How fetal echo can aid in management of non-cardiac fetal anomalies

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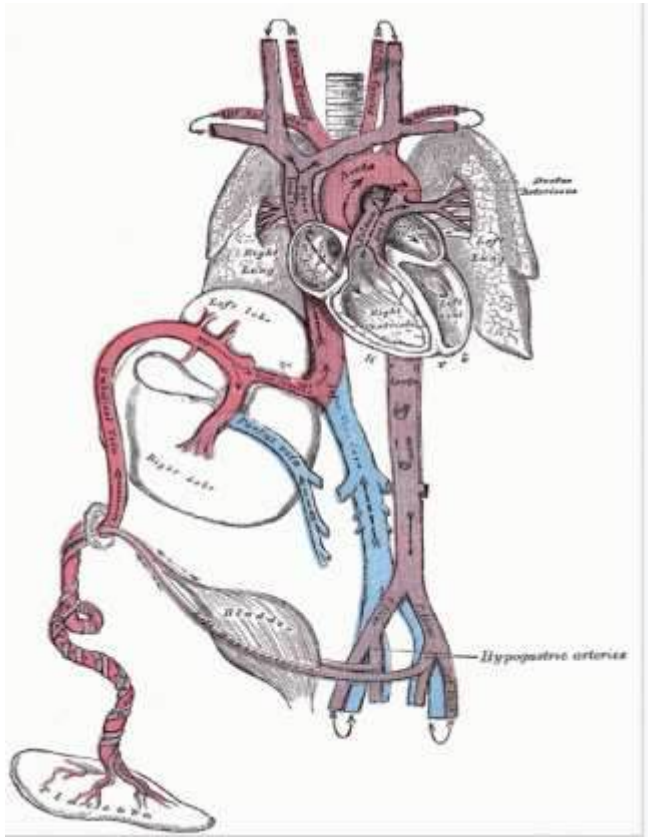
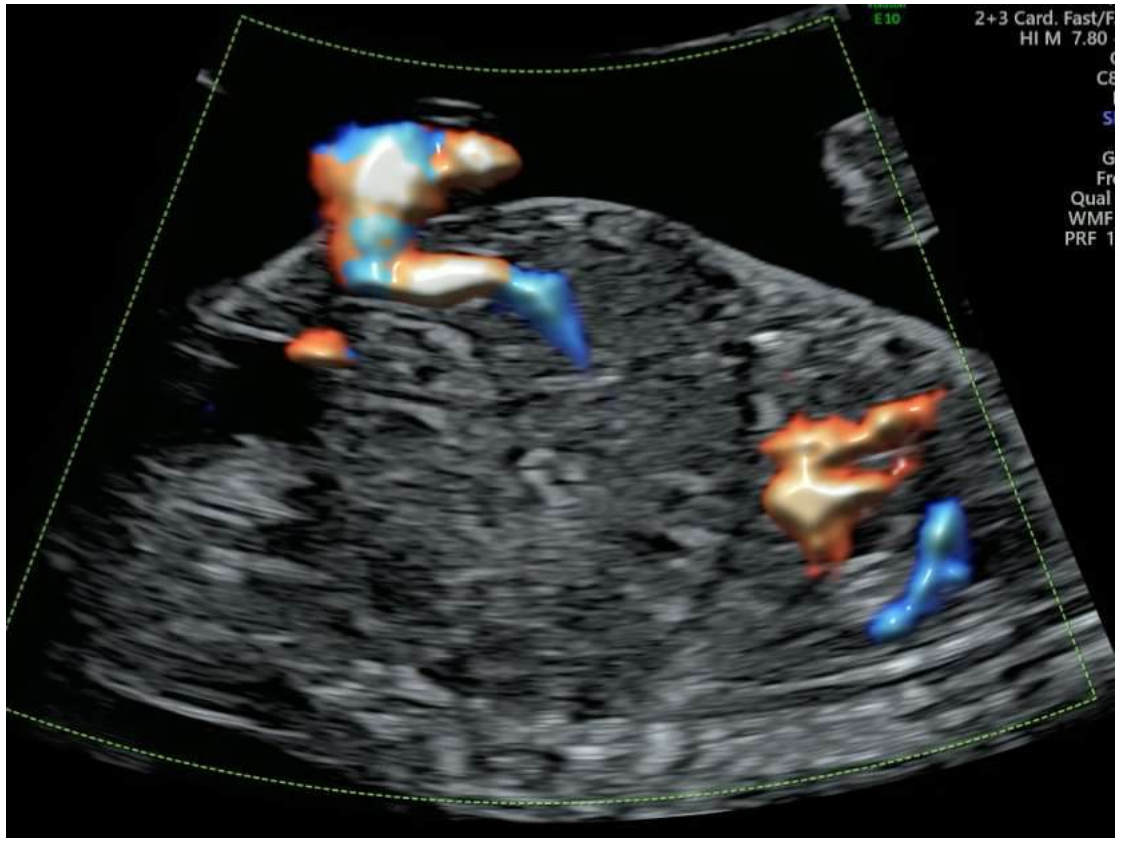
San Francisco

