



Future Thoughts on FGR



**Present
backdrop (what
is accepted)**

**FGR comes in 2
varieties**

1. Early onset

Appearance before 32 weeks

More severe variant

Early placental maldevelopment

2. Late onset

Diagnosed after 32 weeks

**Less chance of IUD or severe
morbidity**

**Dysfunctional placenta resulting in a
supply/demand mismatch**

The current
management
approach
applies
equally to
both types of
FGR

Surveillance methods are similar:

Non stress
test -NST
(CTG)

Biophysical
profile -
BPP

Umbilical
artery
pulsatility
index -(Umb
A PI)

Ductus
venosus -DV
(more for
early onset)

Current treatment for FGR

Limited to the **timing of the delivery** based on standard surveillance methods.

Observational studies are based on chances of adverse neonatal outcome if a test is abnormal.

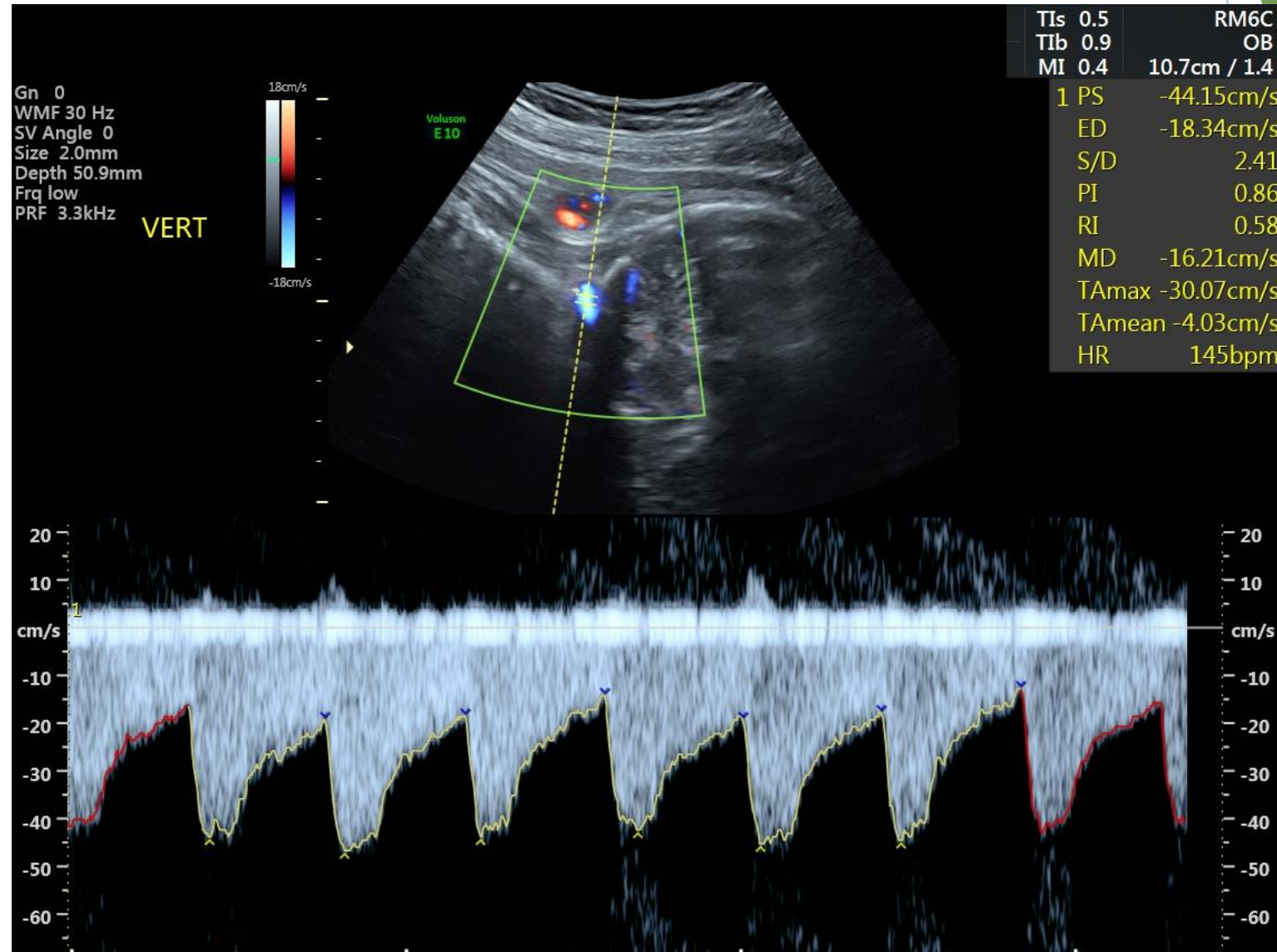
But we really want to know the hypoxic status of a given fetus at a given point in time.

Now: Heavily dependent upon UAPI and EFW alone

Other possible Doppler players

1. **Middle cerebral artery (MCA)**-- chosen vessel to reflect brain sparing
2. **Vertebral artery-(VA)** great potential
3. **Umbilical vein flow (UVF)** a logical option

The vertebral artery: the forgotten vessel



Umbilical Vein: the lifeline of the fetus



Present Status: These Doppler tests have not been “appropriately” vetted

1. **MCAPI**. The “go-to” test to reflect brain sparing. Some management guidelines have included this while others have discouraged its use.
2. **Vertebral artery**: The last vessel in front-to-back brain sparing which takes hypoxia to another level... but no randomized trials undertaken.
3. **Umbilical vein flow**: useful for selecting those at greatest risk of intrapartum asphyxia and is linked with cardiac dysfunction.



Do standard methods improve outcome in FGR?

Yes. Studies show a decrease in perinatal mortality in severe/early onset FGR.

But It is difficult to track how well these methods predict morbidity.

Why?

Late onset neonates destined to later morbidities often don't show immediate signs of compromise via common neonatal metrics: Combined Adverse Neonatal Outcome (CANO).

What we don't know at birth:
How much damage has been done.

What we do know:
Neurological, cardiovascular, and
metabolic morbidities in FGR all have
a common denominator (HYPOXIA).

*So... we need in utero
methods to assess the degree
of hypoxic exposure!*

We need
another
approach to
surveillance.

The size and shape of
the fetal heart provide
a rich source of helpful
information



Cardiac remodeling is an early sign of fetal hypoxemia and later CVD

Detection by a four-chamber video clip

Tells us how the heart adapts to hypoxia through changes in size and shape.

It provides evidence of impairment of ventricular contractility.

It relates to childhood and adult CVD !

