Fetal cardiac MRI – how can we do it?

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Currently available techniques

- Static steady state free precession
- An alternative to fetal echocardiography
- Provides diagnostic imaging for cardiac anatomy
- Non gated sequence
  - Localisers to maternal abdomen and fetal thorax
  - 3 × 10-15 slice stacks in orthogonal planes to thorax
  - 4mm slices, no gap, ~1mm in-plane resolution, scan time ~800 ms per slice

Cine imaging for cardiac function and to overcome artifact from cardiac motion

- Real-time
  - Commercially available, no requirement for gating, temporal resolution ~100 ms, poor spatial resolution
- Gating
  - Self-gating (animal research)
  - Ultrasound gating – MRI compatible cardiotocography (animal research)
  - Metric optimised gating

Metric optimised gating (MOG)

- A retrospective re-ordering of oversampled k-space data using a range of candidate average heart rates
- An image metric, quantifying the severity of artifact, used to identify the best fit average heart rate for any acquisition
- Can be used for cine phase contrast flow quantification and SSFP anatomical cine imaging

Fetal MR oximetry

- BOLD MRI
  - Used in animal research to investigate fetal hemodynamics in response to changes in fetal oxygenation in terms of whole organ BOLD signal and regional liver oxygenation
- MR oximetry
  - Also currently a research technique with feasibility proven in cardiac ventricles of fetal lambs

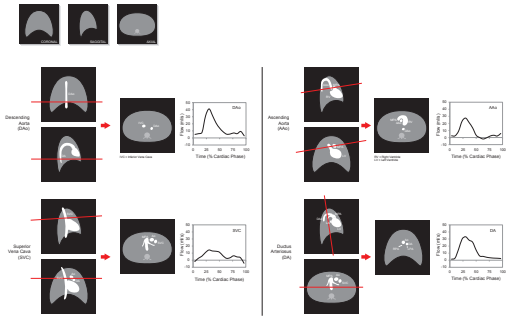
Potential applications

- Phase contrast
  - to measure the distribution of blood flow in the late gestation human fetal circulation:
    - in the normal fetal circulation
    - in congenital heart disease
    - in placental disease
- Anatomical cine imaging
  - to assess ventricular function and better visualize cardiac anatomy
- MR oximetry
  - combined with flow quantification a potentially powerful new tool for assessing fetal hemodynamics

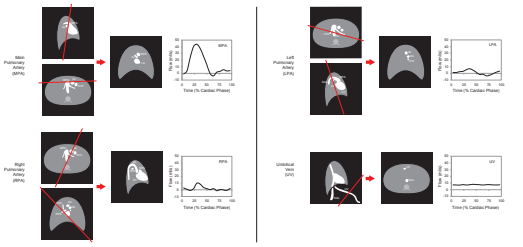
Technique – phase contrast with MOG

- Using SSFP localisers in two orthogonal planes for each of the following vessels
  - Ascending aorta, main pulmonary artery, right pulmonary artery, left pulmonary artery, arterial duct, descending aorta, superior vena cava, umbilical vein
- Scan time ~ 30s for each vessel giving a temporal resolution ~ 50 ms and in plane resolution ~ 1.5 mm (5mm slice thickness)
- Standard post processing package for flow quantification
- 3D SSFP whole uterus and segmentation of fetus for fetal weight for indexed fetal flows

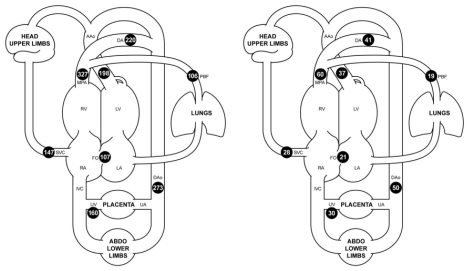
Scan planes and representative flow curves for fetal PC assessment (1)



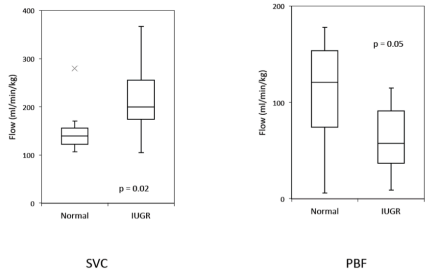
Scan planes and representative flow curves for fetal PC assessment (2)



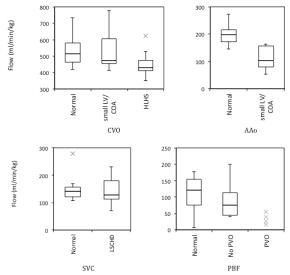
Distribution of the normal fetal circulation by PC MRI with MOG – mean flows (left) and as % of the combined ventricular output



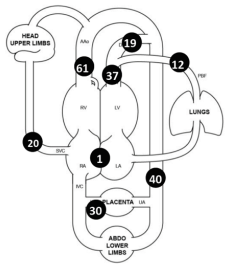
Brain sparing physiology in late gestation small for gestational age



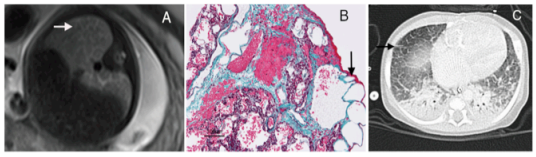
Flow distribution in left sided congenital heart disease



Transposition



Pulmonary lymphangiectasia on T2WFSE, biopsy and postnatal CT in pulmonary vein obstruction



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