Characterizing Form & Function of the Circulation for Decision Making:

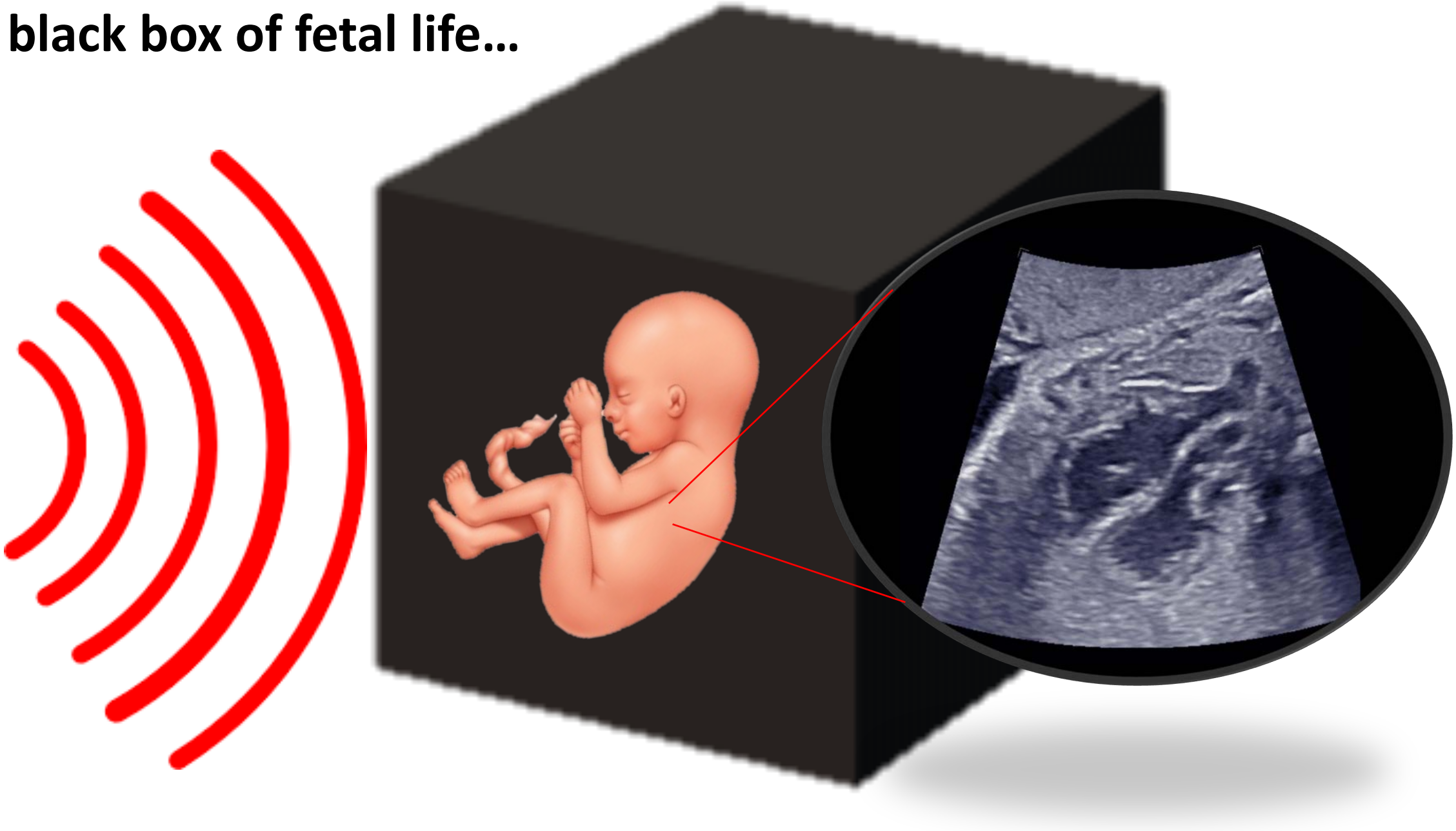
Prenatal Cardiovascular Imaging

Jack Rychik, MD

Director, Fetal Heart Program

Children's Hospital of Philadelphia

The black box of fetal life…



ECHO Provides a Tool-box

- Two-dimensional imaging
- Color Doppler
- Pulsed-wave Doppler
- Advanced modalities

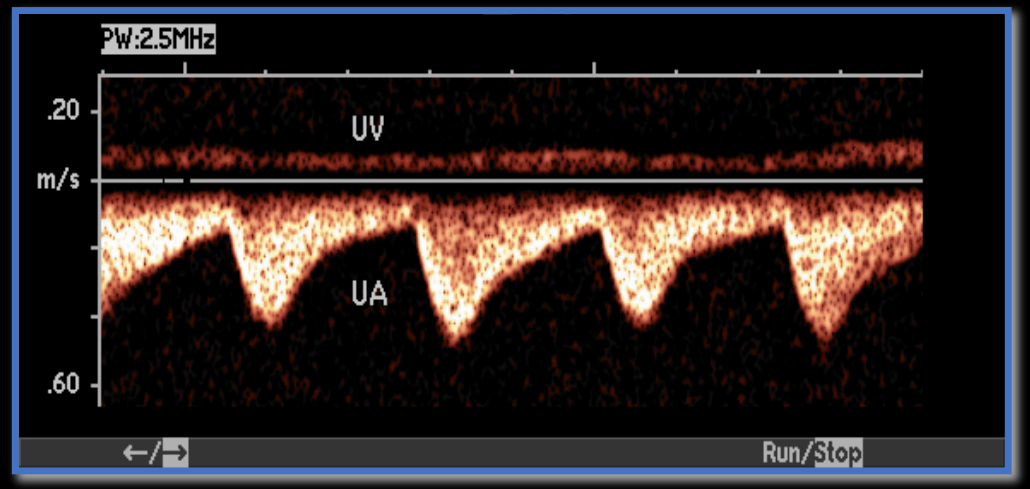
To help us understand:

- Complex anatomical configurations
- Blood flow patterns
- Features and findings that dictate strategies of care and influence outcomes

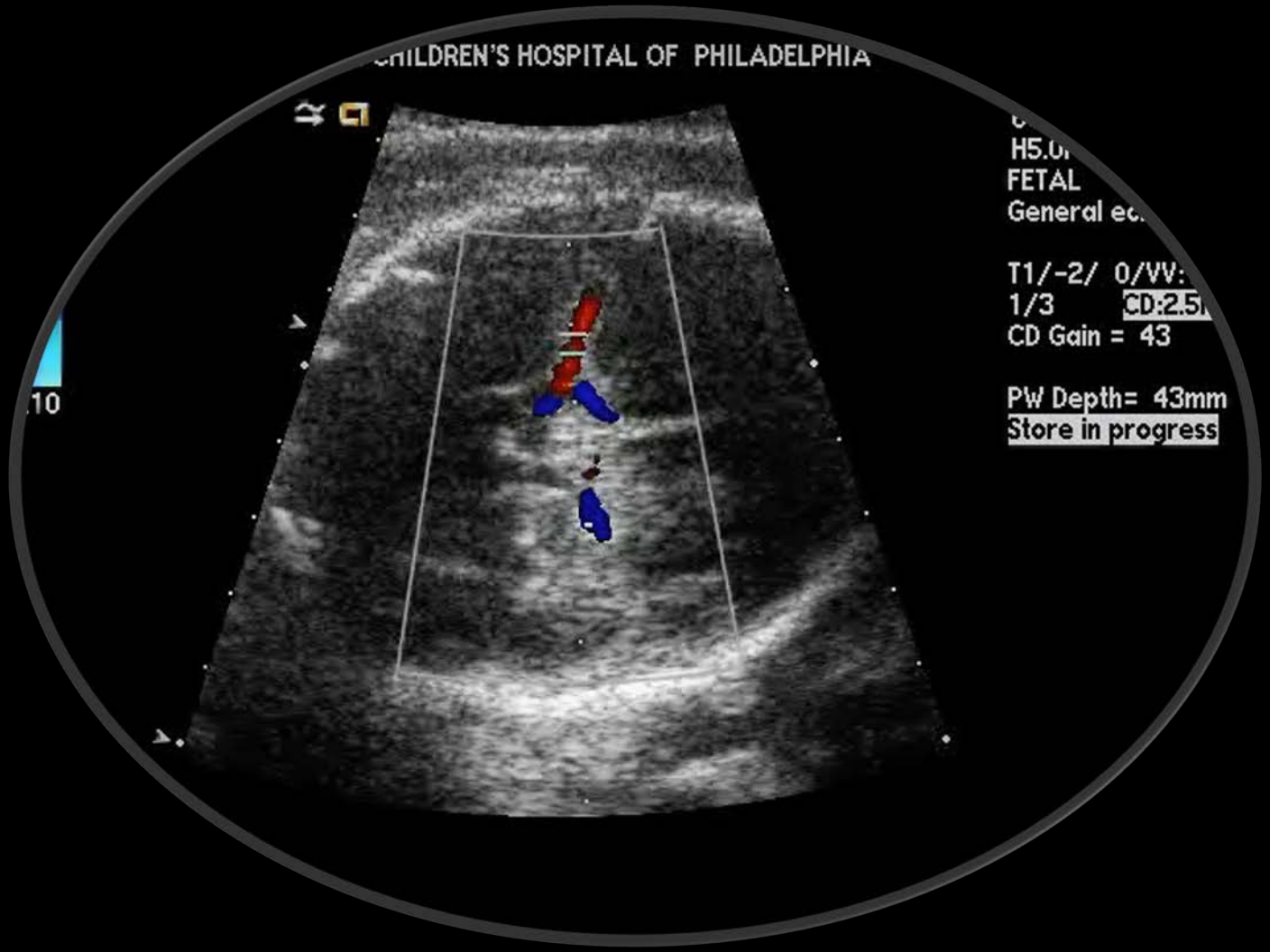
Clinical Parameters of Fetal Cardiovascular Wellness

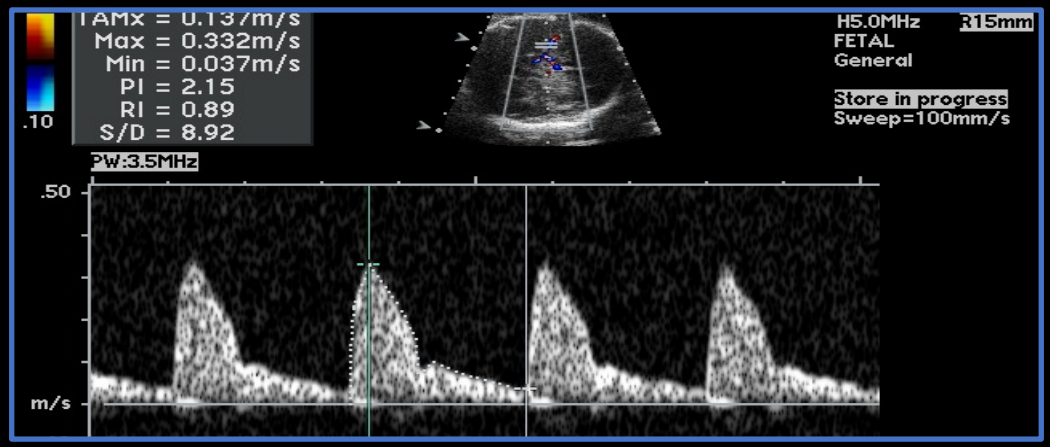
- Hydrops
- Somatic growth
- Cardiothoracic ratio
- Qualitative ventricular function
- Atrioventricular valve regurgitation
- Ventricular inflow patterns
- Umbilical Artery
- Middle Cerebral Artery
- MCA/UA CPR ratio
- Ductus venosus flow
- Umbilical venous flow
- Combined cardiac output

