



CLINICAL GUIDELINE

MRI Unit Protocols for Ventilation and Monitoring

Scope (Staff):	Nursing and Medical Staff
Scope (Area):	NICU KEMH, NICU PCH, NETS WA

This document should be read in conjunction with this [DISCLAIMER](#)

The neonatal unit is responsible for managing the ventilated neonate in the MRI unit at PCH and KEMH.

The Department of Anaesthesia at PCH 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.

Neonates with an implanted device cannot have an MRI scan i.e. Pigtail drain, stents, screws, clips.

Parents should be fully informed with an information sheet and sign the MRI checklist.

Staff Safety

Only medical and nursing staff trained in MRI protocols should take neonates to the MRI unit.

Staff accompanying neonates to MRI, need to have completed the e-learning package [MRI Safety](#).

Preparing the Ventilated Neonate for the MRI Unit

- This generally takes a minimum of 45 minutes; commence preparation well before MRI booking time.
- Overhead warmer or theatre cot must have full air and oxygen cylinders with twin-o-vac for suction checked and working.
- Transfer BabyPac ventilator to overhead warmer if not already attached. See [APPENDIX](#) for ventilator setup and use.
- Transfer ventilated neonate to BabyPac ventilator and stabilise prior to leaving NICU.
- All infusion lines must have extensions primed and attached, and clearly labeled at baby end and end of extensions prior to leaving the NICU, see [Table](#) below. Consider the use of a side line with long lines or central lines to avoid disconnecting TPN.
- Transfer infusion pumps to portable IV pole if applicable.
- If muscle relaxant or sedation required it is to be administered and neonate stabilised in the NICU prior to transfer. Have a stat dose prepared to take with you.

MRI Unit Protocols for Ventilation and Monitoring

- All infants must have metal removed: Metals fasteners in clothes, some IV connectors, ECG leads and toggle of CPAP hat.
- Collect resus equipment. See [Table](#) below.
- Take into account thermoregulation needs of the neonate before leaving neonatal unit (bonnet, booties, covers).

Equipment

Equipment	PCH	KEMH	Instructions
BabyPAC Ventilator	√	√	See setup and use of in APPENDIX
Ventilator Circuit	Re-useable BabyPAC circuit with x2 connectors see Fig 6, 7, 8 and 9 in APPENDIX	Re-useable BabyPAC circuit with x2 connectors see Fig 6, 7, 8 and 9 in APPENDIX	
Monitor	Portable cardiac respiratory monitor	Take X2 monitor from bedside	ECG leads are not compatible in MRI unit. Leave leads in place during transfer to and from MRI unit.
Stethoscope	√	√	
Intubation Equipment	Red intubation role	Standard intubation /resuscitation box	Intubation / resuscitation equipment must be available on transport warmer or theatre cot.
Laerdel Bag and mask with oxygen tubing	√	√	For use when transferring neonate in and out of MRI or <ul style="list-style-type: none"> • ventilator failure • accidental extubation
Humidi-Vent (Swedish Nose)	√	√	Placed between ETT and ventilator circuit, see Fig 1 and Fig 2
IV/IA lines	X 3 long extensions (not including extension already attached to infusion) = total of 4 See Appendix 2	X 4 long extensions (not including extension already attached to infusion) = total of 5	Extensions need to be primed and attached to existing infusions. Each infusion is labelled at baby end and on extensions (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)
Red Caps	√	√	X4 for each infusion + a few extra. Each line will require capping at baby end and extensions when transferring in and again when transferring out of MRI.
2% Chlorhexadine 70%Alcohol swabs	√	√	Use swabs to clean IV/IA connections. Ensure aseptic technique when disconnecting and reconnecting fluids.
Velcro strappitt	√	√	Loop infusion lines and use strappitt to keep lines together and safe.
Transwarmer mattress	Use for small neonates who will have trouble maintaining their temperature. Note: the mattress cannot be positioned under the body part to be imaged.		



FIG 1 - Humidivent on end of circuit



FIG 2 - Humidivent with ETT

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.

Nasal CPAP

- At consultants discretion only, stable neonates on nCPAP can be transferred to MRI.
- Medical staff member to accompany neonate to MRI.
- Follow same process as for ventilated neonate transferring in and out of MRI unit.
- See [Fig 3](#) and [Fig 4](#) for adaptation to circuit.
- **Note:** The BabyPac ventilator functions on a **flow of 10L** which cannot be adjusted.
- CPAP hat toggle has a metal spring and will need to be removed prior to entering MRI.