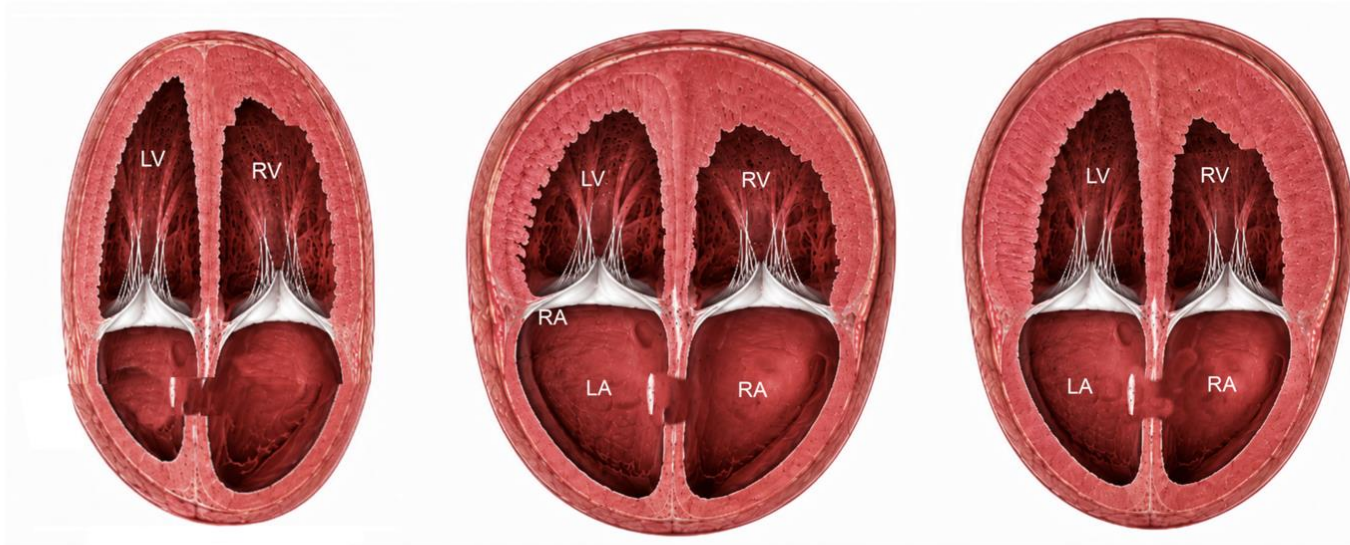
From Barcelona: first description of cardiac phenotypes in FGR

Based on shape of left ventricle:

1. “elongated” heart (54%)
2. “globular” heart (29%)
3. “hypertrophic” heart (17%)

Rodríguez-López et al. Ultrasound Obstet Gynecol 2017; 50:207-214

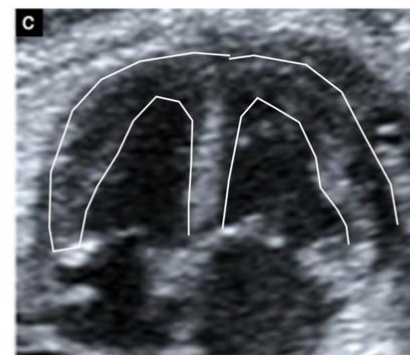
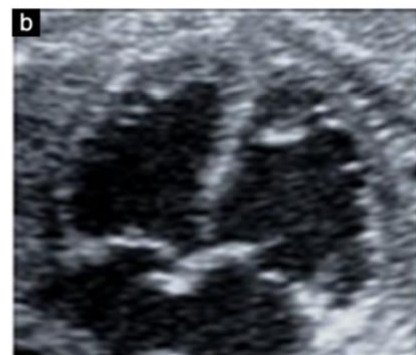
Barcelona experience



Elongated Left Ventricle

Globular Shaped Ventricles

Hypertrophied Ventricular Walls



Focus of our investigation

To assess overall size and shape of the fetal heart

To compare the inner size of the ventricles

To track longitudinal changes

To compare findings with neonatal and later outcomes

All accomplished with standard 4 chamber video clips

4 chamber clip: a great source of info about hypoxemia

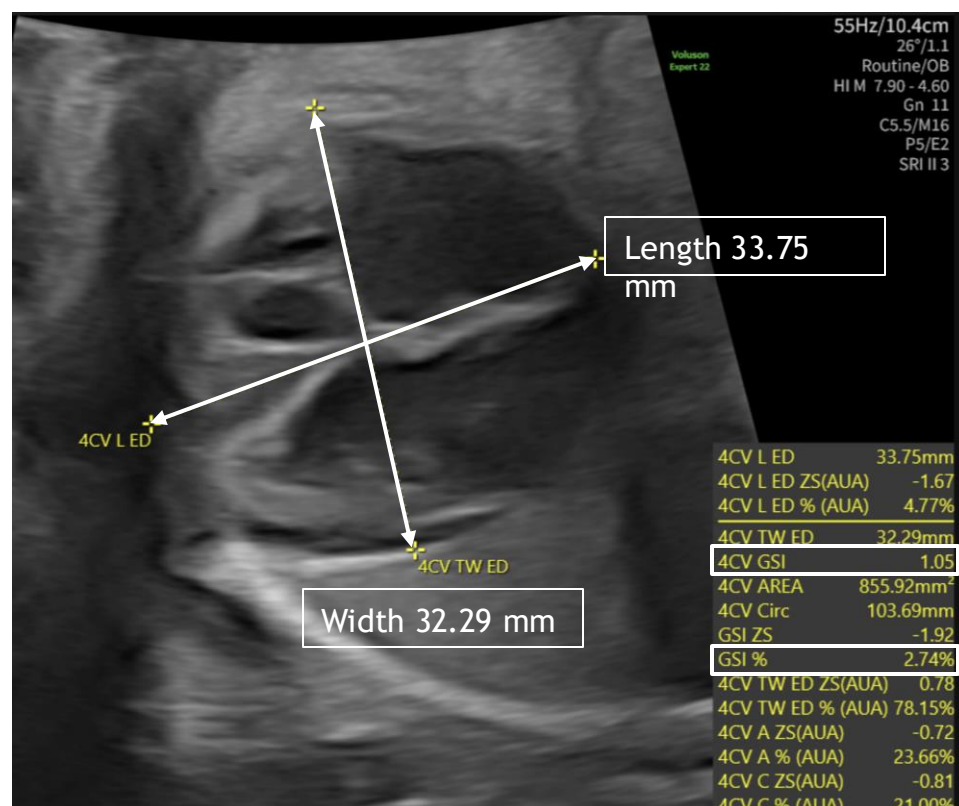


Abnormal Fetal Findings Associated With a Global Sphericity Index of the 4-Chamber View Below the 5th Centile

Greggory R. DeVore, MD , Gary Satou, MD, Mark Sklansky, MD



J Ultrasound Med. 2017 May 30.
doi: 10.1002/jum.14261. [Epub ahead of print]

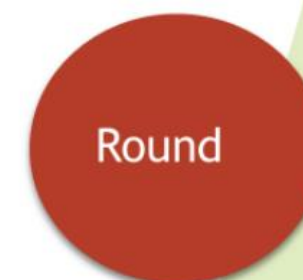


Length/Width



Elliptical

Normal



Round

GSI < 5th
(<1.08)

