

Echocardiographic assessment of heart failure severity in fetus

F. Ashnaei MD

Pediatric cardiologist

Lavasani hospital

Fetal myocardium

- Less T-tubular system
- Less organized myofibrils
- Less sarcoplasmic reticulum
- Decreased Ca uptake
- Less mitochondria
- Decreased sympathetic innervation



- ✓ Reduced ability of the fetal heart to contract and generate force
- ✓ Lower myocardial compliance
- ✓ Diminished Frank Starling mechanism



❖ **Decreased cardiac reserve**

Fetal congestive heart failure

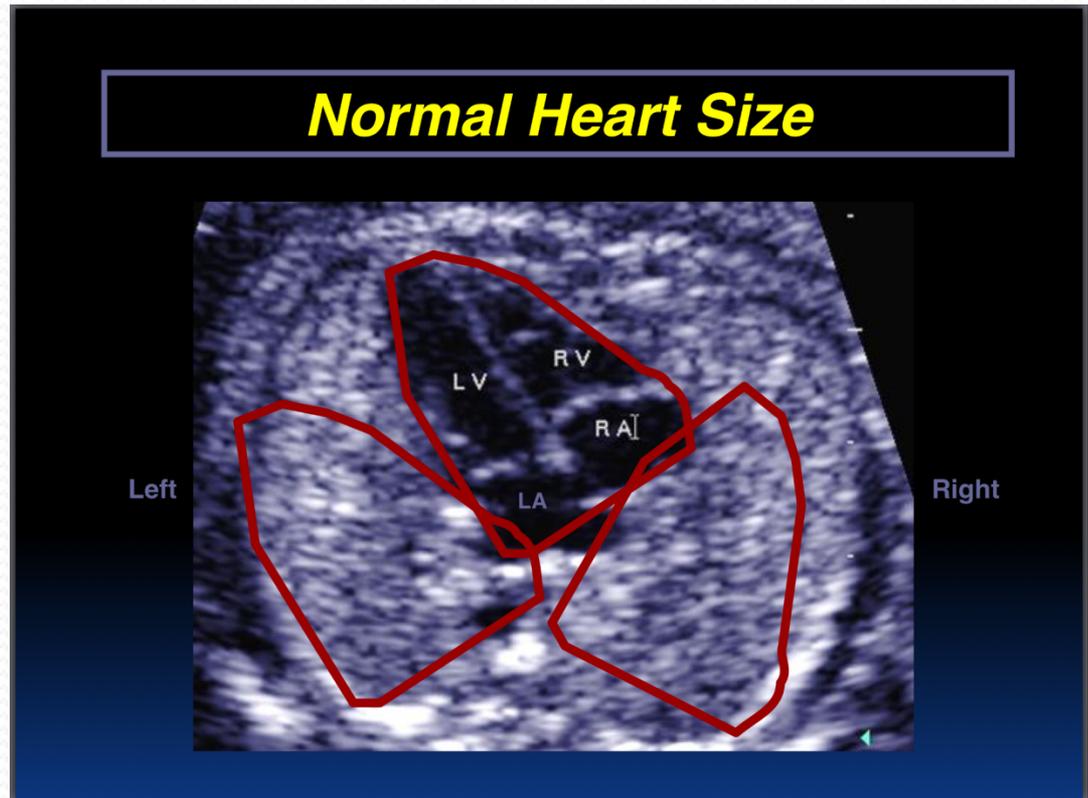
- Heart failure : inadequate tissue perfusion
- The final common pathway to fetal death is poor tissue perfusion and acidosis(CHF)
- Sign of cardiac failure :
 - ✓ **Shortness of breath**
 - ✓ **Exercise intolerance**
 - ✓ **Body swelling**

Assessment of fetal heart failure

- ❖ Heart size
- ❖ Heart function
- ❖ Hydrops
- ❖ Venous doppler (Ductus venosus ,umbilical vein)
- ❖ Arterial doppler(umbilical and middle cerebral artery)

Heart size

- Normal : cardiac area / thoracic area = 20% - 35%
- mild cardiomegaly = 35%-50%
- sever cardiomegaly = > 50%
- Normal Cardio thoracic circumference ratio is < 50%
- ✓ Isolated RA enlargement is a sign of many abnormalities ,especially early in gestation. this may be because the RA is at the Centre of the fetal circulation.



