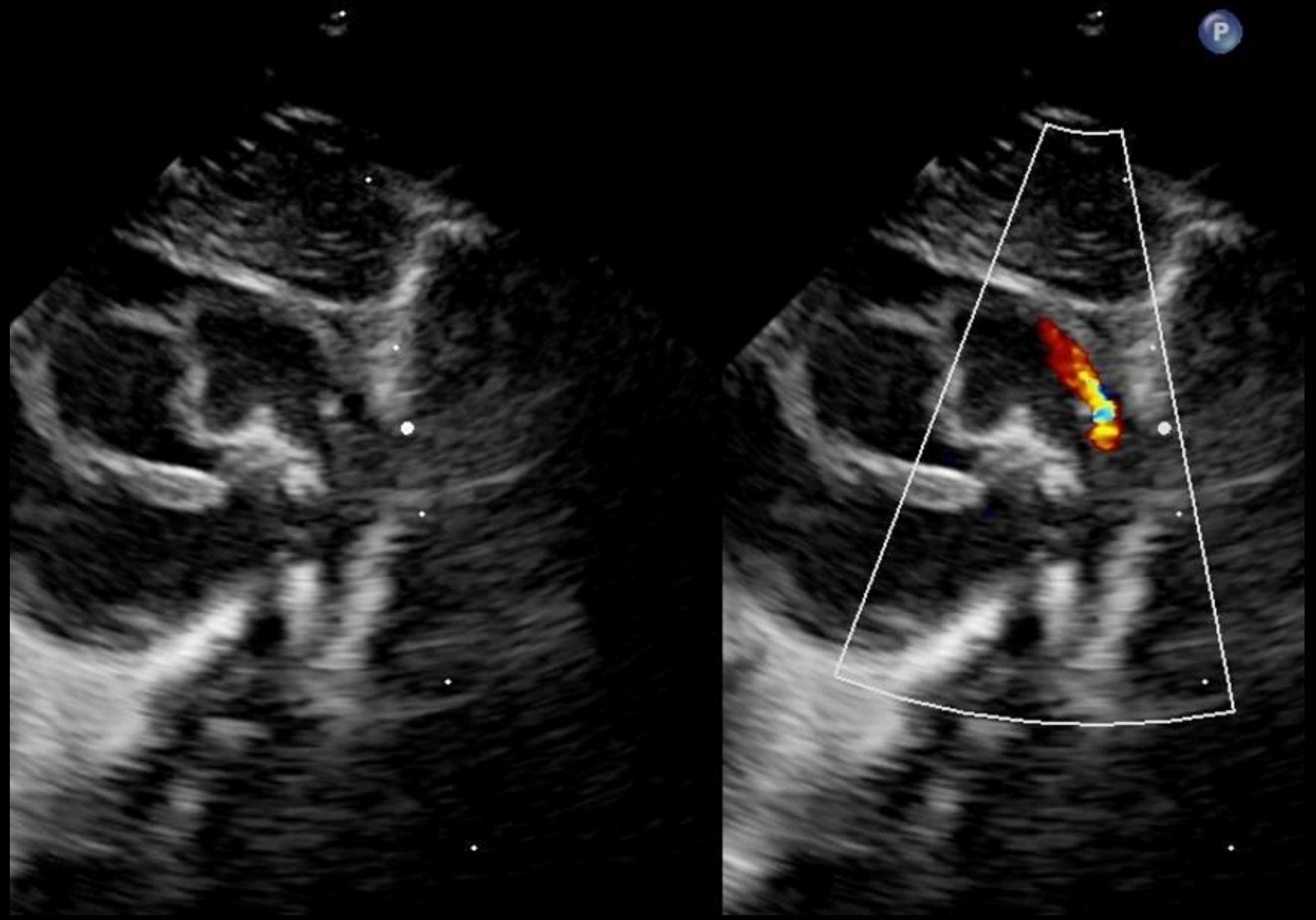

# Assessment of PDA characteristics

- Diameter
  - Narrowest point
  - Color Doppler: potential overestimation



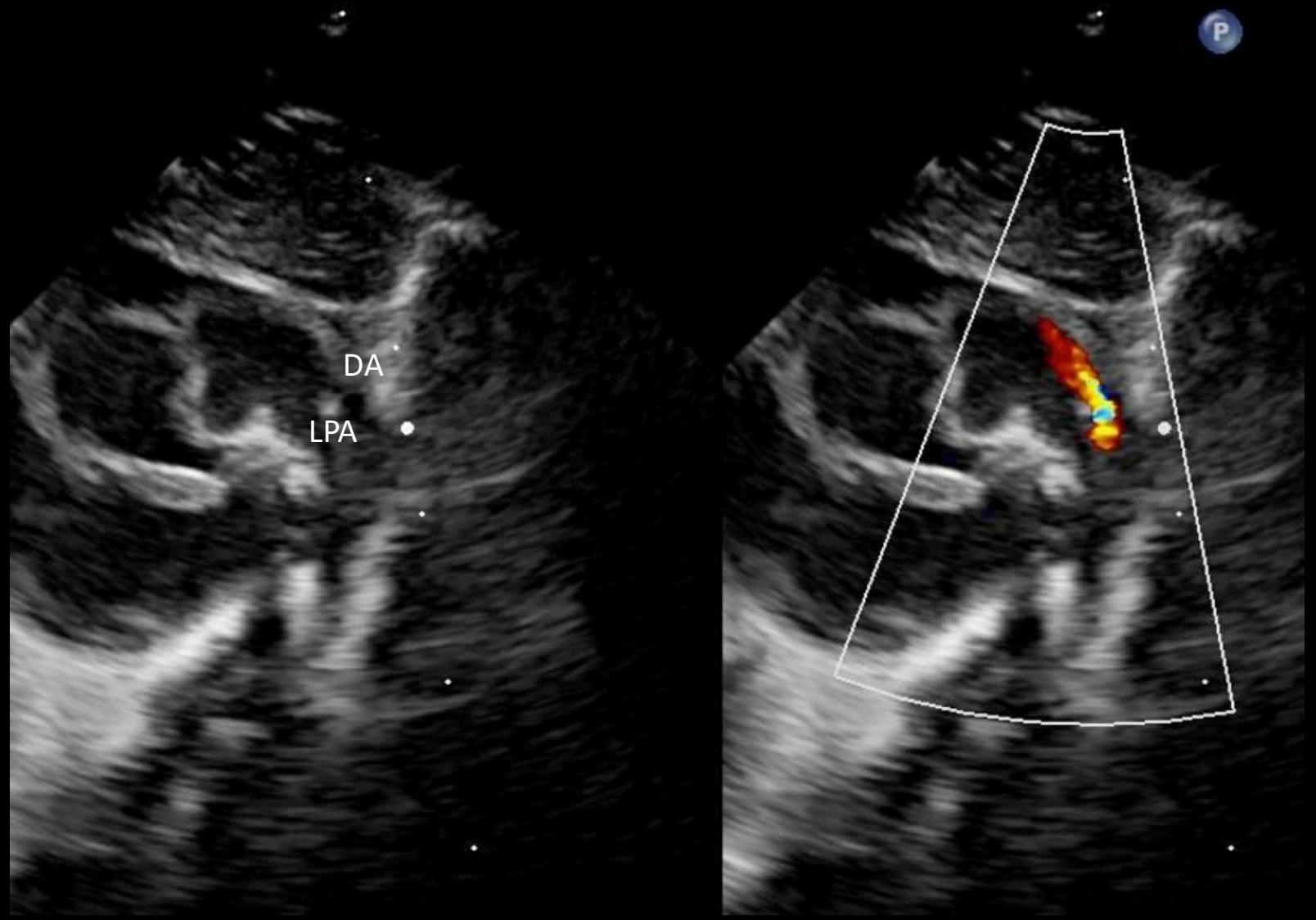
# Assessment of PDA characteristics

- Diameter
  - Narrowest point
  - Color Doppler: potential overestimation
  - Gain increase until background noise suppression