4 Chamber measurements yield important information about adaptive deformation

Transverse width (TW)

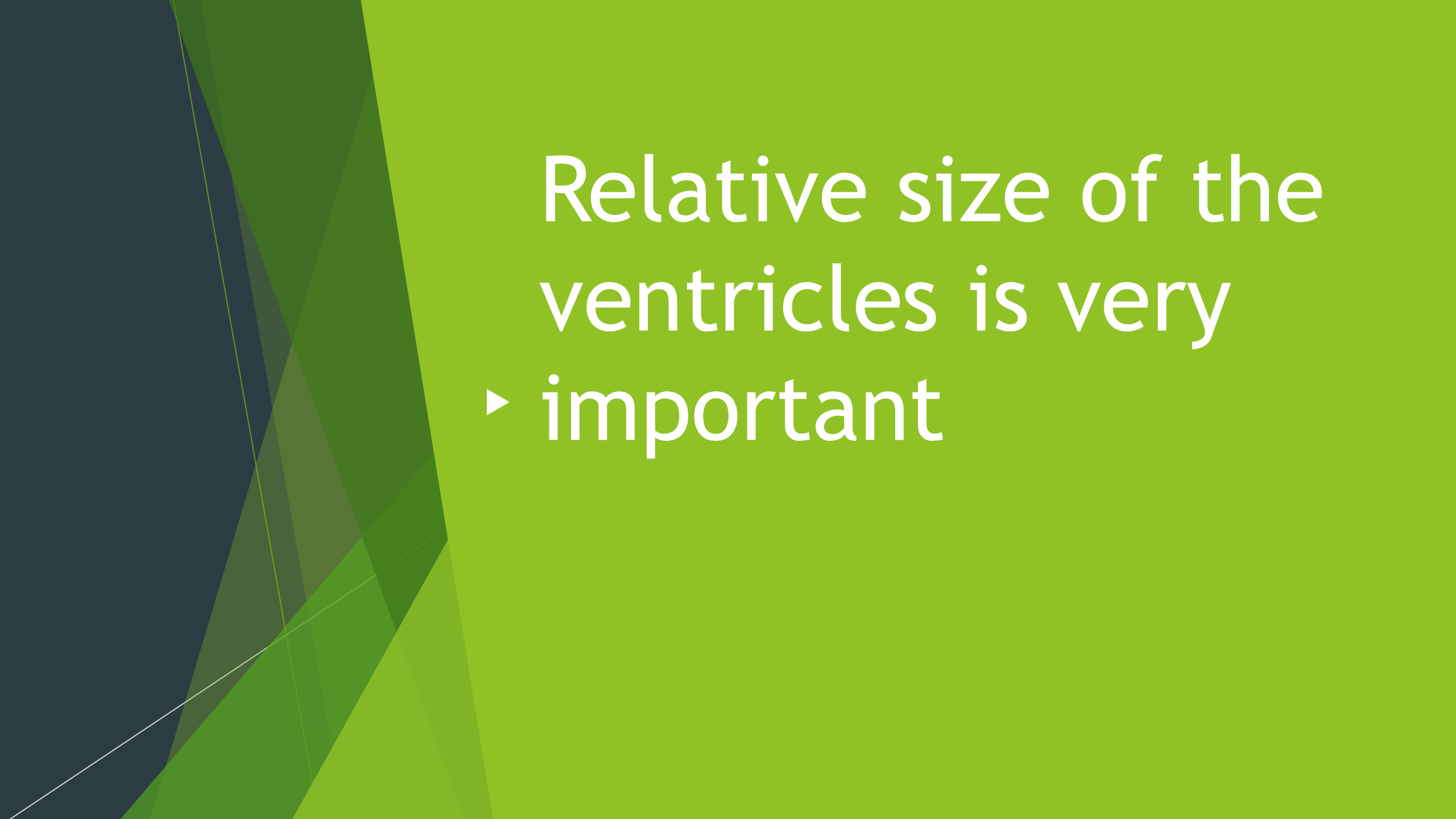
Cardiac area (CA)

Global Sphericity Index (GSI)

Right to left disproportion (RV/LV ratio)

