FGR: A four-chamber clip of the fetal heart should be a diagnostic staple

Time to expand our diagnostic priorities

For years, the focus has been to prevent demise in early, severe FGR.

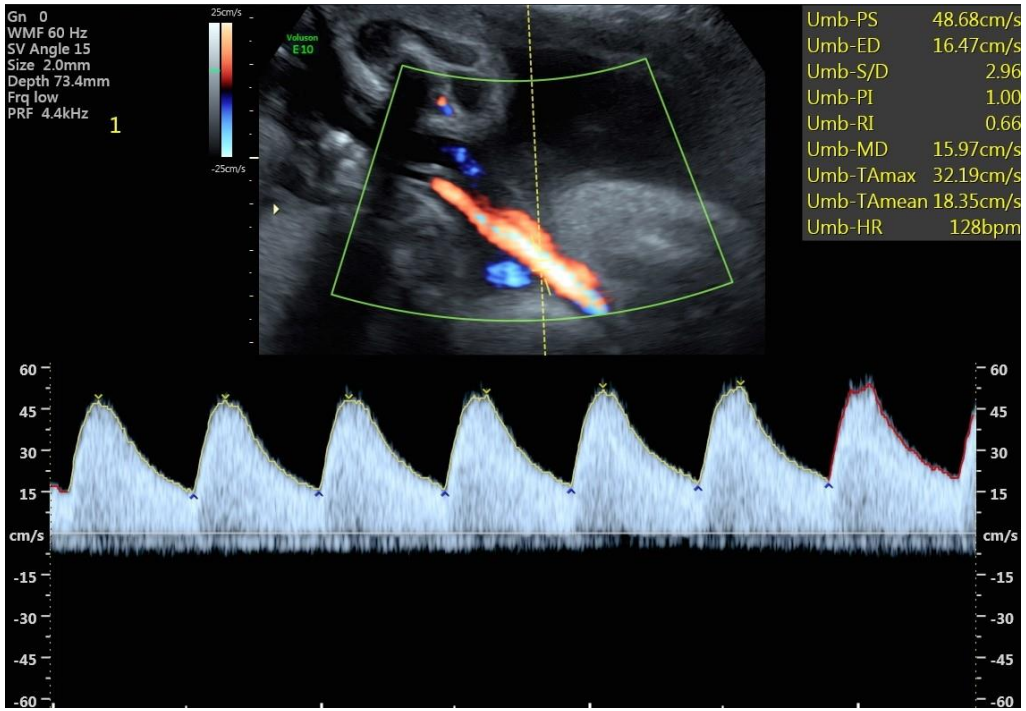
But now the thrust can be to predict morbidity, which can be missed with vintage methods.