heart function

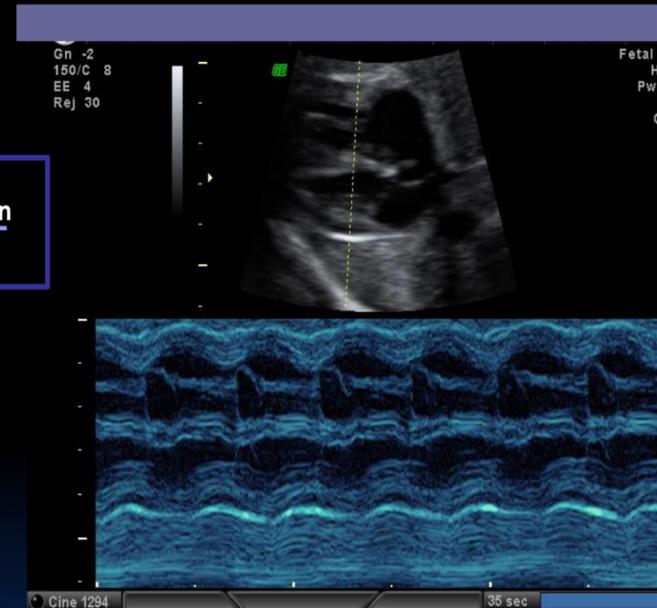
- ✓ Any left ventricular posterior wall thickness greater than or equal to **4 mm** is abnormal in the fetus

Fractional shortening

$$\frac{\text{End-diastolic dimension} - \text{End-systolic dimension}}{\text{End-diastolic dimension}}$$

Fractional shortening is constant throughout gestation
(normal > 0.28)

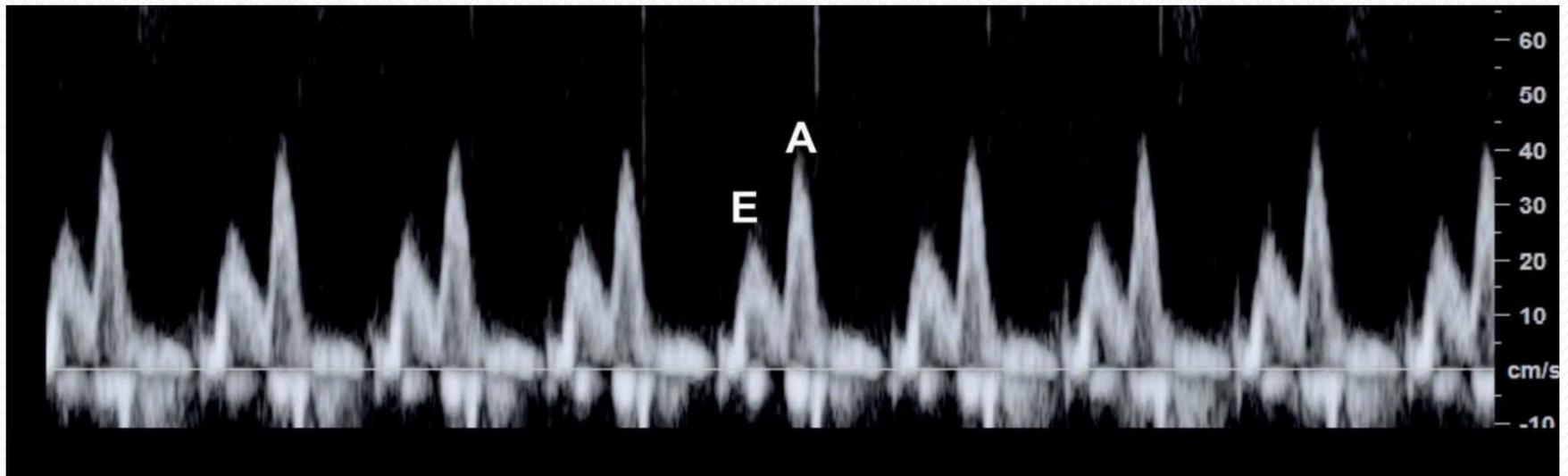
- Myocardial compromise
- Increase in the fetal ventricular workload