Umbilical Artery

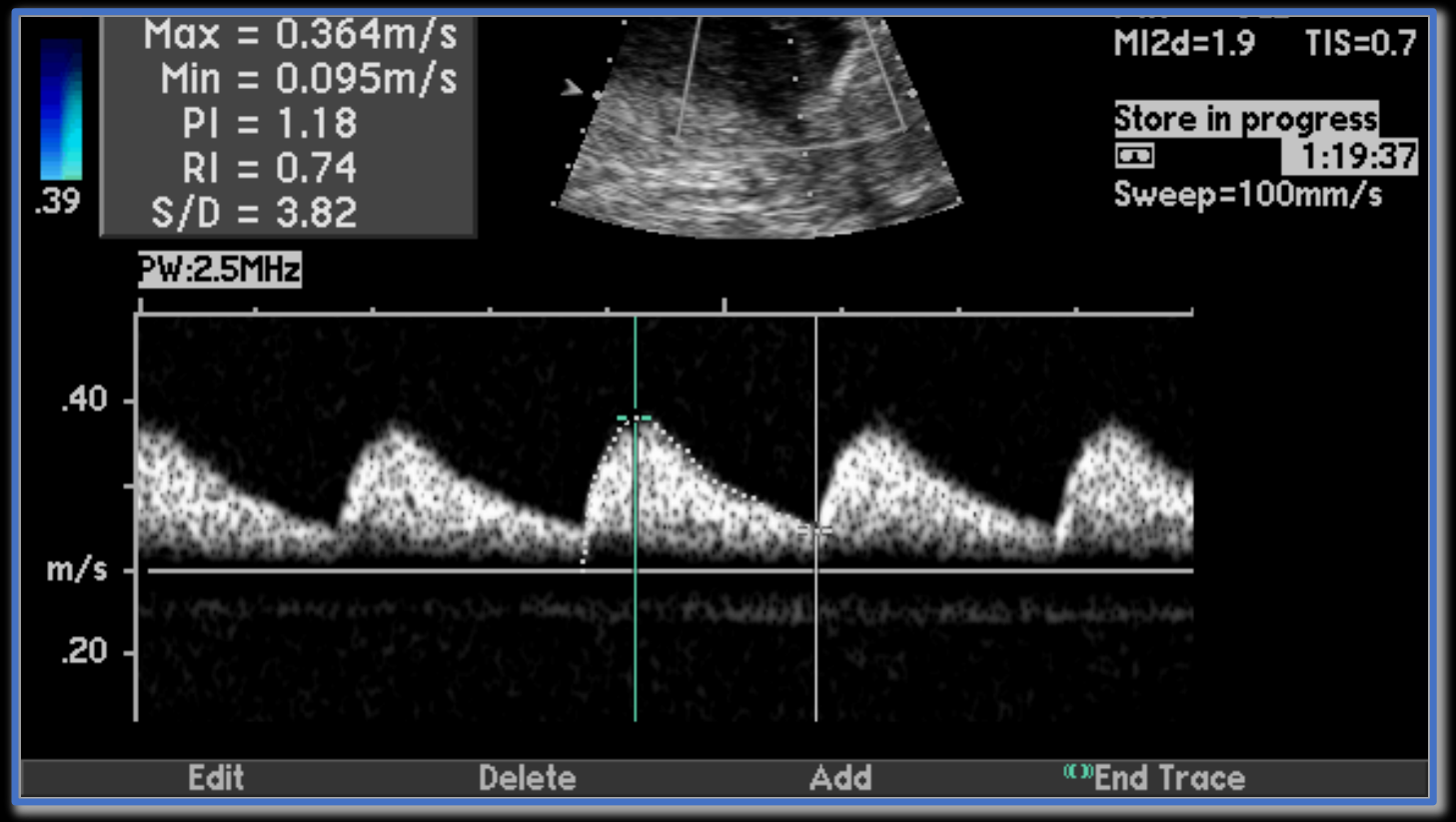


Middle Cerebral Artery





Pulsatility Index

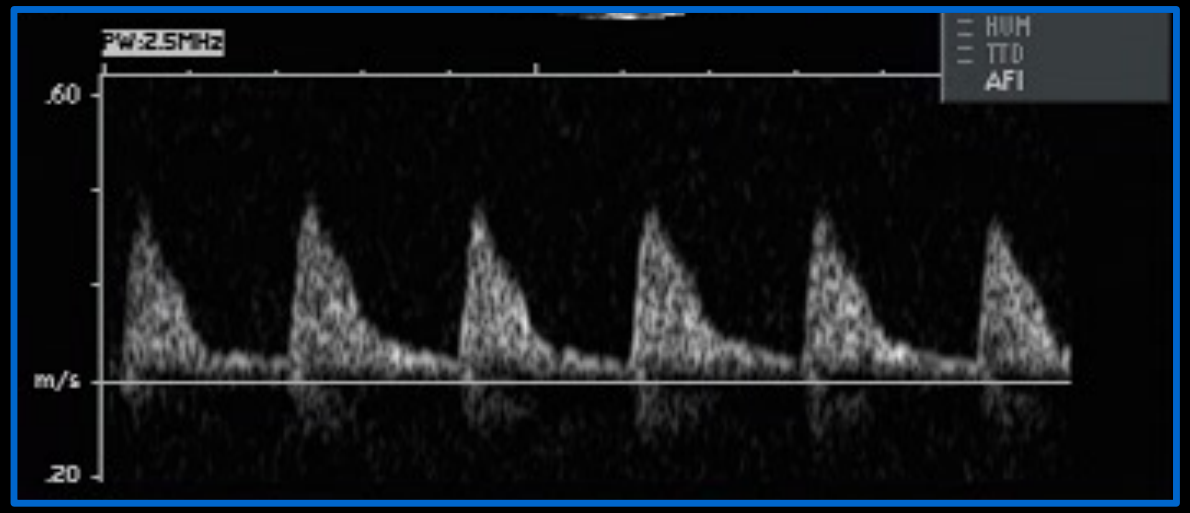


Max Velocity – Min Velocity

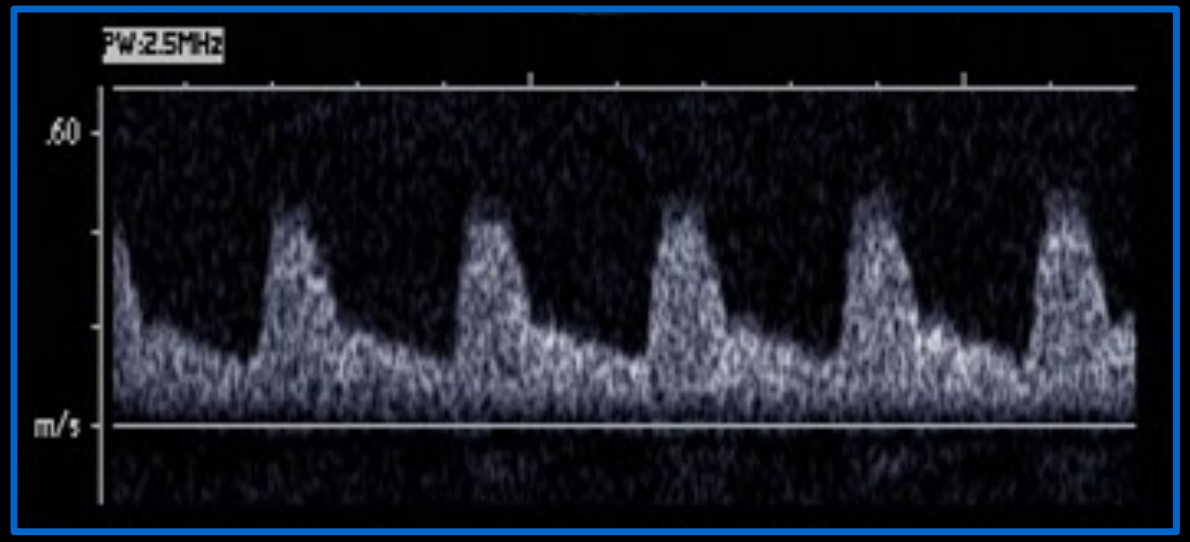
Mean Velocity

Middle Cerebral Artery Flow Patterns

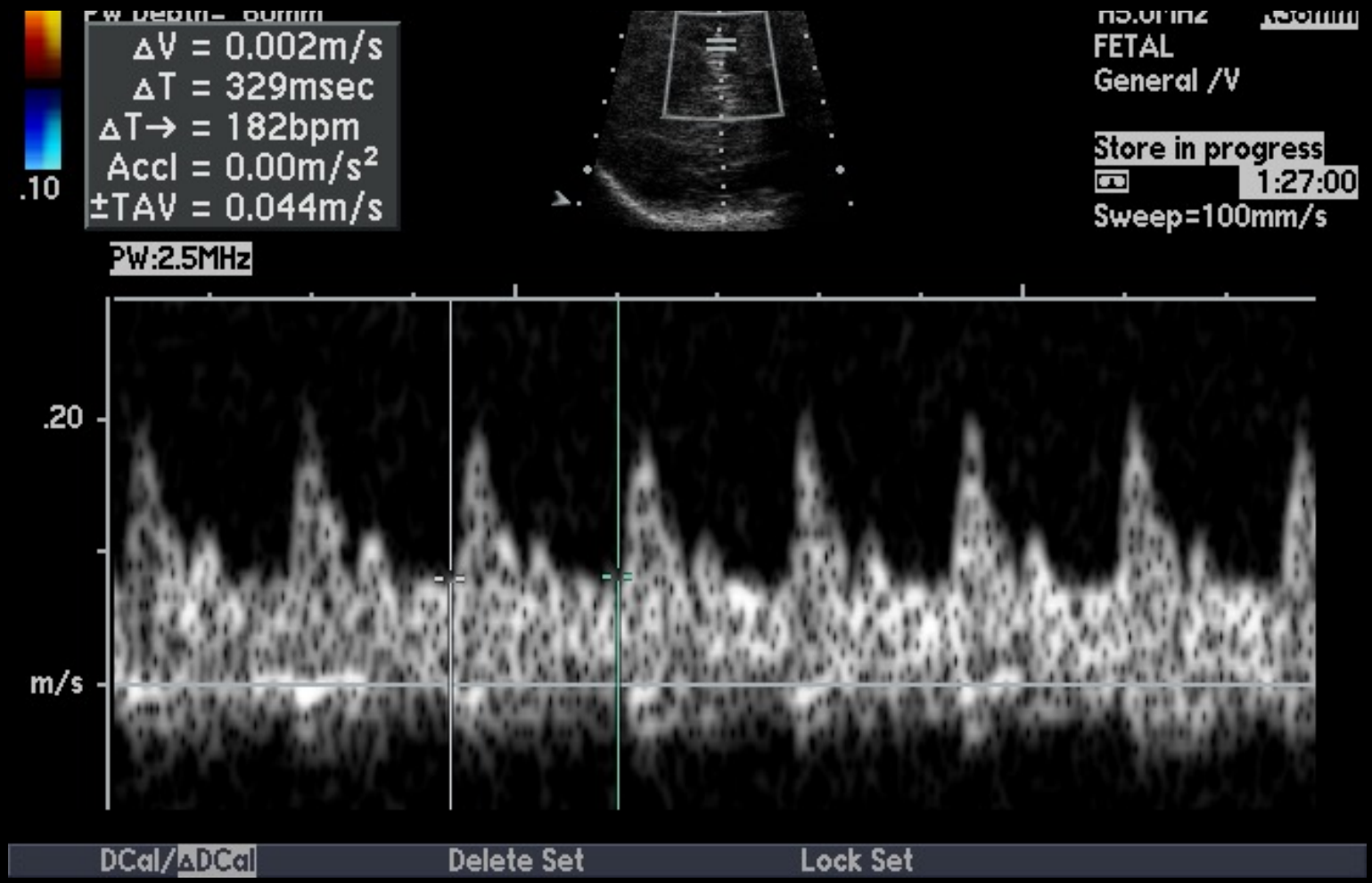
High Resistance



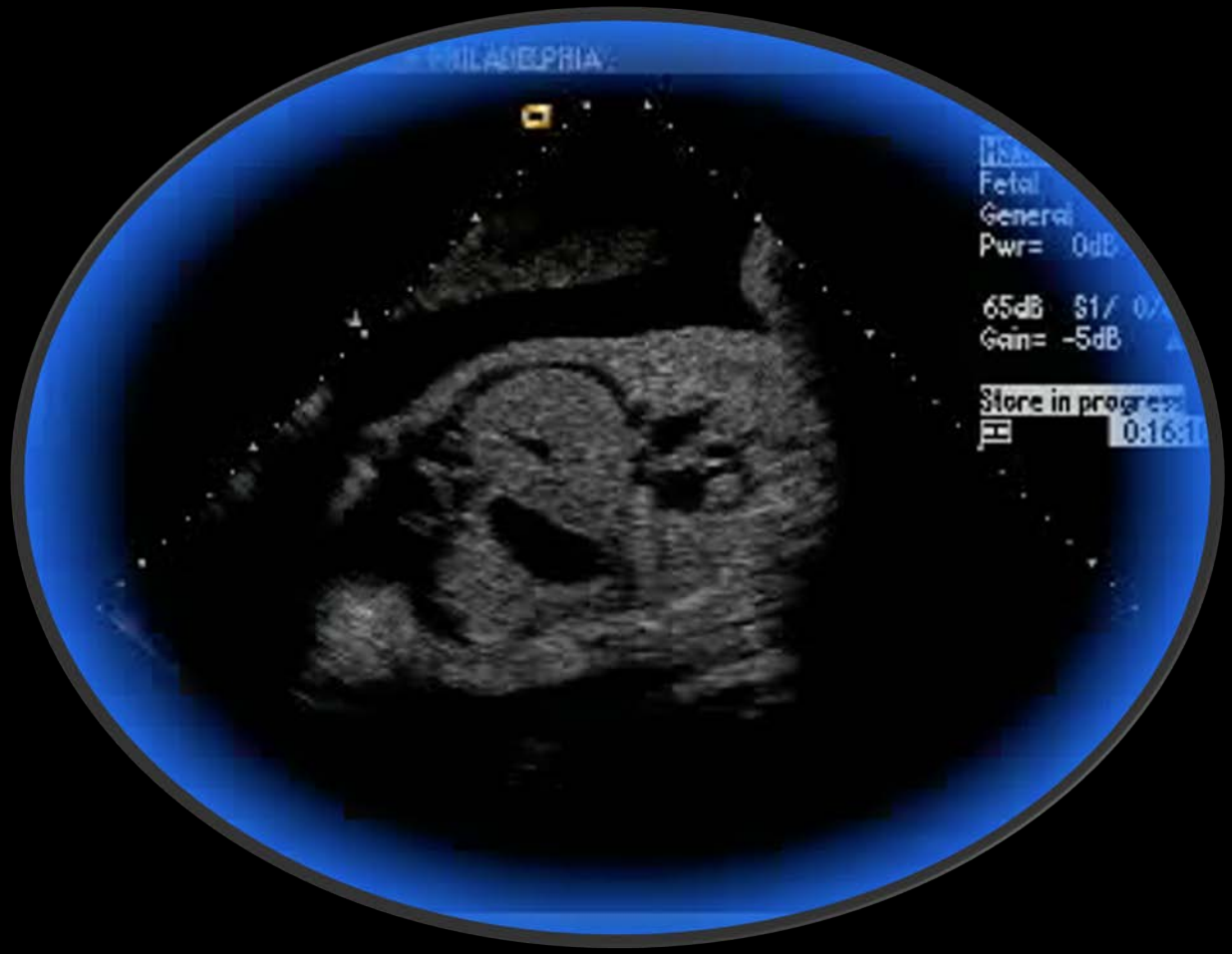
Low Resistance = “cephalization”

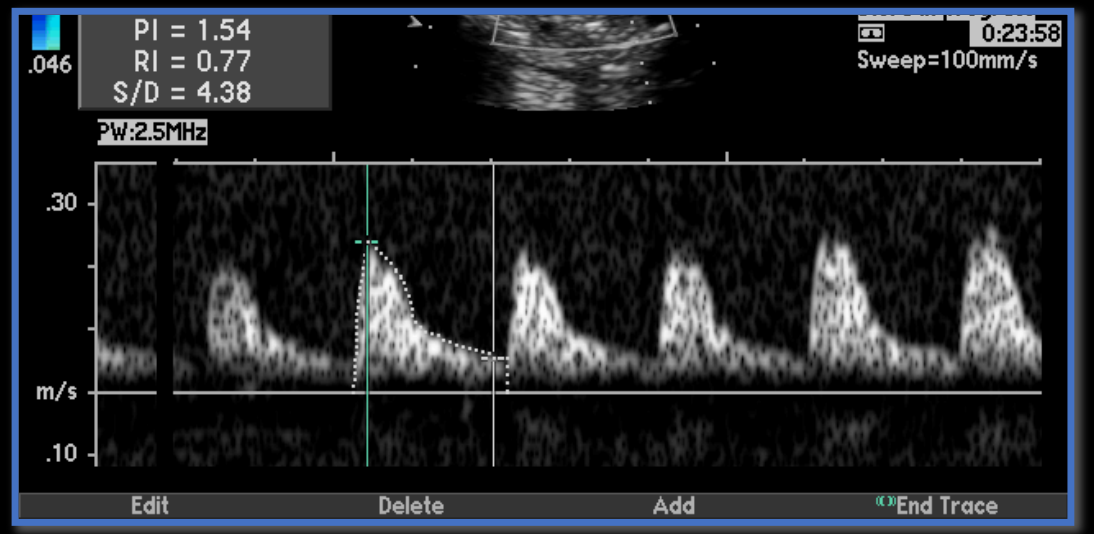


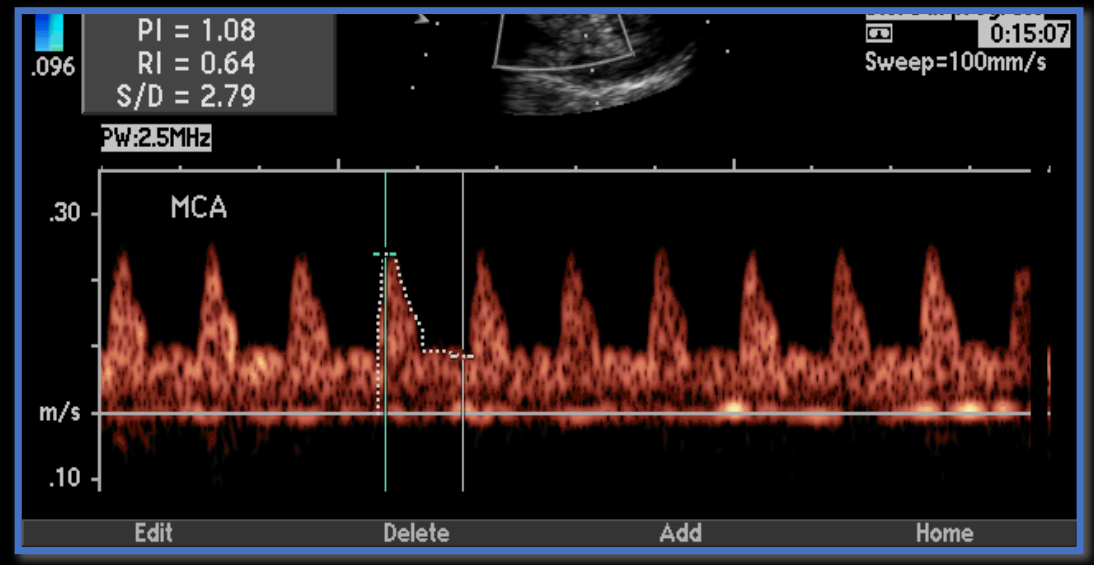
Middle Cerebral Artery Resistance “Cephalization”



Middle Cerebral Artery: Rate Dependent Variability in Vascular Resistance

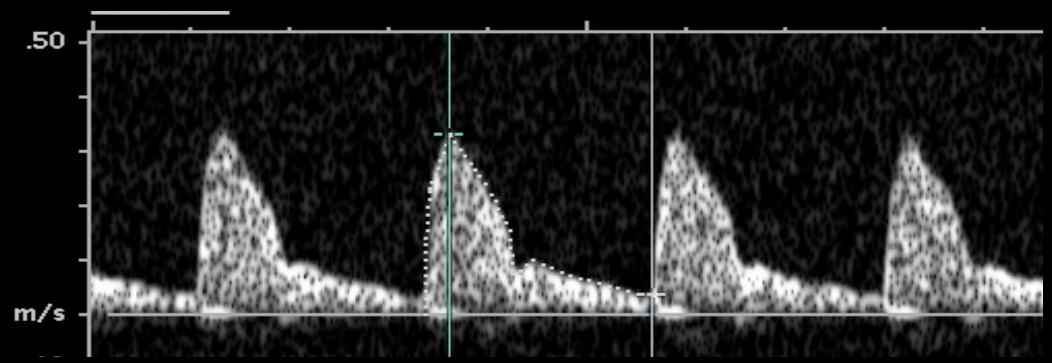


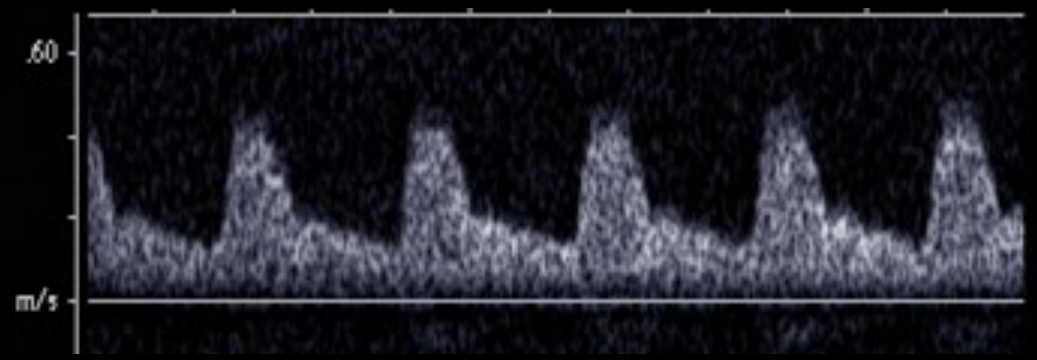




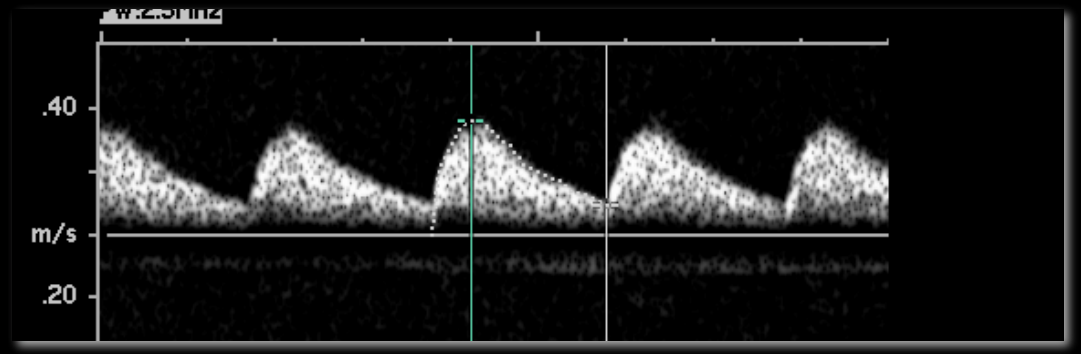
Cerebroplacental Resistance Ratio [CPR = MCA PI/UA PI]