Need to concentrate on long term as well as immediate effects

1. Neuro developmental dysfunction
2. Childhood and adult CV disorders.
3. Metabolic syndrome (obesity, diabetes)

New thrust: Prevention! More later

The umbilical artery: A component of all official management guidelines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Voluson
E10
Umb-PS 48.68cm/s
Umb-ED 16.47cm/s
Umb-S/D 2.96
Umb-PI 1.00
Umb-RI 0.66
Umb-MD 15.97cm/s
Umb-TAmax 32.19cm/s
Umb-TAmean 18.35cm/s
Umb-HR 128bpm
60
45
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cm/s
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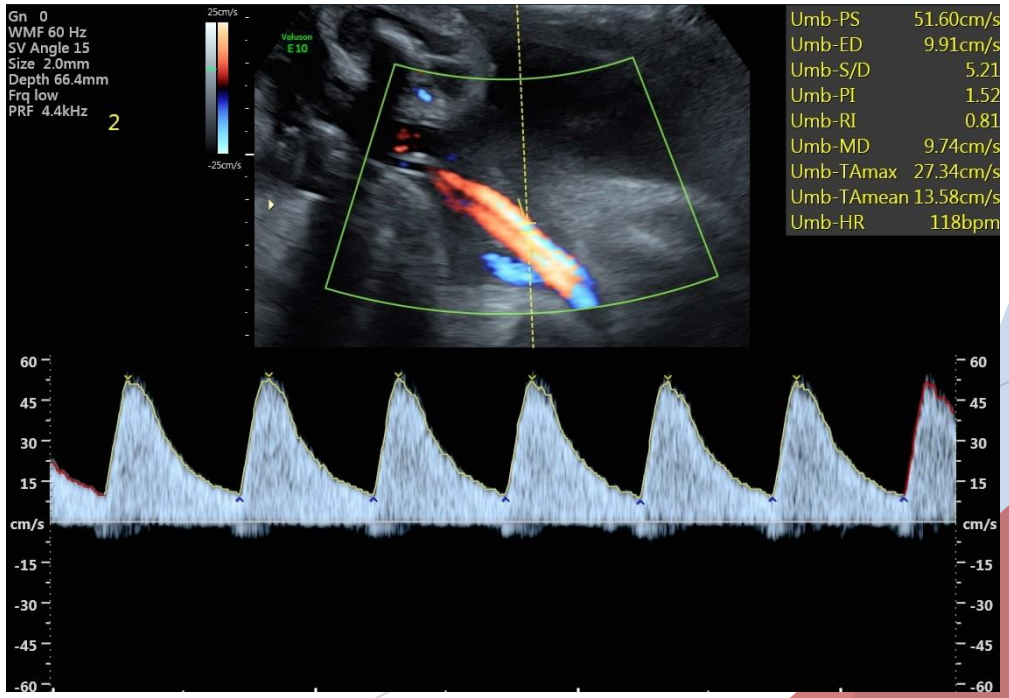
-45
-60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-25cm/s
Voluson
E10
Umb-PS 51.60cm/s
Umb-ED 9.91cm/s
Umb-S/D 5.21
Umb-PI 1.52
Umb-RI 0.81
Umb-MD 9.74cm/s
Umb-TAmax 27.34cm/s
Umb-TAmean 13.58cm/s
Umb-HR 118bpm
60
45
30
15
cm/s
-15
-30
-45
-60

The umbilical artery PI

A diagnostic staple for good reasons.

Assets:

- It reflects placental compromise
- Depicts placental resistance against which the heart works
- Using it may prevent fetal death
- Particularly useful in early onset FGR

Negatives:

- Often normal when less severe FGRs develop later morbidity
- It underpredicts fetal cardiac dysfunction

The UA: It can be normal even with major placental pathology

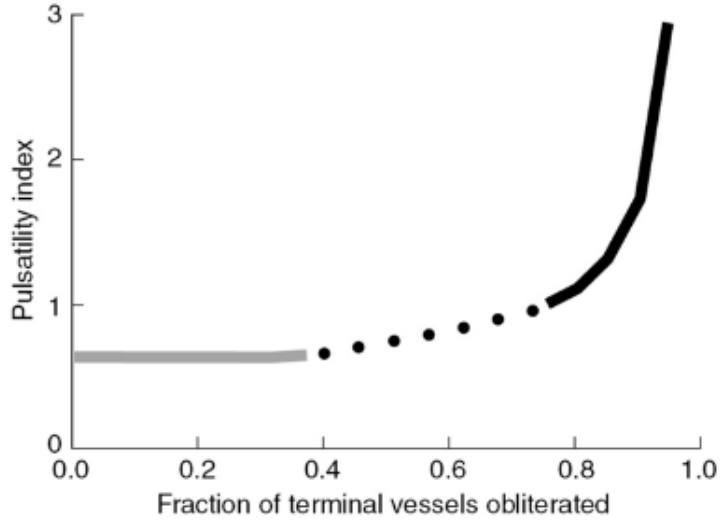


Figure 17.5 The curve reported by Trudinger in his seminal paper: "It was shown using this model that 60–70% of the small arterial channels would need to be obliterated before the umbilical artery indices of resistance became abnormal" (black line). The clinical problem is how to sort out the fetuses within the uncertain boundaries (dotted line) of placental damage.

The fetal heart is a rich source of information in FGR

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

A four-chamber video clip

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

It also suggests evidence of impairment of ventricular contractility.

It relates to childhood and adult CVD

What happens in cardiac remodeling

Macro effect:

Changes in size and shape: increased ventricular size (increased TW and CA) with a more globular shape (decreased GSI), all to counter wall stress and maintain stroke volume.