- No Disclosures

Fetal echocardiogram:
Assessment of circulatory physiology





Management:
1) Fetal/neonatal Intervention
2) Counseling on prognosis

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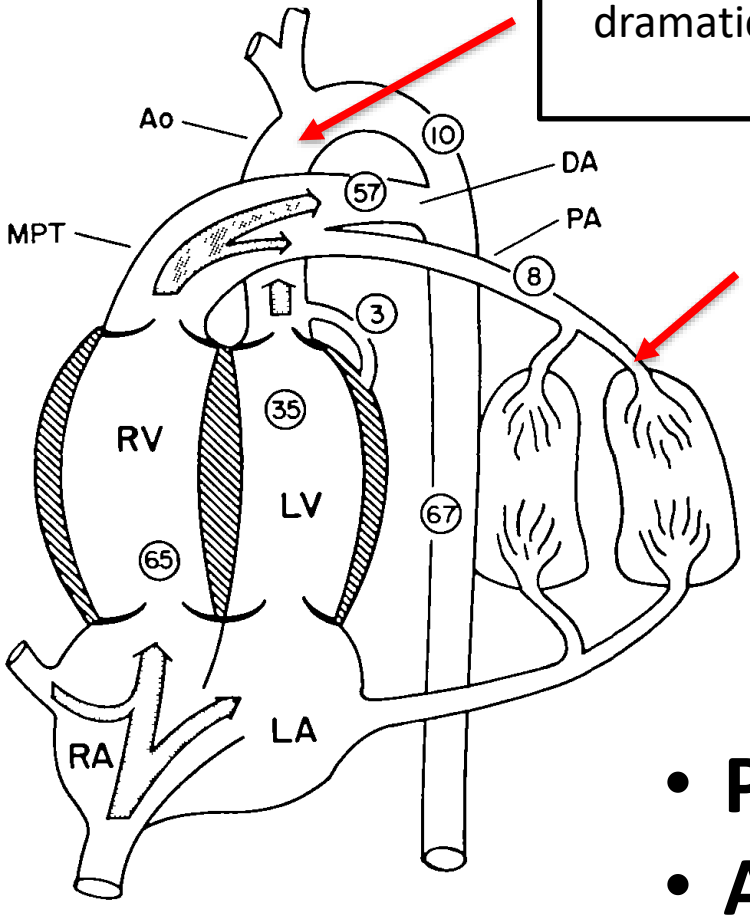
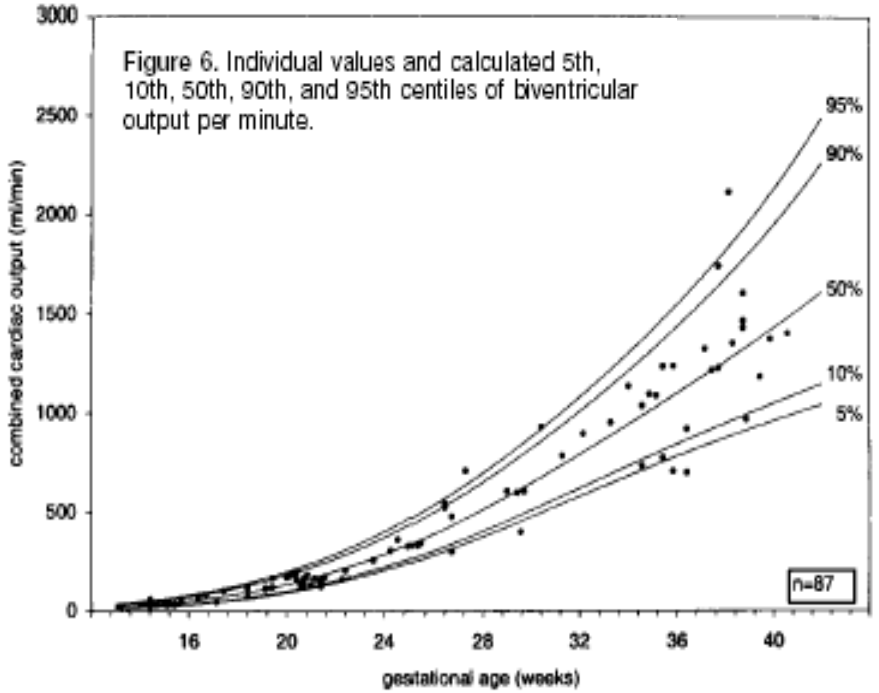
Guiding Principles: Cardiac output

Percentage of Output to brain: dramatic increase in 3rd trimester ~10 → 35%



Percentage of combined ventricular output to lungs increases from 3-4% to 7-9%



- **Preload**
- **Afterload**
- **Myocardial contractility**

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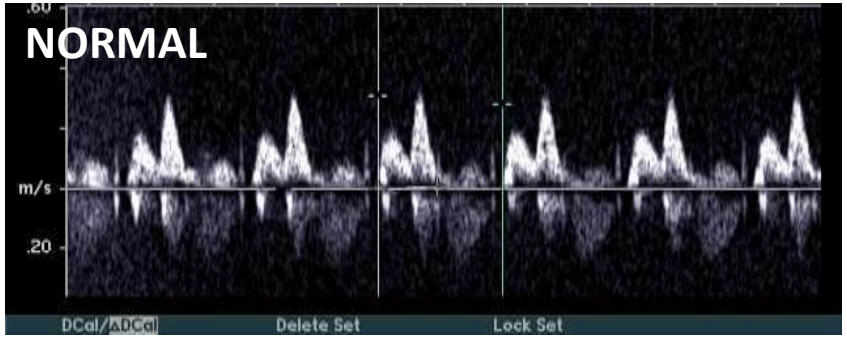
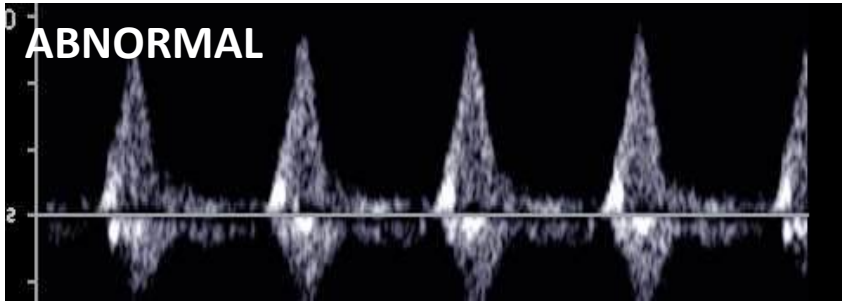
Rudolph AM, 1985
Rudolph AM, 2016
Rudolph AM, 2018

Guiding Principals: Fetal Myocardium

- Fetal myocardium:
  - Relatively non-compliant
  - less tolerant to changes in loading
  - Sensitive to small changes in preload and afterload

Fetal Echocardiography: Assessment of ventricular filling pressures using Doppler





Increased filling pressures

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Guiding Principles: Cardiac output