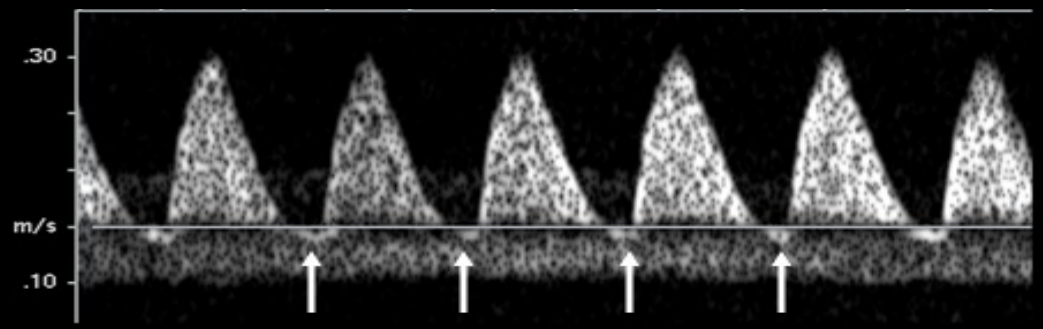
MCA





UA





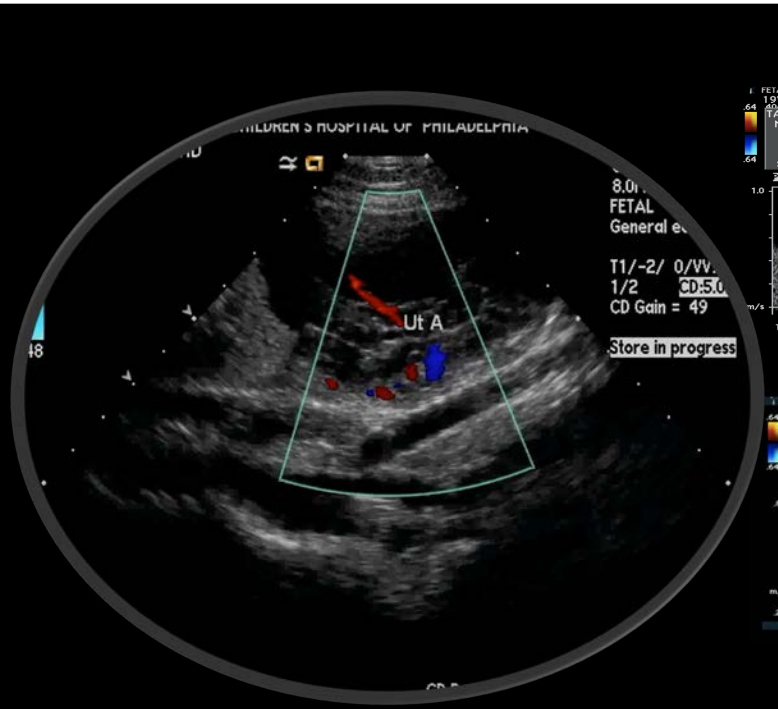
FETUS A

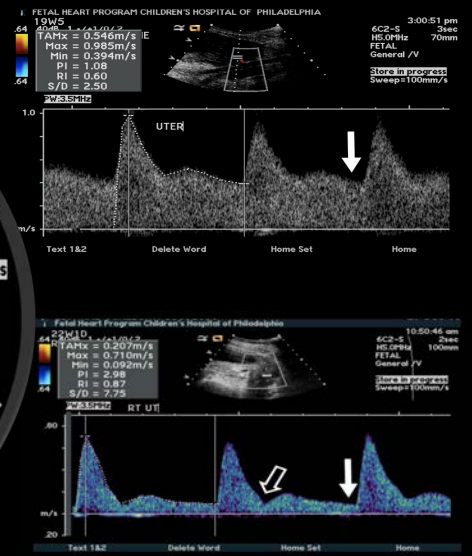
CPR > 1 = NORMAL

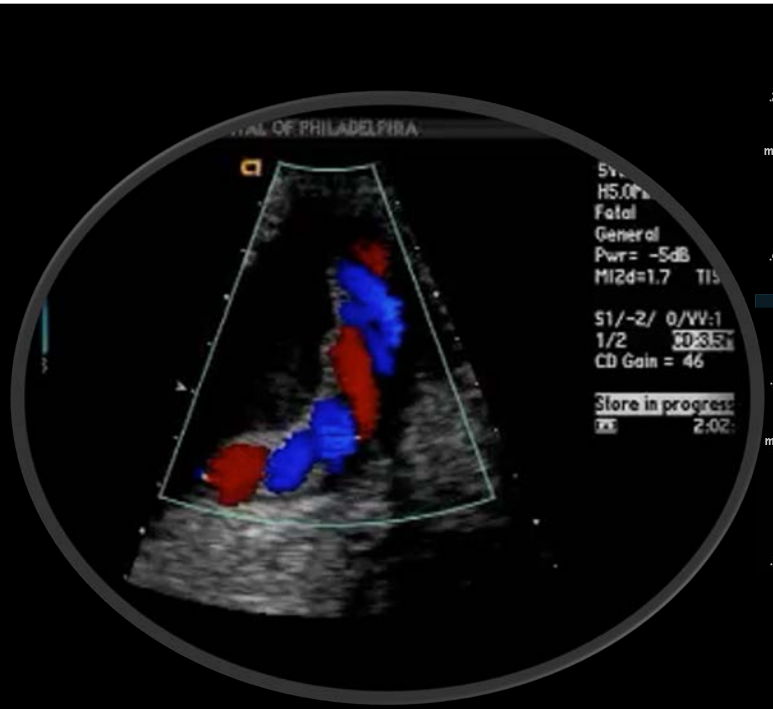
FETUS B

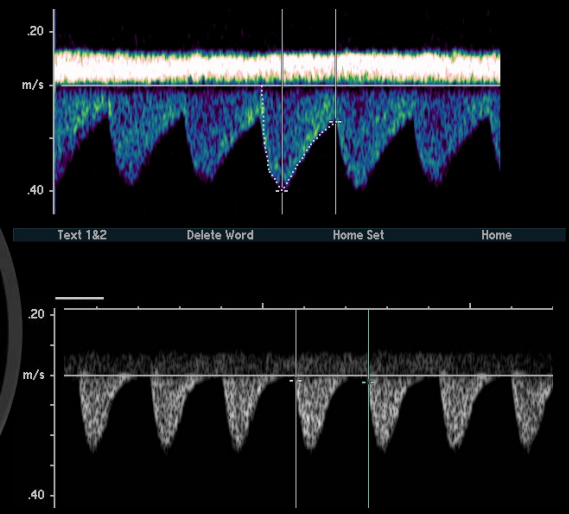
CPR < 1 = ABNORMAL

Placental Blood Flow Assessments: Maternal & Fetal

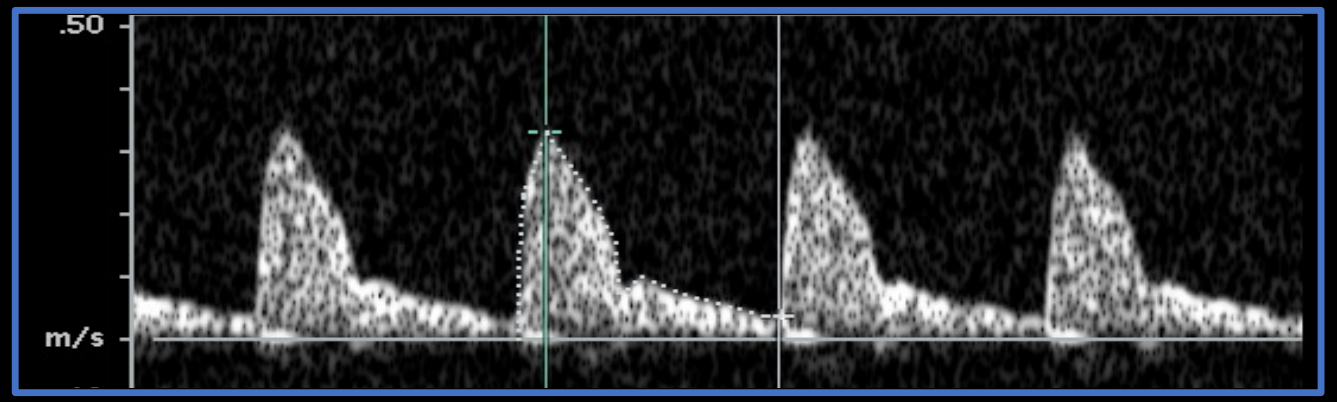




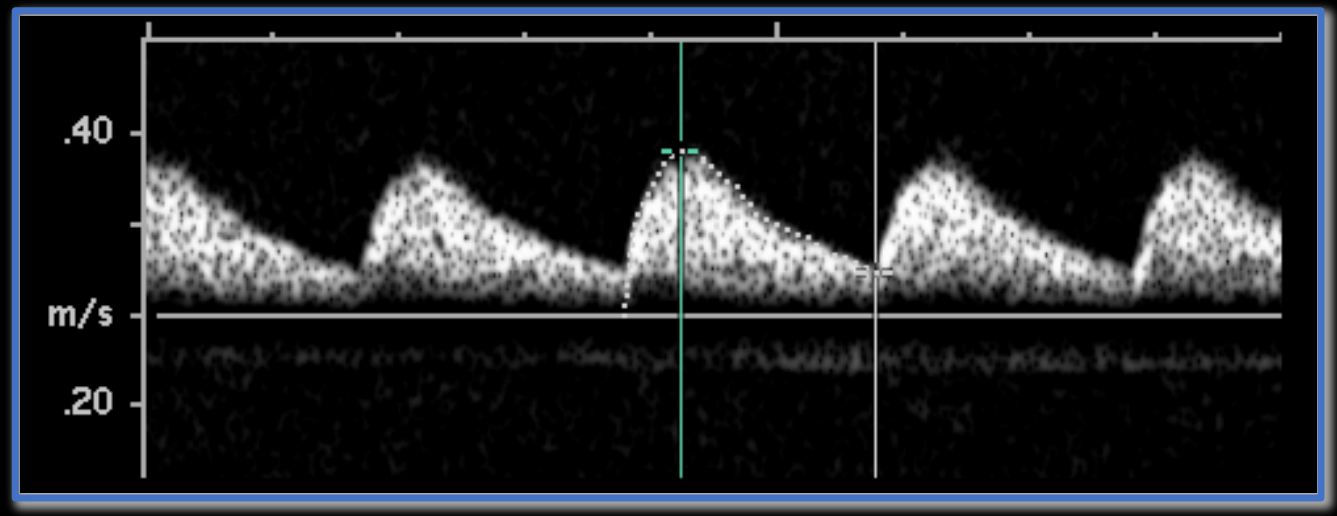




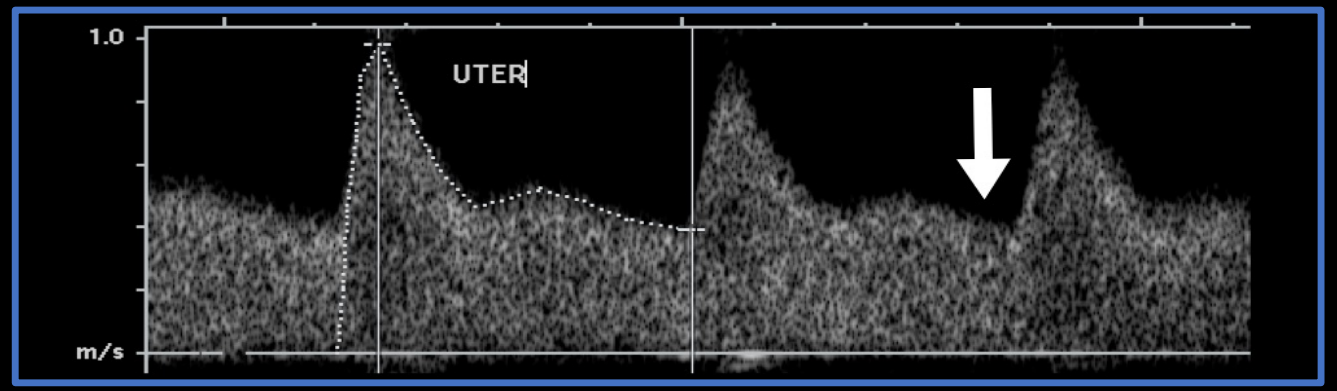
MCA



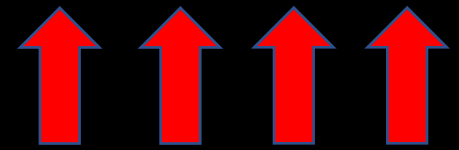
UA

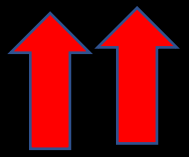


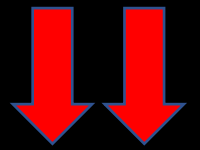
Uterine



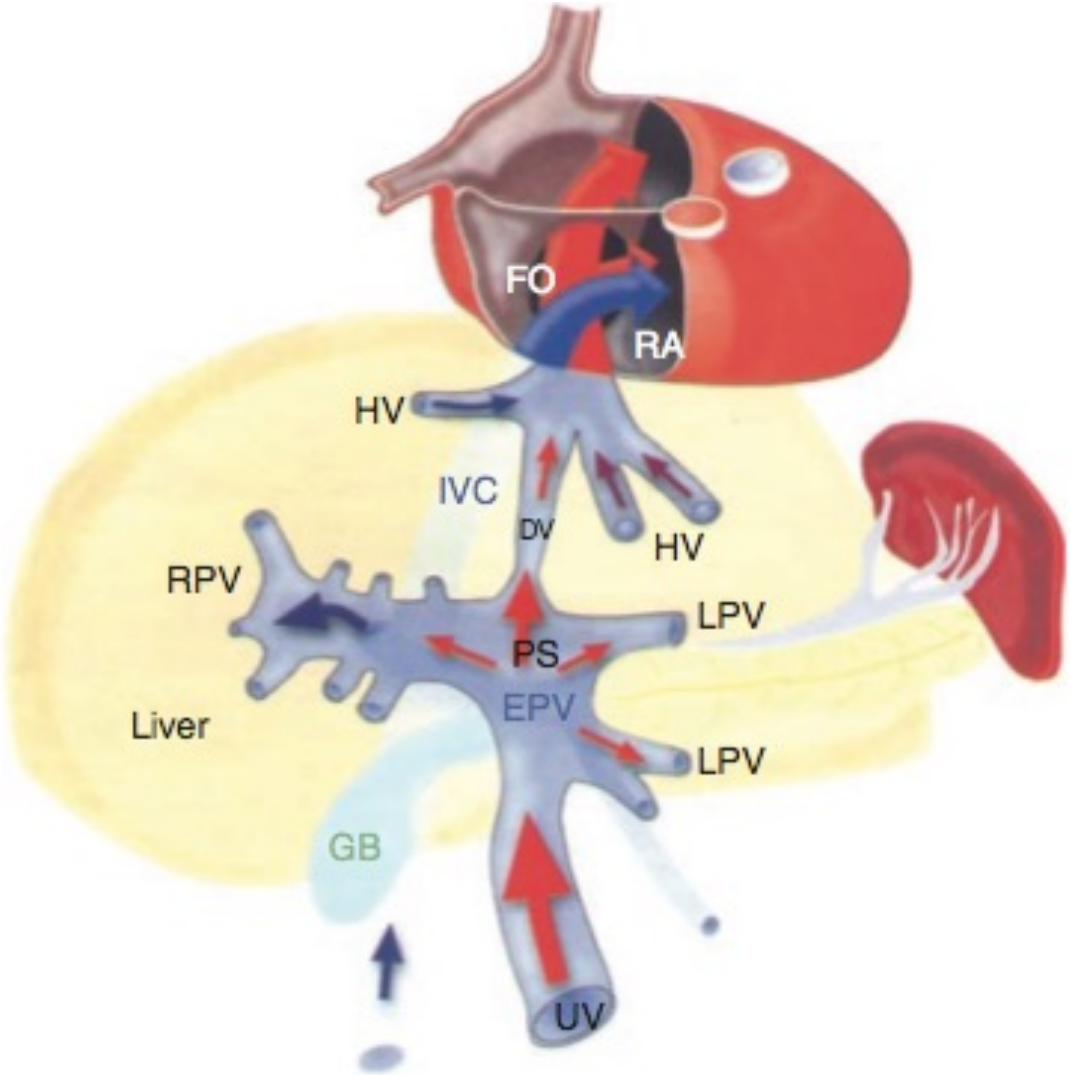
Impedance (Pulsatility Index)