Hypertrophy (increased wall and IVS thickness)

Cellular effect:

Thinning of cardiomyocytes

Shorter sarcomeres

Biochemical: oxidative stress

Beta natriuretic peptide (BNP), a marker of cardiac dysfunction

Erythropoietin and troponin (markers of myocardial damage)

4 chamber clip: a great source of info about hypoxemia

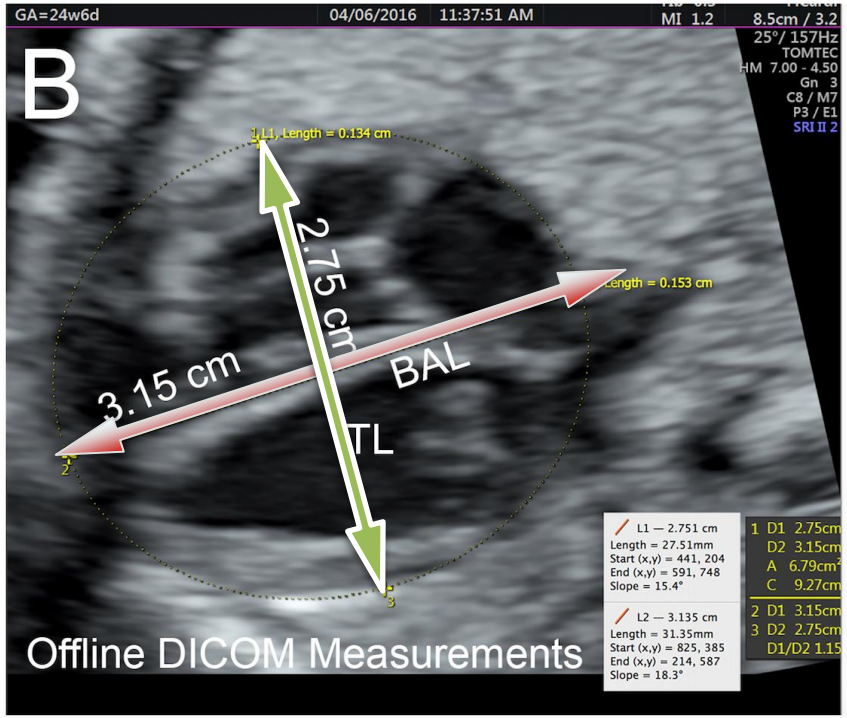
4 Chamber measurements yield important information about adaptive deformation

- Transverse width (TW)
- Cardiac area (CA)
- Global Sphericity Index (GSI)
- Right to left disproportion (RV/LV ratio)

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 → Round

Normal

GSI < 5th (<1.08)

