Section 12 Imaging protocols
MRI unit protocols for ventilation and monitoring
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MRI UNIT PROTOCOLS FOR VENTILATION AND MONITORING

The neonatal unit is responsible for managing the ventilated patient in the MRI unit. The Department of Anaesthesia do not have the staff to supply a theatre operating assistant when neonatal patients are in the MRI (unless they have been added to the ‘General Anaesthesia’ list for the MRI). Safety in the MRI unit is of prime concern at no time should a ventilated neonate be in the MRI unit without adequate monitoring and sufficiently experienced staff to monitor vital signs and provide resuscitation.

MRI scan on ventilated patients must be discussed with the neonatologist in charge. Infants with an implanted device cannot have an MRI scan i.e. Pigtail drain, stents, screws, clips. Infants on nasal CPAP are currently unable to have an MRI scan (incompatible equipment).

If the infant requires sedation or muscle relaxation, this must be initiated in the neonatal unit prior to departure to the MRI unit, to ensure the infant is stable after these medications have been administered. Only medical and nursing staff trained in MRI protocols should take neonates to the MRI unit.

Parents should be fully informed with an information sheet and sign a consent form.

THIS PROTOCOL COMES IN 4 SECTIONS:
1. PREPARING THE VENTILATED/SICK NEONATE FOR THE MRI UNIT
2. USING THE MRI COMPATIBLE VENTILATOR (BABYPAC 100)
3. MONITORING IN THE MRI UNIT
4. PROCEDURE FOR KEMH INFANTS REQUIRING A MRI/EEG

SECTION 1: PREPARING THE VENTILATED NEONATE FOR THE MRI UNIT

1. This generally takes at least 45 minutes, so please leave adequate time prior to the time of the MRI booking.
2. Infants with multiple infusions and/or TPN via a longline/CVC need extra time to prepare side-line of heparinised saline for when inside the scanner. Do not disconnect TPN, leave clamped during MRI procedure so can be resumed after (only lipids may be discontinued for MRI)
3. All staff who are to enter the scanner must not have any implants and be able to remove the following: Glasses, hearing aids, metal hair clips, any metal in their pockets (keys, mobile phones).
4. All infants must have metal removed: Metals fasteners in clothes, some IV connectors and ECG leads (but leave leads on and connected until arrival in the MRI unit).
EQUIPMENT
- BabyPAC 100 ventilator (If an infant is difficult to stabilise on this ventilator then consideration should be given as to whether they should be taken into the MRI unit). This ventilator should only be used by medical and nursing staff who have been trained in its use. Take ‘Red Intubation Roll’ and stethoscope.
- Ventilator circuit with extension tubing and connectors (x2). Note: the connectors used at the expiratory outlet and inspiratory inlet, are different from the connectors used to join the circuit with the extension tubing (see ‘The Circuit’ and fig 4-7 below).
- Swedish nose (Humidivent-mini®) for humidification
- 150cm IV extensions (need 3 additional extensions for each IV infusion)
- Caps (red “stoppers”) for the ends of all the infusions - patient end and IV end. Will need 2 caps for each IV/IA infusion whilst transferring the patient into the MRI room and again when leaving the MRI room (take extra plus cleaning swabs)
- Laerdal bag & oxygen tubing should be present at all times in case of ventilator failure.
- Portable cardiopulmonary monitor for transfer to and from the MRI unit

VENTILATION
- Ensure the ETT is secure and in an adequate position
- Ensure a blood gas has been taken reasonably recently so that respiratory stability has been established
- Suction the ETT prior to departure from ward if necessary
- Prepare any sedatives/muscle relaxants and give on ward prior to going to the MRI unit (to ensure stability). Take extra STAT dose in case needed in MRI Dept.
- Set up the BabyPac ventilator and place the infant on this ventilator prior to departure (see section 2 for more detail)
- Place a ‘Humidivent-Mini’ between the ETT connector and the circuit to ensure humidification during transfer to, during and from the MRI unit (fig. 1 & 2)

INTRAVENOUS / ARTERIAL LINES
- 3 x 150cm extensions should be placed on every IV/IA infusions with the relevant fluid running through (all infusions need to go through the MRI ‘hole in the wall’ and cover at least 5m in length as the pumps are not taken into the MRI room). Each line is to be labeled at the end with the drug or fluid type infusing through it i.e. what will be closest to the patient.
- A separate IV line may be needed so that boluses of fluid / medication / or contrast may be given (check prior to leaving unit)
- Take extra velcro (strappit) to secure the lines together in the MRI room

Figure 1-Humidivent on end of circuit
Figure 2-Humidivent with ETT
ECG LEADS
- Leave the ECG leads on and connected until arrival in the MRI unit

THERMOREGULATION
- If temperature control is difficult, a hat, mitts and booties may be applied and left on in the MRI if they do not interfere with IV access