The bonus: pericardial effusion

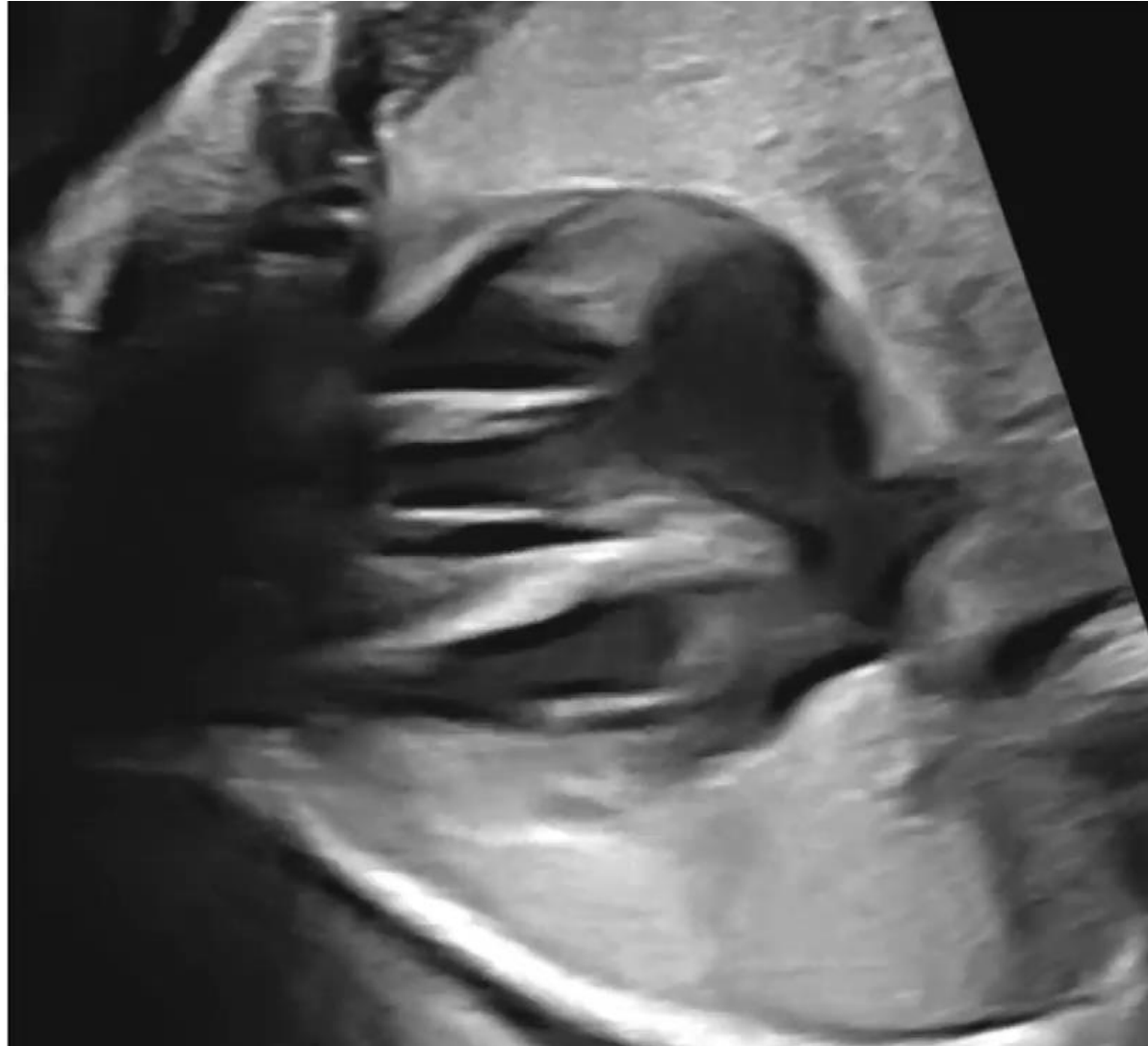




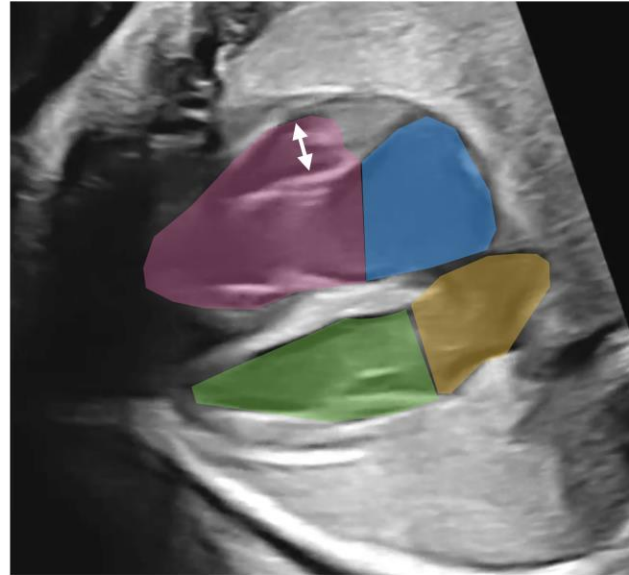
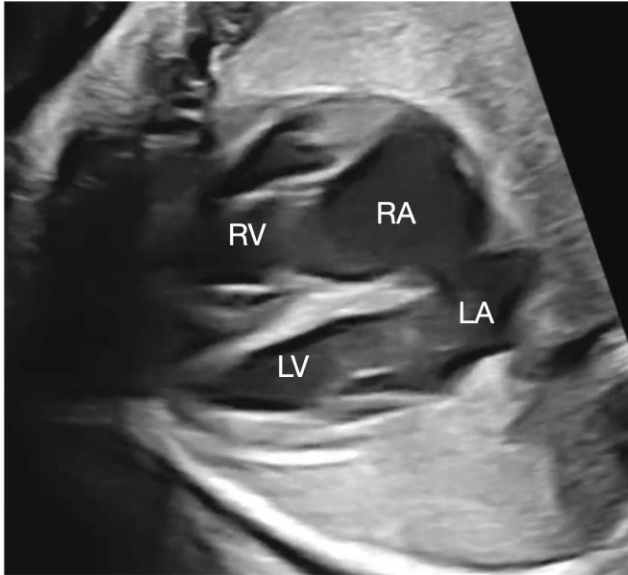
Relative size of the
ventricles is very
▶ important

R/L ventricular disproportion

First, eyeball the 4-chamber view



R/L disproportion is an early sign of fetal compromise



Often R/L disproportion can be assessed by “eyeball” alone

A quick method to tell the RV is dilated to
When the tricuspid valve leaflet does not
Touch the lateral wall of the RV (See double arrow)

Screening for RV/LV ratio

A ratio of 1.28 is a threshold that represents 90th-95th percentile between 33 and 36 weeks

Sequence of cardiac events with worsening hypoxia

RV dilates from workload

1. Overall transverse diameter(TW) increases
2. Thereby decreasing global sphericity index GSI)
3. RV/LV ratio increases
4. LV is compressed and elongated

Then:

LV dilates to maintain stroke volume

1. Both ventricles dilate
2. Cardiac area increases (globular heart)
3. RV/LV ratio equalizes or even reverses
4. In severe FGR, paradoxical septal motion

Pericardial Effusions: a sign of progressive cardiac dysfunction

Observations by DeVore

Progression of pericardial effusion with worsening fetal condition

Small **right** PE in location of the AV groove



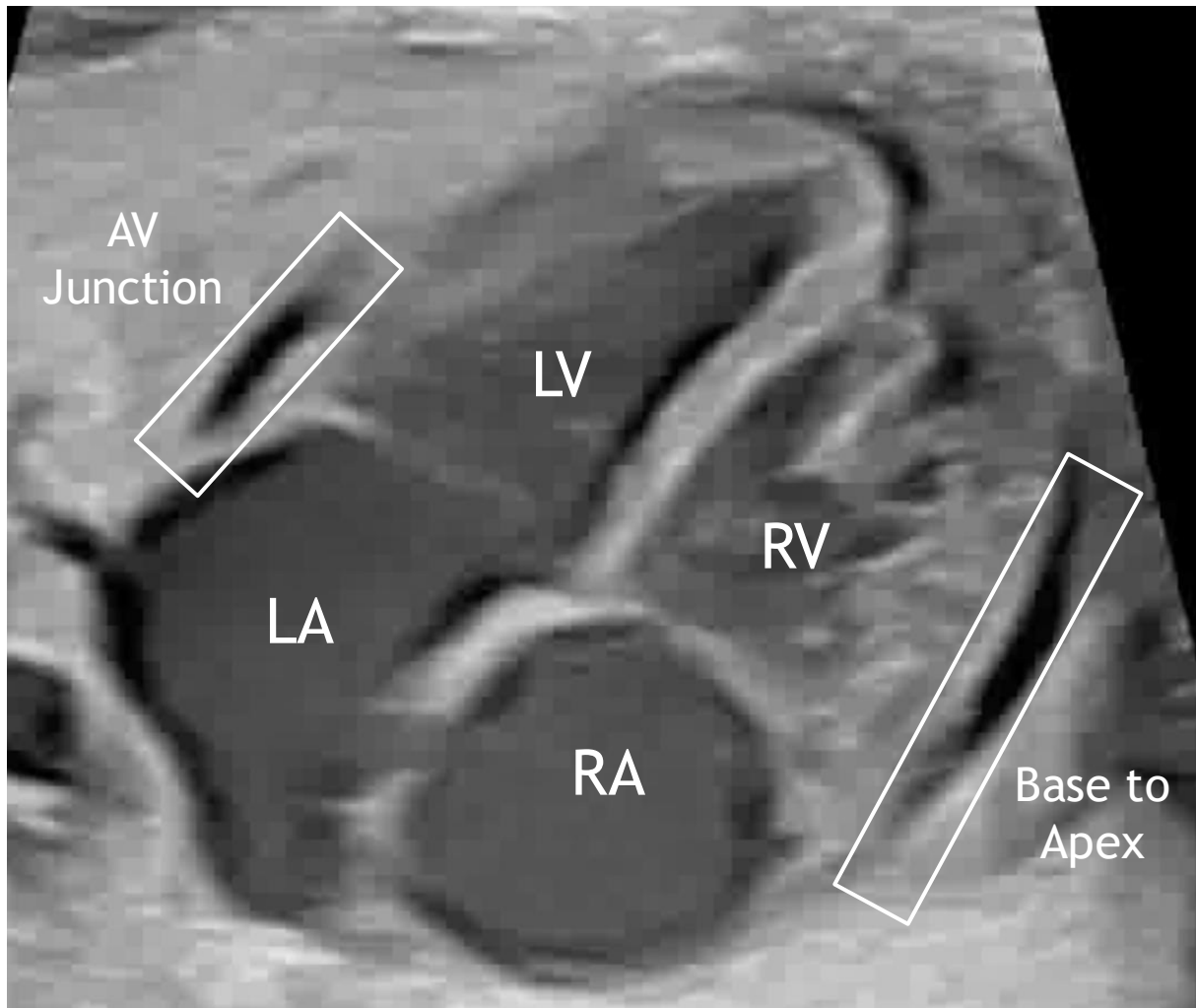
Effusion extending towards base of the heart