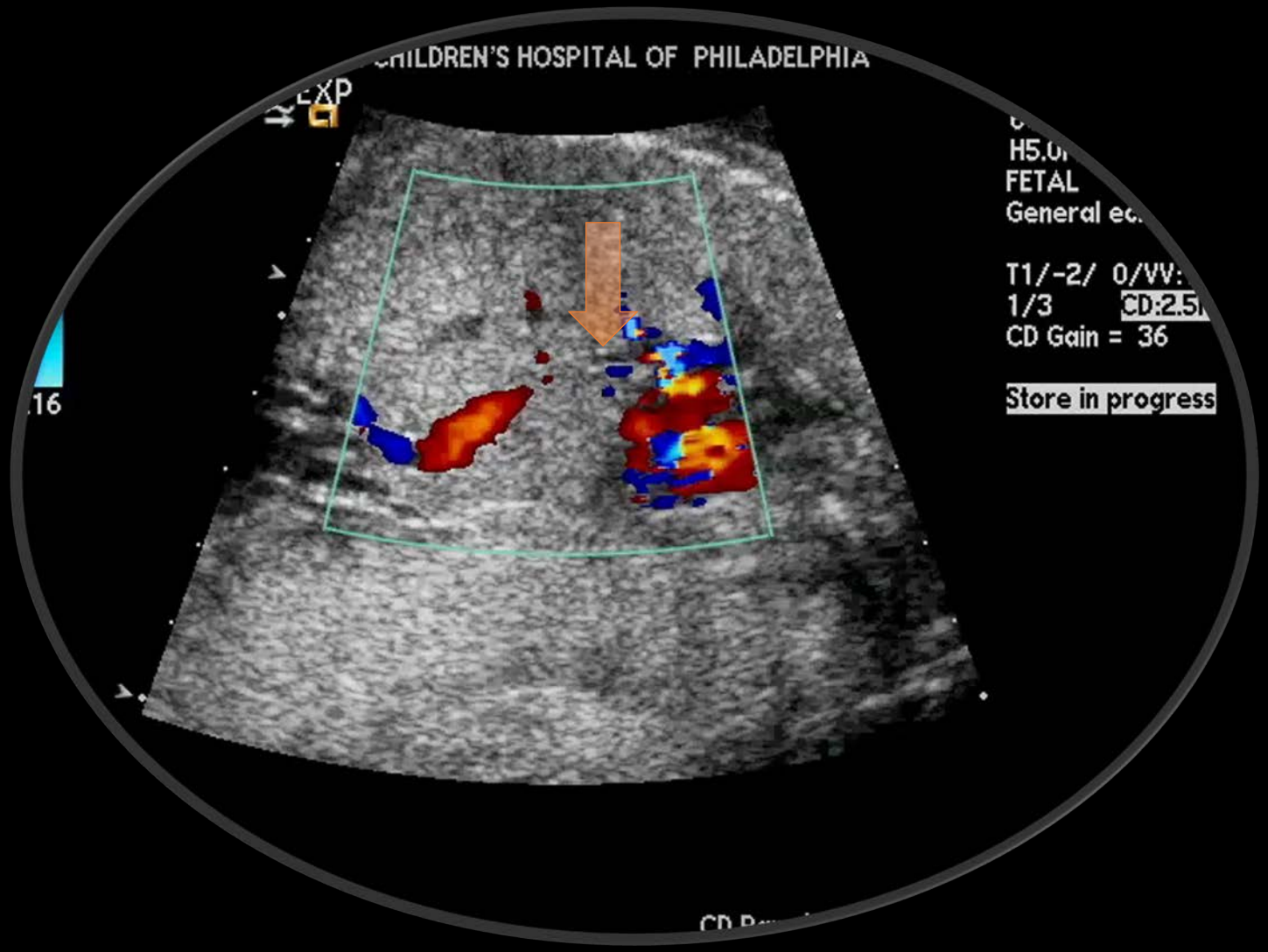




The Curious Significance of the Ductus Venosus

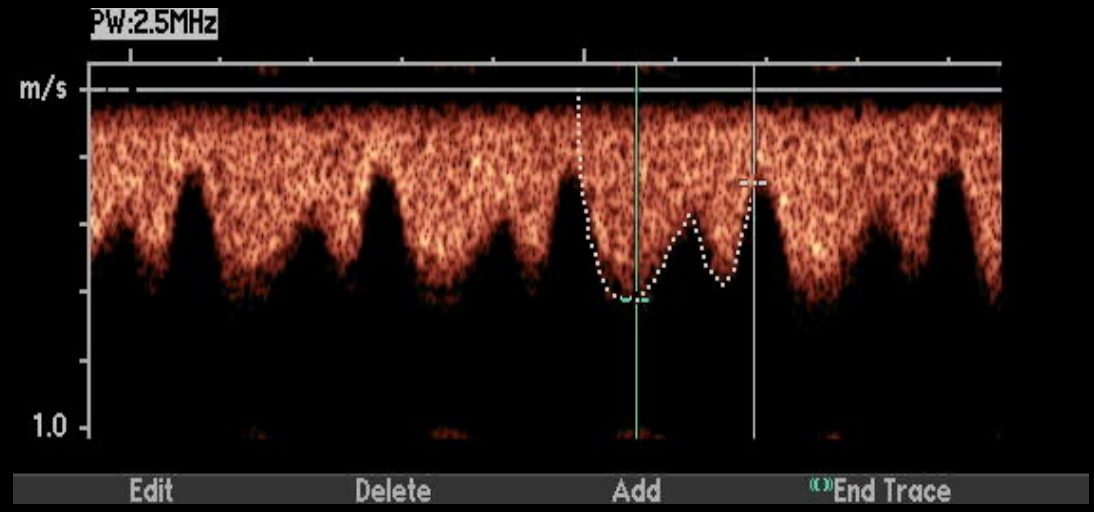


Normal: Ductus Venosus

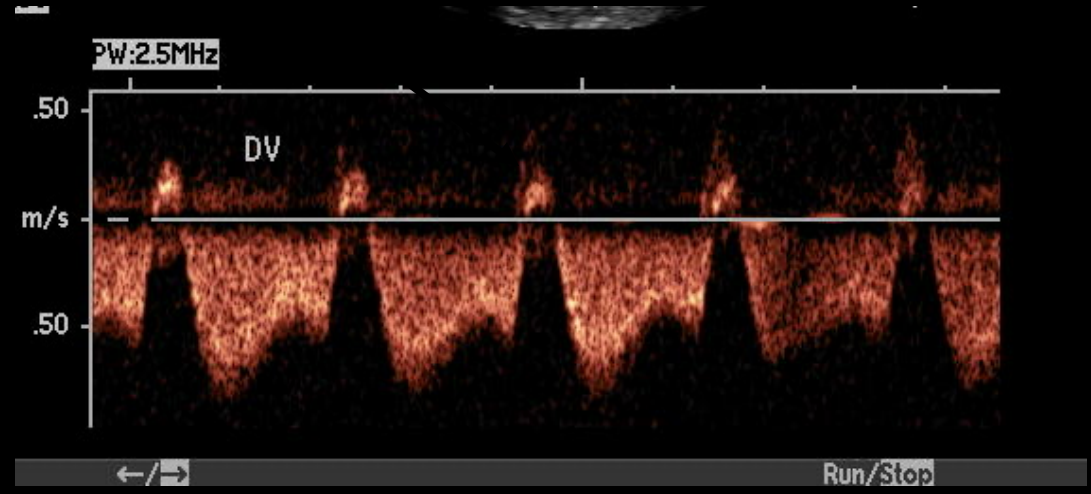


Venous Patterns: Ductus Venosus

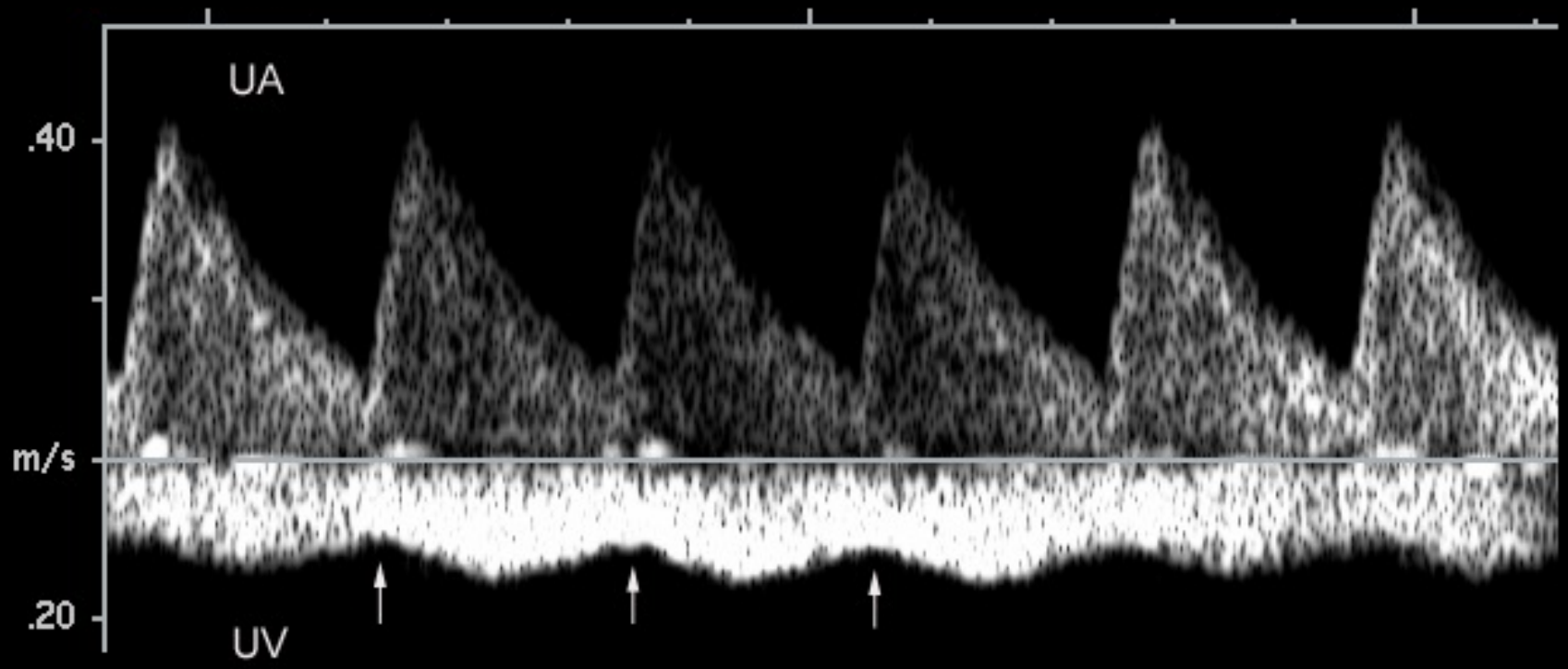
Normal



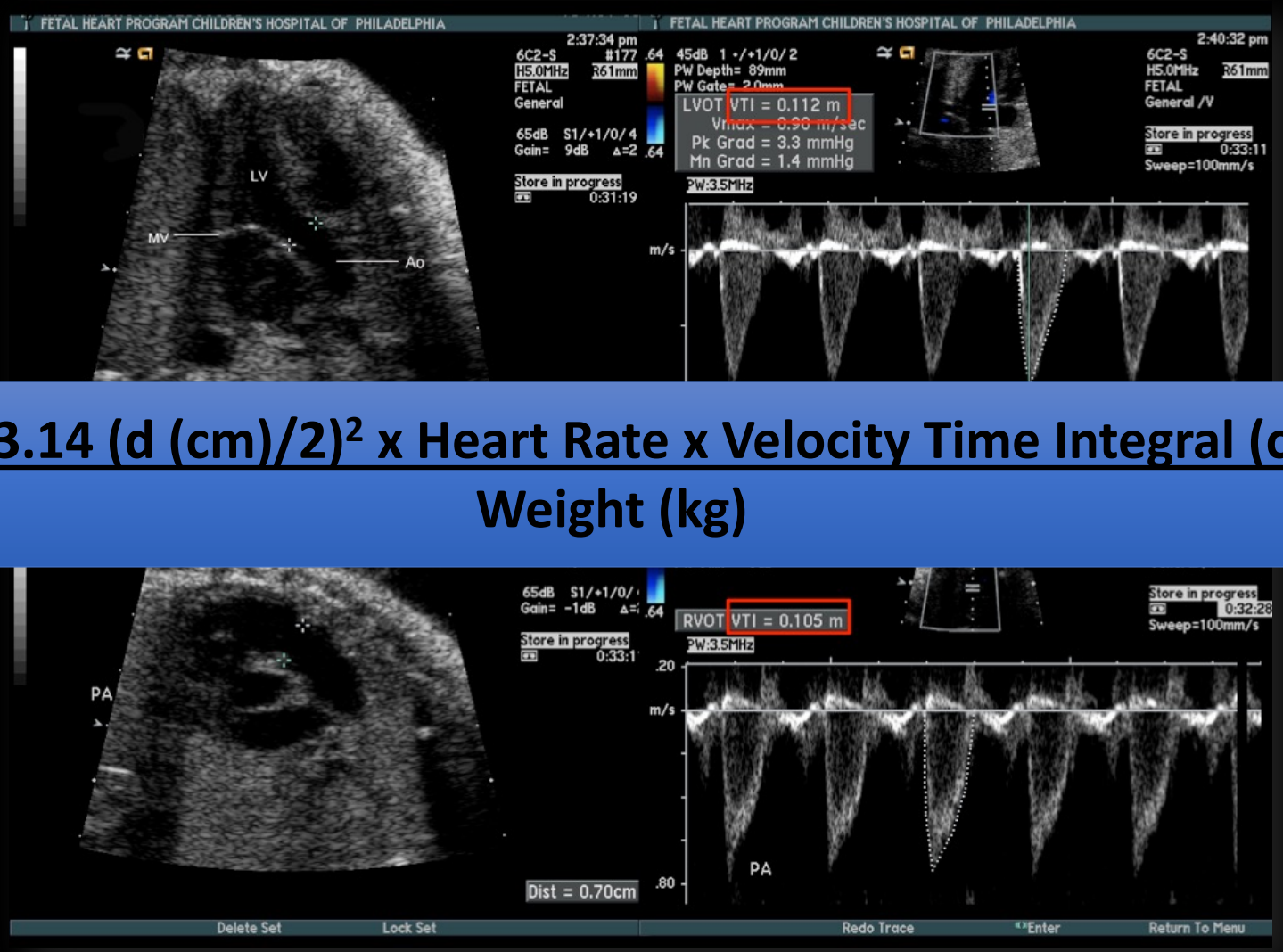
Abnormal



Umbilical Vein - Pulsations



Fetal Cardiac Output



$$CO = \frac{3.14\,(d\ (cm)/2)^2 \times \text{Heart Rate} \times \text{Velocity Time Integral (cm)}}{\text{Weight (kg)}}$$