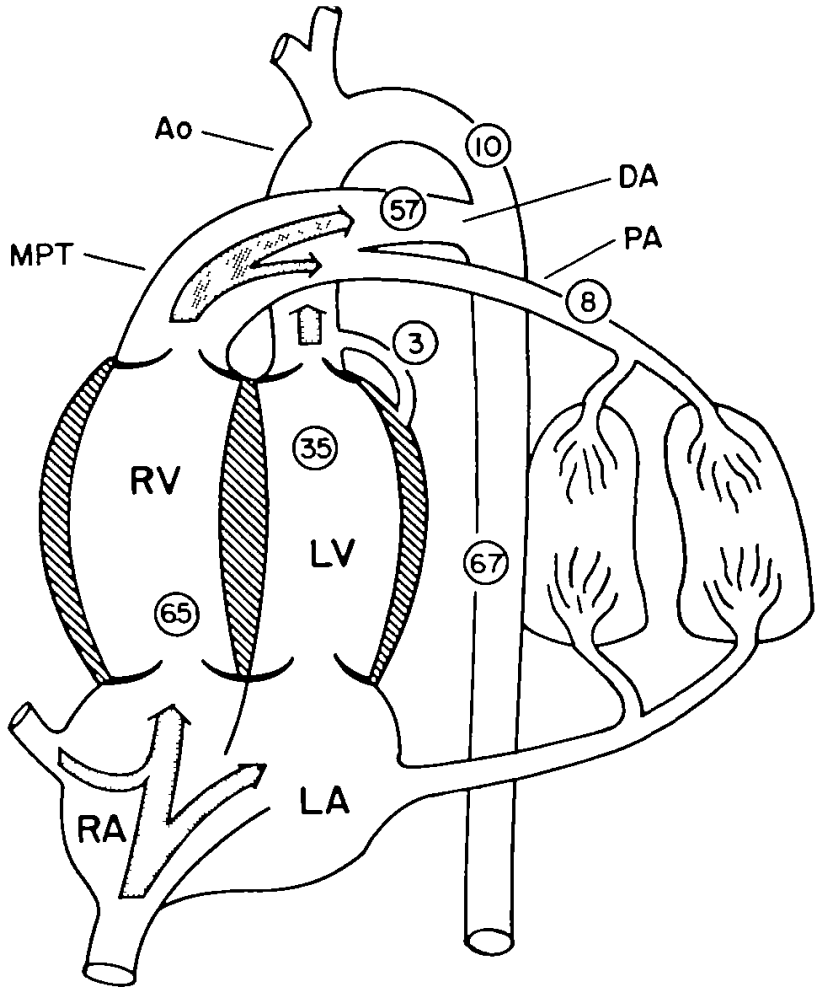


FIGURE 1. Diagram of the fetal heart showing the percentages of

- ⬇ Cardiac Output
- Poor myocardial contractility
- Impaired filling to heart

⬇

Increased atrial pressures/CVP → hydrops

Guiding Principles: Cardiac output

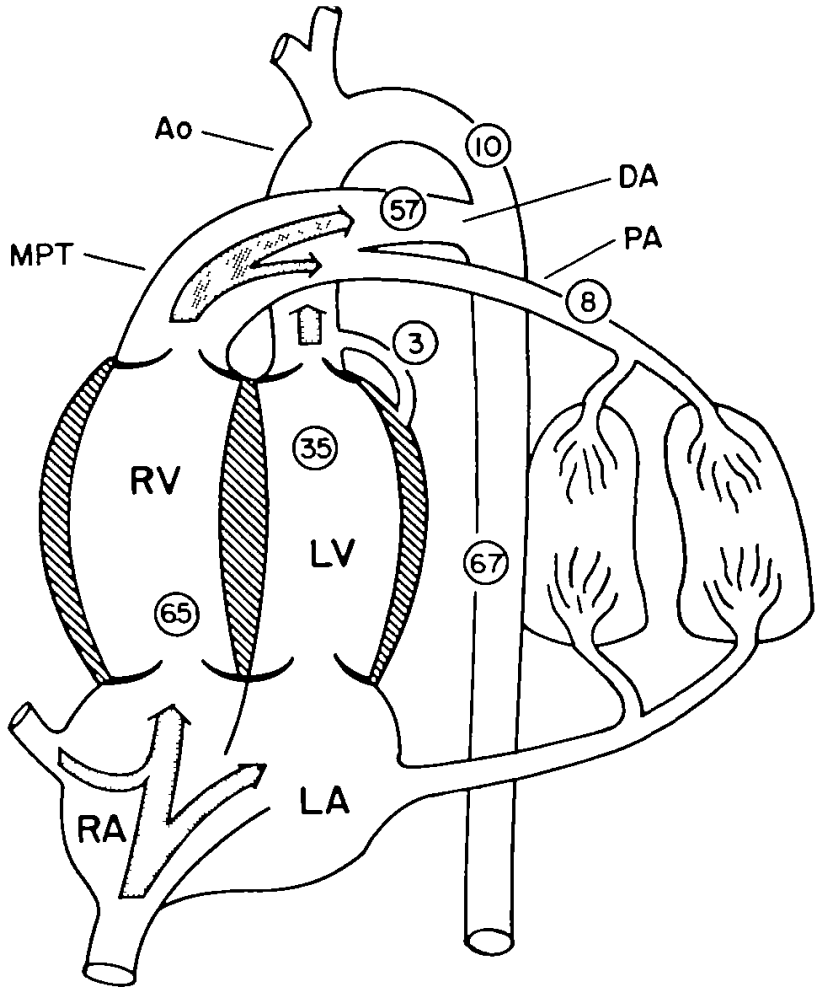


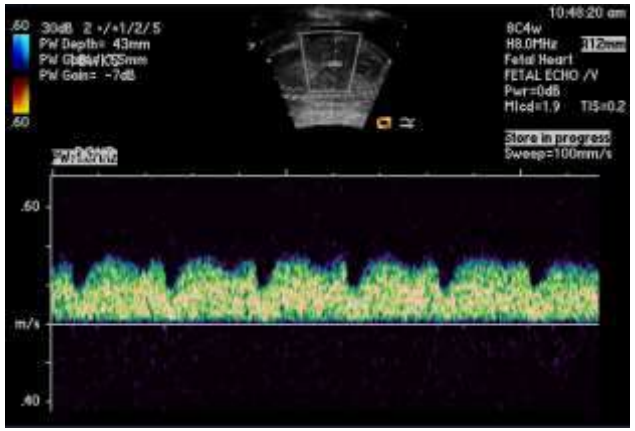
FIGURE 1. Diagram of the fetal heart showing the percentages of

⬆ Cardiac Output

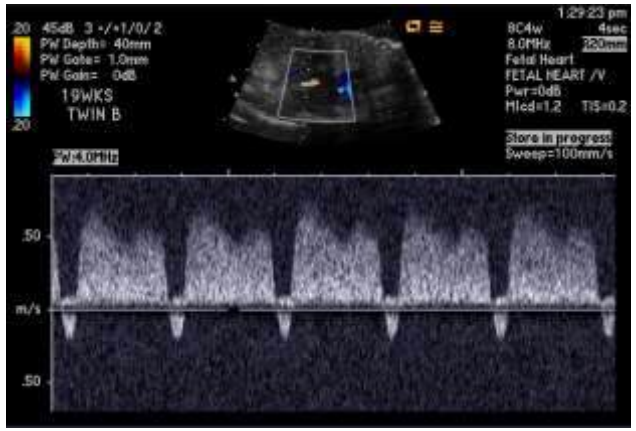
- High output states → heart failure → increased atrial pressures/CVP → hydrops
- Decompensation occurs when CCO > twice normal

