Fetal cardiac function: what to use and does it make a difference?

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No disclosure
Fetal disease and the heart
target organ in fetal adaptation to disease

Adaptive response → Permanent Epigenetic changes
Progressive failure

CLINICAL MONITORING
CARDIAC PROGRAMMING
The primary function of the heart is to **eject blood** in order to provide adequate perfusion of organs.

- **DIASTOLE**
  - Relaxation
  - Ventricular filling
- **SYSTOLE**
  - Contraction
  - Ejection of blood
CHRONIC ADAPTATION SUBCLINICAL CARDIAC DYSFUNCTION CLINICAL CARDIAC FAILURE

longitudinal

radial

M-mode
conventional Doppler
tissue Doppler
2D speckle tracking
4D-STIC

diastolic
systolic
**Ejection fraction**

\[
\text{Ejection fraction} = \frac{\text{end diastolic ventricular volume} - \text{end systolic volume}}{\text{end diastolic volume}}
\]

**SYSTOLE**

Fraction of blood ejected from the ventricle with each heart beat

**LIMITATIONS**

Angle dependency
Late-event

cardiac output

\[ \text{cardiac output} = \text{stroke volume} \times \text{heart rate} \]

\[ = 4\pi \times (\text{valvular diameter})^2 \times (\text{velocity time integral}) \times \text{heart rate} \]

CONVENTIONAL DOPPLER

SYSTOLE

Volume of blood being pumped by the ventricle per minute

LIMITATIONS

Variability
Late-event

CARDIAC OUTPUT

CARDIAC INDEX (adjustment by estimated fetal weight)
CHRONIC ADAPTATION   SUBCLINICAL CARDIAC DYSFUNCTION

CLINICAL CARDIAC FAILURE

CARDIAC OUTPUT

EJECTION FRACTION

diastolic

systolic
Pulsatility index

Peak systolic - minimum diastolic velocities / mean velocity

LATE DIASTOLE
atrial contraction

Pattern of blood during atrial contraction that indirectly reflects cardiac compliance

LIMITATIONS
Late-event

Hecher et al. UOG 1996
Conventional Doppler

**E/A RATIOS**

**DIASTOLE**

Ratio between early (E) and late (A) ventricular filling velocity

**LIMITATIONS**

Clinical variability
Interpretation

Allan et al. B Heart J 1987
conventional Doppler

MYOCARDIAL PERFORMANCE INDEX

DIASTOLE

SYSTOLE

Sample 4-5 mm
Maximum sweep
Gain 60 Hz

LIMITATIONS
Variability
Interpretation

Mitral closure
Aortic opening
Mitral opening
Aortic closure

Aorta
S
ICT
IRT
ET

MPI = \frac{ICT + IRT}{ET}

CHRONIC ADAPTATION

SUBCLINICAL CARDIAC DYSFUNCTION

CLINICAL CARDIAC FAILURE

myocardial motion

DISPLACEMENT

VELOcity

longitudinal

MPI

E/A RATIOS

DUCTUS VENOSUS

diastolic

radial

EJECTION FRACTION

CARDIAC OUTPUT

systolic
longitudinal motion
mitral/tricuspid annulus
(1 point)

M-mode & tissue Doppler
MYOCARDIAL MOTION

M-mode

tissue Doppler online

displacement
MAPSE / TAPSE

mm

mm

cm/s

DISPLACEMENT
VELOCITY

peak velocity

S'

E'

A'
CHRONIC ADAPTATION

SUBCLINICAL CARDIAC DYSFUNCTION

LONGITUDINAL

motion

DISPLACEMENT

VELOCITY

myocardial deformation

E/A RATIOS

DUCTUS VENOSUS

systolic

diastolic

radial

EJECTION FRACTION

CARDIAC OUTPUT

CLINICAL CARDIAC FAILURE

CLINICAL

CARDIAC FAILURE
Deformation of a myocardial segment (2 points)

Strain deformation

Strain-rate speed of deformation

Tissue Doppler & 2D-speckle tracking offline

MYOCARDIAL DEFORMATION

Crispi et al. Fetal Diagn Therapy 2012
CHRONIC ADAPTATION  SUBCLINICAL CARDIAC DYSFUNCTION

CLINICAL CARDIAC FAILURE

DIASTOLIC SYSTOLIC

E/A RATIOS

DUCTUS VENOSUS

CARDIAC OUTPUT

EJECTION FRACTION

辖区内

motion

longitudinal

radial

deformation

displacement

velocity

systolic
limitations of fetal cardiac function

- Fetal position
- Fetal movement
- Fetal size
- Fetal heart rate and high frame rate
- Impossibility of fetal ECG
- Understanding requirements and rationale
- Differences in algorithms/processing
- Fetal differences with postnatal life:
  - Cardiomyocyte maturation
  - Geometry/deformation

Strict criteria
Definition of fetal physiology
Understanding limitations
Application to clinical conditions
Fetal disease and the heart

target organ in fetal adaptation to disease

Adaptive response
Progressive failure

CLINICAL MONITORING
MPI and long-axis motion sensitive markers of dysfunction

Permanent Epigenetic changes

CARDIAC PROGRAMMING
predictive of postnatal cardiovascular outcome

UNDERSTANDING

IMPACT OF ENVIRONMENT

Fetus, Child, Young, Mature, Old
Although fetal cardiac function requires formal training and special care with the acquisition and postprocessing, in experienced hands, it is feasible and reproducible.

Fetal cardiac function is a promising tool for monitoring and prediction postnatal outcome.
thank you