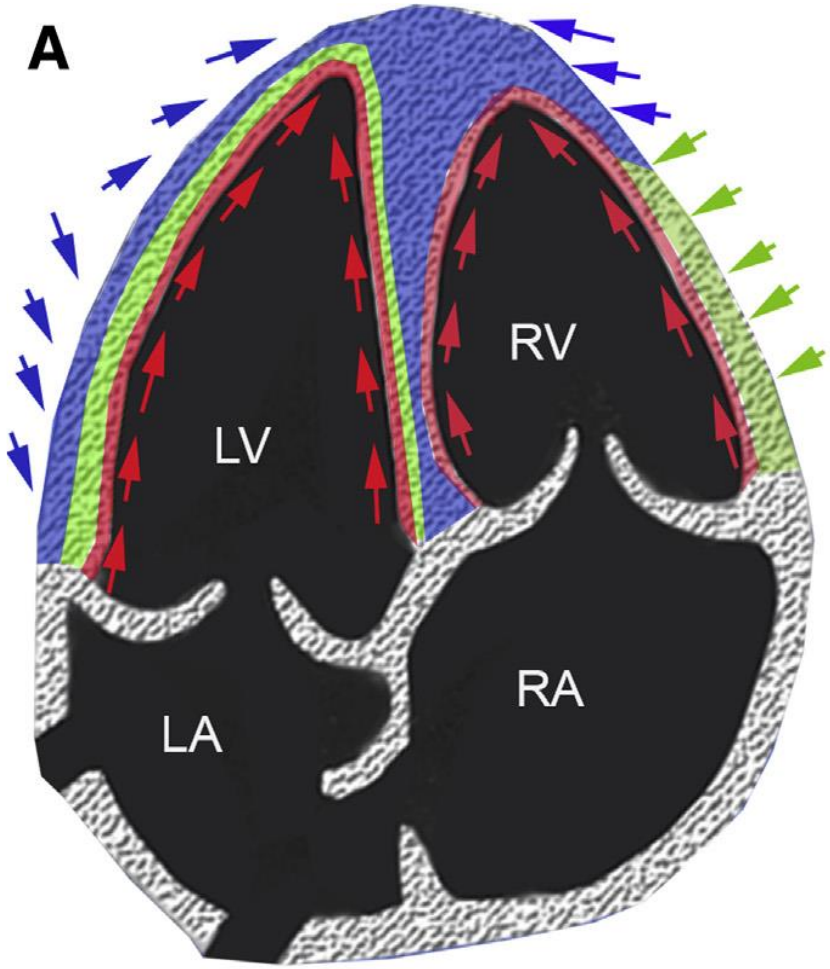
Contractility: The basics

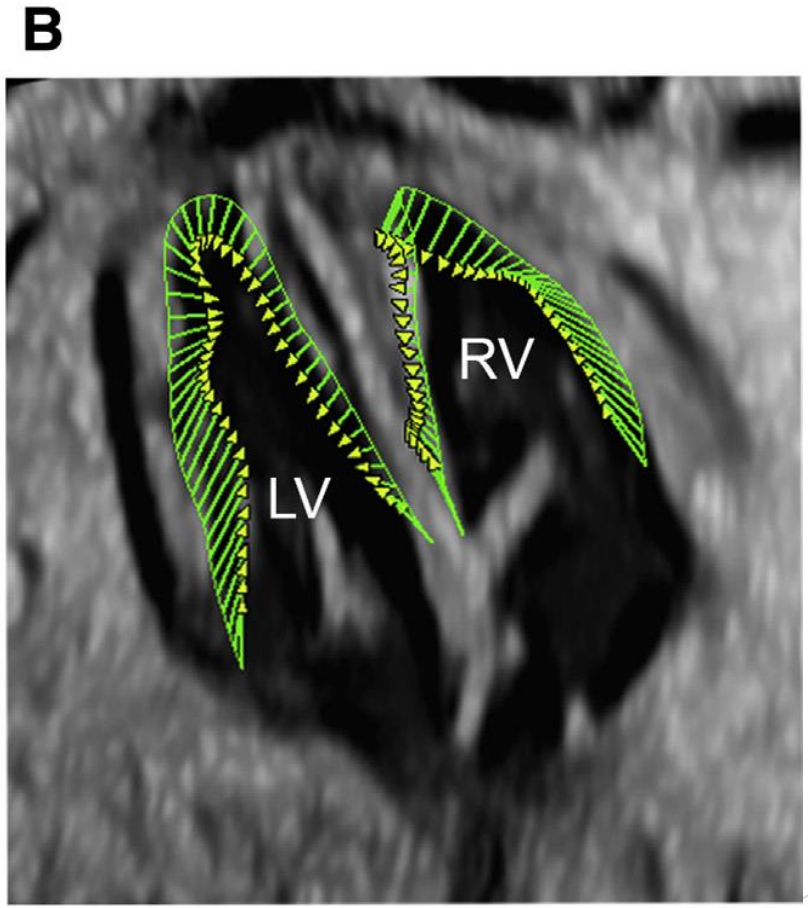
Transverse

Longitudinal

Circumferential

[redacted]