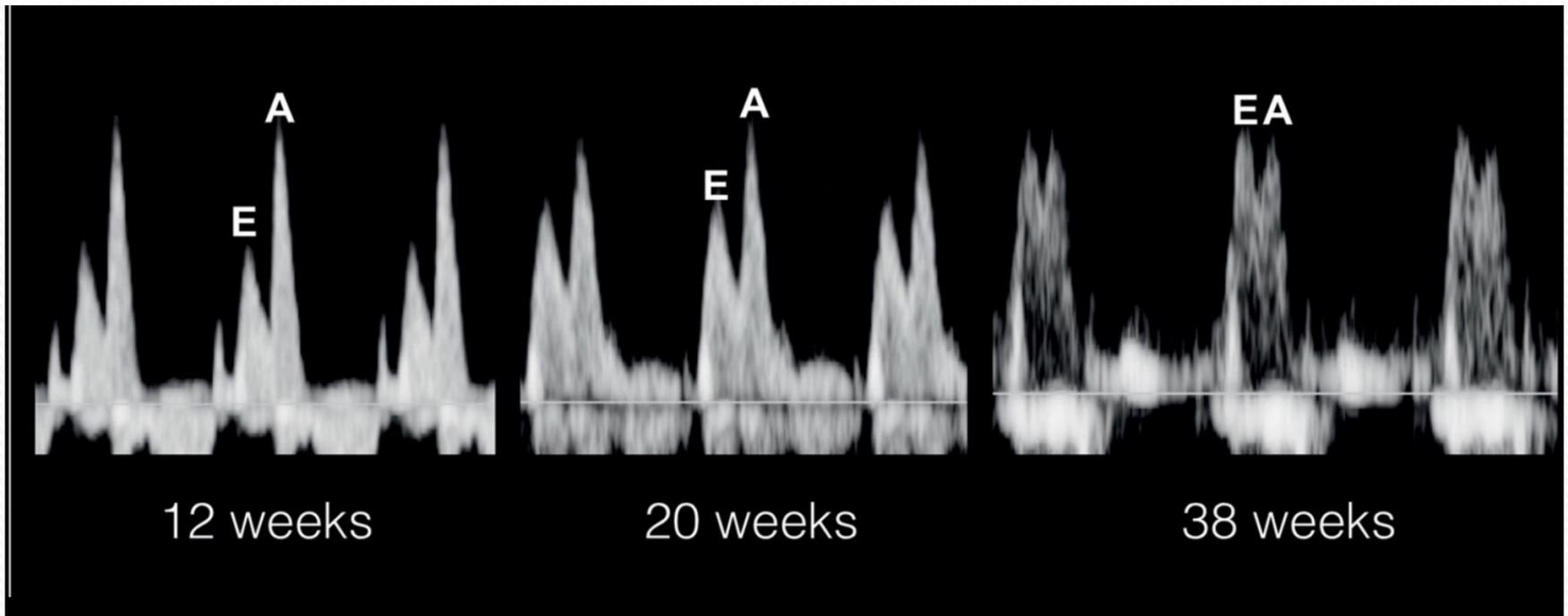
heart function

- ✓ The atrioventricular and semilunar valves are competent in the normal fetus and any regurgitation is abnormal
- ✓ Tricuspid valve regurgitation can be a reversible sign of heart failure but regurgitation of other valves is usually a sign of more advanced CHF
- ✓ Order of valvular regurgitation with advance of CHF:
TR → MR → PI AND AI