PAPERWORK
Ensure the infant is identified and take all the necessary paperwork
- Inpatient notes
- Consent and MRI checklist
- Observation sheet and medication chart

SECTION 2: USING THE MRI-COMPATIBLE VENTILATOR (BABYPAC 100)

Set up the BabyPAC ventilator next to the infant on the over-head warmer. The ventilator consists of a control module with a conventional Y patient circuit. It is a gas powered, time-cycled, Pressure generator, which depends solely on the pressure of the supply gas for its operation. There is a constant flow through the ventilator breathing circuit during the inspiratory phase of 10L/min. When ‘CMV + Active PEEP’ is selected, this flow is also maintained during the expiratory phase.
1. THE CIRCUIT
The ventilator circuit is made up of the Y-piece that comes with the ventilator and 2 extension tubings, with connectors. (Figures 4-7)

- Connect the expiratory and inspiratory limbs of the extension tubing with specific connectors (Fig 4& 5) and then insert into the outlets (Figure 6).
- Connect the Y-ventilator circuit to the extension tubing with specific connectors (Figure 7)
- Connect the Humidivent-mini to the Y-circuit

![Exhalation valve](image1)

Figure 4: Connector to outlet & inlet

![Connector fittings](image2)

Figure 5: Connector fittings

![Extension tubing](image3)

Figure 6: Extension tubing

![Connectors between extension configuration tubing and ventilator circuit](image4)

Figure 7: Connectors between extension configuration tubing and ventilator circuit

### PNEUPAC CLEANING POST MRI

2. GAS MIX
Attach only an oxygen cylinder if the infant is requiring a FiO₂ greater than 0.4. Otherwise attach oxygen and air cylinders.

<table>
<thead>
<tr>
<th>If oxygen and air cylinders are attached, follow the yellow scale on the oxygen &amp; Air selection (gives 21-70% O₂) (Fig 3)</th>
<th>If only an oxygen cylinder is attached, follow the white scale on the oxygen &amp; air selection (gives 50-100% O₂) (Fig 3)</th>
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<tr>
<td>The oxygen air indicators will be “white”</td>
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**OXYGEN CONCENTRATION:** One of the safety features is that the BabyPac will continue to operate after the failure of one of the supply gases during 2-gas operation. If both O₂ and air are
connected as gas sources, then the 21-75% concentration (yellow scale) becomes operative. If the compressed air supply is turned off the unit automatically reverts to the 50-100% concentration scale (white scale). However a change in oxygen concentration will inevitably occur. Therefore in the event of medical air supply failure, the oxygen concentration should be reset if clinically necessary.

3. RATE
Set the Inspiratory and Expiratory times to give the required rate for the patient (Fig 3)

4. PRESSURE
- Set the required PEEP with the gases attached-look at the level delivered on the manometer to determine the cmH$\text{O}_2$
- Set the required PIP with gases attached-look at the level delivered on the manometer to determine the cmH$\text{O}_2$
- Set the airway pressure limit to give a top pressure alarm

5. FUNCTION SELECTION & TURNING ON THE VENTILATOR
Turn on the ventilator by selecting the function selection:
- ‘CMV + PEEP’ 2/3rds of the gas flow in the patient circuit during the inspiratory phase is ambient air and the compressed gas usage will be most economical as there is no flow during expiration. PEEP is maintained by the patient’s expiratory flow passing through the expiratory valve.
- ‘CMV + Active PEEP’. ‘Active PEEP’ setting gives continuous flow during expiration as well as inspiration. Much more gas is used in this setting (80% more), but it is much better for the patient. It must be on this setting when 70-100% oxygen is being used
- ‘IMV + CPAP’ gives an expiratory time 10 times longer than stated (this should not be selected in neonates)-this mode also uses maximum gas flow
- the ‘CPAP’ position should not be selected for patients in the MRI unit

- The ventilator should commence cycling and all the alarm lights flash in turn.
- A single burst of the high priority audible alarm is given at the same time.
- The orange silenced indicator should flash for 60 seconds.
- Check that flow is coming from the patient connection port by feeling the flow.
- The green cycle indicator light should flash during each inflation as the pressure rises

TO CHECK PRESSURES ALARMS:
- Occlude the proximal connection port of the patient circuit and check that the manometer gives a required reading during the inspiratory phase
- Leave the high pressure limit at 30cmH$\text{O}_2$ and set the PIP at 40cmH$\text{O}_2$ then occlude the proximal port and the pneumatic audible alarm should sound, as well as the high inflation pressure visual alarm.
- After 60sec initial silenced period, the electronic audible alarm will operate if an alarm condition persists.