Guiding Principals: Fetal wellness

- Atrial pressure

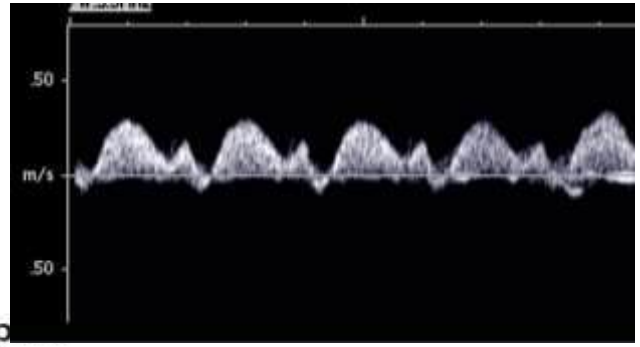


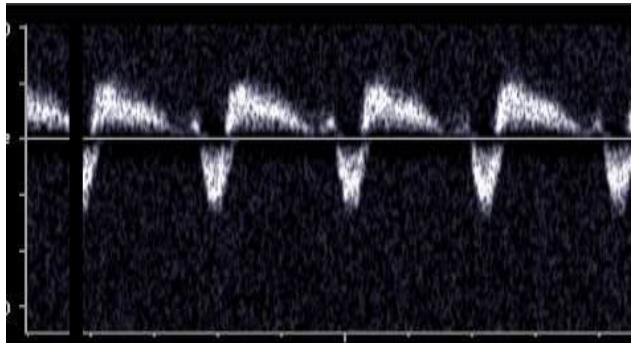
Normal



Ductus Venosus

Abnormal- Increased atrial filling pressures





IVC

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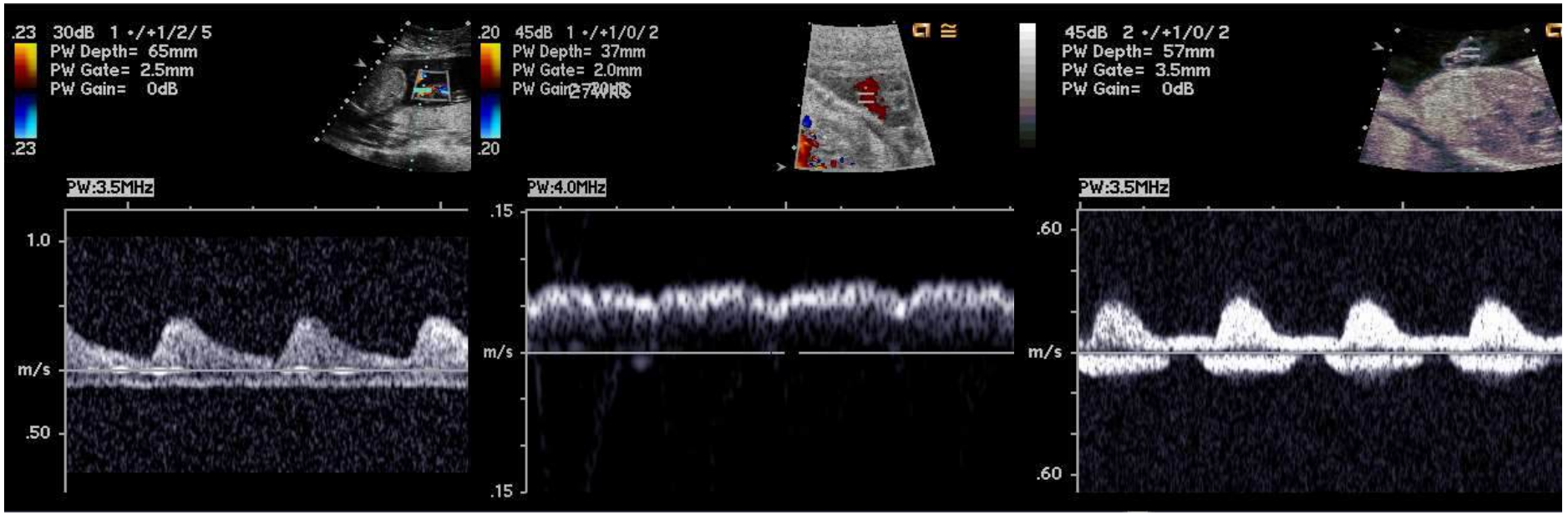
Guiding Principals: Fetal wellness

- Umbilical vein



Normal:
Continuous low velocity

Abnormal:
Notching at end-diastole

Abnormal:
Venous pulsations

CVP

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Non-cardiac disease can impact cardiovascular physiology

Thoracic and mediastinal masses

High Output

- Anemia
- SCT
- TRAP
- AVMs

Tamponade

- CPAM
- Pericardial teratoma

Cardio-pulmonary disease

- CDH

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Case 1: Volume Loading lesions

Referral: Cardiomegaly

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Case #1- Sacrococcygeal Teratoma

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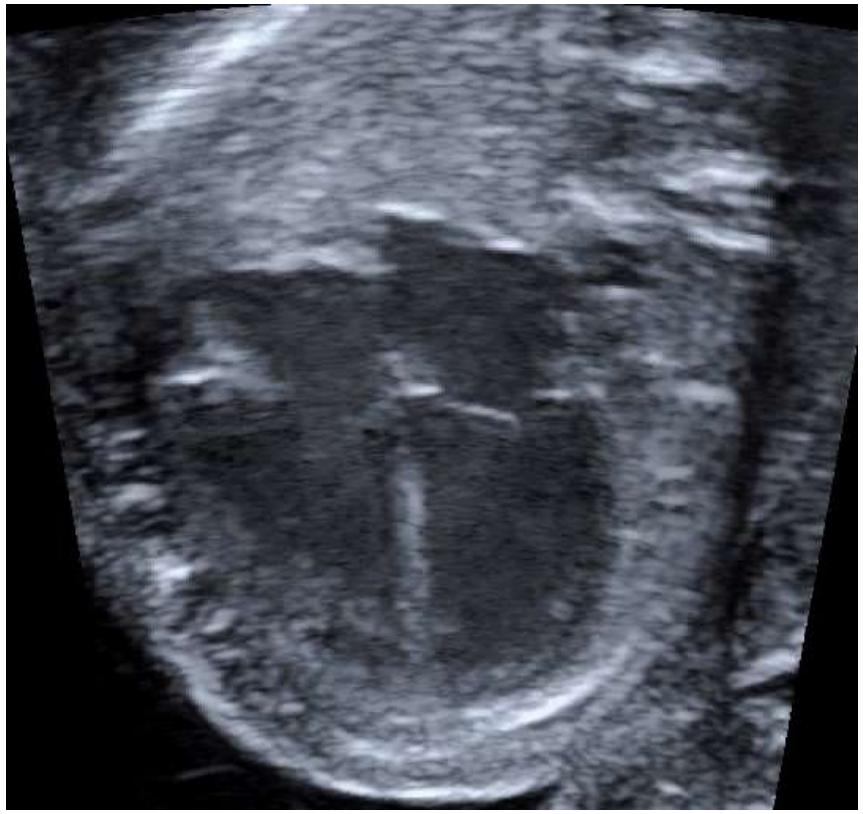
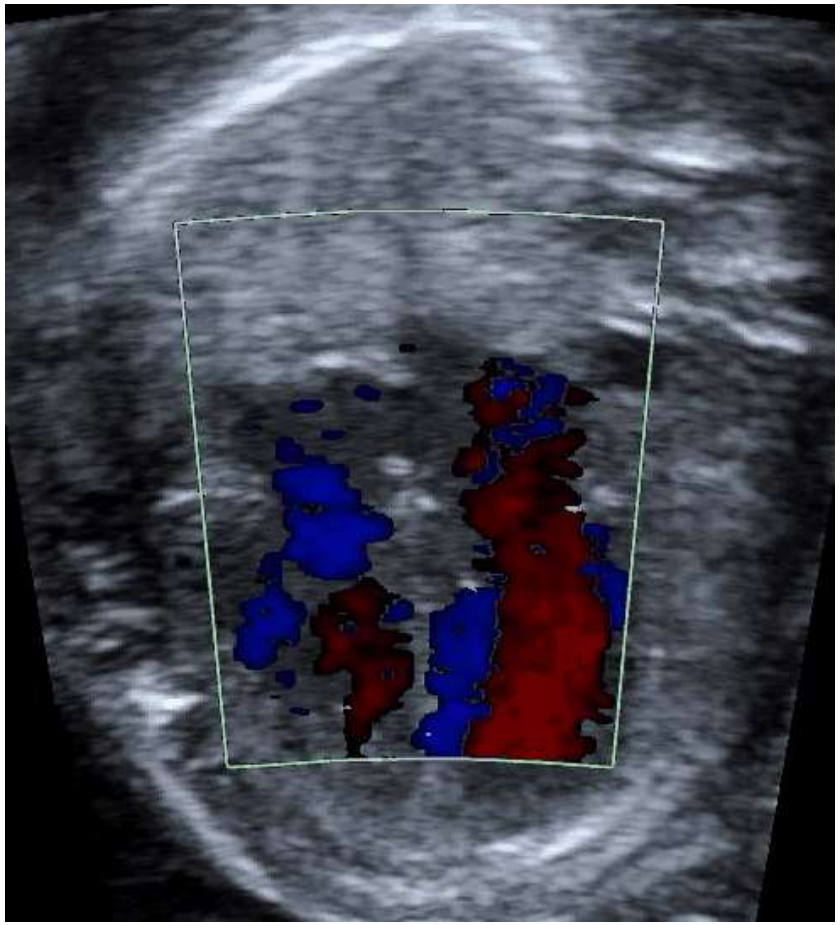
Case #2- Sacrococcygeal Teratoma