FIG 3

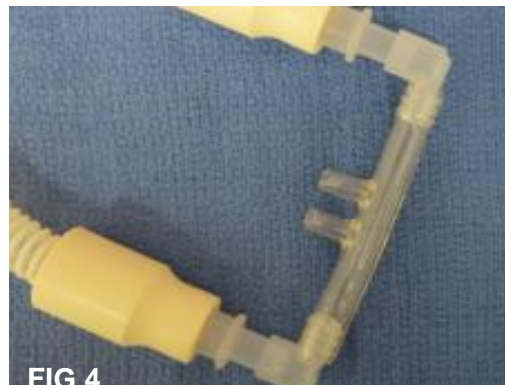


FIG 4

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 neonate is identified and take all the necessary paperwork:

- Inpatient notes.
- MRI checklist signed by parent.
- Observation sheet and medication chart.

On Arrival to MRI Unit

- Parents will be required to wait in the waiting room.
- Disconnect IV/IA infusions. Cap patient and IV line ends. Leave arterial lines and inotropes until last.
- Disconnect the ventilator. The doctor will ventilate with the Laerdal bag and mask.
- Transfer the ventilator to the MRI room and connect to gas supply. Check settings. Occlude the end of Y-connector to check alarms are functioning.
- Remove monitoring and ECG leads.
- Transfer neonate to MRI room.
- Attach ventilator and oximetry monitor.
- Settle neonate into bean bag on table.
- Pass infusion extensions through hole in the wall and reconnect infusions.
- Ensure ETT is secure and positioned safely, monitoring is adequate and neonate is stable before leaving room.
- Ensure theatre cot or warmer is plugged in and on while scan in progress.
- Warm blankets are available in PMH MRI unit. KEMH to have blanket available and warming on overhead warmer.

Monitoring in the MRI Unit

SaO₂ and Heart Rate as a Minimum

ECG leads are not compatible for use in the MRI unit therefore ensure satisfactory SpO₂ trace and reading prior to scan commencing. All ventilated neonates **must** have continuous heart rate and SpO₂ monitoring visible.

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 or SR 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.

Completion of MRI

- Disconnect IV/IA infusions. Cap patient and IV line ends. Leave arterial lines and inotropes until last.
- Disconnect the ventilator. The doctor will ventilate with the Laerdal bag and mask.
- Transfer the ventilator and connect to gas supply. Check settings. Occlude the end of Y-connector to check alarms are functioning.
- Transfer neonate out of MRI room.
- Attach ventilator and monitoring.
- Pass infusion extensions through hole in the wall and reconnect infusions.
- Ensure ETT is secure and positioned safely, monitoring is adequate and neonate is stable before transferring back to the neonatal unit.

Non Ventilated Infants

A competent nursing staff member must accompany the neonate from the neonatal unit and have completed the MRI safety training.

EQUIPMENT	PCH	KEMH
Transport to MRI	Theatre cot If not available transport in their perspex cot or on warmer	In their own cot
Intubation/Resuscitation Equipment	Red intubation roll Portable cylinders with twin-o-vac Laerdel Bag and mask with oxygen tubing	Neonatal resuscitation warmer and equipment is available in MRI department.

All neonates **must** have SpO₂ monitoring during the scan.