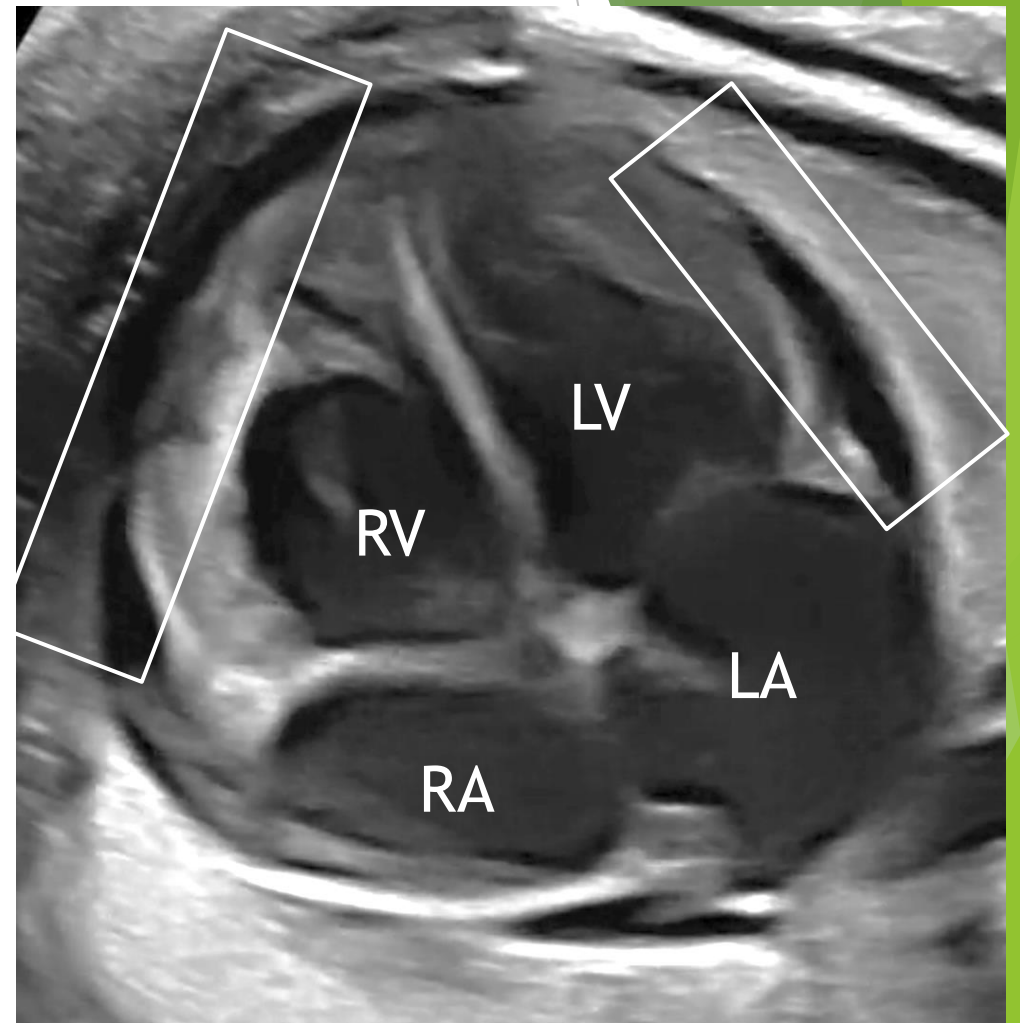
Effusion now extending south to the apex