CTR= 41%
CCO= 750 cc/kg/min

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SCT: Natural History Fetal Echo Study

- At least one of the following was present among those that had a poor outcome:
  - CTR > 0.5
  - CVO > 550 ml/min/kg
  - Tricuspid or mitral regurgitation
  - Mitral or aortic valve Z score >+2
- Fetal echo measures may help with need or timing of fetal resection

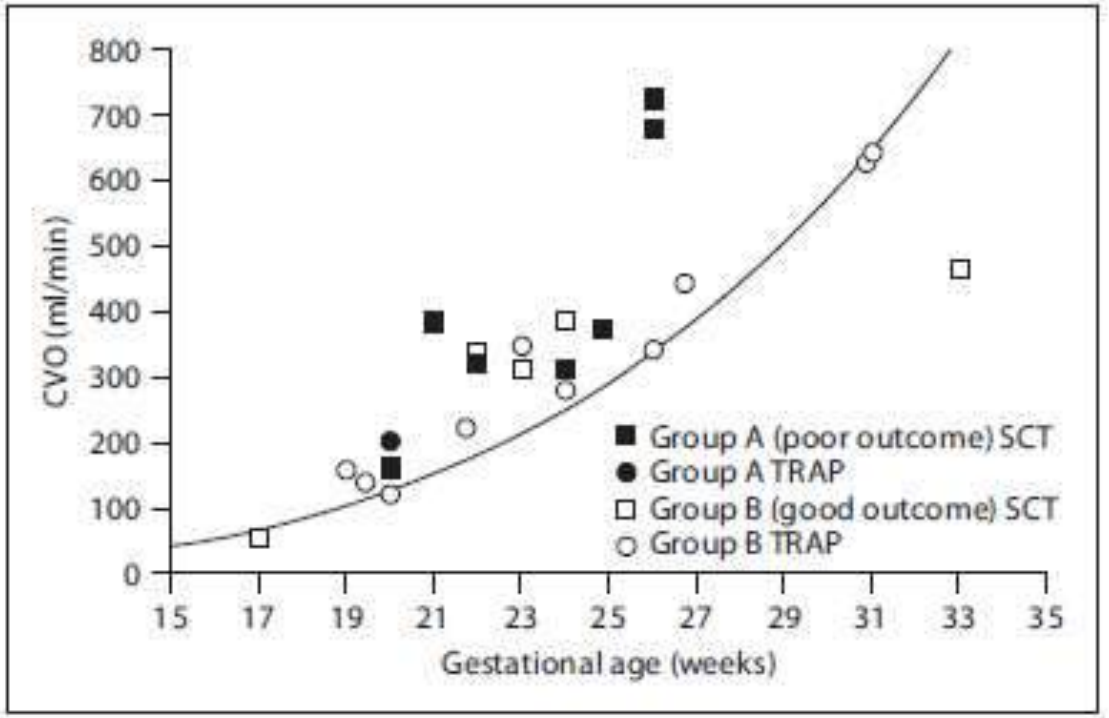

Fig. 1. Scatter plot demonstrating CVO (ml/min) and gestational age (weeks) of individual study fetuses at presentation. The solid line represents the 50th percentile for gestational normals [29].

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Byrne F et al, 2011

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Case 2: Thoracic Masses

Referral: Congenital Pulmonary Airway Malformation (CPAM)

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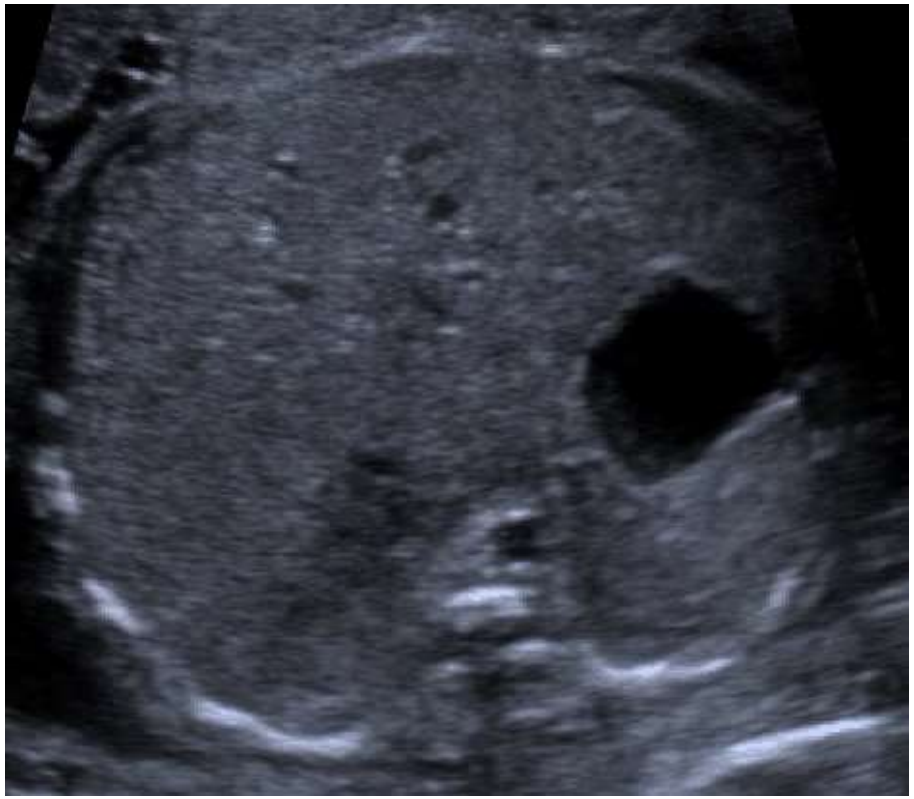
Congenital Pulmonary Airway Malformation