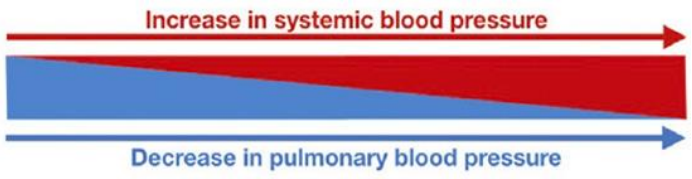
# Assessment of PDA characteristics

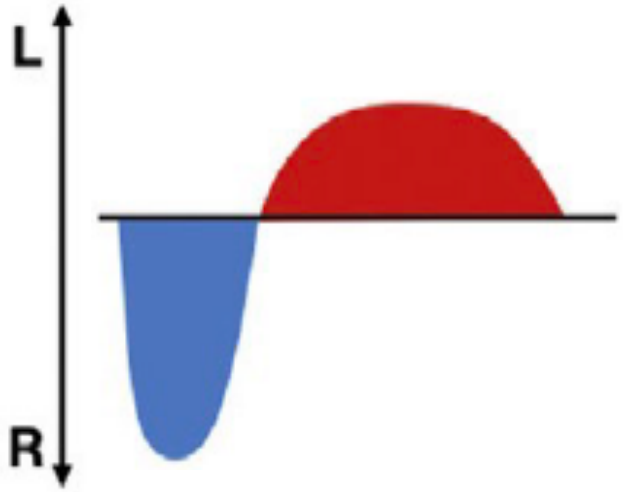
- Diameter
  - Absolute (≥1.5-2 mm)
  - Indexed to body weight (≥1.4 mm/kg)
  - Indexed to the LPA diameter (≥0.5-1)



# Assessment of PDA characteristics

- Transductal shunt pattern

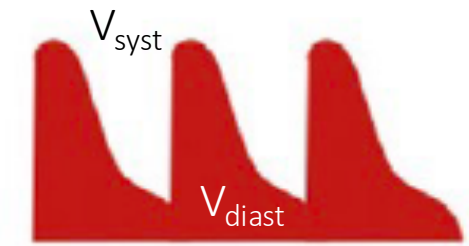



**Blood flow direction**

| | RtL (away) | LtR (towards) |
|---|---|---|
| *Color Doppler* | Blue flow | Red flow |
| *PW/CW Doppler* | Below baseline | Above baseline |

**Blood flow velocity**

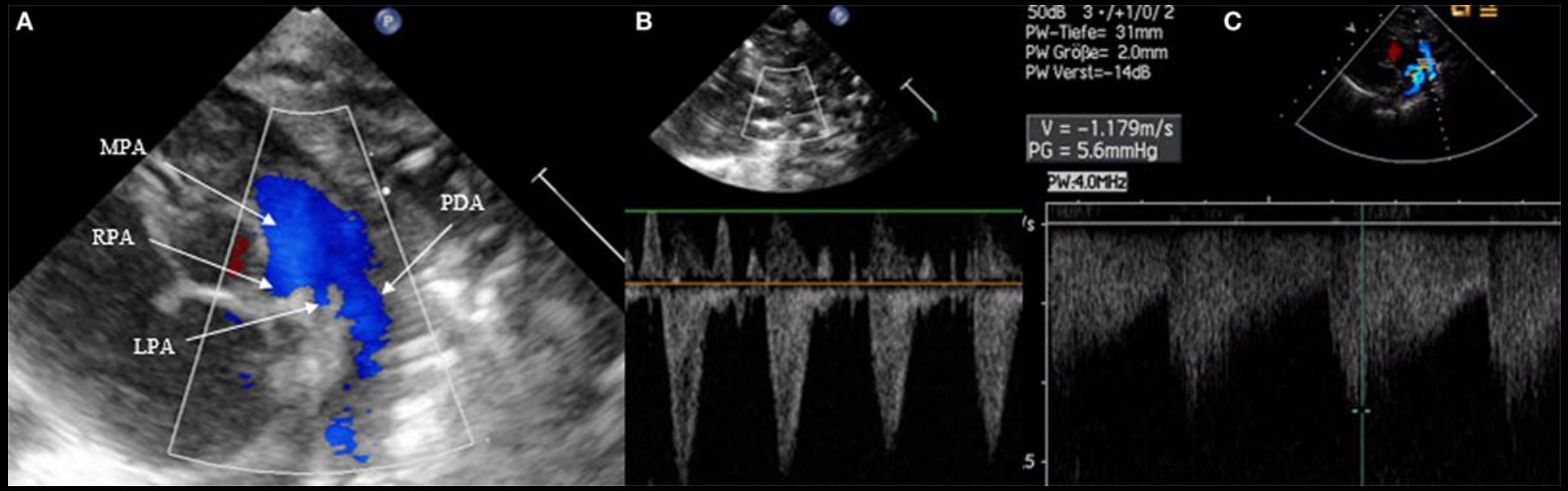



*PW/CW Doppler*

- Pulsatile: $V_{syst}/V_{diast} \geq 2$
- Restrictive: $V_{syst}/V_{diast} < 2$

# Assessment of PDA characteristics

- Transductal shunt pattern

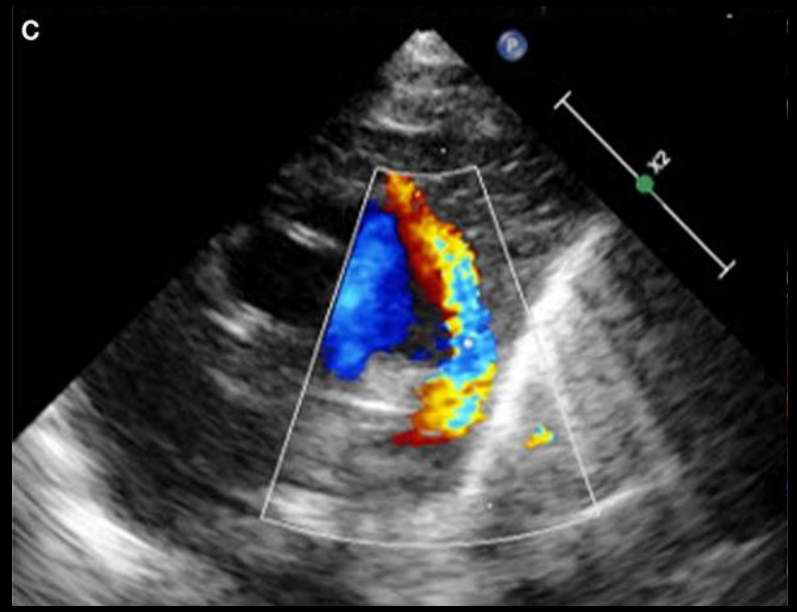


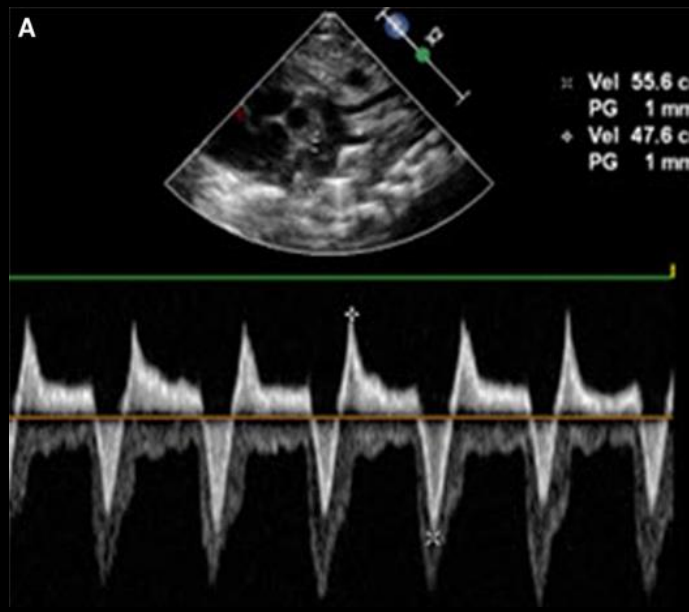

Right-to-left
(suprasystemic pulmonary pressures)