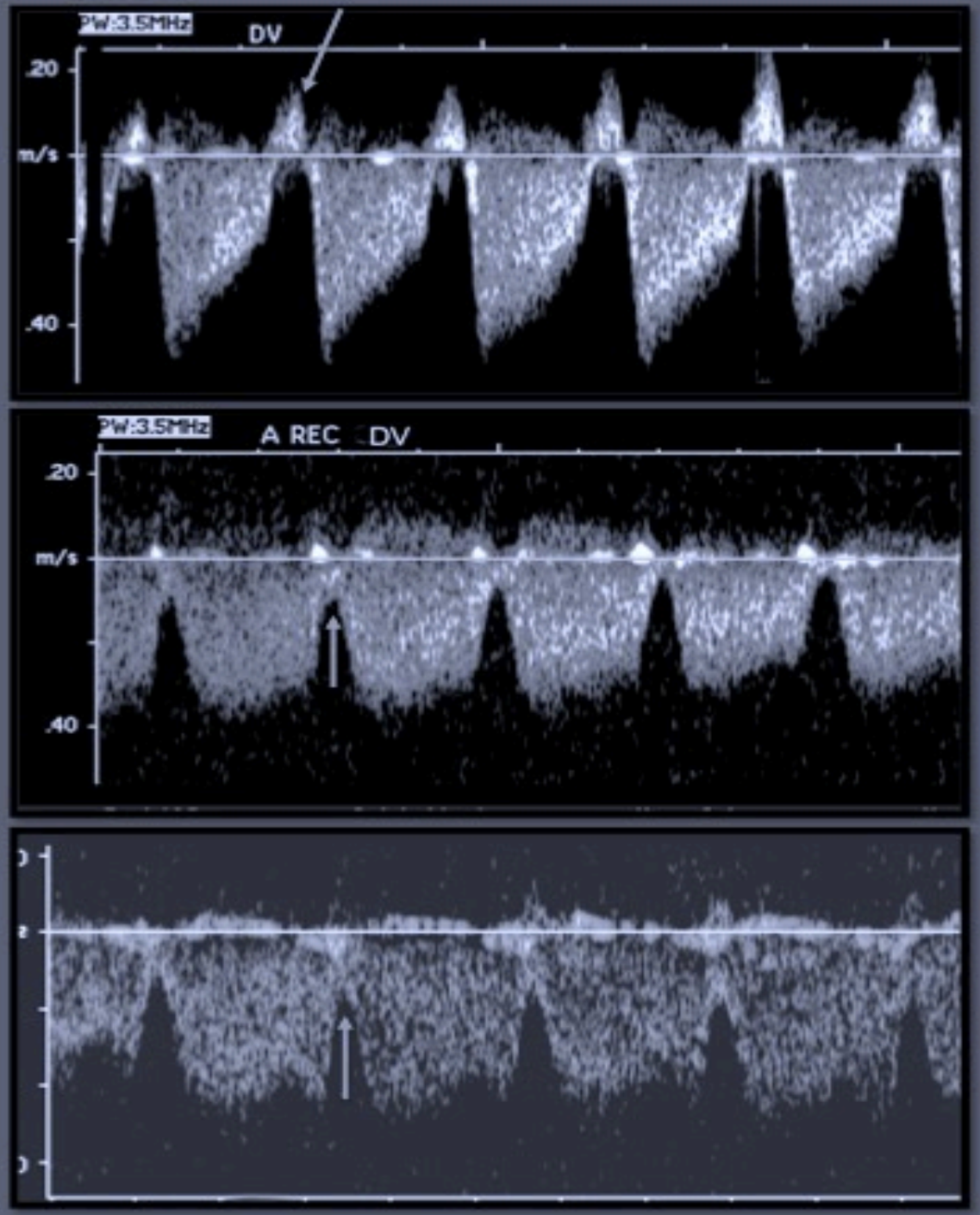
Unique Conditions

Ductus Venosus Flow

A. Before laser therapy.

B. One day after laser.

C. One week after laser.

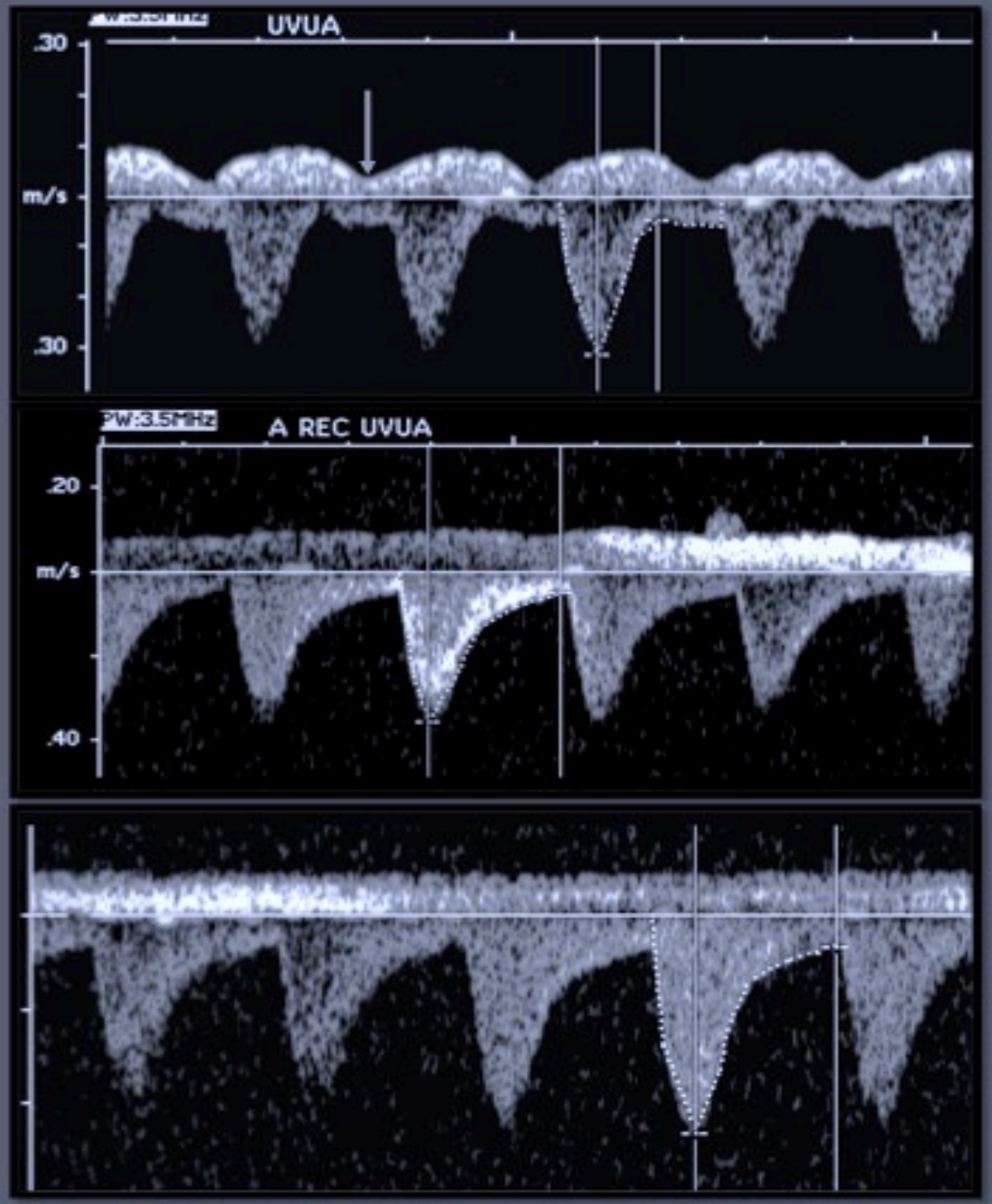


Umbilical Venous Flow

A. Before laser therapy.

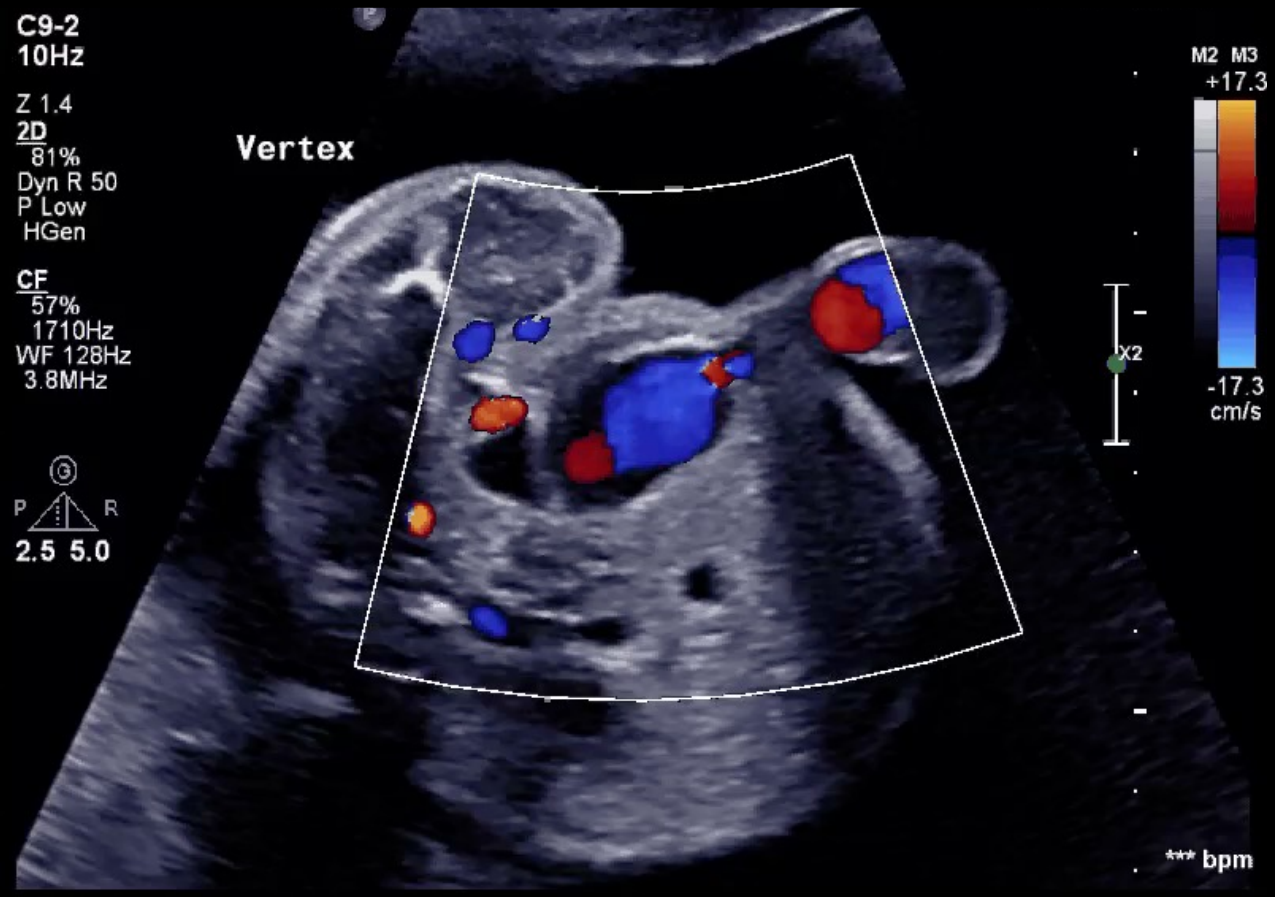
B. One day after laser.

C. One week after laser.



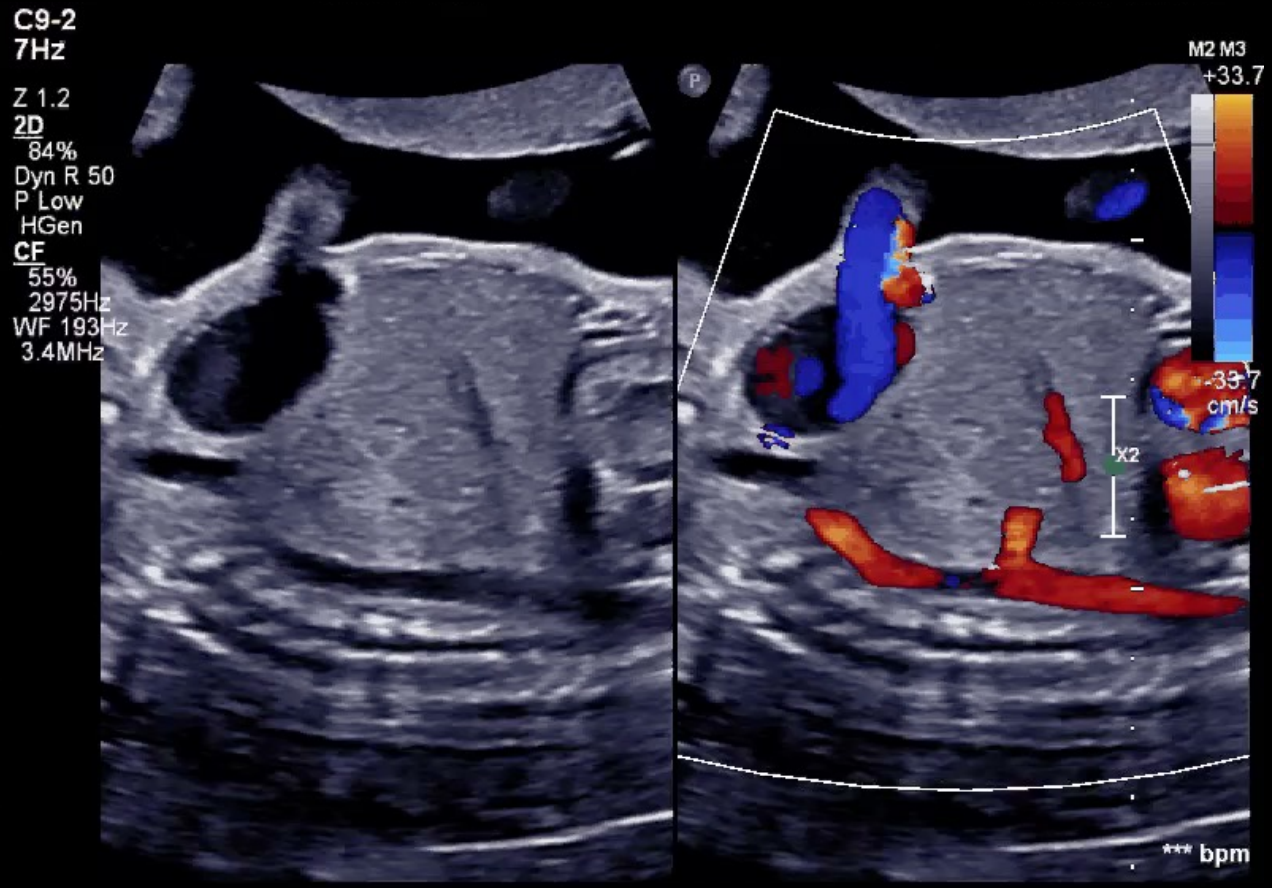
Extrahepatic ADV: UV to Iliac-Femoral Vein

UV enters the abdomen



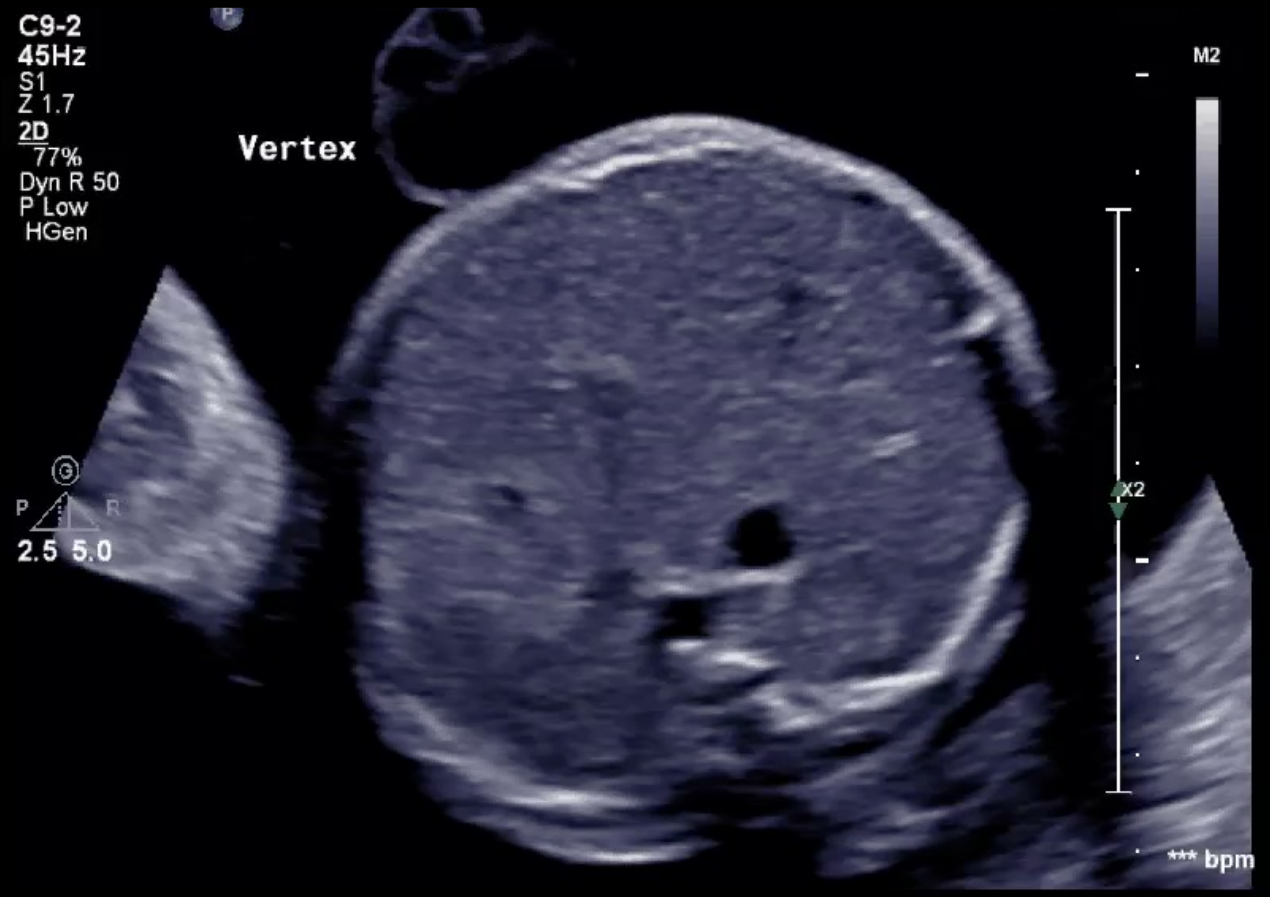
Extrahepatic ADV: UV to Iliac-Femoral Vein

UV drainage and connection to femoral vein



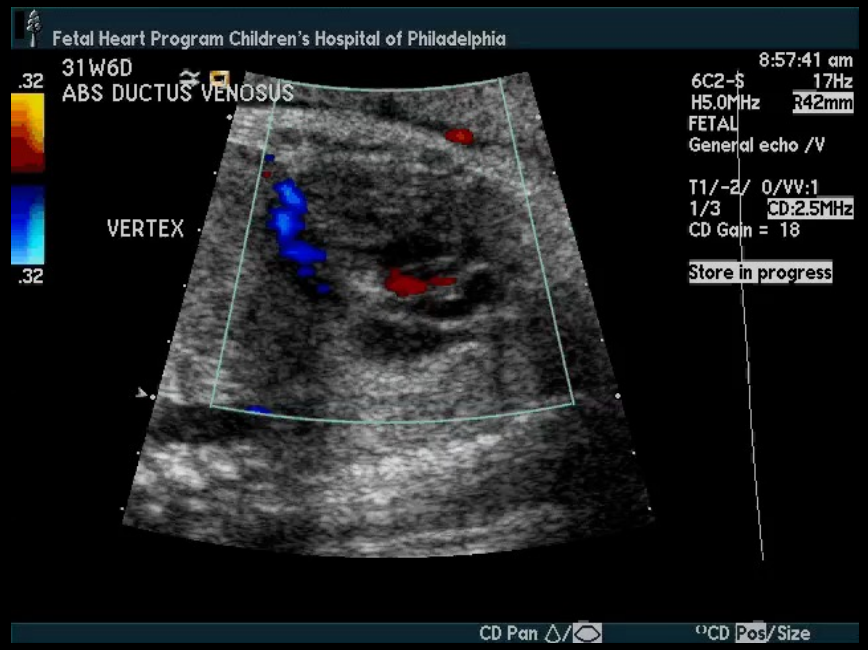
Extrahepatic ADV: UV to Iliac-Femoral Vein