- Intrathoracic Mass
- Extrinsic Compression
  - Smaller CTR
  - +/- decreased CCO
  - Abnormal inflow Doppler
  - Increased atrial pressure + CVP
    - Decreased venous return (+IVC distortion)
  - Tamponade physiology



Congenital Pulmonary Airway Malformation

- Rapid Growth
- May be associated with hydrops
- Fetal therapy possible
  - Steroid treatment
  - Percutaneous cyst drainage
  - Surgical resection (less desirable)

Table 3. Echocardiographic Doppler indices

	Hydrops (n = 15)	Nonhydrops (n = 26)	P
Tricuspid valve			
E velocity (m/s)	0.38 ± 0.10	0.34 ± 0.04	0.13
A velocity (m/s)	0.46 ± 0.11	0.50 ± 0.05	0.27
E/A ratio	0.78 ± 0.15	0.66 ± 0.12	0.03
Mitral valve			
E velocity (m/s)	0.42 ± 0.11	0.28 ± 0.04	0.001
A velocity (m/s)	0.59 ± 0.16	0.44 ± 0.10	0.34
E/A ratio	0.84 ± 0.14	0.65 ± 0.10	0.0001
Inferior vena cava			
Peak velocity (m/s)	0.44 ± 0.14	0.33 ± 0.12	0.06
S/D ratio	1.59 ± 0.43	1.72 ± 0.31	0.34
% reversal with atrial contraction	30.0 ± 17.0	15.1 ± 6.0	0.008
Umbilical artery			
$Velocity_{max}$ (m/s)	0.31 ± 0.17	0.35 ± 0.09	0.60
S/D ratio	4.72 ± 1.15	3.90 ± 1.05	0.30
Pulsatility index	1.55 ± 0.42	1.28 ± 0.21	0.07

E, early ventricular filling; A, atrial contraction; S, systolic; D, diastolic.

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Mahle et al, UOG 2000

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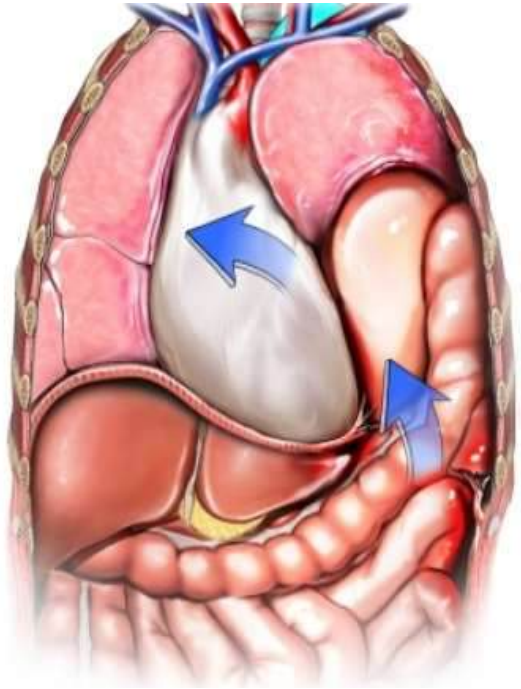
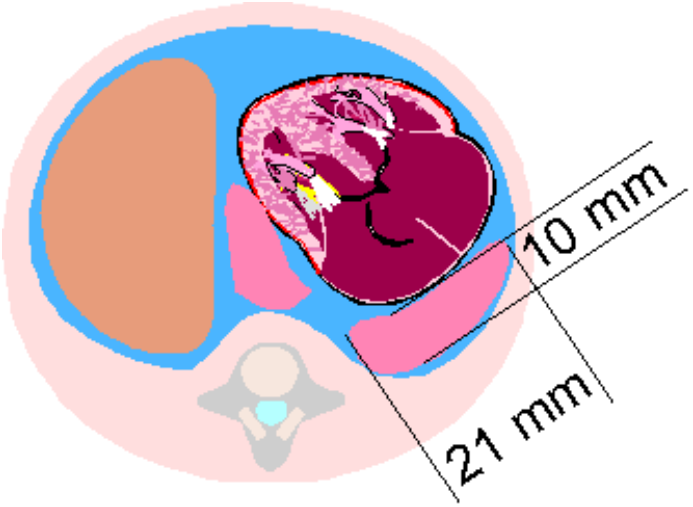
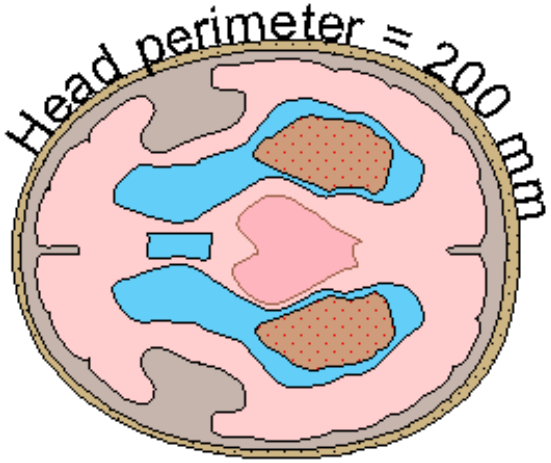
Pulmonary Hypoplasia: Congenital diaphragmatic hernia

- Outcomes correlate with degree of pulmonary hypoplasia
- Prognostication:
  - Lung to Head ratio (LHR)- ultrasound
  - Lung volumes- MRI