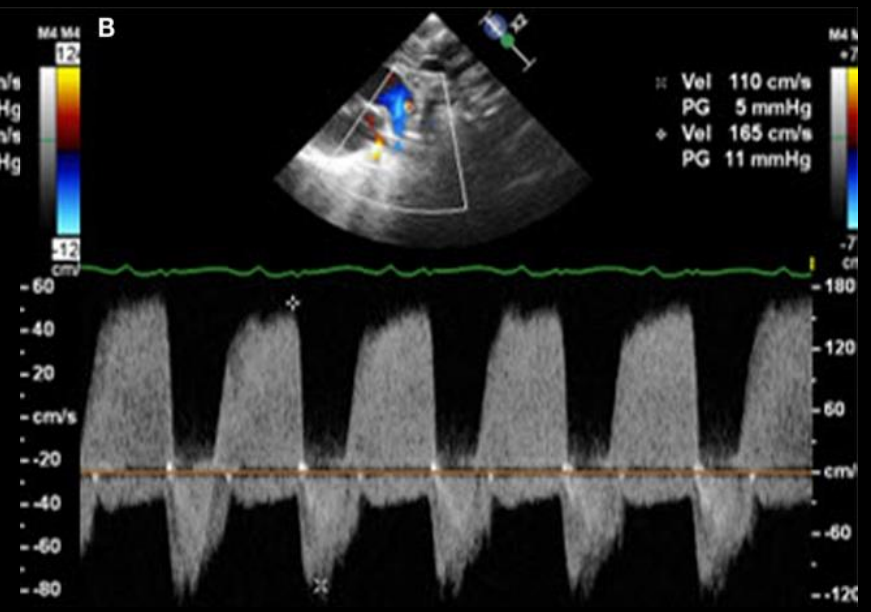
*Arlettaz R. Front Pediatr 2017*

# Assessment of PDA characteristics

- Transductal shunt pattern



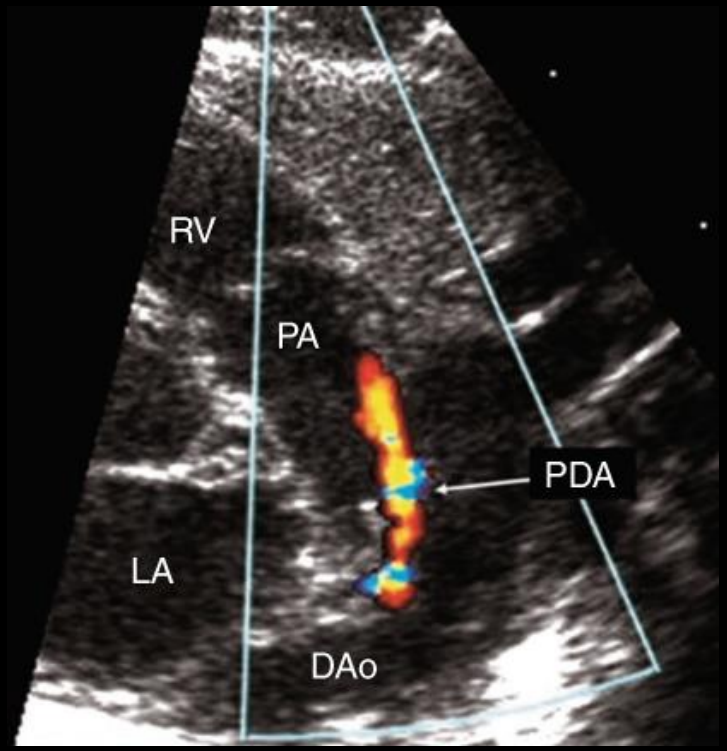

Bidirectional
(near-systemic pulmonary pressures)

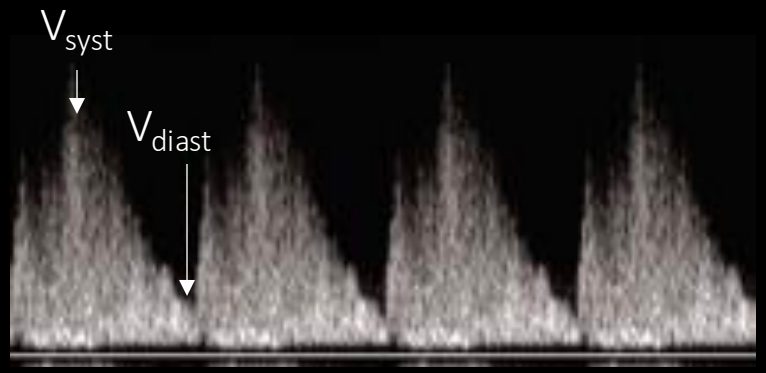
*"growing"*
(RtL<30%)