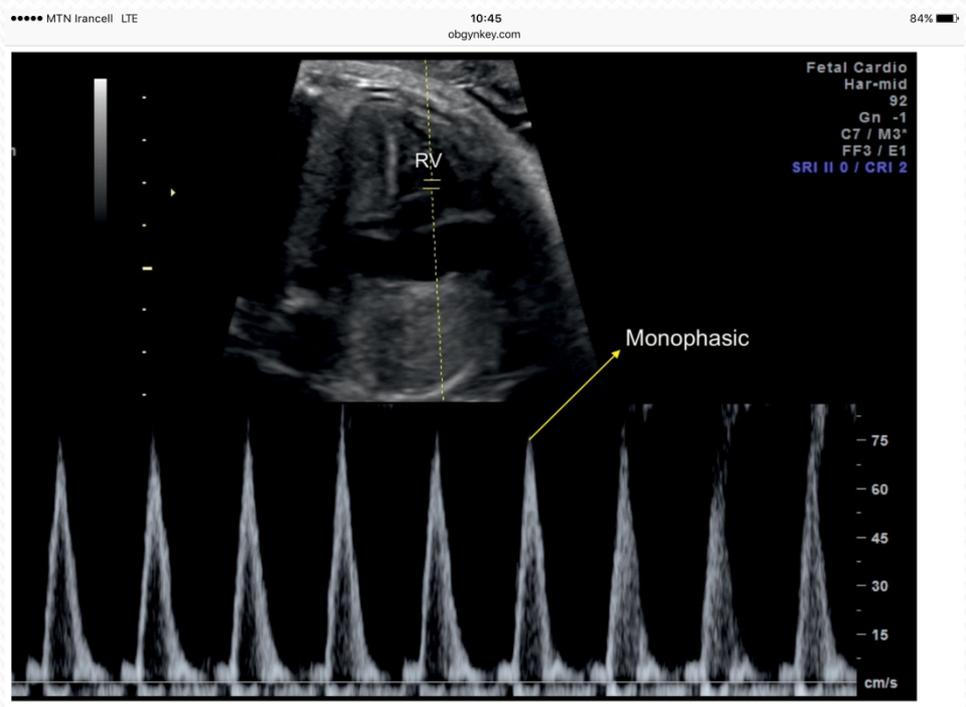
- greater percentage of ventricular filling in fetus occurs during **active atrial contraction** rather than during passive filling.
- Unlike in postnatal life , the velocity of the A wave(atrial contraction) is higher than that of the E wave($A/E > 1$) in the fetus. This explains why fetuses with **atrial arrhythmias** are at increased risk of developing hydrops fetalis.



Normal atrioventricular valves doppler in fetus

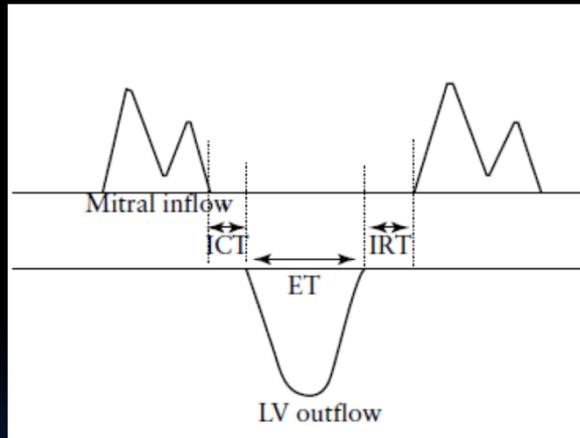


✓ Monophasic filling of the ventricles is a sign of compromised diastolic function and severe fetal heart failure.