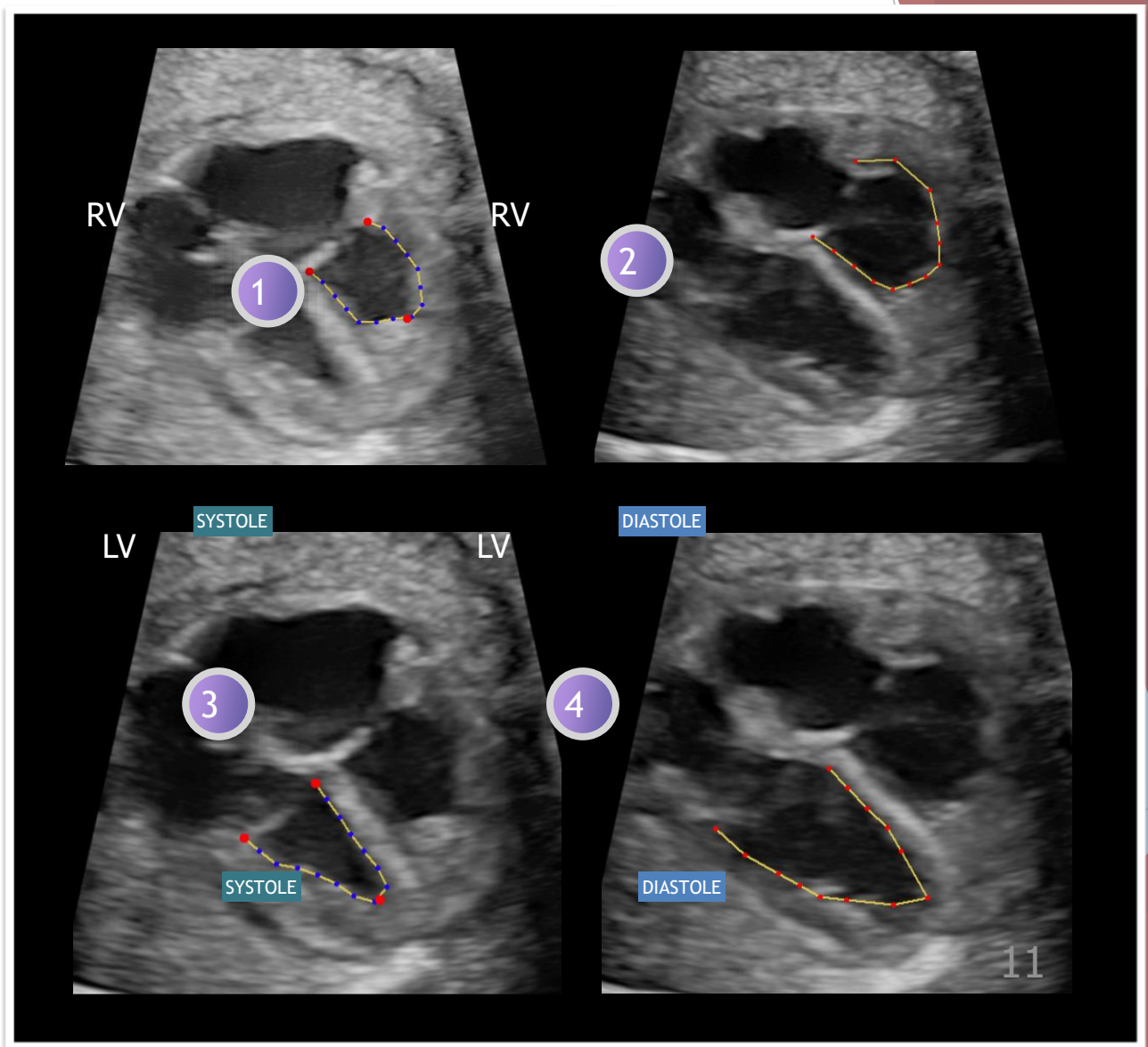


Longitudinal Helical Circumferential

Out with the old, in with the new: Speckle tracking

A way to assess global, transverse and longitudinal contractility from a simple 4 chamber view clip

Ventricular Contractility



SPECKLE-TRACKING ANALYSIS

Perelman publications on fetal heart function/remodeling in FGR

Hobbins JC, Gumina DL, Zaretsky MV, Driver C, Wilcox A, DeVore GR. Size and shape of the four-chamber view of the fetal heart in fetuses with an estimated fetal weight less than the tenth centile. Am J Obstet Gynecol. 2019 Nov;221(5):495.e1-495.e9. doi: 10.1016/j.ajog.2019.06.008. Epub 2019 Jun 14. PMID: 31207236.