Arlettaz R. Front Pediatr 2017

# Assessment of PDA characteristics

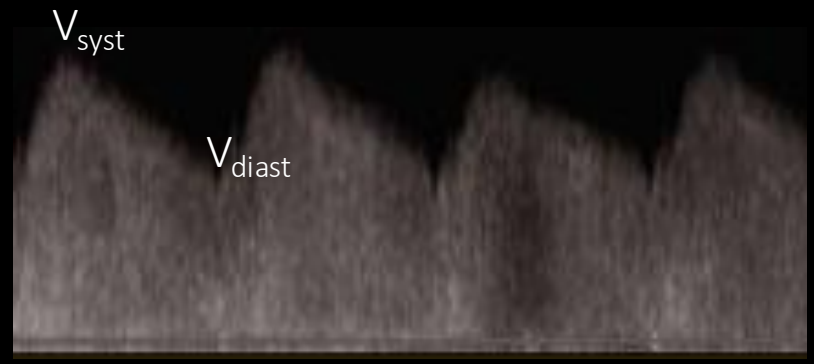
- Transductal shunt pattern




*Pulsatile (hsPDA)*

$V_{syst}/V_{diast}$ ≥2.0



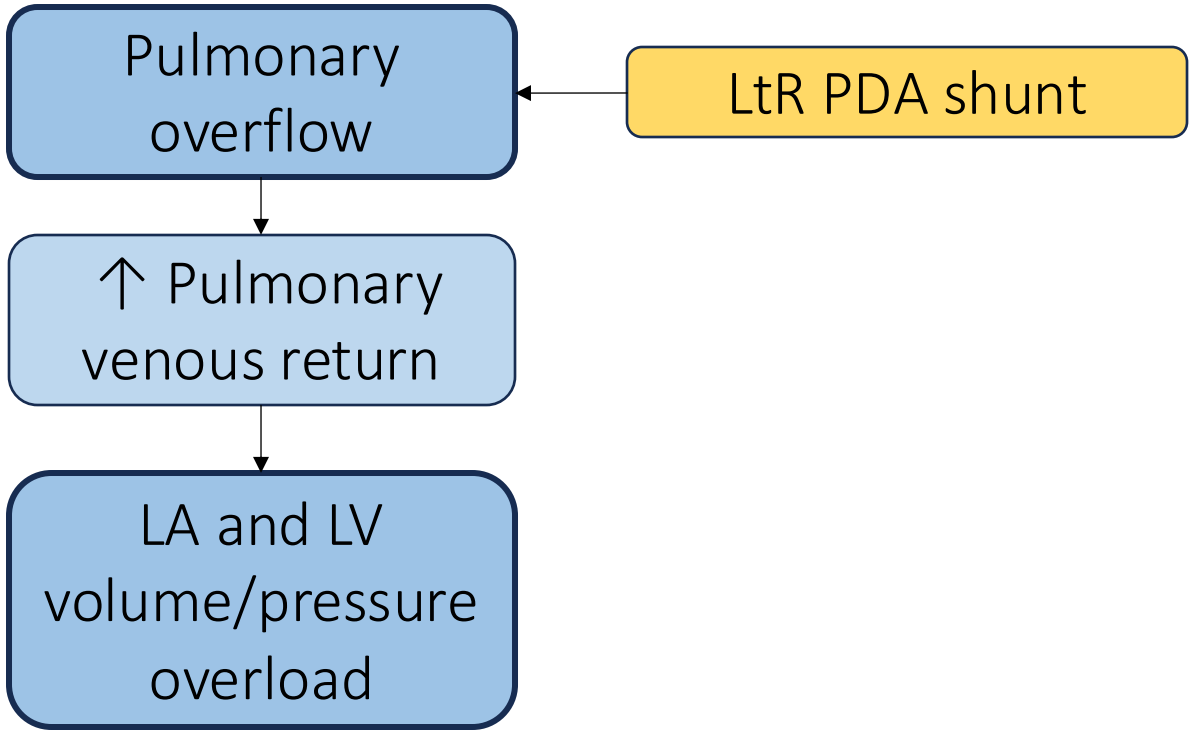

*Restrictive or closing*

$V_{syst}/V_{diast}$ <2.0

Left-to-right

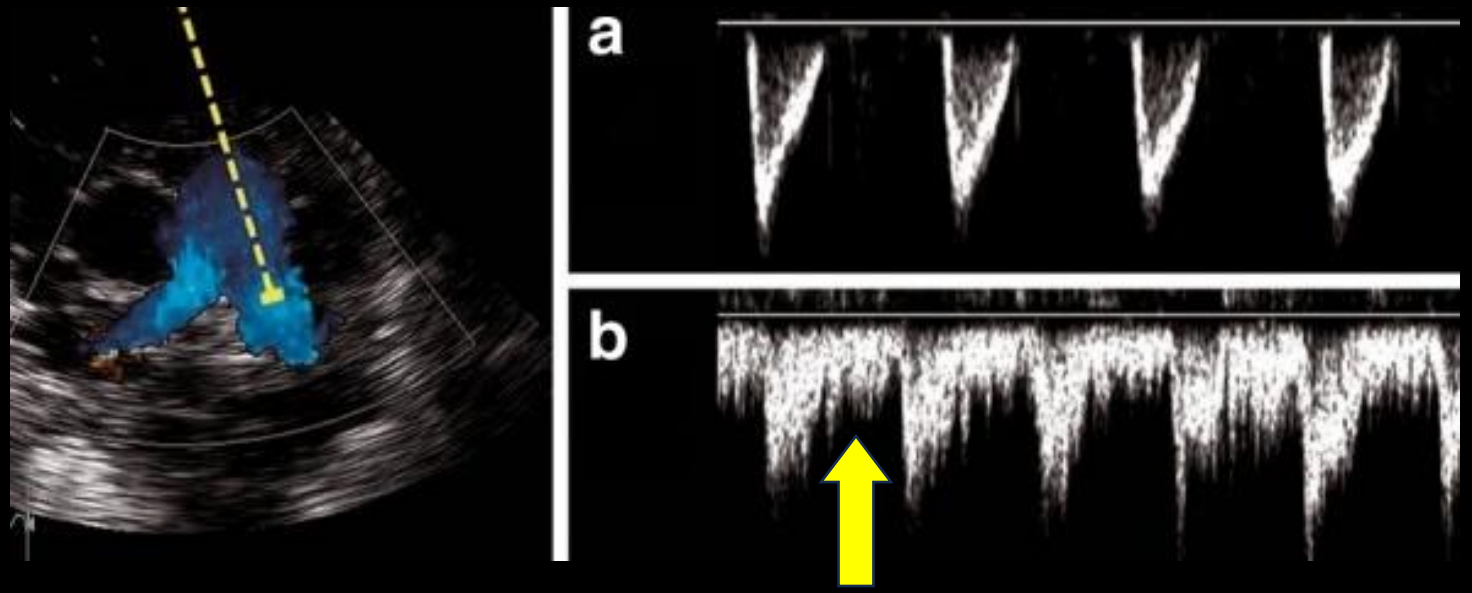
Van Laere et al. Ped Res 2018

# LtR DA shunting: haemodynamic effects



# Pulmonary overflow: EDV LPA

- Ductal view with color Doppler, PW-Doppler beam on the LPA
- End-diastolic velocity is quantified tracing PW-Doppler signal
- Proposed cut-off: 0.2 m/s (moderate shunt);  0.5 m/s (large shunt)



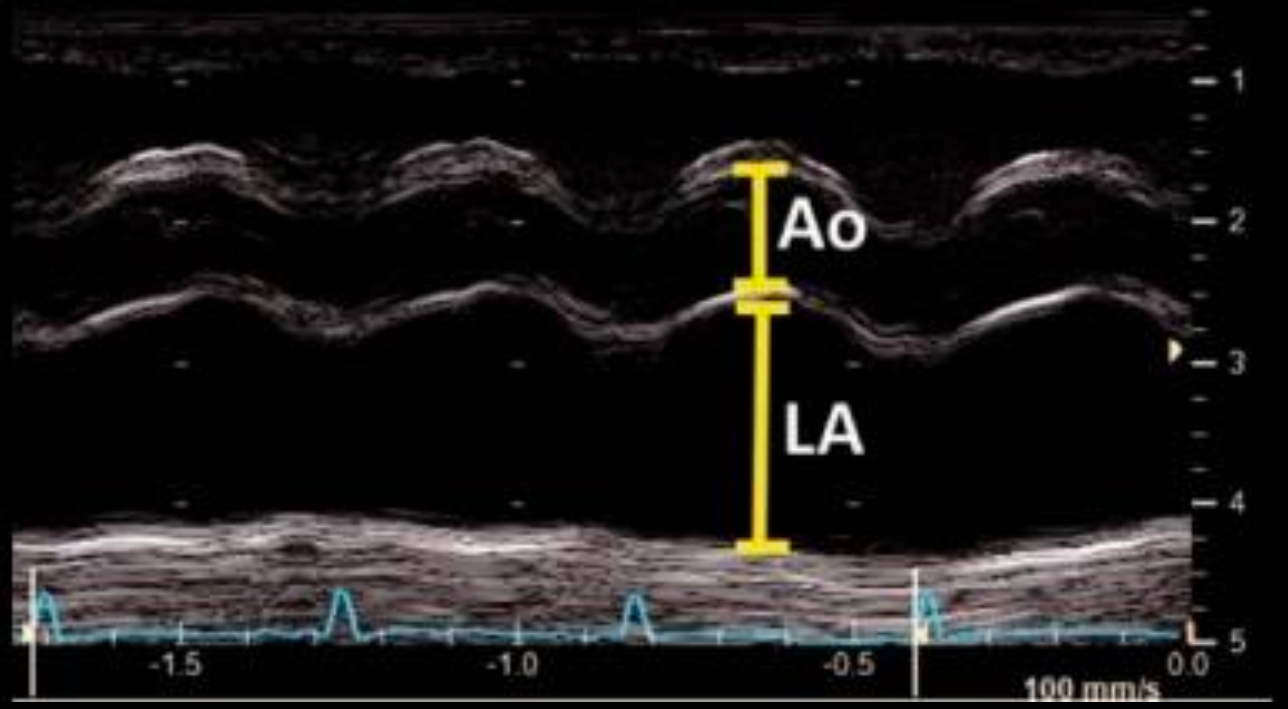

Normal finding

Forward diastolic flow in the LPA (LtR hsPDA)