LHR

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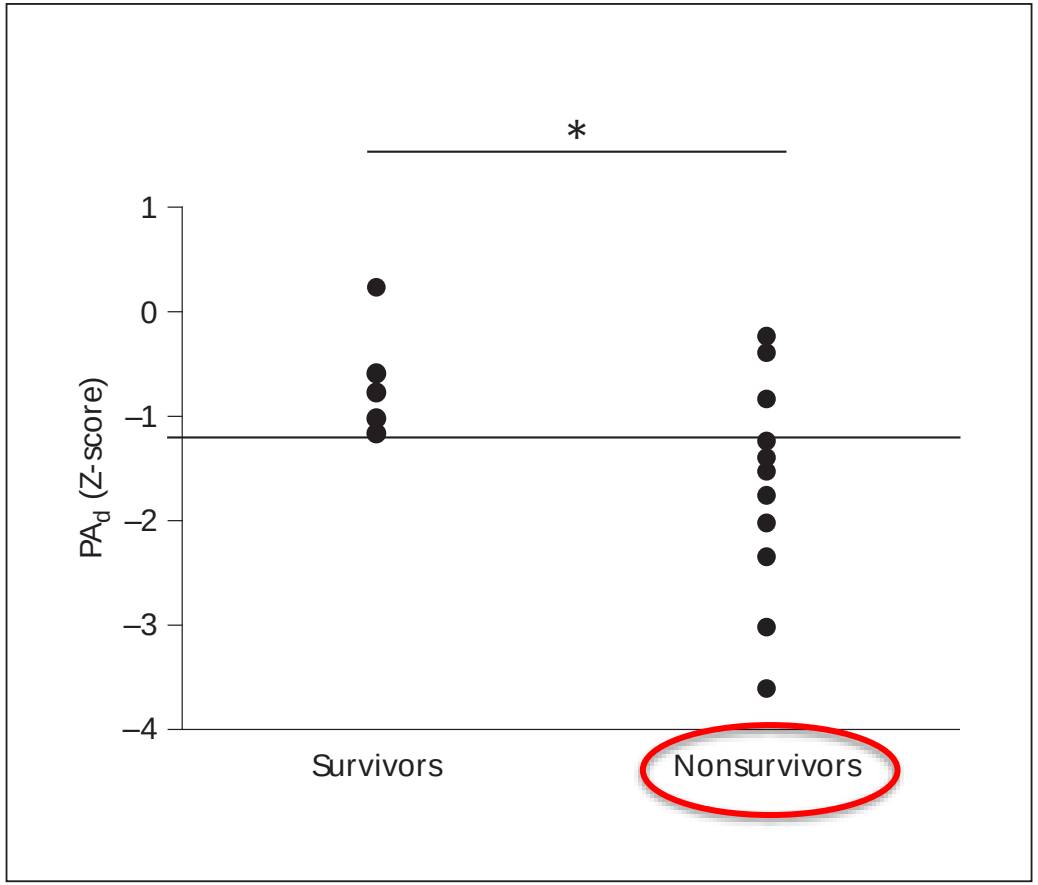
Assessment of pulmonary vasculature in CDH: Aid in prognosis



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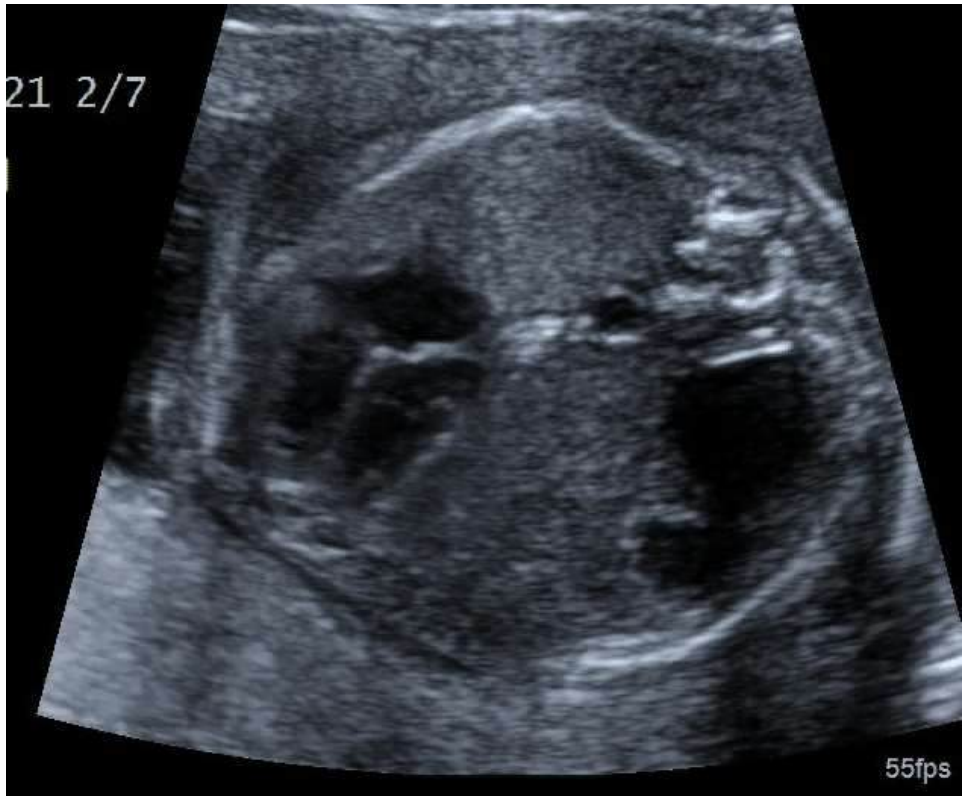
Derderian et al, 2015

CDH and the left heart

- Association of left CDH and left heart hypoplasia
- Thought to be due to compression (Allan), altered venous return to heart (Kohl), lung hypoplasia
- Resolves after birth (Vogel)



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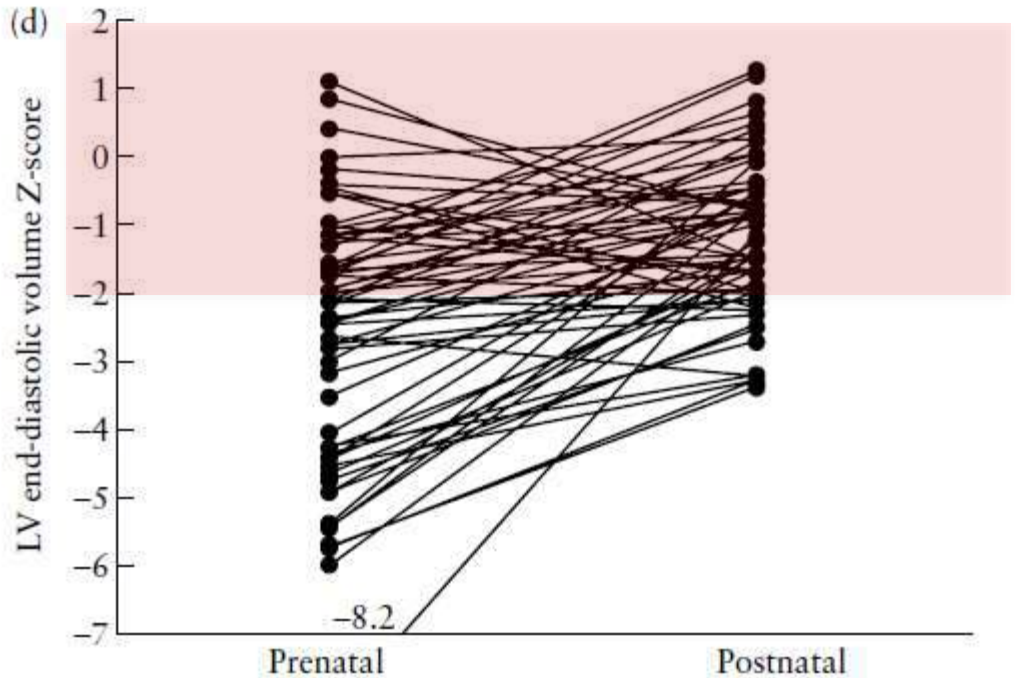
Ultrasound Obstet Gynecol 2010; 35: 310–317
Published online 8 February 2010 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/uog.7497