DeVore GR, Gumina DL, Hobbins JC. Assessment of ventricular contractility in fetuses with an estimated fetal weight less than the tenth centile. Am J Obstet Gynecol. 2019 Nov;221(5):498.e1-498.e22. doi: 10.1016/j.ajog.2019.05.042. Epub 2019 May 30. PMID: 31153929

Sayres, L., Sahi, R.K., Straub, H., Peek, E. and Hobbins, J.C. (2024), Association of Amniotic Fluid Volume and Fetal Cardiac and Cerebrovascular Parameters in Fetal Growth Restriction. J Ultrasound Med. https://doi.org/10.1002/jum.16531

Putra, M., Peek, E.E.H., Devore, G.R. and Hobbins, J.C. (2024), Umbilical Vein Flows and Cardiac Size, Shape, and Ventricular Contractility in Fetuses With Estimated Weight Less-Than 10th Centile. J Ultrasound Med. https://doi.org/10.1002/jum.16536

Devore GR, Putra N, Hobbins JC. Assessment of atrial size, sheep, and contractility in growth restricted and small for gestational age fetuses. Journal of the International society of ultrasound in obstetrics and gynecology.

Findings generated by these studies

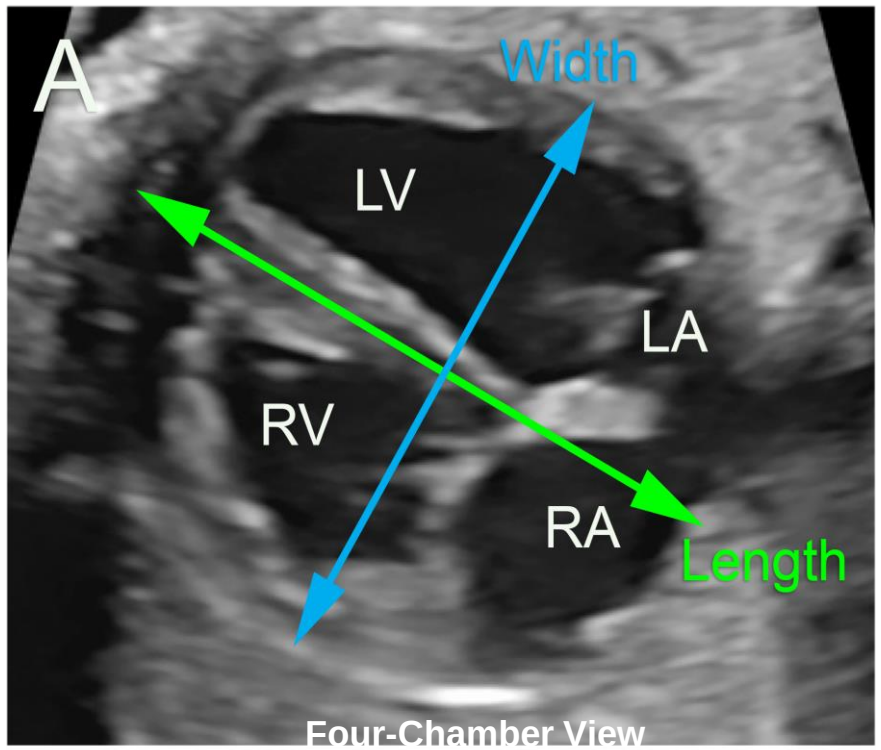
1. SGA fetuses have almost as many abnormalities of cardiac size and shape, as well as contractility as FGR fetuses.