*Van Laere et al. Ped Res 2018*

# Left heart volume overload: LA:Ao root ratio

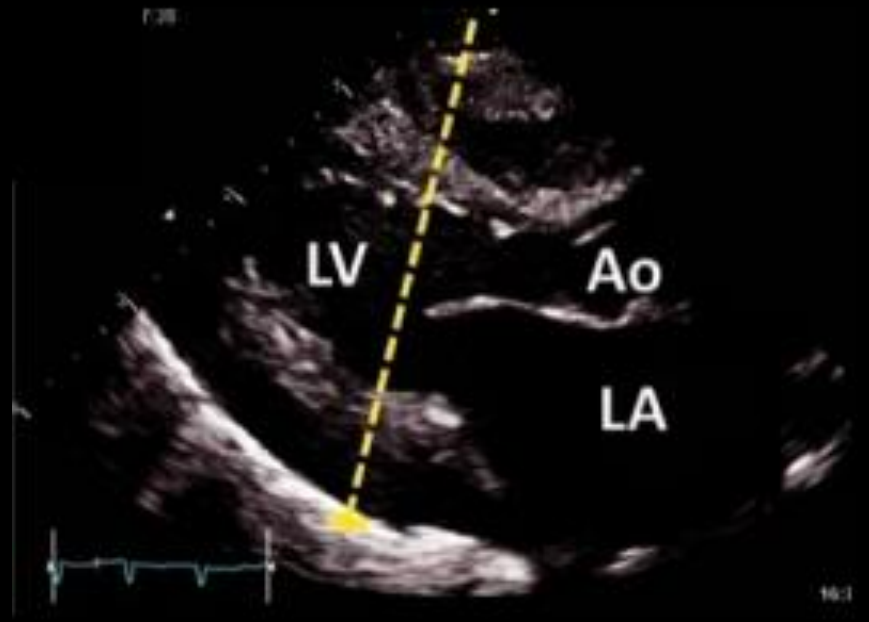
- LAX M-mode
- Commonly used cut-off: ≥1.5
- High intra- and inter-observer variability
- Potentially underestimated by interatrial LtR shunting

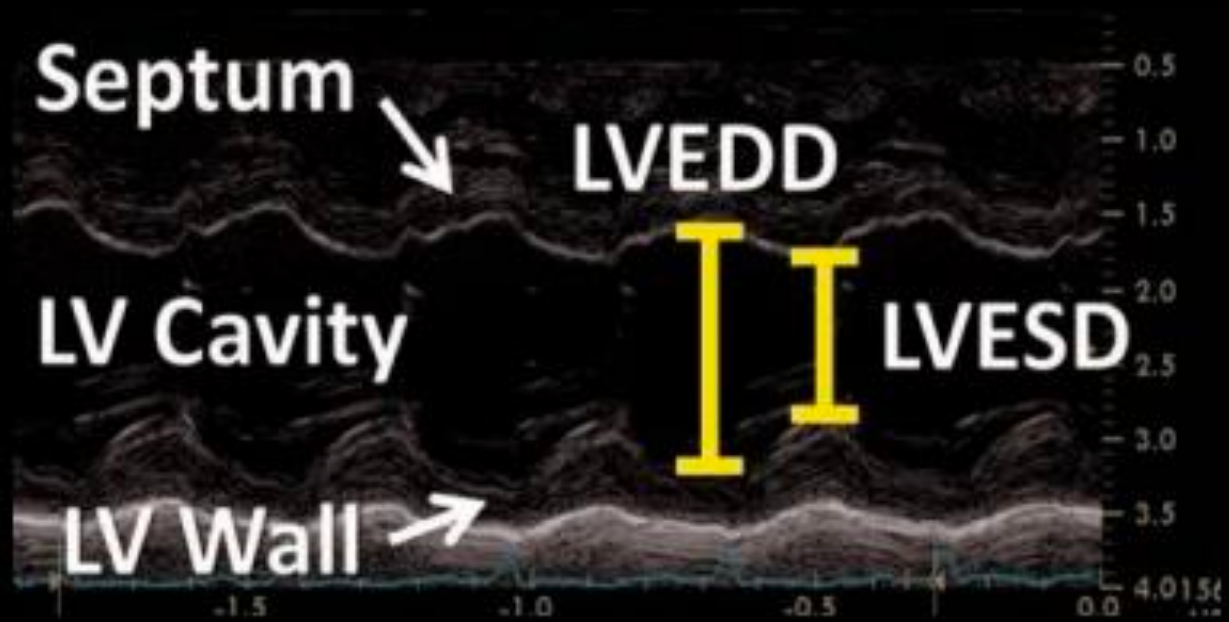




*Van Laere et al. Ped Res 2018*

# Left heart volume overload: LVEDD

- LAX M-mode, cursor perpendicular to IVS
- Reference Z-scores indexed for body weight and postnatal age
- High intra- and inter-observer variability
- Potentially underestimated by interatrial LtR shunting

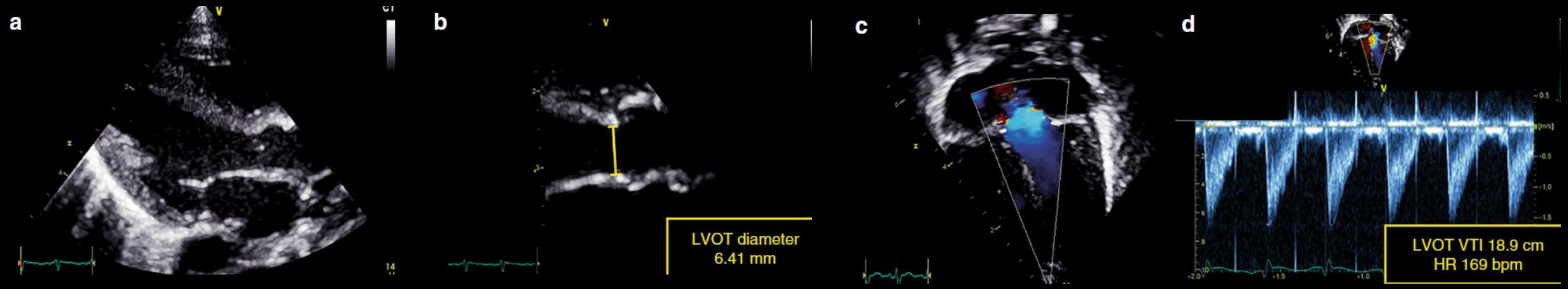



*Van Laere et al. Ped Res 2018*

# Left heart volume overload: LVO

- Left ventricular output: $\frac{\text{AoCSA x VTI x HR}}{\text{weight}}$




- Proposed cut-off: 300 ml/kg/min (large shunt)

*De Boode et al. SFNM 2018*

# Left heart volume overload: LVO

- Marked changes of myocardial performance during postnatal transition make this parameter difficult to use for hsPDA assessment in the first days of life.