severe cardiomegaly



UV to Coronary Sinus

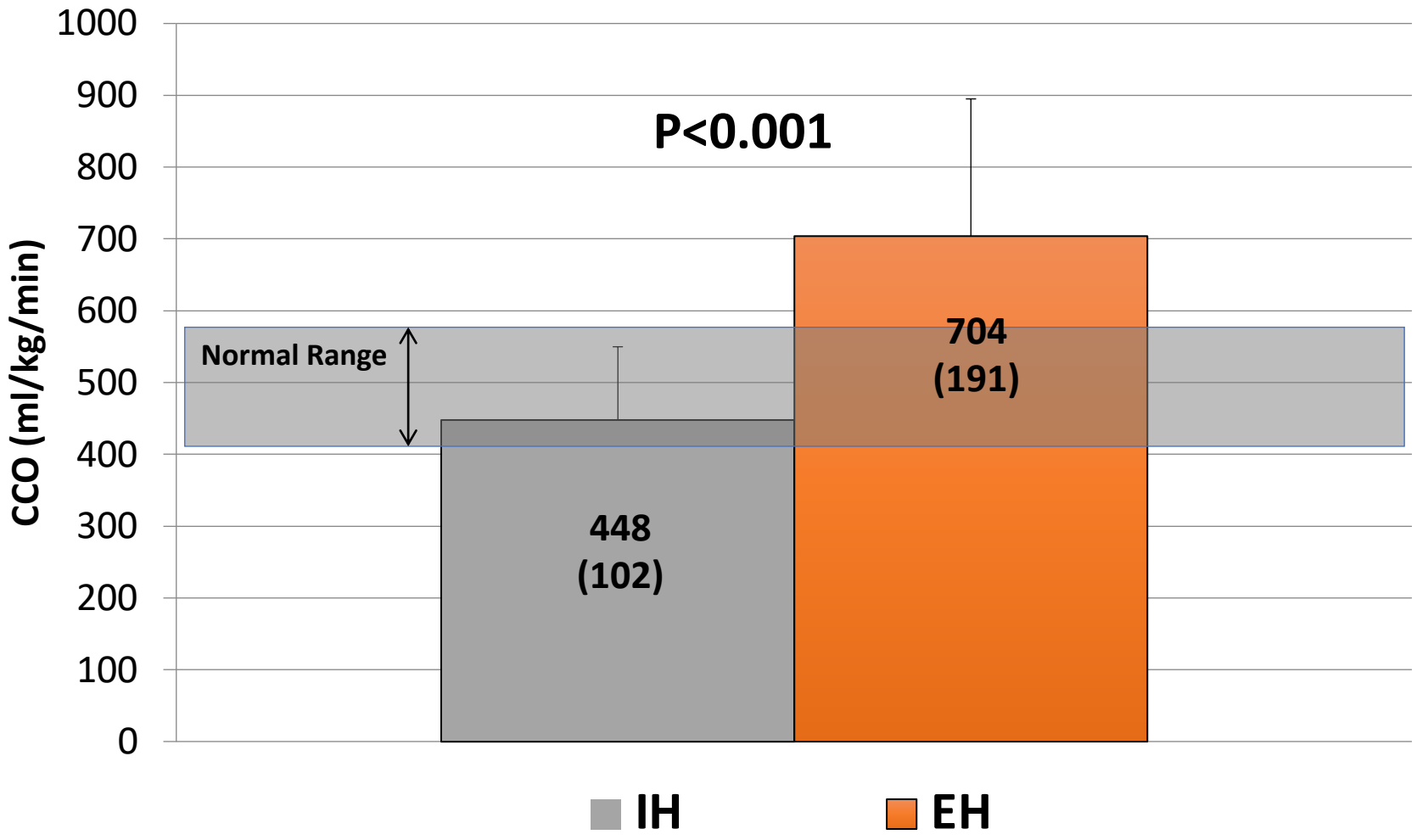
UV drainage to the heart



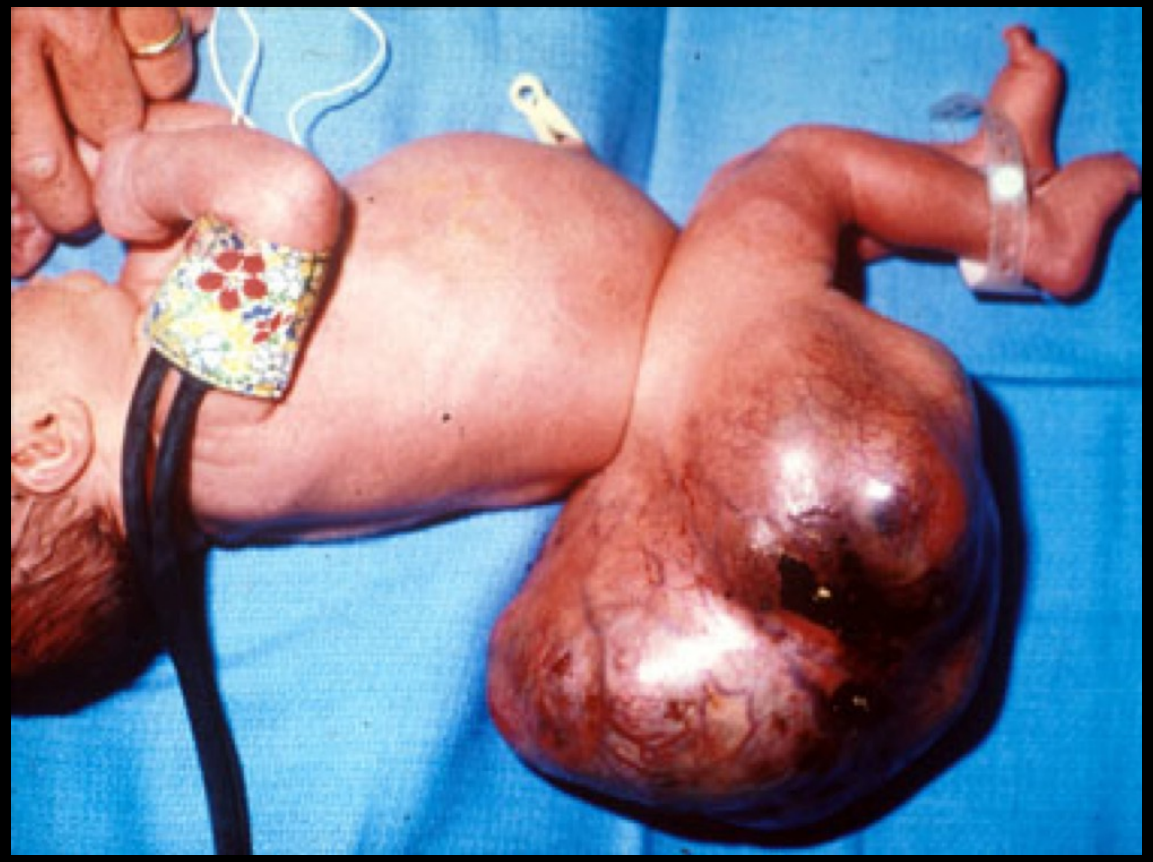
UV to Coronary Sinus

cardiomegaly and dilated coronary sinus

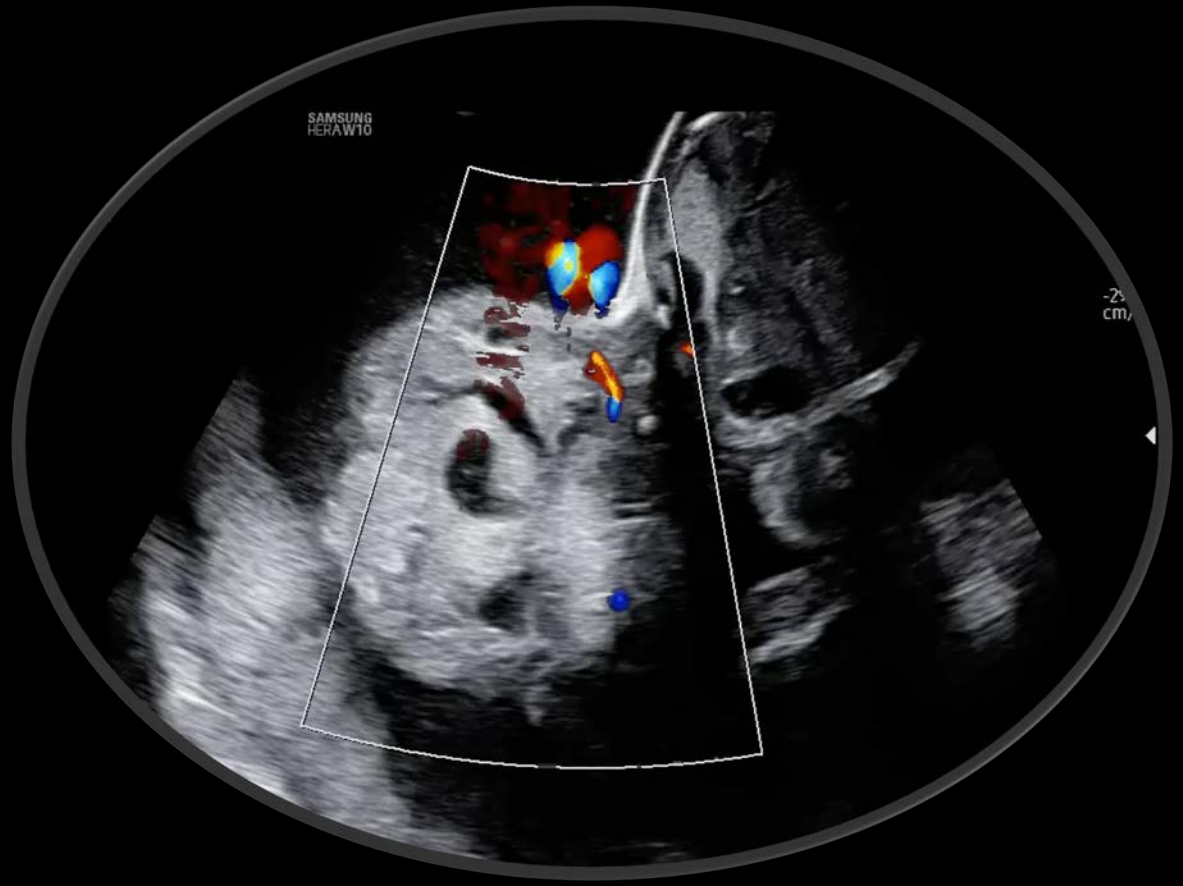
RESULTS: COMBINED CARDIAC OUTPUT



Newborn with Sacrococcygeal Teratoma

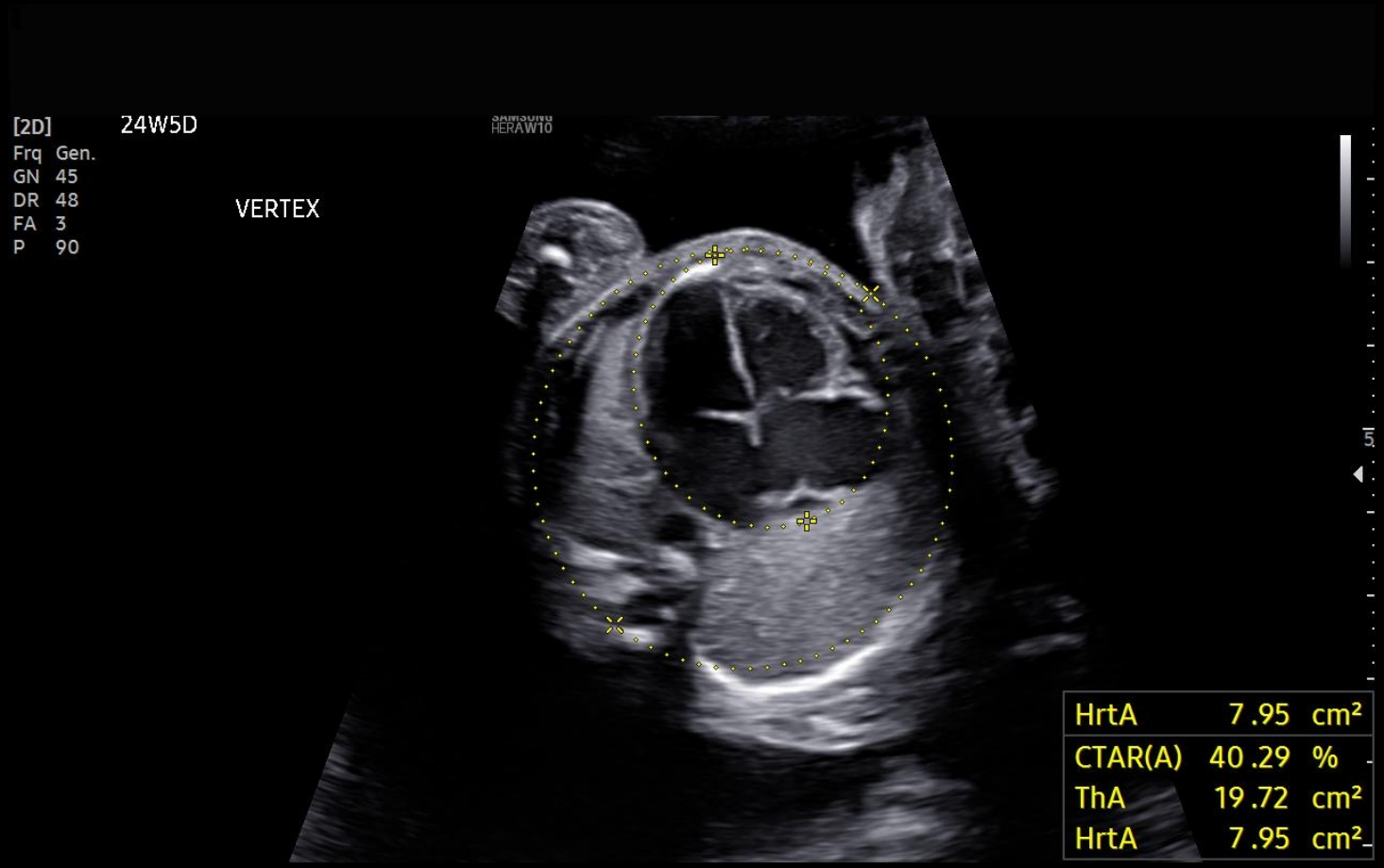


Giant Sacrococcygeal Teratoma

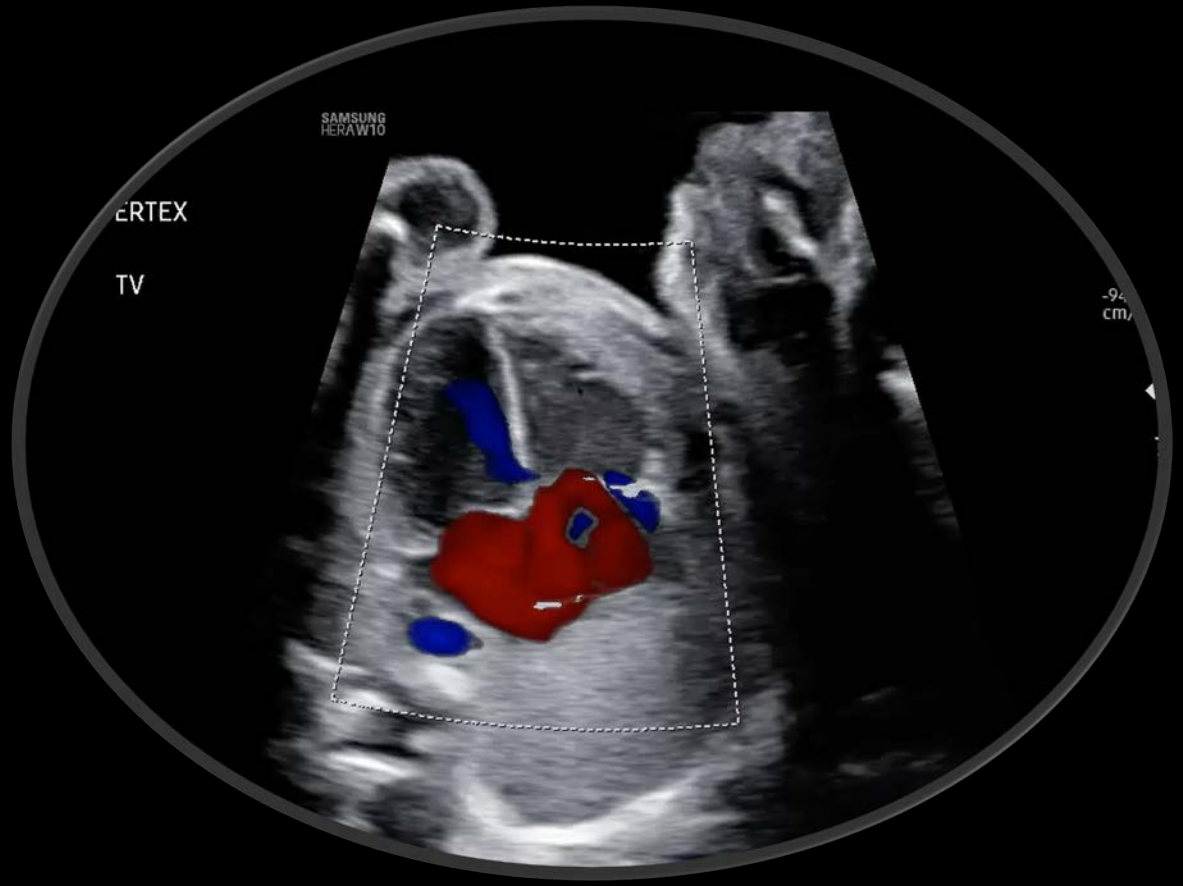


Cardiovascular Consequences

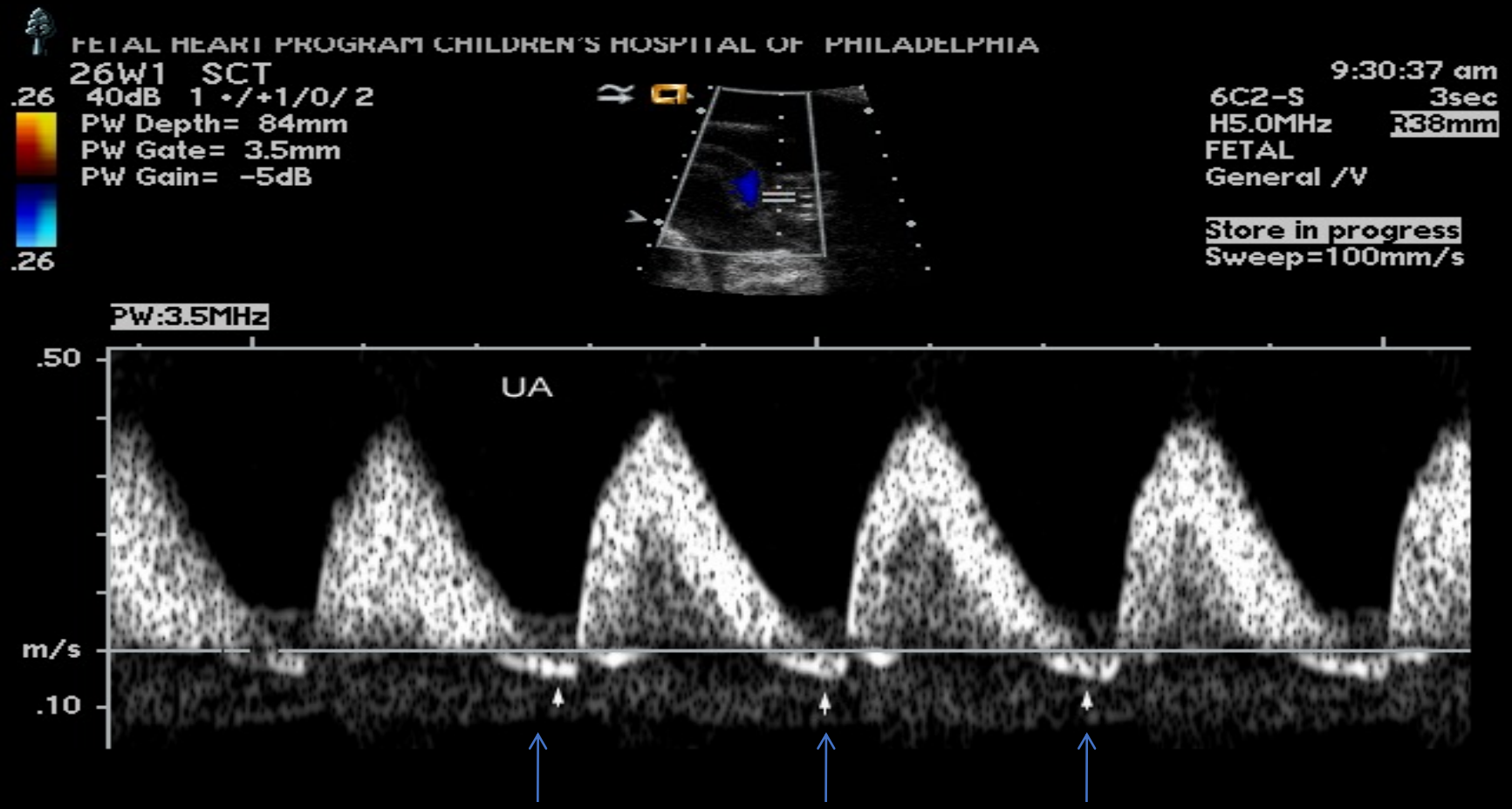
Cardiomegaly



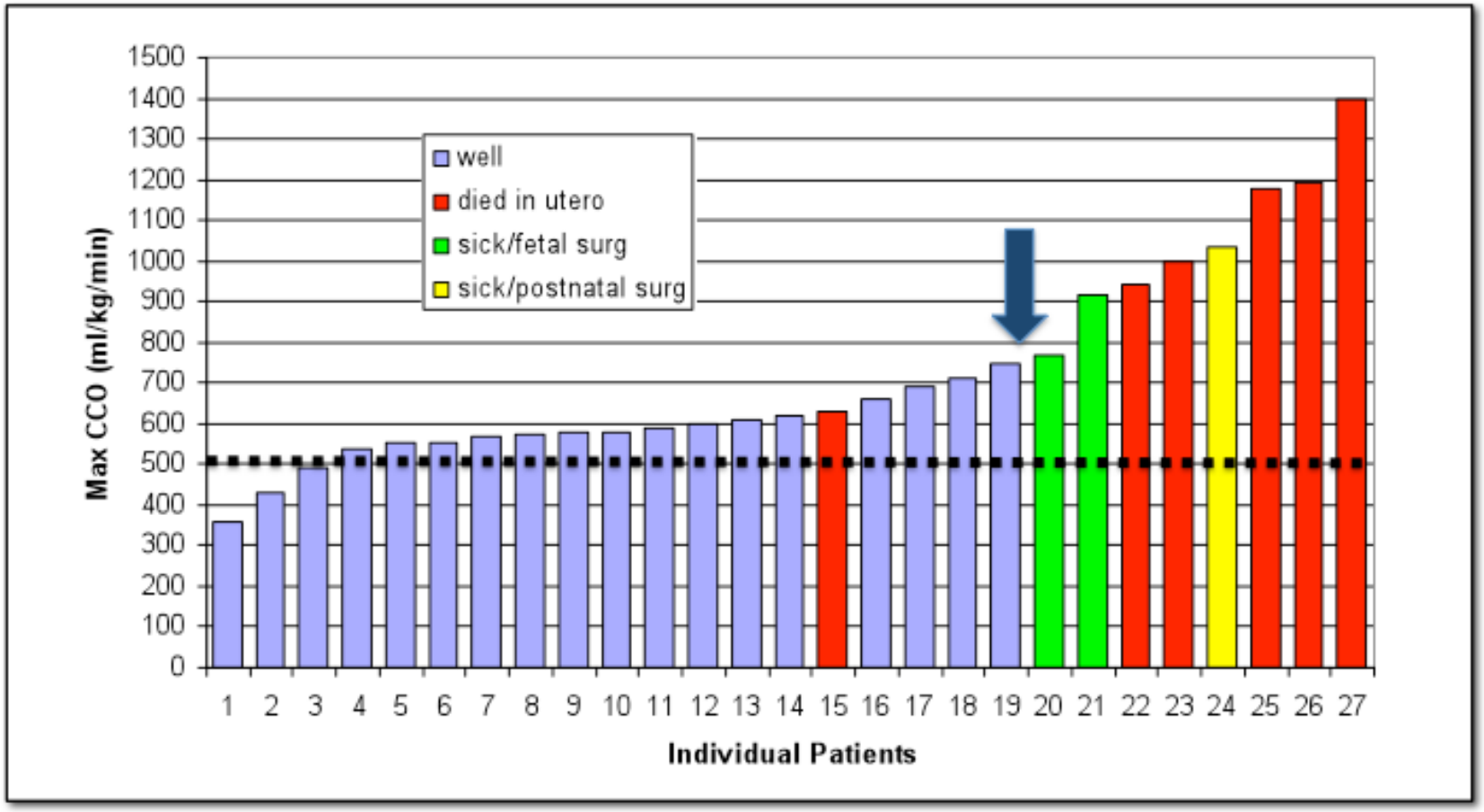
Cardiovascular Consequences



SCT: Abnormal UA Doppler flow