heart function

Myocardial performance index



Systolic and Diastolic function

- independent of heart rate
- independent of ventricular geometry
- non invasive

$$\text{Index} = \frac{a - b}{b} = \frac{(\text{ICT} + \text{IRT})}{\text{ET}}$$

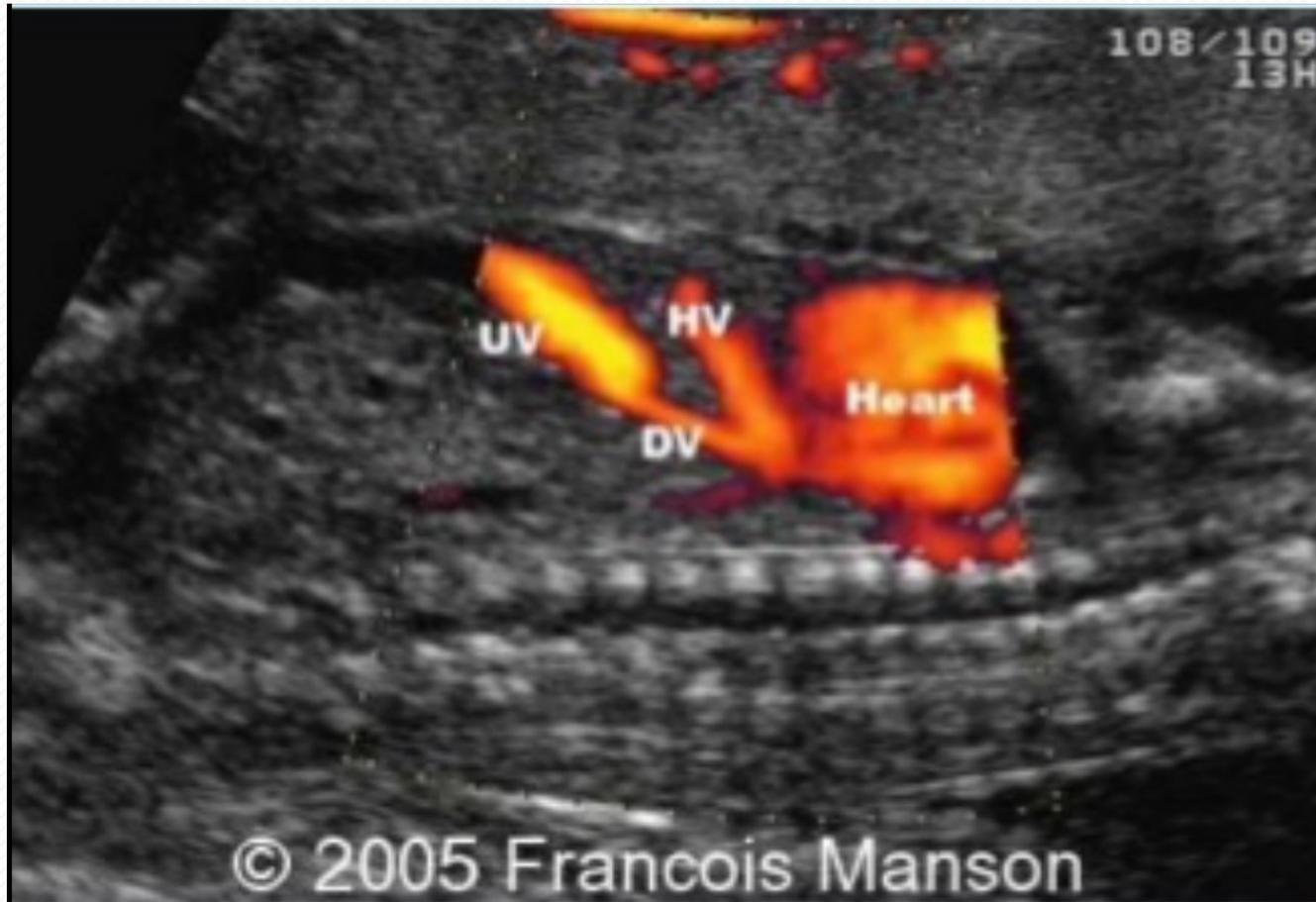
Hydrops fetalis

- ✓ The most useful predictor of perinatal death in fetal hydrops is the presence of umbilical venous pulsations