GAS SUPPLY ALARMS
Two mechanically operated visual alarms are provided to give warning if either of the supply gases is below the pressure required to operate the ventilator (oxygen & air indicator- Fig 3). With low pressure they show RED, and with adequate pressure they show WHITE (O$_2$) or BLACK & WHITE for the air supply respectively.
If manual breaths are required (ie the ventilator has failed), the circuit can be disconnected at the exhalation valve (Fig 4) and select the CPAP function on the selector switch. An inflation will be achieved each time the connector on the circuit is occluded. Pressure will be limited by the upper patient inflation pressure limitation device.

**Alarm Signals**

- **High inflation pressure visual alarm** - flashed red twice after the high pressure relief valve is used
- **Cycle Indicator** - The green light flashed once every time the patient inflation pressure rises through the pre-set threshold pressure: *This indicates normal function*
- **Low Pressure/Disconnect Visual Alarm** - the yellow light flashes 30 times/minute if the “cycle detect” or “breathing detect” has not been activated for 10 seconds
- **Single gas operation** - this green light gives a burst of 3 flashes every 30 seconds whenever the ventilator is operating on a single gas supply (oxygen or air only)

If one of the gases fails an audible alarm will sound until muted. After the ventilator has been set up and other patient checks have been performed (ventilation & monitoring sections above) the circuit can now be attached to the patient.

**ON ARRIVAL IN THE MRI UNIT PRIOR TO TRANSFERRING THE PATIENT TO THE MRI ROOM:**

- Disconnect IV/IA infusions and cap both the patient and IV line ends (make sure all infusions are clearly labelled at both ends). Leave arterial lines and inotropes until last of all.
- The nurse will disconnect the ventilator. The doctor will commence bagging the patient. The nurse will transfer the ventilator to the MRI room, connecting it to a gas supply and ensuring the settings are not changed after connection.
- The nurse will then return to carry the patient to the MRI bed whilst the doctor bags the patient.
- Again, if more than 40% FiO2 is required, attach the white oxygen tubing only. If the patient is in less than 40% FiO2, attach the white oxygen, and black air tubing.
- Occlude the end of the y-connector and establish that the alarms are working again.
- Re-attach the circuit to the patient and ensure adequate chest movement. Ensure the ETT is well secured and the ventilator circuit is aligned.
- Ensure adequate monitoring (see below Section 3)
- Parents can stay in the parent waiting area in the MRI department during the procedure if they wish.

**ONCE THE MRI IS FINISHED, COMPLETE THE ABOVE IN REVERSE.**

- The infant remains ventilated whilst the IV/IA lines are recapped and passed back through the ‘hole in the wall’.
- Disconnect the ventilator and ventilate with laerdal bag. Transfer to the OHW and attach the gas tubing to portable cylinders
- Carry the infant out of the MRI unit and reconnect the ventilator. Reconnect the IV/IA line and monitoring and wait until all parameters are stabilised prior to transferring back.

### SECTION 3. MONITORING IN THE MRI UNIT

Neonates are not well visualized when in the MRI unit and visualizing colour of lips or skin is impossible. If monitoring is inadequate, and a neonatal consultant is not present in the MRI unit, immediately call and discuss with the neonatal consultant in charge as to whether or not the MRI scanning should proceed. All ventilated neonates must have at least one or more of the following parameters continuously monitored and an adequate trace at all times.

**SAO₂ & HEART RATE AS A MINIMUM.**

ECG monitoring should be used when oxygen saturation monitoring is inadequate (as is often the case in the poorly perfused patient). This is usually not difficult to obtain and is currently used during all cardiac MRI scanning. The ECG leads that come with the Schiller monitor are carbon filled, therefore having an extremely low risk of burning, particularly when applied appropriately by trained staff.

### SECTION 4: REFERRAL AND MANAGEMENT OF KEMH INFANTS REQUIRING MRI SCANS (EEG INCLUDED).

1. The SCN Reg/SR will ring and make an appointment with MRI and/or neurophysiology departments and will document the date/time and notify nursing staff of appointment date/time. MRI's should not be booked for 0800 hrs or earlier as there is no NETS transport driver available until 0730 hrs.
2. If the NETS transport Cot and/or the NETS Team (ventilated infants) are needed to transport the infant this is to be formally arranged with NETS by the SCN Reg/SR and documented.

**NON VENTILATED INFANTS:**

Nursing staff accompanying the infant from SCN who are not competent in the MRI unit protocols will relieve on Ward 6B whilst a 6B nursing staff member takes the infant to MRI. If the infant requires an EEG the nursing staff from SCN will stay with the infant.

### REFERENCES

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- Joint Commission on Accreditation of healthcare Organisations: Accreditation manual for MRI. 1993
- Behrens J. MRI Safety. [www.erads.com/mrsafety.htm](http://www.erads.com/mrsafety.htm)
- PNPM Section 6.4: MRI Scans