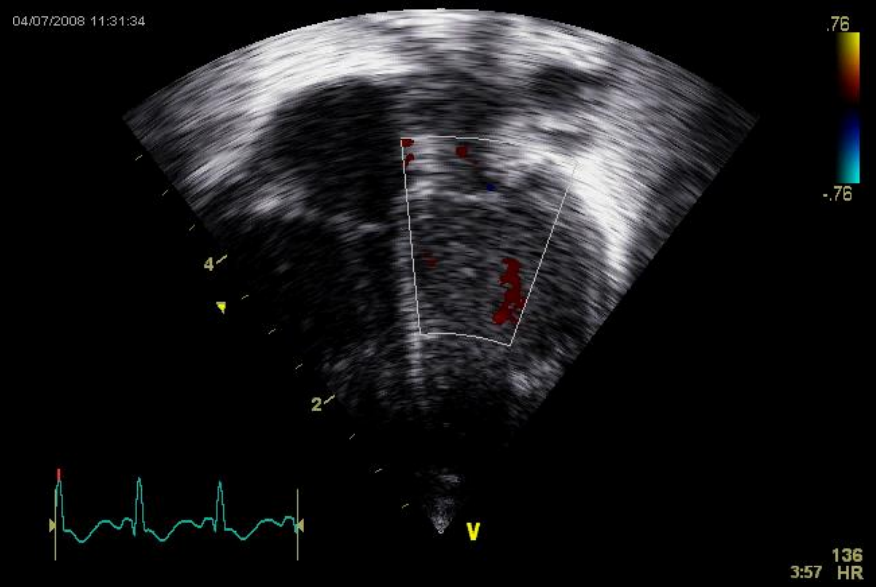
| ***LVO,*** *mL/Kg/min* | ***24h*** | ***48h*** | ***Days 7-14*** |
|---|---|---|---|
| Preterm infants | 240 | 260 | 400 |

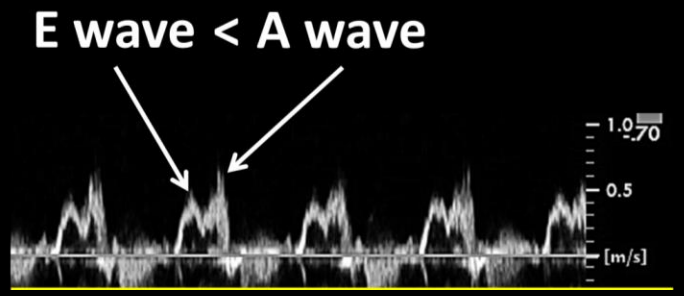
Adapted by De Boode et al. Ped Res 2018

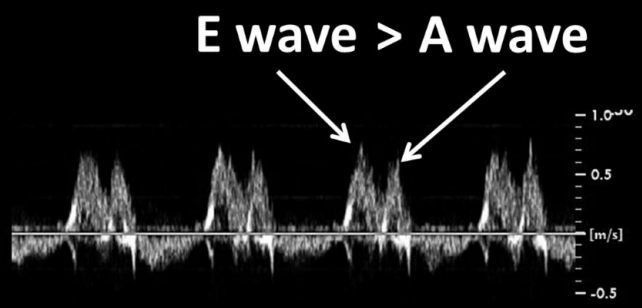
- Underestimated by interatrial LtR shunting and by a compromised LV function (<u>even secondary to a hsPDA itself</u>!)

# Left heart pressure overload: E/A-wave ratio

- Velocities of early diastolic ventricular filling (E-wave) and late diastolic atrial contraction (A-wave)
- 4-chamber view, PW-Doppler beam slightly below the mitral valve annulus



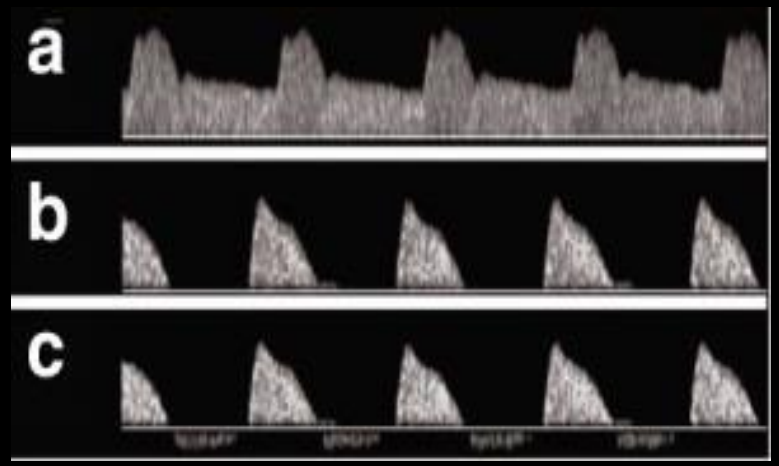

*Preterm Pattern: E/A ratio <1*

*Increased LA pressure (hsPDA): E/A ratio ≥1*

# LtR DA shunting: haemodynamic effects

Pulmonary hyperperfusion ← LtR PDA shunt → Systemic hypoperfusion (post-ductal vessels)

*Diastolic blood flow in post-ductal systemic arteries (PW Doppler)*




Normal pattern

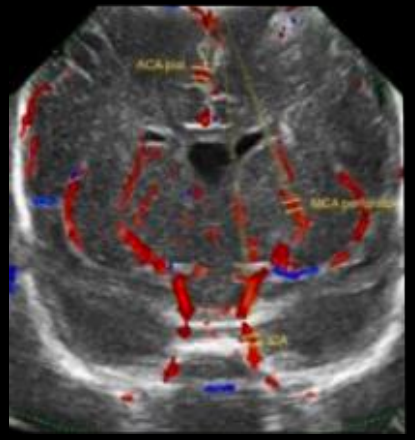
Absent flow

Reversed flow (large LtR shunt)

# Systemic hypoperfusion: diastolic blood flow patterns

*Subcostal view:*
- Abdominal aorta
- Celiac trunk
- Superior mesenteric artery


*Anterior fontanel:*
- Middle cerebral artery
- Anterior cerebral artery
- Pericallosal artery