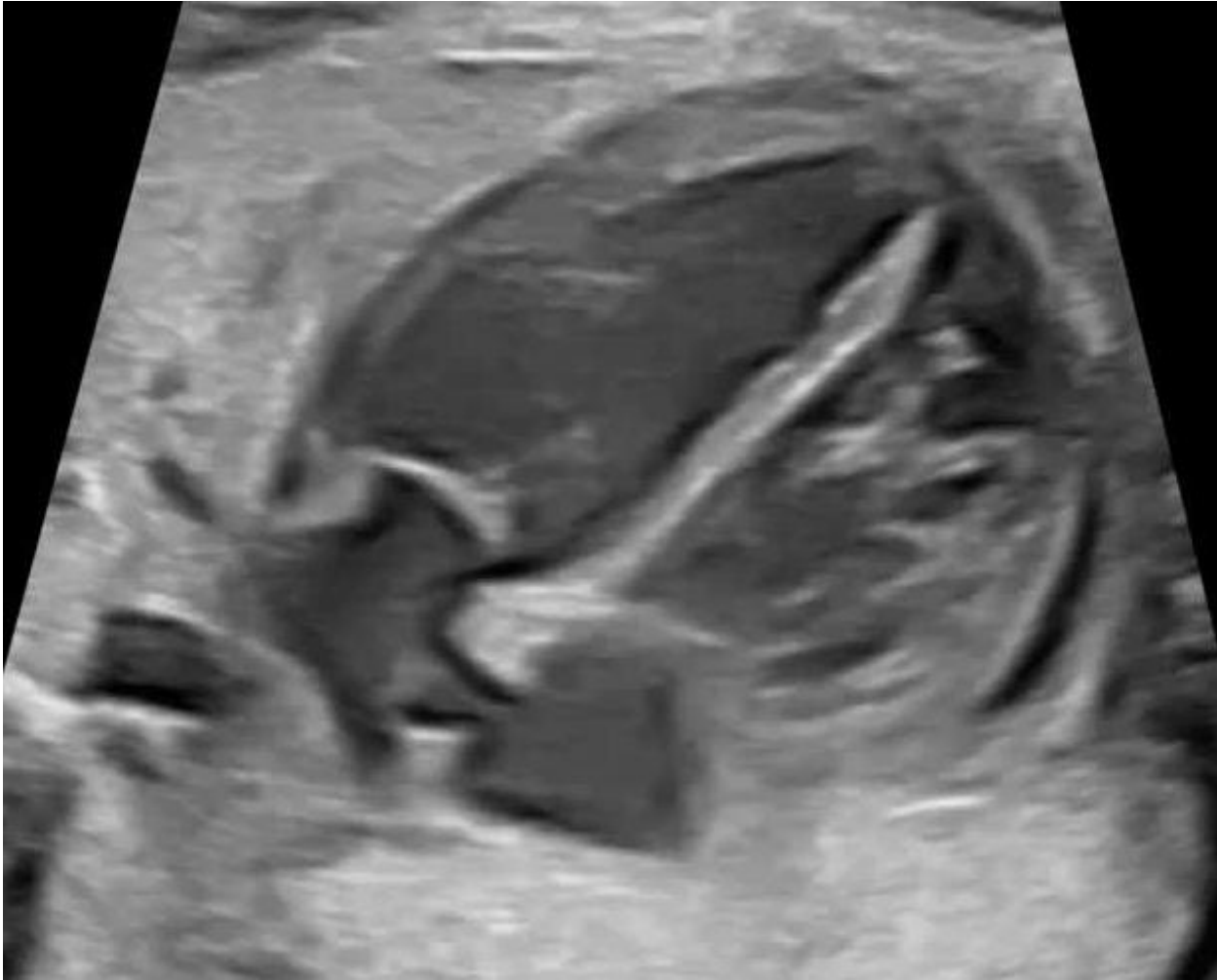
Effusion now on the **left** (bilateral PEs)



