ANESTHESIA FOR PEDIATRIC CARDIAC MRI

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Introduction:
Before 2003, all UK institutions performing paediatric cardiac surgery submitted their patients to echocardiography; if diagnostic problems remained, they underwent cardiac catheterisation. Since 2003, many patients with complex congenital heart problems now undergo MRI or CT rather than catheterisation, unless measurement of pressure is essential or interventions are required. In the past five years, the number of infants and children undergoing diagnostic cardiac catheterisation in our institution has fallen by 52%, and the number of infants and children undergoing cardiac MRI has increased by 130%.

Advantages vs. Echocardiography: [1]
- Large field of view (no constraints due to acoustic windows)
- Three dimensional imaging with high spatial resolution
- Tissue characterisation
- Freedom from artefacts due to calcification or surgical patches
- Reproducibility
- Serial accurate measurements of ventricular function with no geometric assumptions
- Most accurate method for quantifying regurgitant fractions, stroke volumes, etc.

Advantages vs. CT:
- Equally good three-dimensional imaging is acquired
- No exposure to X-radiation or iodine-based contrast media
- Provides more accurate measure of ventricular function (25-40 frames per cardiac cycle vs. 10 frames per cycle for CT)
- Phase-contrast imaging offers good assessment of valve function (CT unable to quantify regurgitant valve lesions using flow measurements)

Disadvantages:
- Requires general anaesthesia if behavioural problems or mental age <8 yr (threshold higher for CT as scan time shorter); usually not required for transthoracic echocardiography
- Exposure to gadolinium-containing contrast agents (though less toxic than iodine-based contrast); contraindicated in patients with severe renal dysfunction
- Take much longer (30-60 min) than CT (4-6 min)
- Waiting list relatively long (about 4 weeks) unless ‘urgent’; no waiting list for CT or echo Airway (relatively) poorly visualised, so suspect vascular ring best imaged using CT
- Cannot be used for patients with some metallic implants (including those being paced)
- Image quality less good in patients with high heart rates; ECG gating severely limits time
- Image quality less good for very small structures, as maximum image resolution = 1 mm2 (CT image resolution 0.7 mm2)
- CT better for patients with pulmonary venous abnormalities or aorto-pulmonary collaterals

**Particular indications for MRI:**[2]
- Assessment of right ventricular outflow tract obstruction
- Aortic disease (and left ventricular function)
- Post-arterial switch repair (imaging of branch pulmonary arteries and coronary arteries)
- Assessment of complex congenital heart disease

**Sedation vs. general anaesthesia**

Remaining motionless in the MR scanner is essential for data integrity because motion blurs the image and gives erratic volume measurements. Most sensible children over six years old can remain still in the scanner and cooperate with breath-holding as requested. (Respiratory movement also produces artefact). However, for high quality cardiac imaging in infants and young children, general anaesthesia (including paralysis and controlled ventilation) is commonly used to ensure complete lack of motion artefact and the highest possible image quality. Nonetheless, a few institutions perform ‘deep sedation’ rather than general anaesthesia on young children requiring cardiac MR imaging. A typical sedation protocol for a two year old would include intravenous midazolam 0.1 - 0.2 mg/kg and fentanyl 1-2 mcg/kg. A recent retrospective review of a similar sedation technique in 652 children was compared to general anaesthesia in 153 (sicker) children; it showed no statistical or clinical differences amongst images obtained, according to the blinded observer examining 30 samples from each group. [3] Fourteen sedated children awoke before scanning was complete, but there were no serious adverse events during or after the scan. The authors concluded that young children requiring
cardiac MRI can be safely sedated (as long as you use a dedicated sedation team and carefully select your patients), with a high success rate and no compromise in image quality.

**Specific concerns for the anaesthetist working in the MRI suite include:**

- Effect of magnetic fields, radiofrequency emission & electromagnetic interference on conventional monitors means that special MRI-compatible equipment is essential
- Remote access to patient; lack of visibility of patient
- Effect of magnetic field on implants containing ferromagnetic material (including stainless steel alloys) Effect of magnetic field on external ferromagnetic objects
- Noise (up to 120 decibels in 1.5 T scanner)
- Isolated working environment; lack of immediately available help in event of emergency

The advent of 3 Tesla scanners increases the challenge to providing safe patient care; a recent survey found that burn injuries (secondary to heat generated in a conductor lying on a patient), and projectile injuries increased substantially in these much more powerful magnetic fields.

A recent review of infants requiring cardiac MRI during their stay in the PICU (either preoperative or postoperative) suggested that general anesthesia is safe even in this critically ill group of patients who required intensive monitoring.[5] All patients were paralysed, intubated and ventilated for the procedure. 70% of patients had procedures or interventions initiated purely on the basis of their MRI findings.

**Anaesthetic Management of Infants And Children Requiring Cardiac MRI**

**Preoperative assessment:**

- Diagnosis and current problems, including exercise tolerance
- Past anaesthetic history
- Past medical and surgical history
- Current medications & allergies
- Examination, including HR, BP, O2 sats

**Anaesthetic technique:**

- Propofol or sevoflurane induction
- Paralysis using rocuronium (0.5-1 mg/kg)
- Intubation and IPPV (circuit loop from ventilator to patient through control room)
- Maintenance using inspired nitrous oxide 50-60% and isoflurane 1.0% in oxygen
- Reversal at end of procedure
- Extubation when awake in recovery (usually within 5 min)

**Postoperative care:**
- Most of our cardiac MRIs are performed on patients expected to return home within 2 h of the end of the procedure
- Patients are admitted first to our day case ward and return there for observation after the scan is complete
- If patients are asymptomatic and normally have oxygen saturations >95% in air, then we aim to discharge them home after only one hour
- For chronically hypoxic patients, a minimum observation period of 2 h is required

**Problems:**
- Atelectasis (develops in up to 37% of patients); risk factors include age <1 yr & tracheobronchial narrowing [7]
- Inadvertent bronchial intubation (in about 10% of patients); related to patient & MR coil positioning Postoperative exacerbation of hypoxia in chronically hypoxic patients (<5%); oxygen required for >1 h

**References:**