Combined Cardiac Output Measures



Fetal Surgery: SCT

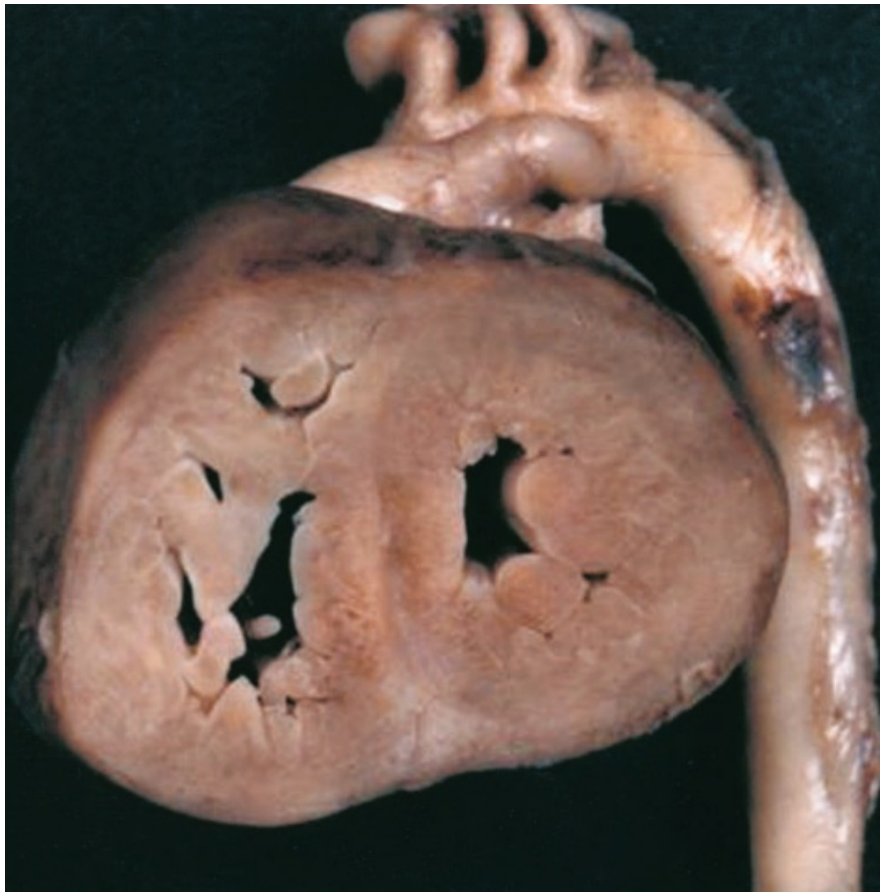
Circulation
Volume 110, Issue 12, 21 September 2004; Pages 1549-1556
https://doi.org/10.1161/01.CIR.0000142294.95388.C4

American Heart Association.

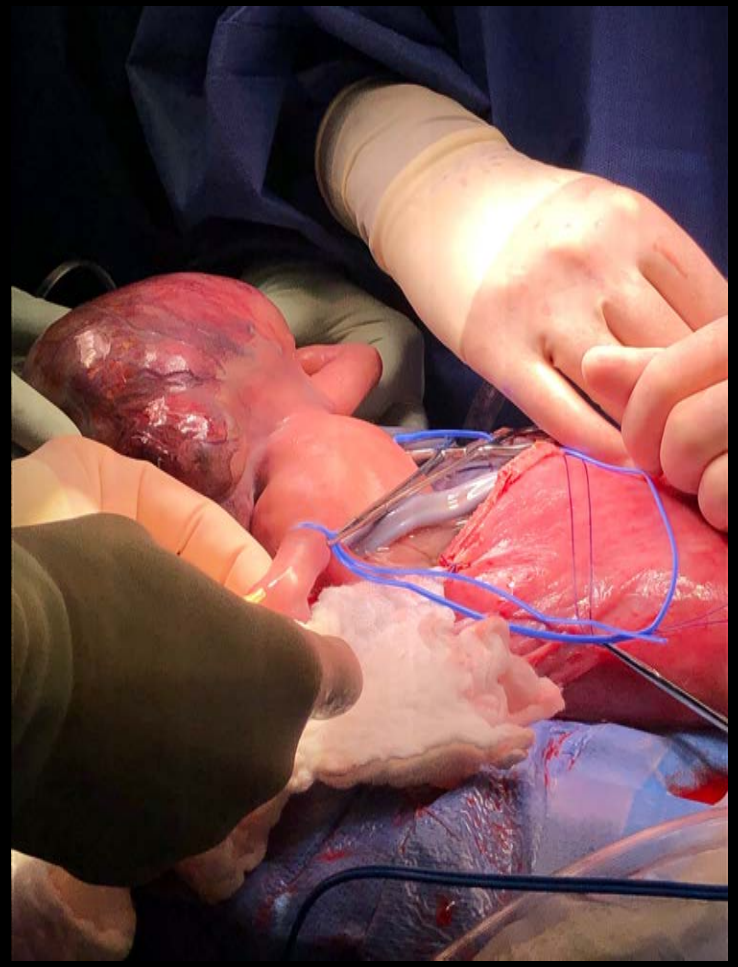
CONGENITAL HEART DISEASE

Acute Cardiovascular Effects of Fetal Surgery in the Human

Jack Rychik, MD, Zhiyun Tian, MD, Meryl S. Cohen, MD, Stanford G. Ewing, MD, David Cohen, MD, Lori J. Howell, MD, R. Douglas Wilson, MD, Mark P. Johnson, MD, Holly L. Hedrick, MD, Alan W. Flake, MD, Timothy M. Crombleholme, MD, and N. Scott Adzick, MD