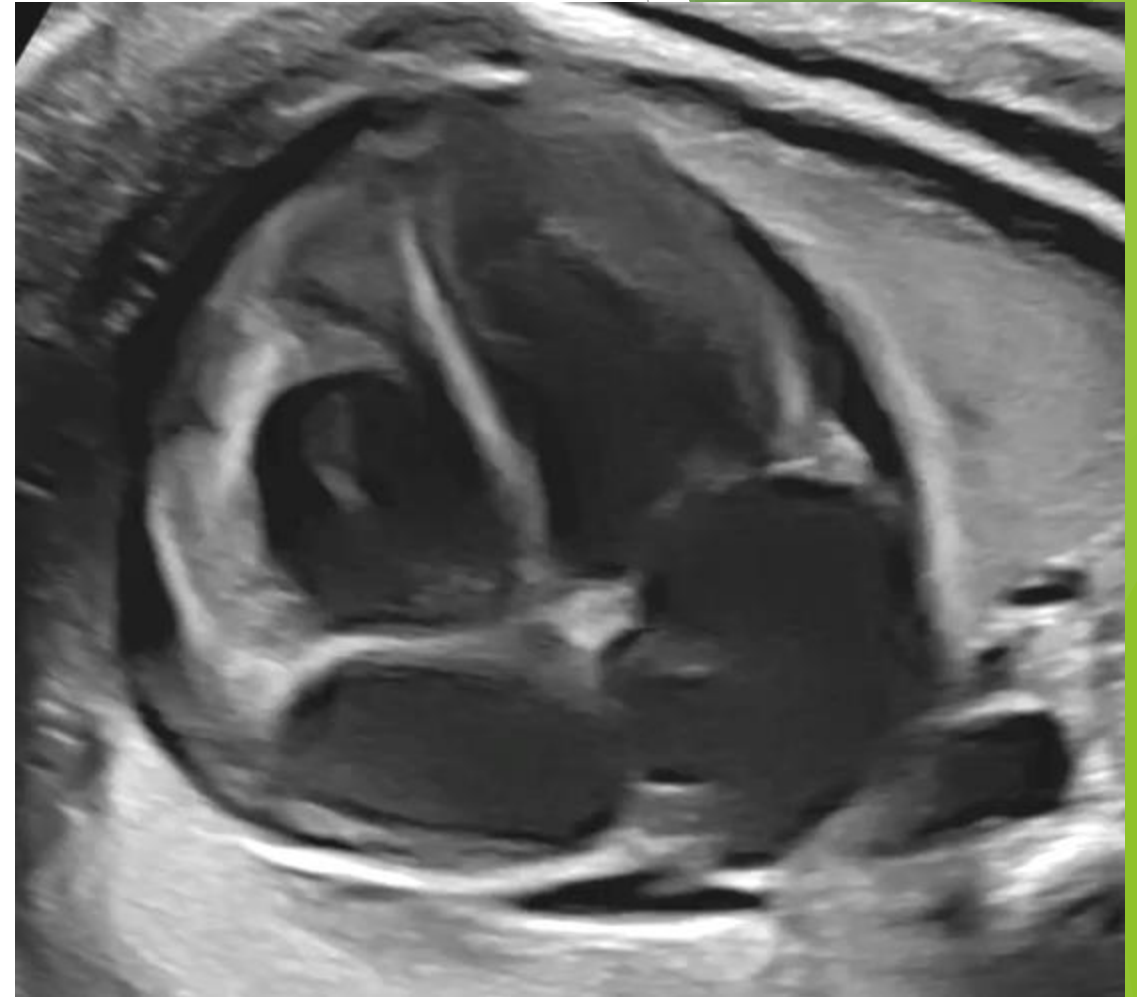
Right Ventricular Pericardial Effusion



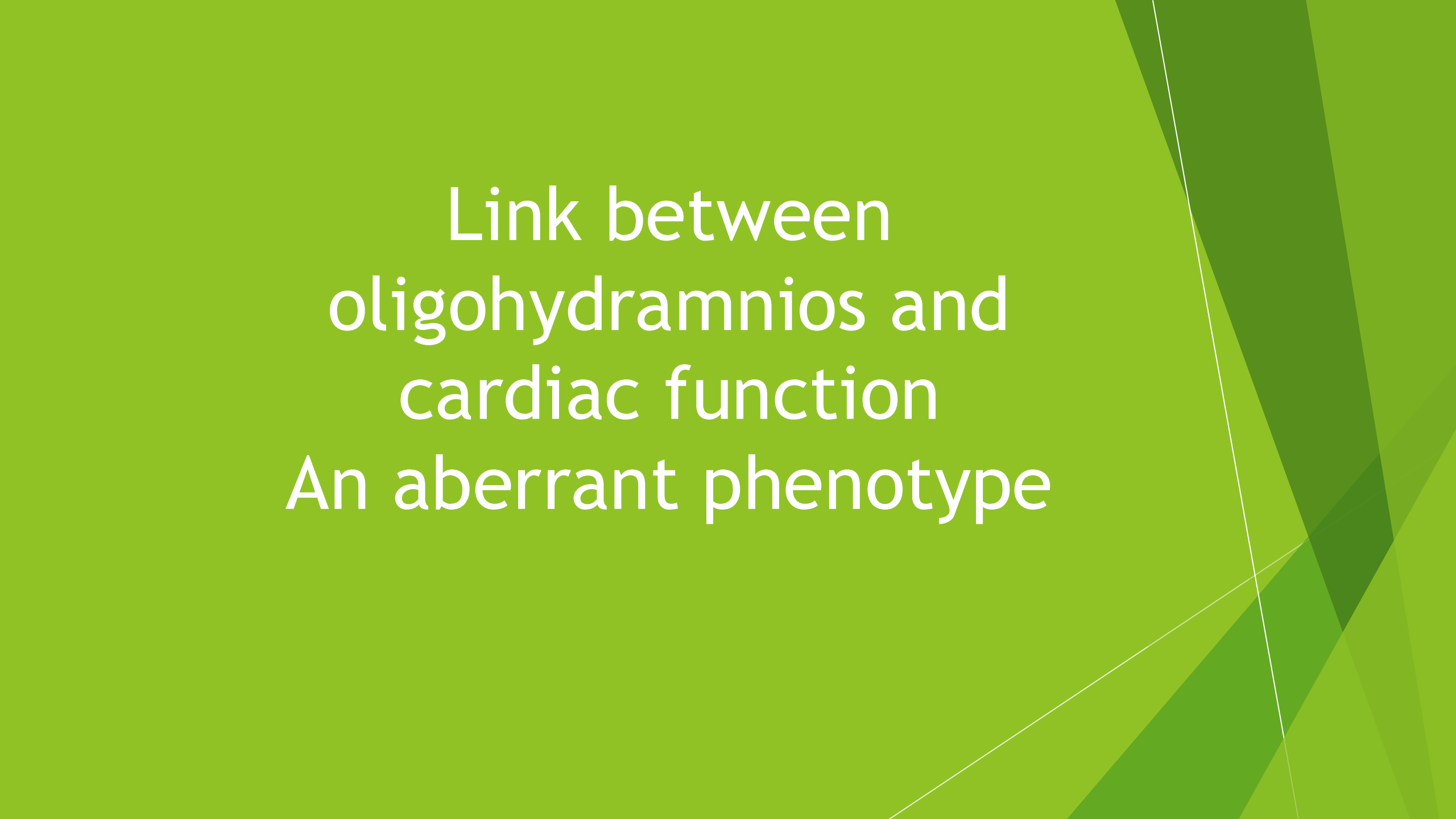
Bilateral Pericardial Effusions



Right Ventricular Pericardial Effusion



Bilateral Pericardial
Effusions



Link between oligohydramnios and cardiac function An aberrant phenotype

FGR pregnancies with Oligohydramnios

229 SOM patients with FGR
(2024)

2 with MVPs < 2cm (0.8%)

126 patients in the Perelman
FGR study

3 with MVPs < 2 cm (2.3%)

Unusual phenotype

2/3 with CA < 3rd %

3/3 with GSI < 5th %

Very small round hypertrophic
hearts!

Measurements of oligo patient



**Now take a deep
breath before
we summarize**



Studies from our Perelman team applying cardiac function to FGR

DeVore, G. R. et al. (2018). Right and left ventricular 24-segment sphericity index is abnormal in small-for-gestational-age fetuses. *Ultrasound in Obstetrics & Gynecology*, 52(2), 243-249.

DeVore, G. R. et al. (2019). Assessment of ventricular contractility in fetuses with an estimated fetal weight less than the tenth centile. *American Journal of Obstetrics and Gynecology*, 221(5), 498-e1.

Hobbins, J. C. et al. (2019). Size and shape of the four-chamber view of the fetal heart in fetuses with an estimated fetal weight less than the tenth centile. *American Journal of Obstetrics and Gynecology*, 221(5), 495-e1.

Hamidi, O. P. et al. (2023). Umbilical Venous Volume Flow in Late-Onset Fetal Growth Restriction. *Journal of Ultrasound in Medicine*, 42(1), 173-183.

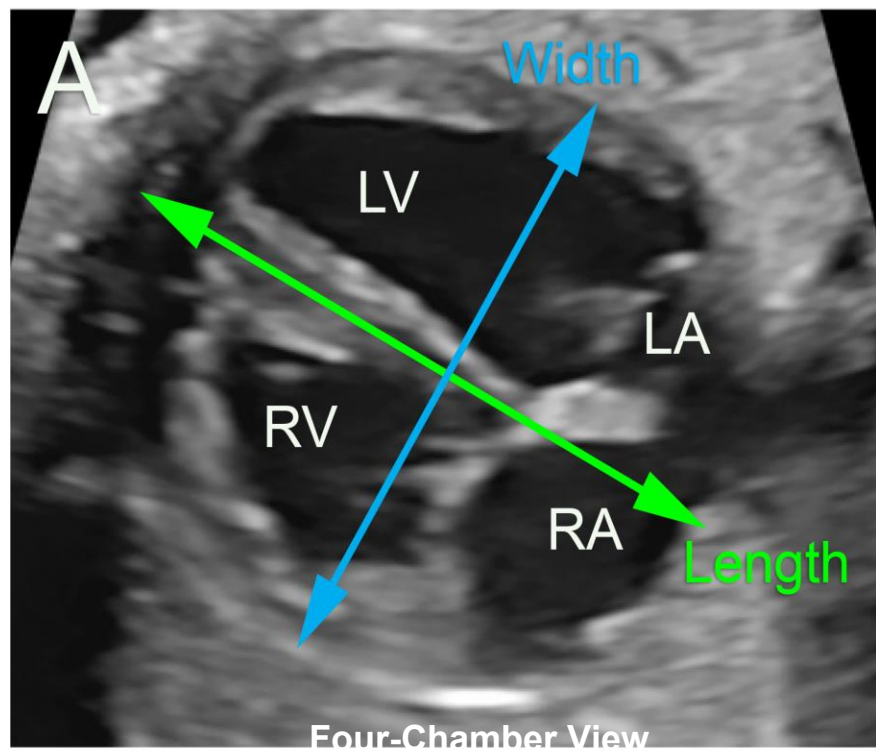
Steller, J.G. et al. (2023) Addressing pitfalls in the study of discrepant umbilical artery Dopplers. *American Journal of Obstetrics & Gynecology*. 2023 Aug 1;229(2):186-7.