Venous doppler

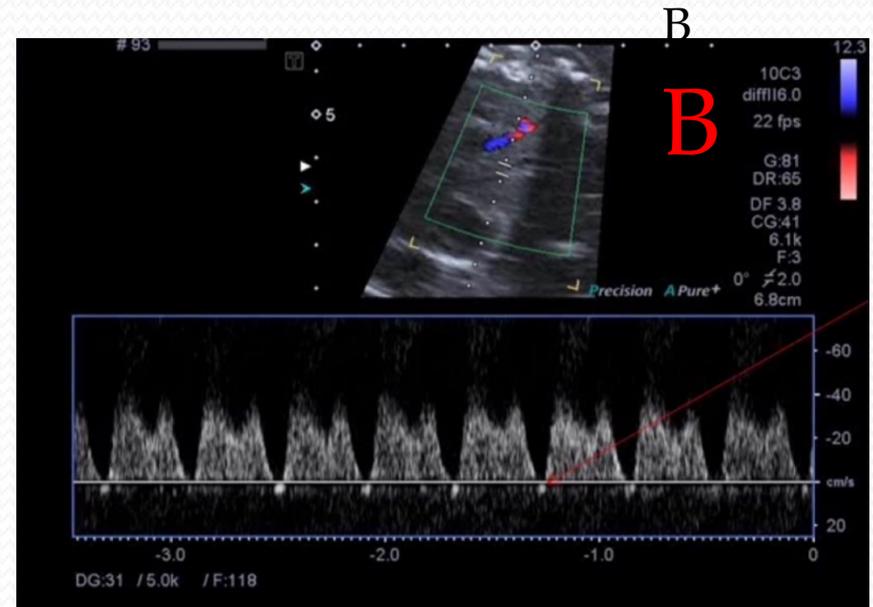
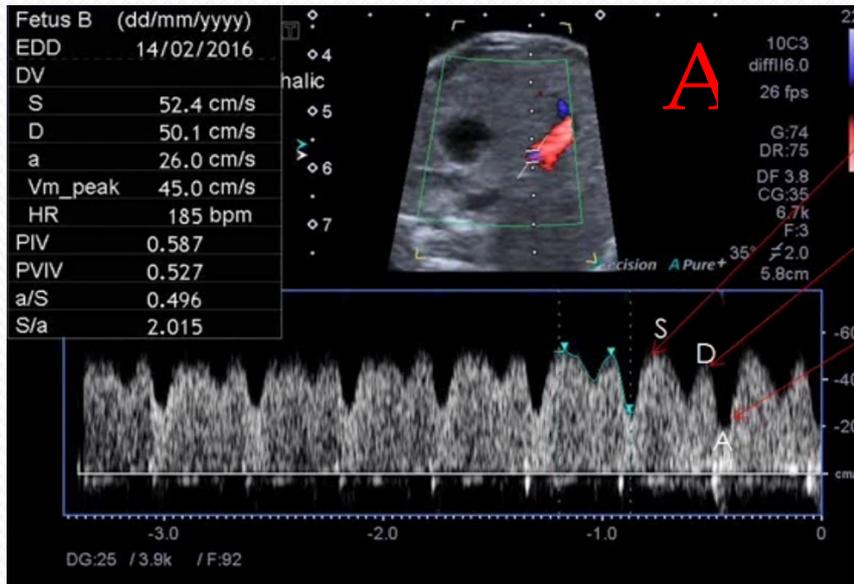
- ✓ As systemic venous pressure rises in heart failure, changes within the Doppler flow patterns are **first seen** in the inferior vena cava, then in the ductus venosus ,and finally in the umbilical vein
- **Ductus venosus doppler** identify what is happening in the heart
- Of all the precardial veins DV yields **the best and most reliable information** on fetal myocardial hemodynamics and cardiac function

Color doppler of ductus venosus(sagittal view)