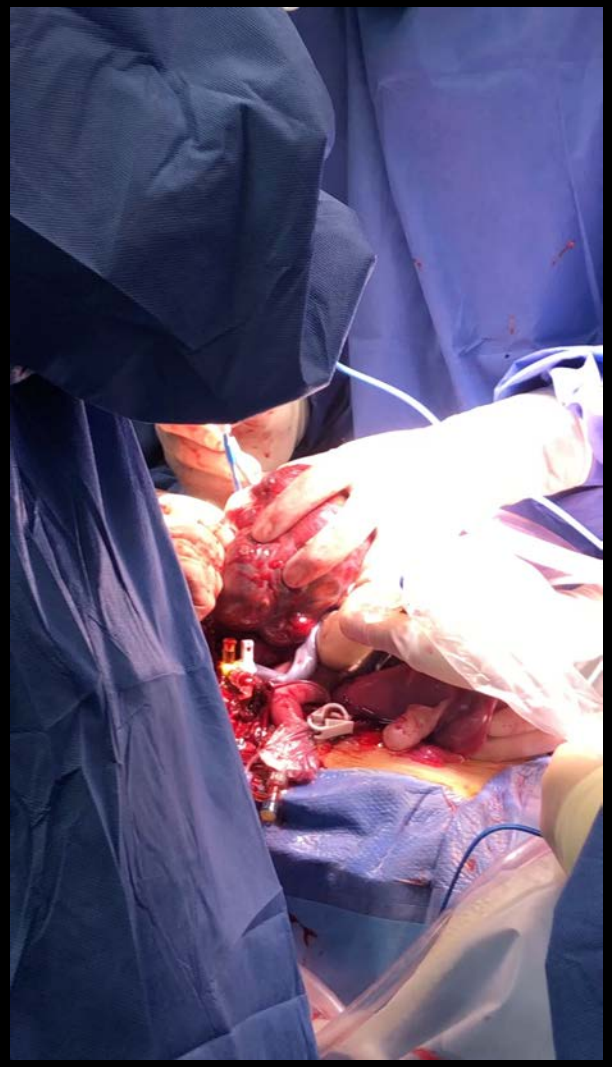


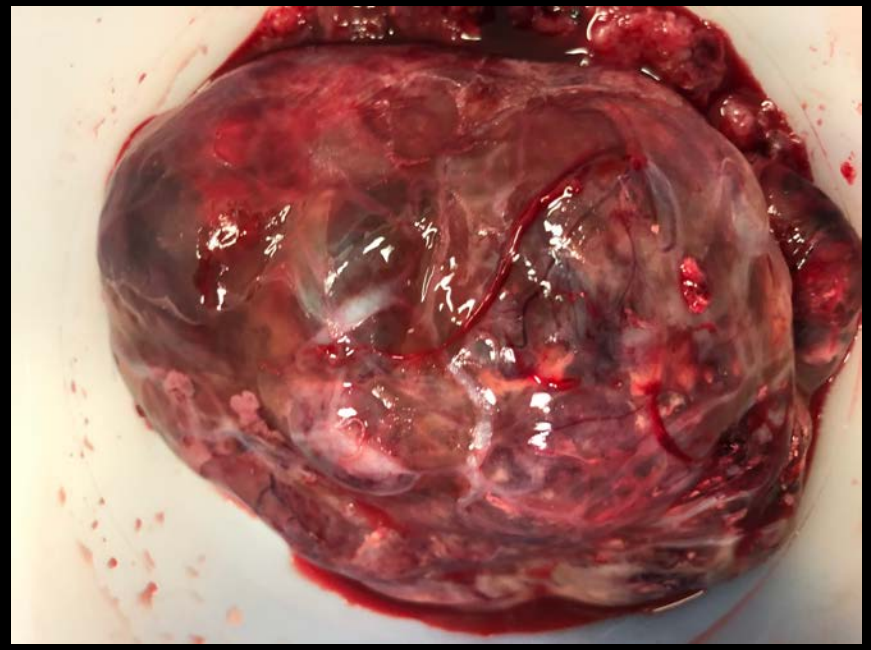
Open Fetal Surgery for SCT



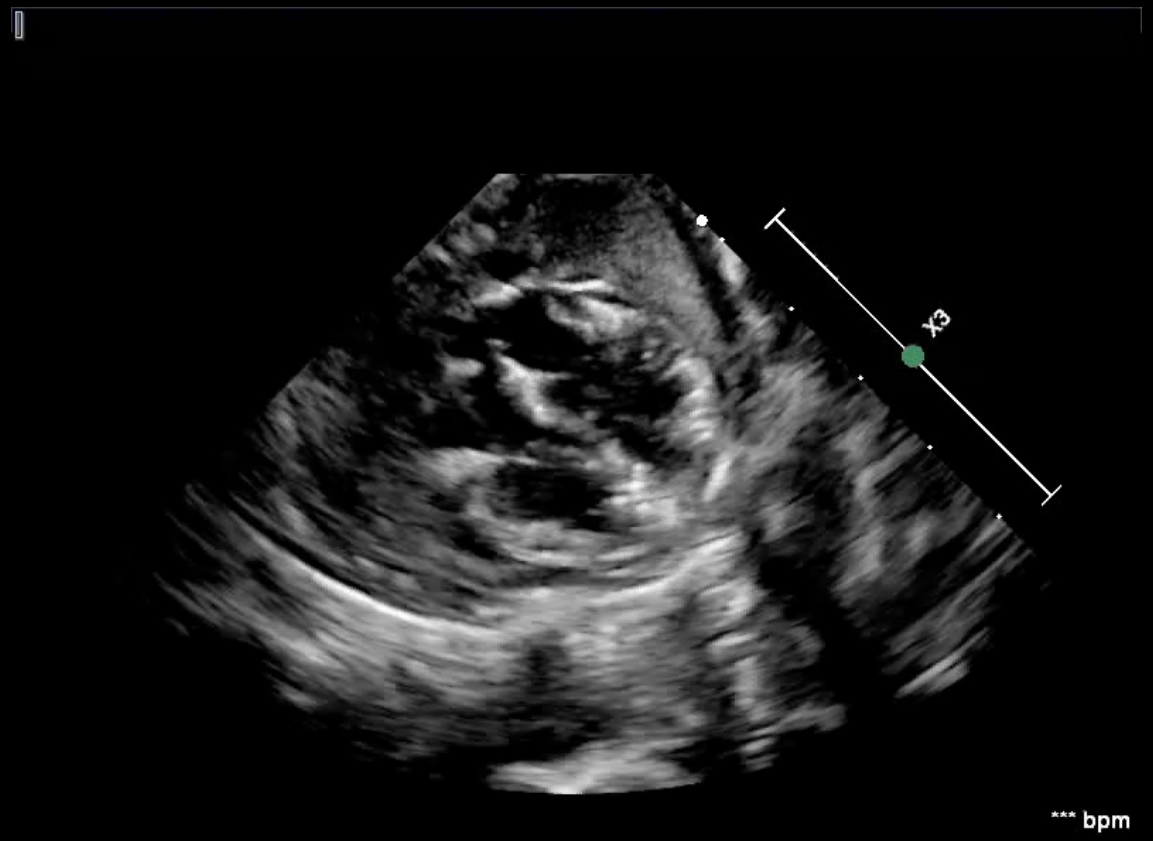
Open Fetal Surgery for SCT

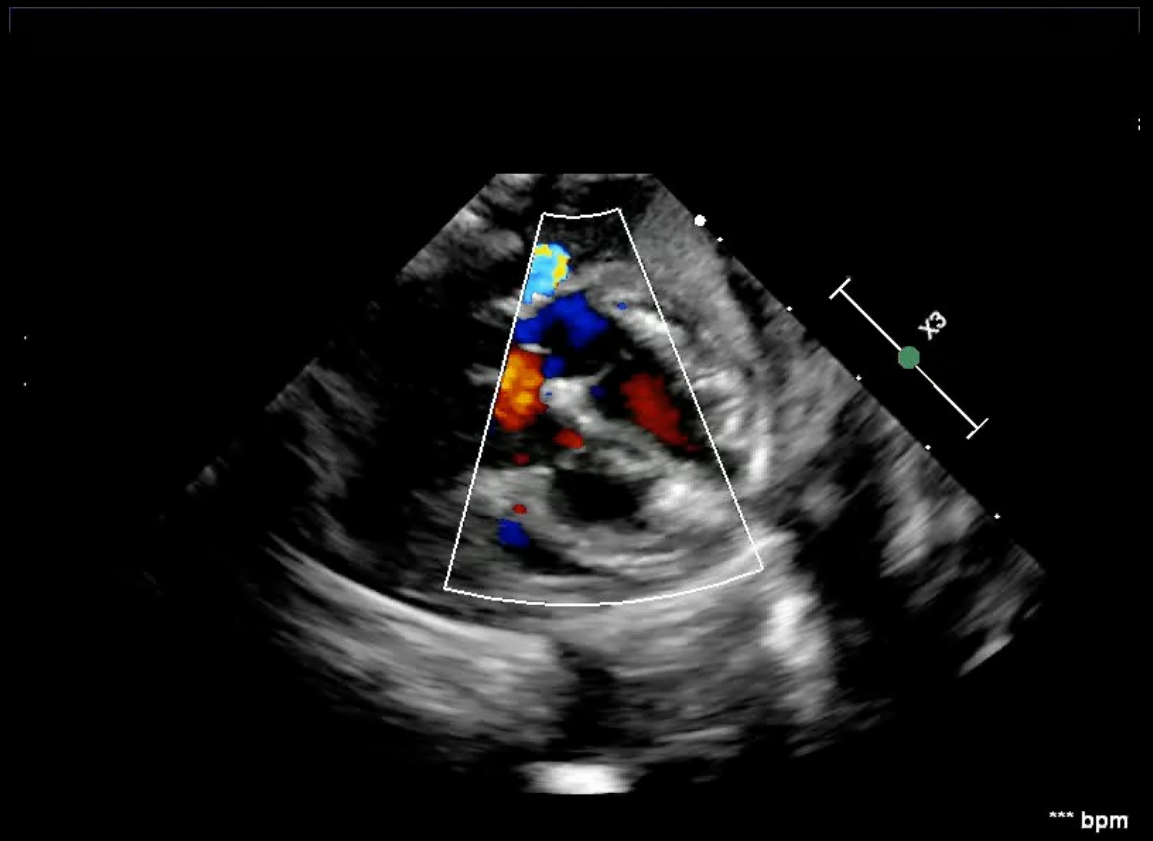
Open Fetal Surgery for SCT



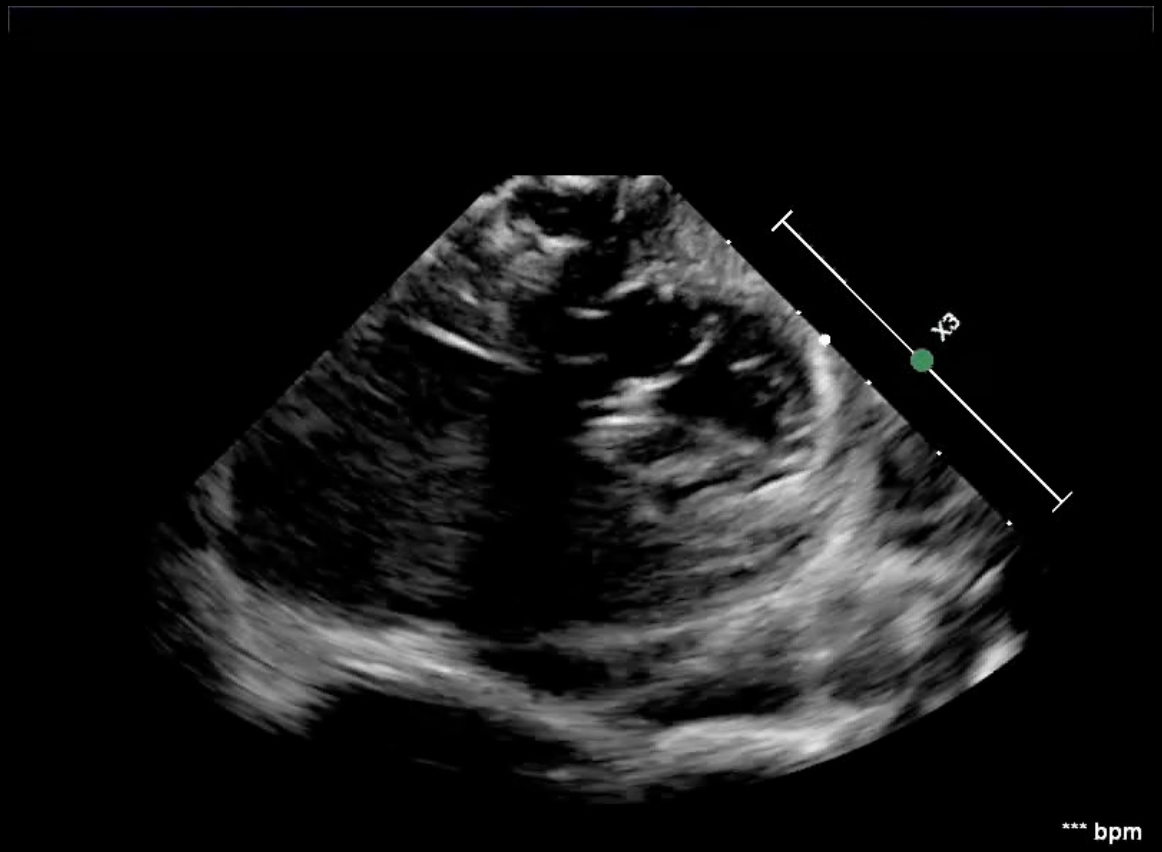


Intraoperative Imaging

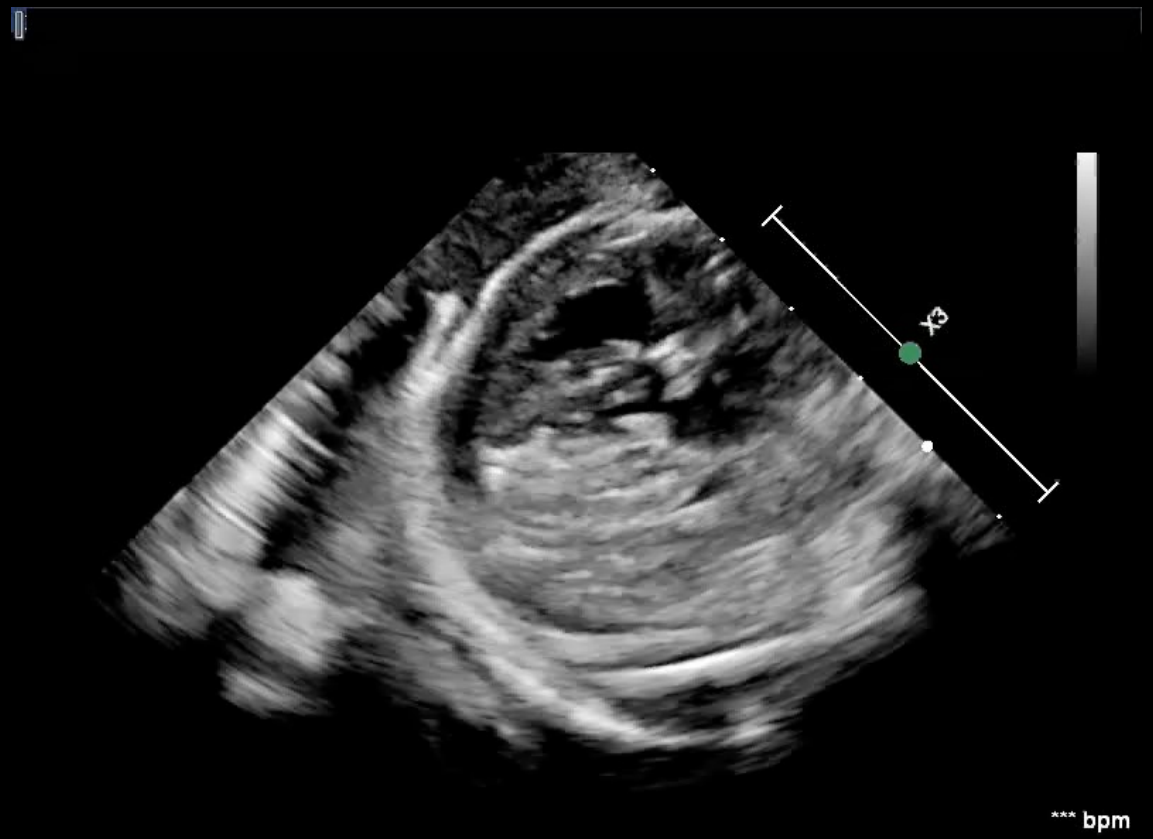


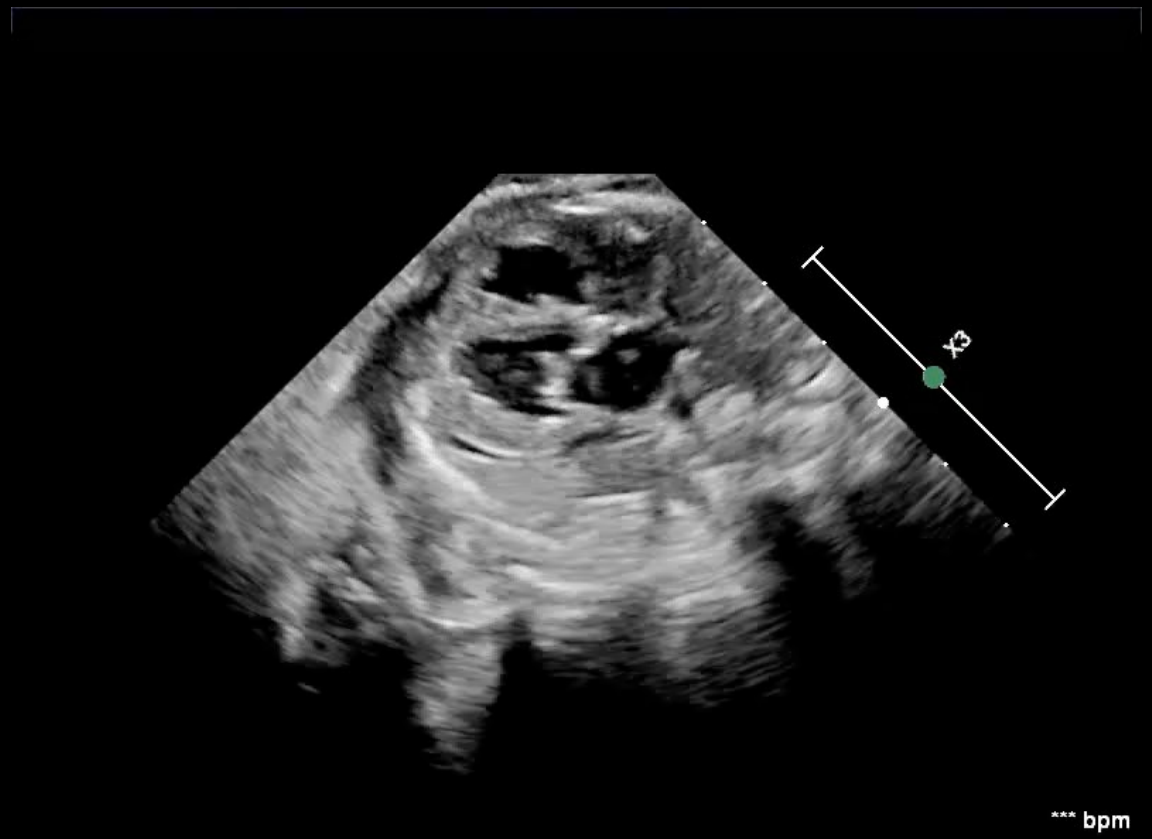


Blood Transfusion

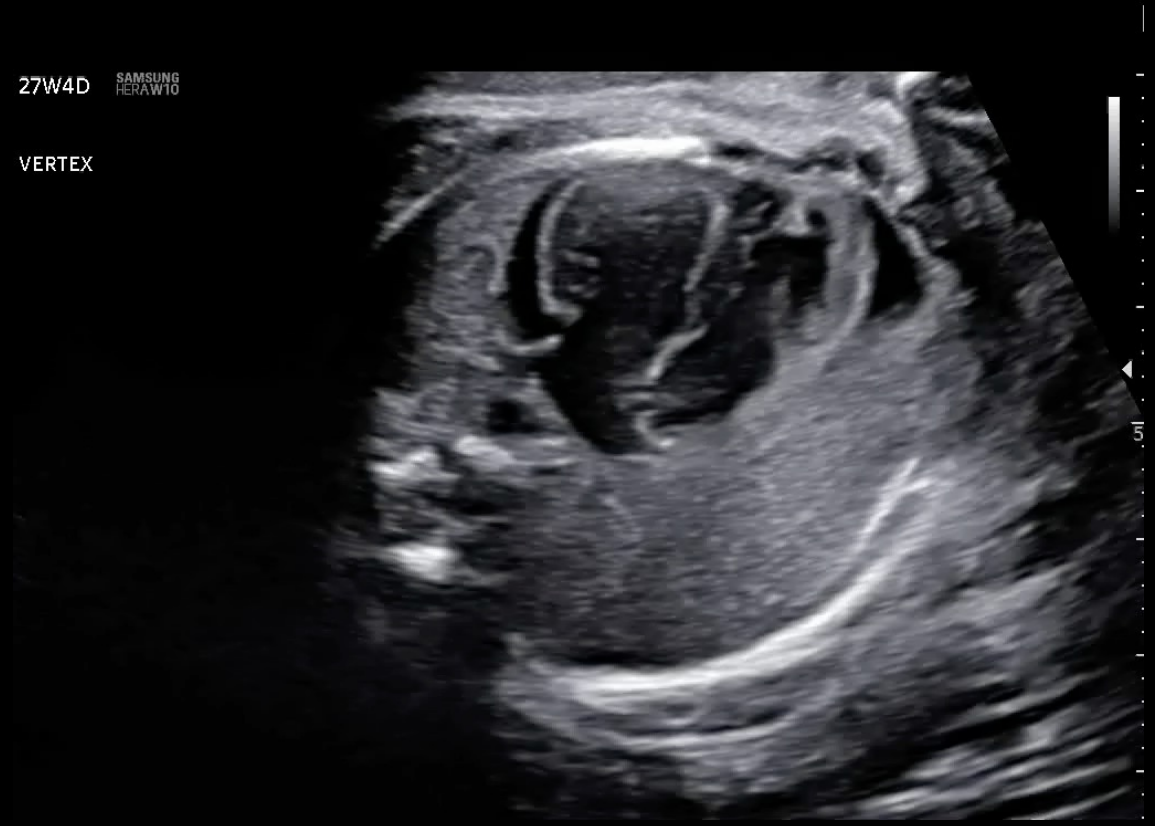


Intraoperative Imaging: Immediate After Resection of SCT

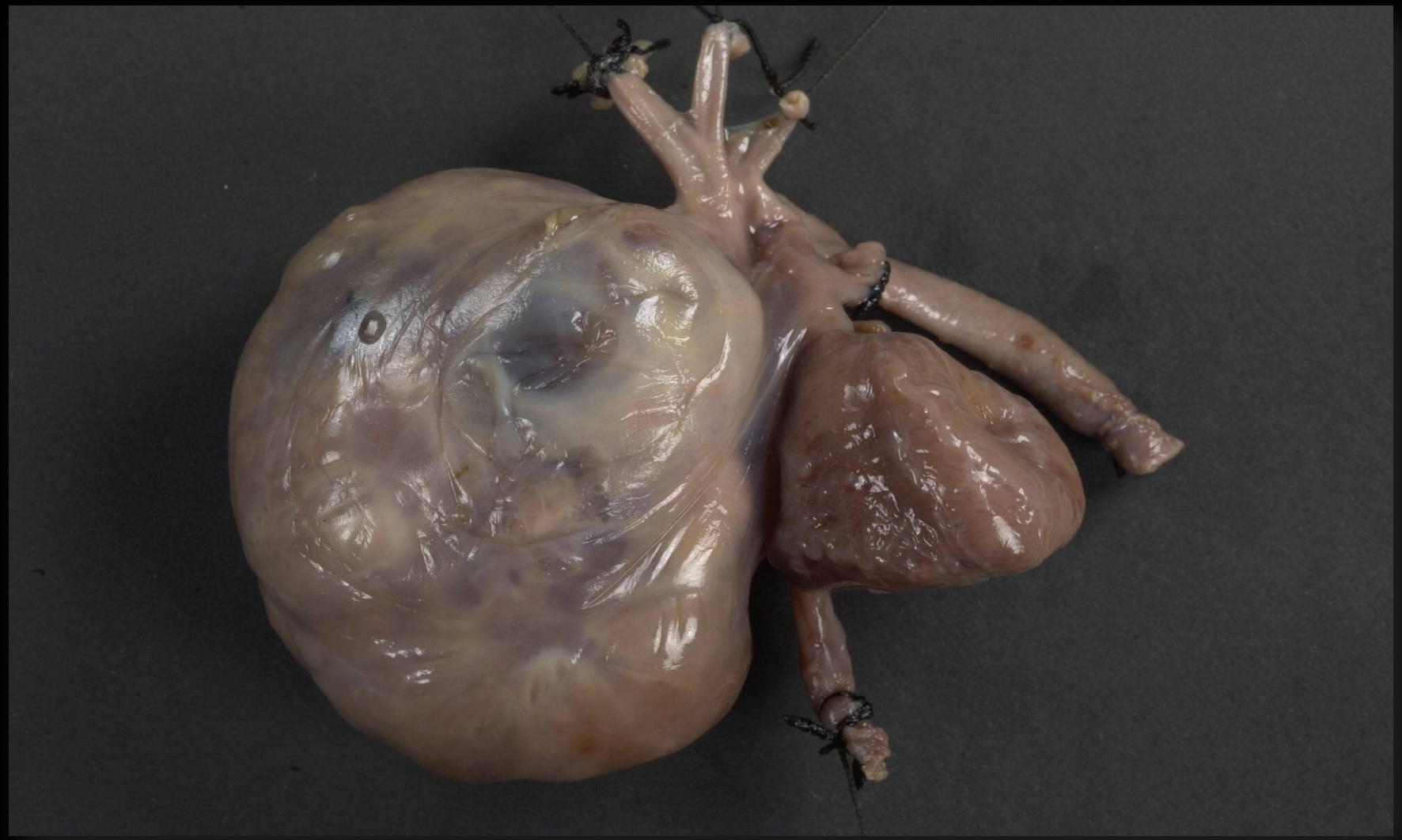




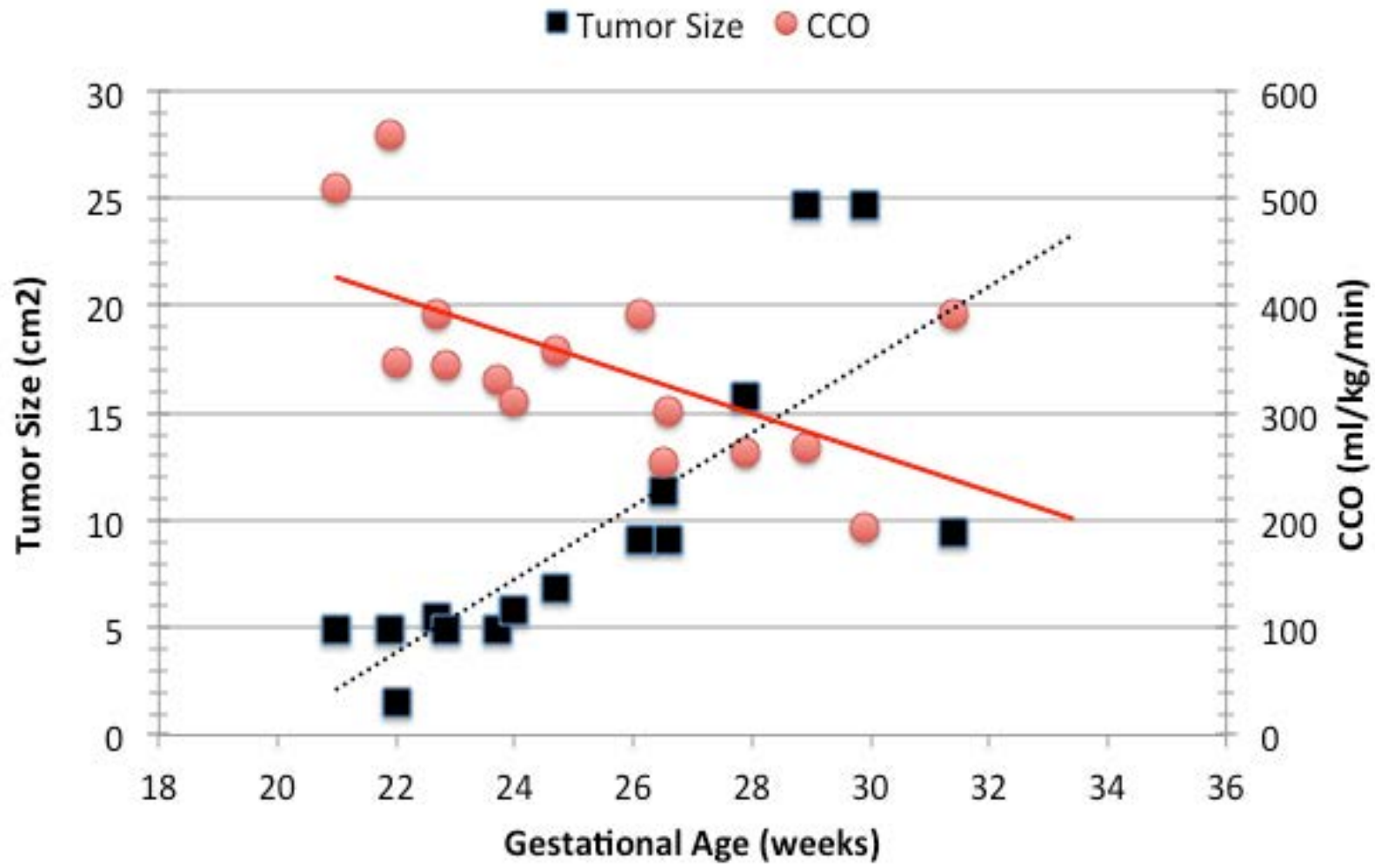
Postop Fetal Surgery:SCT



Pericardial Teratoma



Relationship Between Tumor Growth & Cardiac Output



Rychik *AJOG* 2016

CONCLUSIONS

- A variety of echocardiographic tools are available to help characterize fetal hemodynamics
- Serial evaluation and application of these tools allows for accurate determination of timing for various interventions