Sayres, L. et al. (2024) Association of Amniotic Fluid Volume and Fetal Cardiac and Cerebrovascular Parameters in Fetal Growth Restriction. *Journal of Ultrasound in Medicine*. 2024 Oct;43(10):1969-78.

Putra, M. et al. (2024), Umbilical Vein Flows and Cardiac Size, Shape, and Ventricular Contractility in Fetuses with Estimated Weight Less-Than 10th Centile. *J Ultrasound Med*, 43: 2069-2084.

DeVore, G.R. et al. (2025) Assessment of Atrial Size, Shape, and Contractility in Growth-Restricted and Small-for-Gestational-Age Fetuses. *Journal of Ultrasound in Medicine*. 2025.

Is There A Screening Test That Would Identify Fetuses With an EFW<10th Centile Who Would Be At Risk For Cardiac Dysfunction?



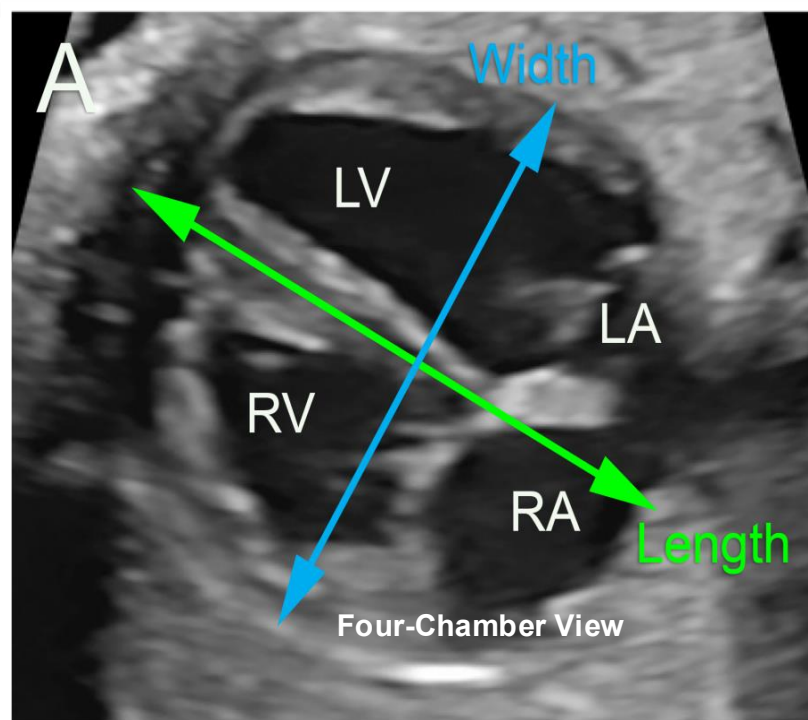
25 Fetuses With An EFW <10th Centile
ABNORMAL UAPI and/or CPR

92% Had One or More of the
Following End-Diastolic
Abnormalities Of the 4-Chamber View

- 1 Increased Width
- 2 Increased Area
- 3 Decreased Global SI

97%
Had Abnormal
Ventricular
Contractility
Using Speckle
Tracking Analysis

Is There A Screening Test That Would Identify Fetuses With an EFW<10th Centile Who Would Be At Risk For Cardiac Dysfunction?



25 Fetuses With An EFW <10th Centile
NORMAL UAPI and CPR

80% Had One or More of the
Following End-Diastolic
Abnormalities Of the 4-Chamber View

- 1 Increased Width
- 2 Increased Area
- 3 Decreased Global SI

85%
Had Abnormal
Ventricular
Contractility
Using Speckle
Tracking Analysis

Findings from these cardiac studies

1. SGA fetuses have almost as many abnormalities of cardiac size and shape, as well as contractility, as FGR fetuses.



2. Cardiac abnormalities appear to be independent of most Doppler methods of surveillance (except UVF).



3. Cardiac deformation appears early in the gradual hypoxia pathway.



4. Their pattern of frequency follows a logical physiological pattern.

The message regarding Dopplers in FGR

Assessing fetal condition requires using all available Doppler options since each one has separate meaning.

Certainly, umbilical arteries are the less informative by themselves, especially in late FGR but if abnormal, it takes FGR to a different level.

The MCA as an indicator of early-ish hypoxia

The VA reflects a higher level of hypoxic exposure

Even if the Dopplers are normal, at least 50% of fetuses with EFWs <10th % will have some evidence of cardiac dysfunction.

The UVF represents the best reflector of contractile dysfunction.

Goals of surveillance methods

1. Avoiding intrauterine demise and severe morbidity
2. Guidance in timing of delivery
3. Management of delivery itself
4. Identifying those at greater risk of later morbidity
(so that preventive measures can be started)

Categories of hypoxia severity based on expanded surveillance in late onset FGR

Mild

UAPI normal
MCAPI decreased
CPR decreased
VAPI normal
Ut A usually normal

UVF decreased

Elongated LV
CA normal or $>95\%$
GSI normal
RV/LV disproportion

Small right PE

Moderate

UAPI PI $>95^{\text{th}}$ %
MCA $< 5^{\text{th}}\%$
CPR $< 5^{\text{th}}\%$
VAPI decreased
Ut A may be $> 95^{\text{th}}\%$

UVF $< 5^{\text{th}}\%$

Globular heart
CA $>95\%$,
GSI $< 5^{\text{th}}\%$
RV/LV proportional

Right PE to apex of
the heart

Severe

UAPI $>95^{\text{th}}\%$ or $>99^{\text{th}}\%$
MCAPI may normalize
CPR $< 5^{\text{th}}\%$
Vert A $< 5^{\text{th}}\%$
Ut A PI often $>95^{\text{th}}\%$

UFV remains $< 5^{\text{th}}\%$

Hypertrophic heart
CA $>$ remains $>95^{\text{th}}\%$
GSI remains $< 5^{\text{th}}\%$
LV dominance

Bilateral PEs³⁸

Timing of delivery: Important concepts

Most late onset FGR fetuses do not need delivery prior to 35 weeks and most decisions for “early” delivery are between 35 and 38 weeks

But this window incorporates many critical developmental activities:

34 0/7 -36 6/7 weeks (late preterm) during peak development of white matter

37 0/7- 38 6/7 weeks—early term during fine tuning of gray matter

Since both activities require **highest energy requirements**, they are very vulnerable to hypoxia.

So, we need to know the duration and extent of the hypoxia at the time of decision-making

The goal of surveillance methods in FGR

To make cogent management decisions based the degree of hypoxia the fetus has been exposed to and to weigh this information against the risk of morbidity from early delivery.

In late onset FGR the tools we have will only tell us when the fetal condition is severe enough to cause imminent demise or severe morbidity.

Now we have an array of methods to assess indirectly varying degrees of severity (hypoxia).

None of this would be
available using current
protocols



We need a bigger toolbag!