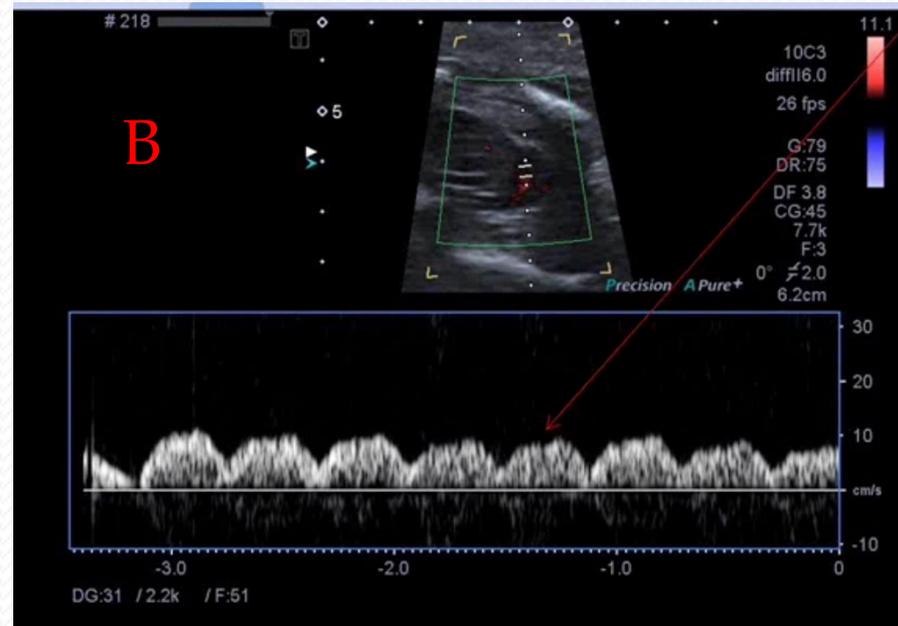
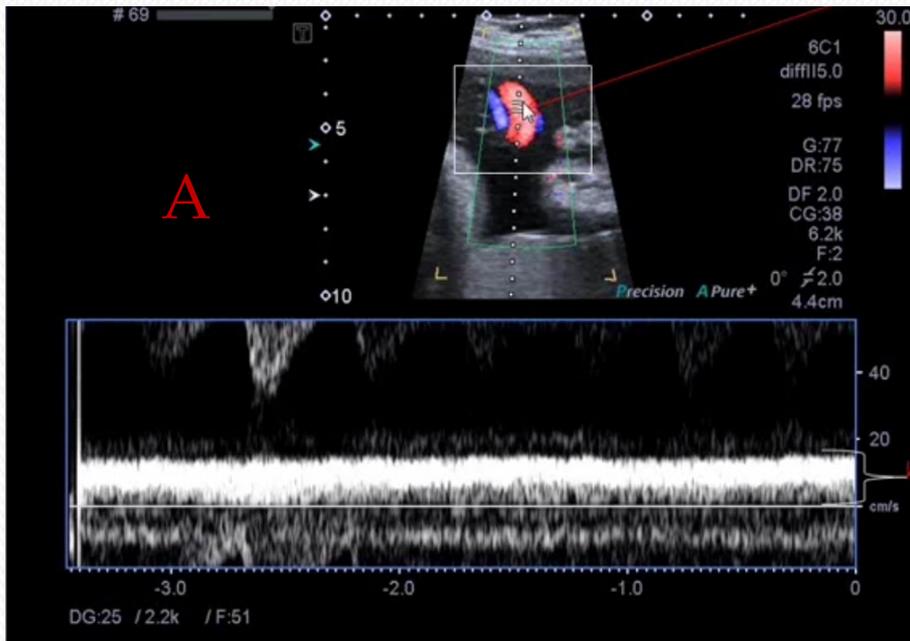
A: normal ductus venosus doppler