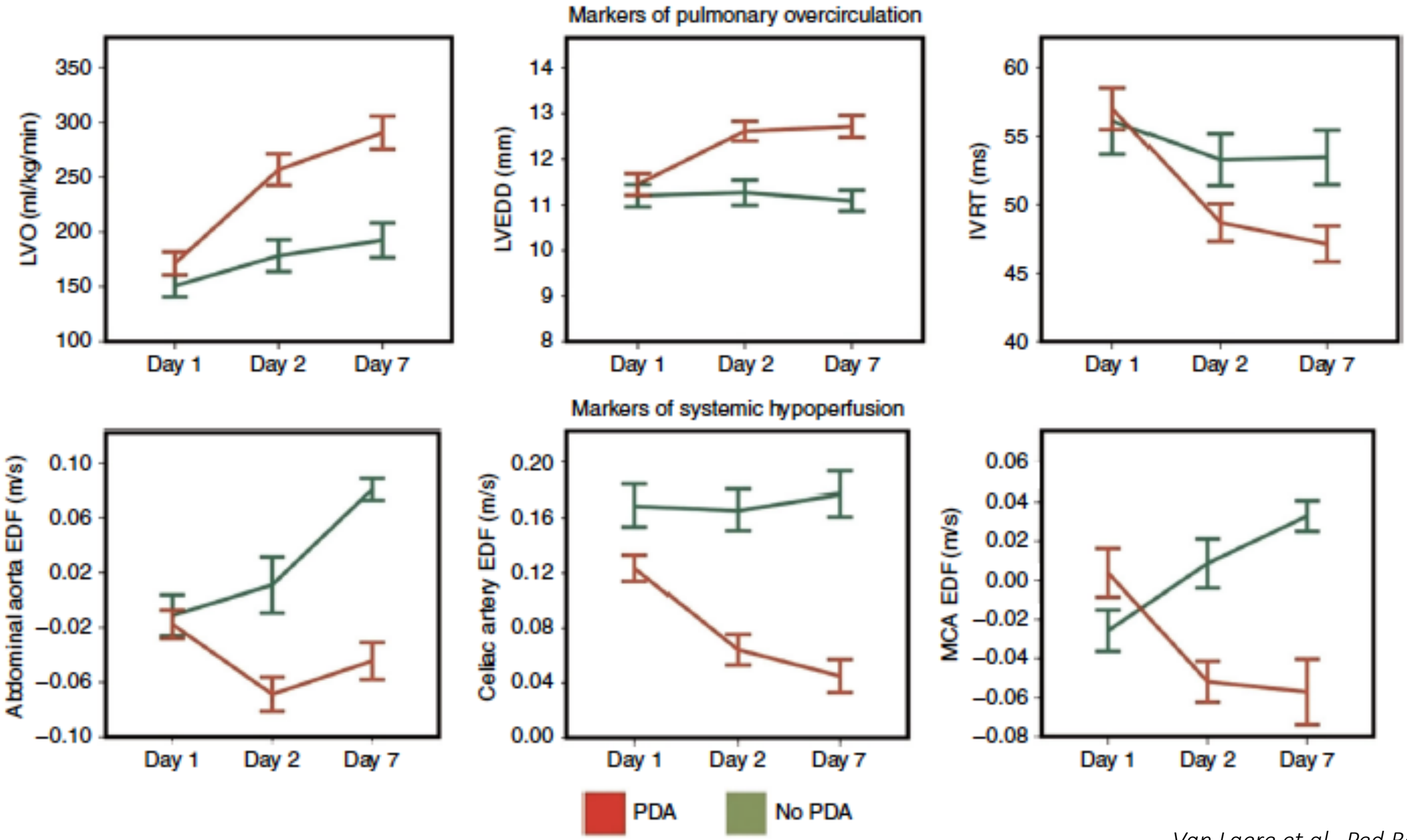
Surfactant

Postnatal transition

«hsPDA»

Respiratory support

Cardiovascular support




*Van Laere et al. Ped Res 2018*

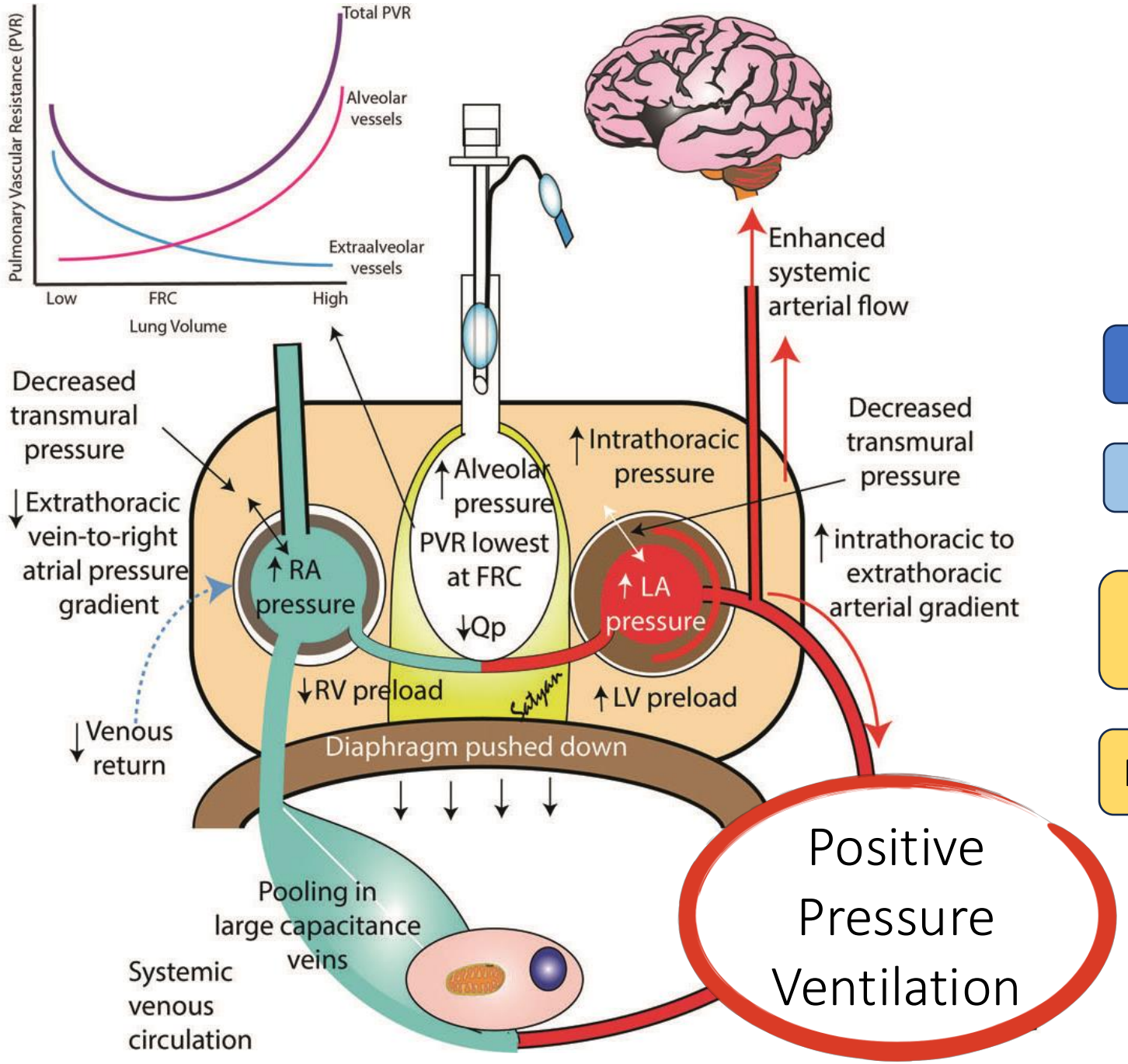
Increased lung pressure/volume

↑ PVR

RV dysfunction

IVS bowing

LV dysfunction




Surfactant

↓ PVR

Transductal P gradient

PDA shunt direction

*Sehgal et al.*
*J Perinatol 2022*

## Vasoactive Drugs Mode of Action

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

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

*Mullaly & El-Khuffash, ADCFN 2023*

# Cardiovascular support

- Ventricular contractility
  - LVO
  - E:A-wave ratio
  - IVRT
- SVR/PVR
  - Transductal shunting features
  - LPA EDV, systemic EDV