Significance and outcome of left heart hypoplasia in fetal congenital diaphragmatic hernia

M. VOGEL*, D. B. McELHINNEY*, E. MARCUS*, D. MORASH†, R. W. JENNINGS† and W. TWORETZKY*

**Departments of Cardiology, Children's Hospital Boston and Pediatrics, Harvard Medical School and †Department of Surgery, Children's Hospital Boston and Harvard Medical School, Boston, MA, USA*



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CDH and the “cardiovascular system”

Variable	Controls (*n* = 27)	Left CDH (*n* = 53)	*P**	Right CDH (*n* = 11)	*P*†
CCOi (mL/min/kg)	364.2 (308.4–420.0)	414.5 (378.2–450.0)	0.17	366.5 (240.3–492.7)	0.9
LVCO (% of CCO)	38 (33–42)	32 (29–35)	0.04	42 (34–50)	0.26
RVCO (% of CCO)	62 (58–66)	68 (65–71)	0.01	58 (50–66)	0.26

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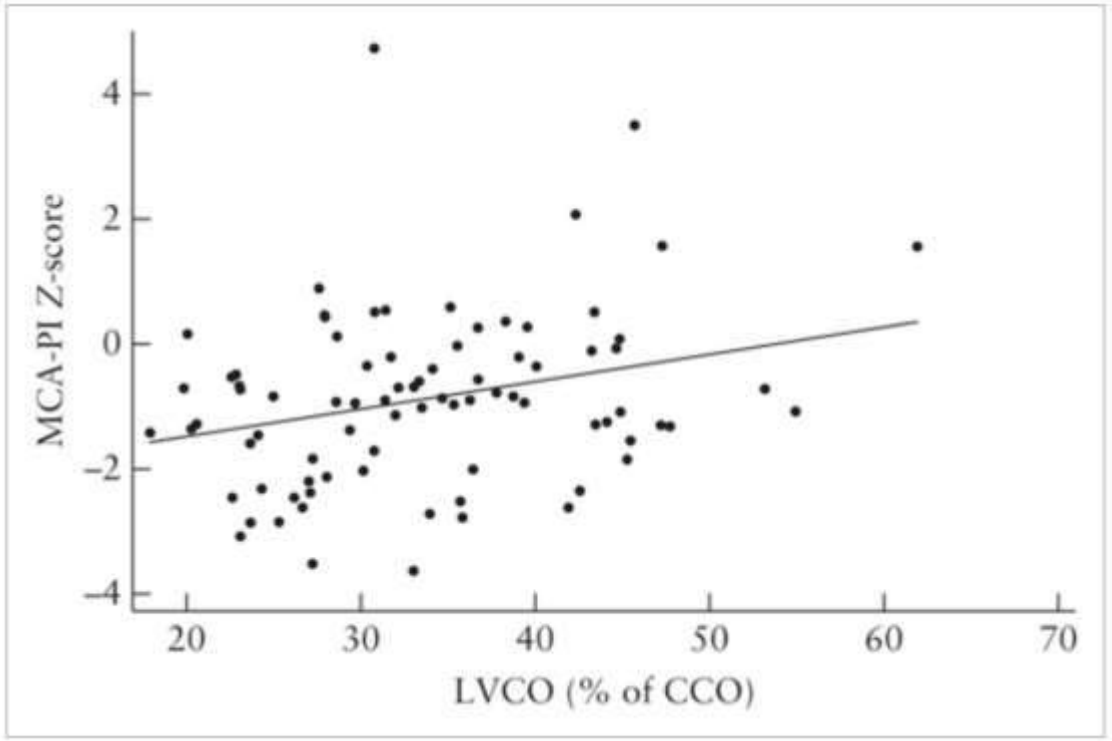
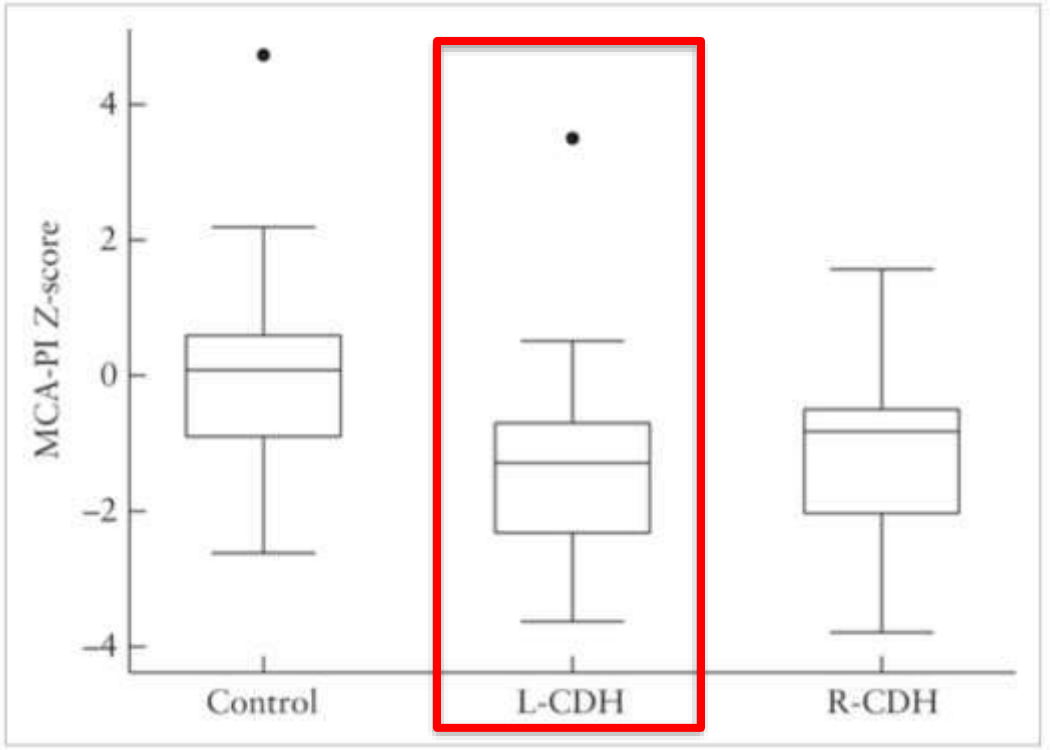
Kosiv et al, UOG 2020

CDH and the “cardiovascular system”: don’t forget about the brain





Impedance in middle cerebral artery (MCA) lower in left-CDH due to less output to the brain→ ? Compensatory mechanism + effects on Neurodevelopment?

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Thank you

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