B: abnormal ductus venosus doppler



Umbilical vein

A: normal, monophasic non pulsatile flow
B: abnormal, pulsatile flow



Umbilical artery doppler

Normal color Doppler frequency spectrum sampled from the umbilical artery



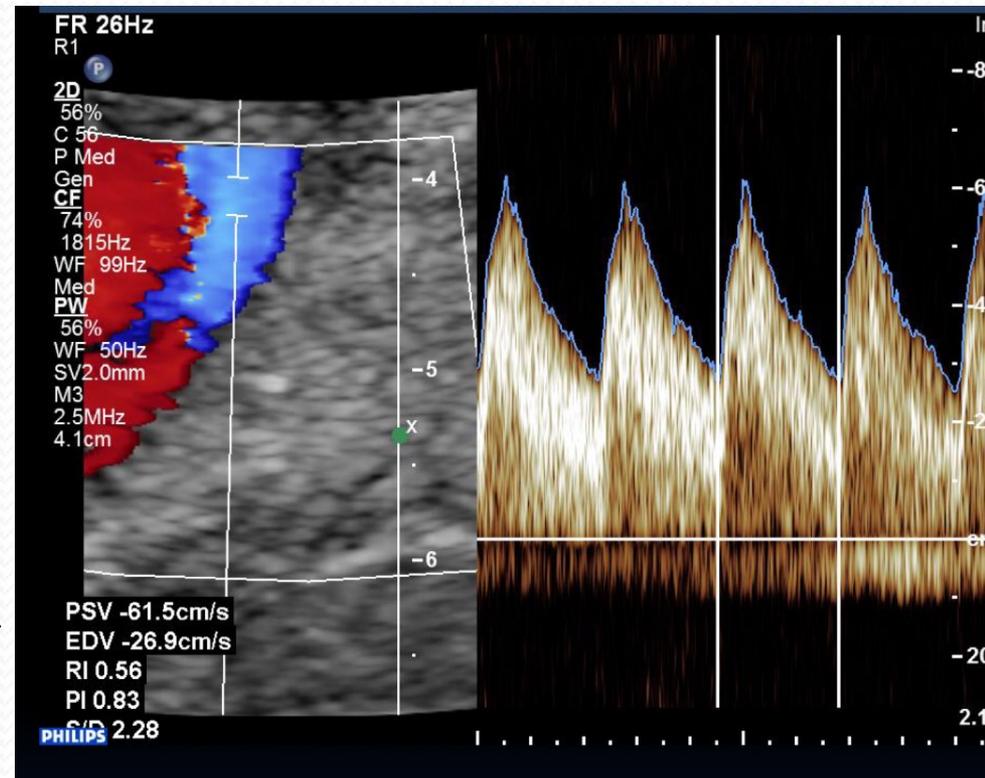
Doppler analysis-the indices

-Resistance index (RI) =
$$\frac{\text{systole (S)} - \text{diastole(D)}}{\text{S}}$$

-Pulsatility index(PI) =
$$\frac{\text{S} - \text{D}}{\text{A(average)}}$$

-Systole / diastole ratio=S / D

-diastolic average ratio=D / A



umbilical artery

- ✓ Findings of an increased resistance index in the umbilical artery and a decreased index in the middle cerebral artery, are non-invasive signs of redistribution of blood flow.
- ✓ The most common cause of elevated vascular resistance in the fetus is placental dysfunction secondary to vasculopathy leading to asymmetrical growth retardation.
- ✓ The umbilical artery manifests this problem with a loss or reversal of diastolic blood flow.
- ✓ Diastolic flow reversal within the umbilical artery, is a marker for poor outcome and a risk factor for in utero fetal demise

Abnormal umbilical artery doppler

- ✓ Umbilical artery $RI \geq 0.8$ is always abnormal at any gestational age
- ✓ PI value range from 2 to 1.5 in second trimester and 1.5 to 1 in third trimester . values above this is abnormal.
- ✓ S/D ratio >3 in umbilical a. beyond 30 weeks is abnormal.

Why middle cerebral artery (MCA) is chosen for sampling

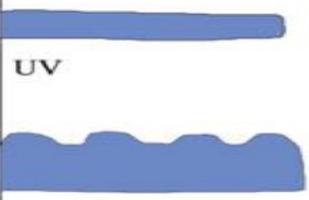
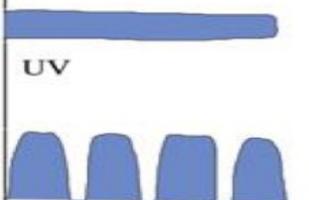
- ✓ Easy to identify
- ✓ MCA has a conducive course ,so can be studied easily with an angle of 0 degrees between the ultrasound beam and the direction of blood flow
- ✓ Unlike the uterine and umbilical artery vascular beds which constantly change with advancing gestational age ,the MCA vascular bed resistance is almost constant throughout pregnancy ($RI=0.75- 0.85$) ,so this change is great value in hypoxia and heart failure

middle cerebral artery (MCA) doppler

- Fetal middle cerebral arterial (MCA) Doppler assessment is an important part of assessing fetal cardiovascular distress, fetal anaemia or fetal hypoxia
- in the normal situation the fetal MCA has a high resistance flow which means there is minimal antegrade flow in fetal diastole
- during hypoxia ,fetal compensatory mechanism cause constriction of the vascular beds of other organs with redistribution of arterial blood flow to the cerebrum(fetal brain sparing theory)

Fetal cardiovascular profile score

CVP score of ≥ 8 is associated with good perinatal outcome

	Normal	-1 point	-2 points
Hydrops	None (2 pts)	Ascites or Pleural effusion or Pericardial effusion	Skin edema
Venous Doppler (Umbilical vein) (Ductus venosus)	 UV DV (2 pts)	 UV DV	 UV pulsations
Heart Size (Heart Area / Chest Area)	>0.20 and <0.35 (2 pts)	$0.35 - 0.50$	>0.50 or <0.20
Cardiac Function	Normal TV & MV RV/LV S.F. >0.28 Biphasic diastolic filling (2 pts)	Holosystolic TR or RV/LV S.F. <0.28	Holosystolic MR or TR $dP/dt < 400$ or Monophasic filling
Arterial Doppler (Umbilical artery)	 UA (2 pts)	 UA (AEDV)	 UA (REDV)