2. Cardiac abnormalities correlate poorly with most Doppler methods of surveillance.

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

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

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

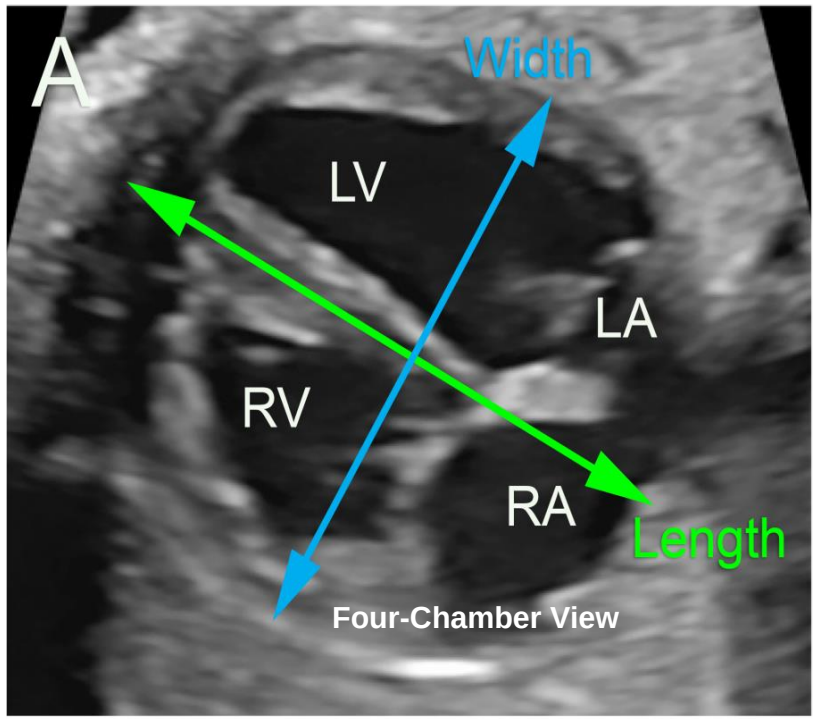
92% Had One or More of the Following End-Diastolic Abnormalities Of the 4-Chamber View

1. **Increased Width**
2. **Increased Area**
3. **Decreased Global SI**

97% Had Abnormal Ventricular Contractility Using Speckle Tracking Analysis

(Hobbins JC et al. Am J Obstet Gynecol, 2019)

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

Hypoxia and cardiac function in FGR

Observations in 95 patients with EFWs < 10th%

Screening by Size and Shape

TW ↑ as ventricles expand to maintain stroke volume.

GSI ↓ as rounding occurs.

CA ↑ in less severe FGR and decreases in severe FGR (reasons).

RV/LV ratio ↑ in less severe FGR

Ventricular contractility

Global FAC, then longitudinal strain and, last, transverse FSC.

LVCO is the most common contractile abnormality and correlates best with RV/LV ratio.

FGR pregnancies with Oligohydramnios

229 SOM patients with FGR

2 with MVPs < 2cm (0.8%)

126 patients in Perelman FGR study

3 with MVPs< 2 cm (2.3cm)

Unusual phenotype

2/3 with CA<3rd %

3/3 with GSI < 5th %

Very small round hearts!

Measurements of oligo patient

Doppler surveillance methods that correlate with fetal cardiac changes?

Yes!

A new kid on the block who has gotten a make over:

The Umbilical Vein flow.

Umbilical Vein: a largely forgotten vessel

Umbilical vein flow: the lifeline

Correlates well with placental mass (Galan 1999)

Decrease in volume flow occurs earlier than A/R flow in umbilical artery (Rigano 2001).

Excellent correlation with need for emergency CSx and neonatal outcome, especially when combined with MCA (Parra-Saavedra 2014).

Then: In late onset FGR, UBF/AC correlated with adverse neonatal outcomes better than UA, CPR, and MCA. (Rizzo et al. ISUOG 2020;55:793)

Our study: Absolute UVF and UVF/ AC were lower in FGR vs controls but not significantly different from SGA.

Does umbilical blood flow predict abnormal ventricular dysfunction?

In 76 patients with FGR, it doubled the pickup rate of modest (1 or more) or severe (3 or more) contractile abnormalities when added to a regimen of UAPI, CPR.

UAPI alone (SMFM)	10/58(17%)	6/31 (19%)
UAPI, CPR (ISUOG)	14/58(24%)	7/31 (22%)
UAPI, CPR, UVF	28/58 (48%)	14/31 (45%)

The big bonus for the fetus: Evidence of remodeling may allow preventive measures to be implimented

Why is it important to diagnose cardiac dysfunction?

Evidence that cardiac remodeling might be reversable with early intervention with:

Diet (Skilton et al Hypertension 2013;61:972)

Breast feeding (Rodriguez et al Ped Research 2016;79;110-16)

Supplements (alpha linoleic acid) (Skilton et al. 2013)

Exercise (Cruz-Lemli et al. AJOG 2014;210:552e1-6)

Vitamins (folic acid, B12) (Jiang et al Gen Molec Research 2016;15)

Morbidity prevention should be the future of perinatal medicine, but you need a bigger diagnostic toolbox