3
5
4

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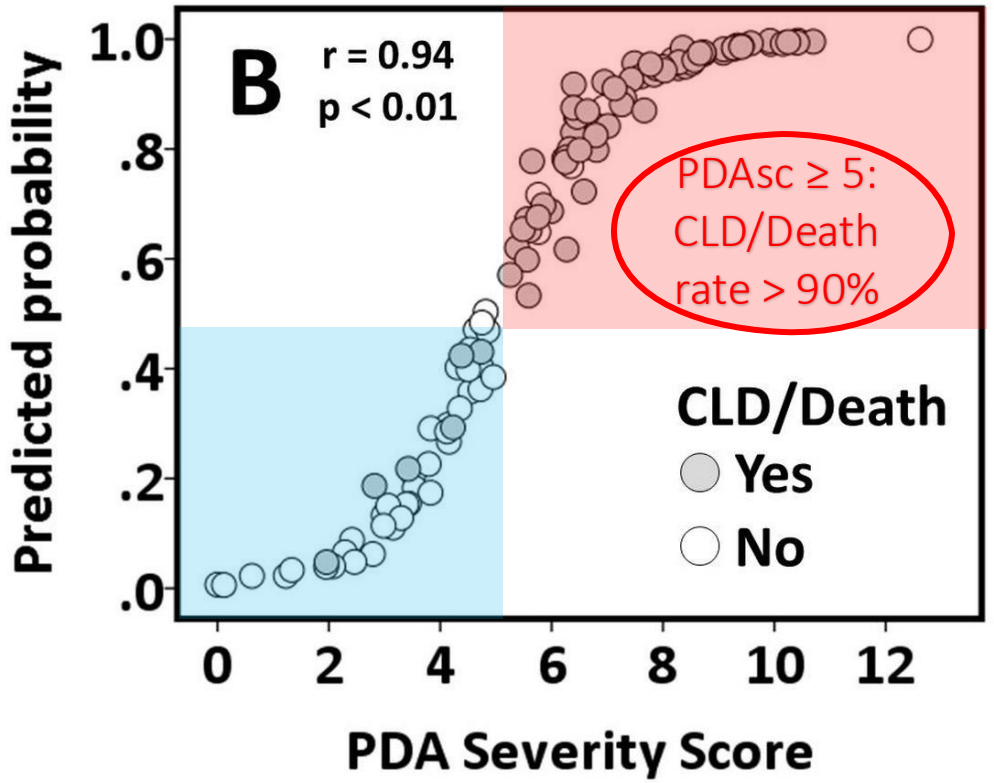
# A Patent Ductus Arteriosus Severity Score Predicts Chronic Lung Disease or Death before Discharge

Afif EL-Khuffash, FRCPI, MD, DCE[1,2], Adam T. James, MB[1], John David Corcoran, MD, FRCPI[1,2], Patrick Dicker, MSc, CStat[3], Orla Franklin, MB, MRCPCH[4], Yasser N. Elsayed, MD[5], Joseph Y. Ting, MD[6], Arvind Sehgal, MD[7,8], Andra Malikiwi, MD[7], Andrei Harabor, MD[9], Amuchou S. Soraisham, MD[9], and Patrick J. McNamara, MD, MRCPCH[10,11]

- Preterm infants <29 weeks' GA
- ECHO on day 2
- To predict CLD or death before discharge

**Table III. Results of the regression model used to devise the PDAsc**

| Predictor variable | Unstandardized β | Standardized β | P |
|---|---|---|---|
| Gestation | −1.304 | −0.398 | <.01 |
| PDA diameter | 0.781 | 0.079 | .07 |
| LVO | 0.008 | 0.272 | .03 |
| PDA Vmax | −1.065 | −0.163 | .02 |
| LV a′ | −0.470 | −0.236 | .01 |




*PDAsc [range: 0-13]: (GA x 1.304) + (PDA diameter x 0.781) + (LVO x 0.008) + (max PDA velocity x 1.065) + (LV a-wave x 0.470) + 41*

# Predictive Model of Early Spontaneous Ductus Arteriosus Closure Based on Neonatologist Performed Echocardiography in Preterm Infants

*María Carmen Bravo[1]*, Rebeca Sánchez[1], Ana Isabel Blanco[1], Itsaso Losantos[2] and Adelina Pellicer[1]*

frontiers in Pediatrics

ORIGINAL RESEARCH
published: 26 February 2021
doi: 10.3389/fped.2021.644519

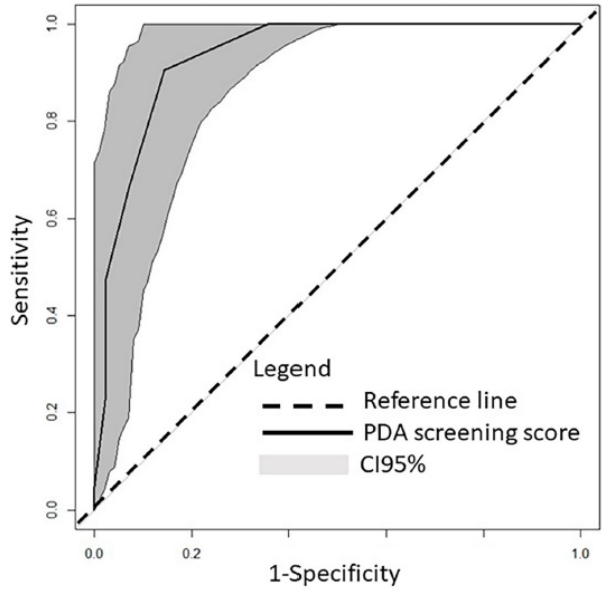
- Infants <29 weeks' GA
- NPE performed within 72h of life
- Prediction of spontaneous DA closure within 2 weeks of life

| | Modality/position of sample gate | Score 0 | Score 1 | Score 2 | Score 3 |
|---|---|---|---|---|---|
| Transductal diameter, mm | Color Doppler, high left-sided parasternal | 0 | <1.5 | 1.5–3 | >3 |
| Ductal velocity Vmax/Vmin ratio, m/s | PWD at pulmonary end of duct view | 0 | <1.5 | 1.5–2 | >2 |
| Antegrade LPA diastolic flow, cm/s | PWD within left pulmonary artery | 0 | <30 | 30–50 | >50 |
| Descending aorta diastolic velocity | PWD within descending aorta. High parasternal | Forward | Absent | Reverse | |

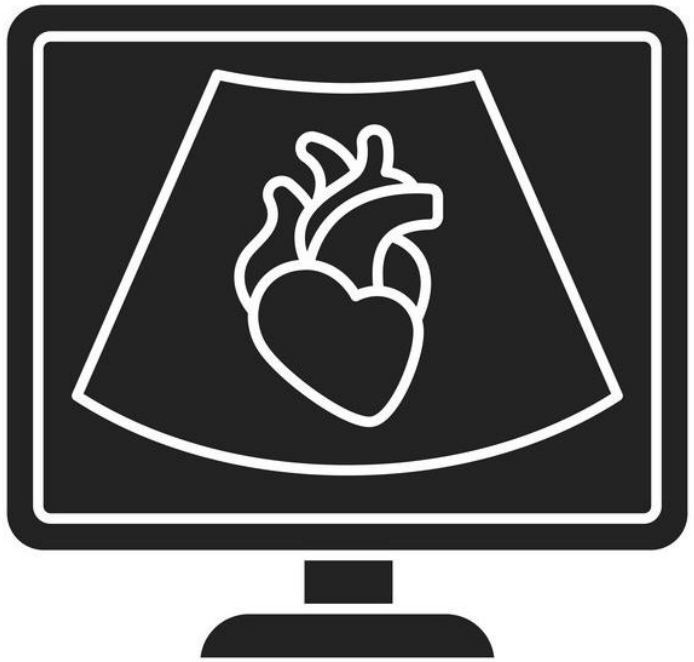
*Log (p/1-p) = −28.41 + **1.23 GA** −0.87 PDA score*

## *Prediction of spontaneous DA closure*

- **Cut-off <4.5**
- AUC 0.93 (0.88-0.99)
- Sensitivity 0.90, specificity 0.86
- PPV 0.76, NPV 0.95



# Take-home messages



1. Look for consistency among different ECHO parameters assessing matched haemodynamic effects
2. Bear in mind the effects of:
   - concomitant intracardiac shunts (PFO/ASD/VSD)
   - factors influencing PVR/SVR/cardiac function (e.g., surfactant, respiratory or cardiovascular support)
   - physiological changes occurring during the transitional period
3. Usefulness of serial ECHO repeats over time
4. Consider PDA score for outcome prediction (further validation in clinical settings required)

# Thank you for your attention!

European School of Neonatology

The ESN is a project by the European Society for Paediatric Research