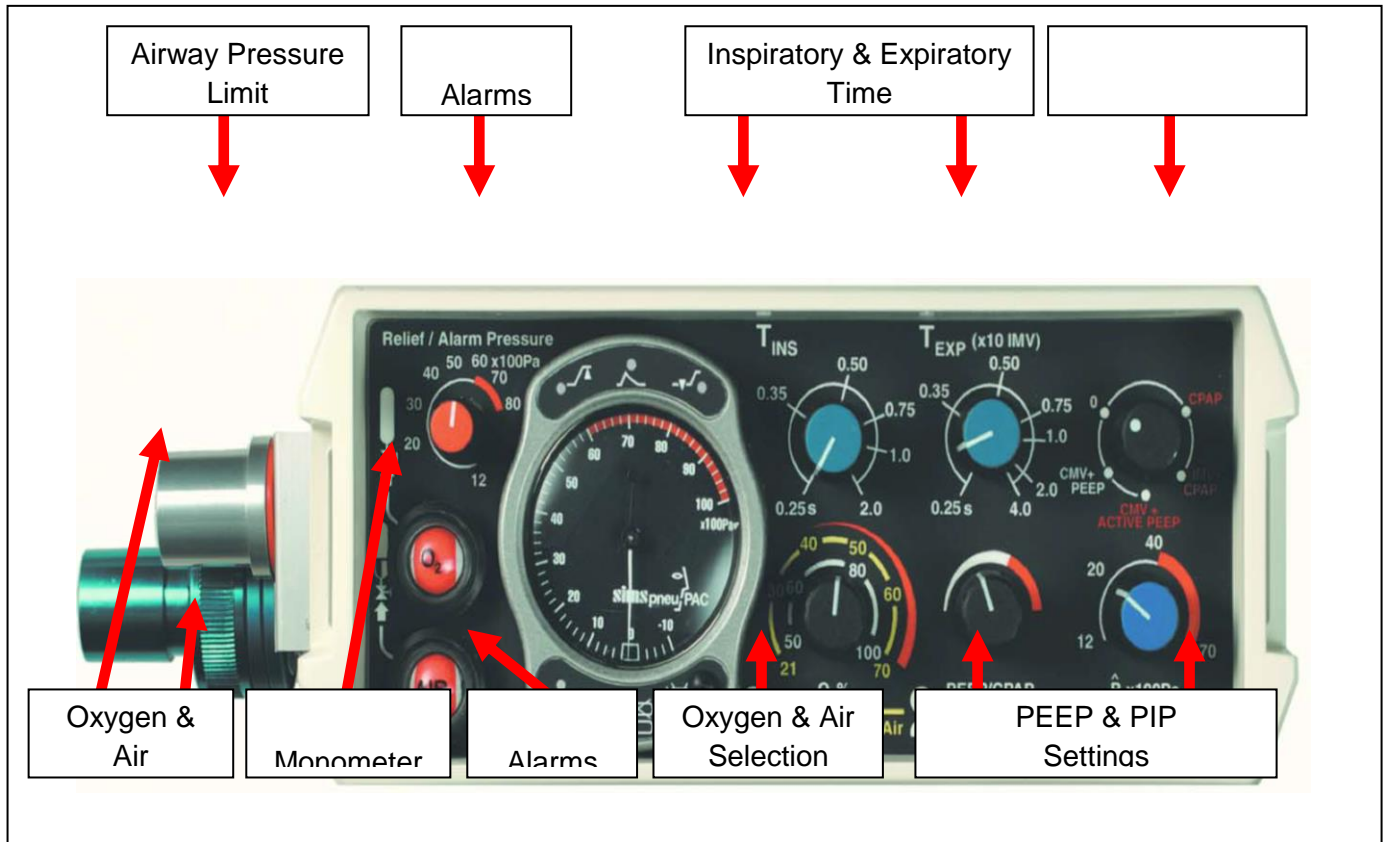
Ventilator Circuit Post Procedure

PCH: Send ventilator circuit to CSSD in a bag for processing. Remove the exhalation valve house and the diaphragm for PCA to clean. Wipe over unit and reset with clean circuit and diaphragm. **See Fig 8 below.**

KEMH: Send ventilator circuit, exhalation valve house and the diaphragm to CSSD in a bag for processing. Wipe over unit and reset with clean circuit and diaphragm. **See Fig 8 below.**

Appendix 1

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 10 L/min. **When 'CMV + Active PEEP' is selected, this flow is also maintained during the expiratory phase.**

The Circuit

PCH: The ventilator circuit is made up of the Y-piece that comes with the ventilator and 2 extension tubings, with connectors (Fig 4, 5, 6 and 7).

KEMH: Single use circuit is used. Re-usable circuit is also available. **Please note** - extensions mentioned are only used routinely at PMH.

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

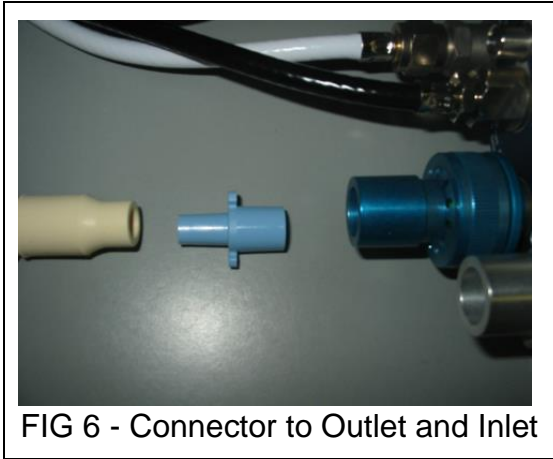


FIG 6 - Connector to Outlet and Inlet

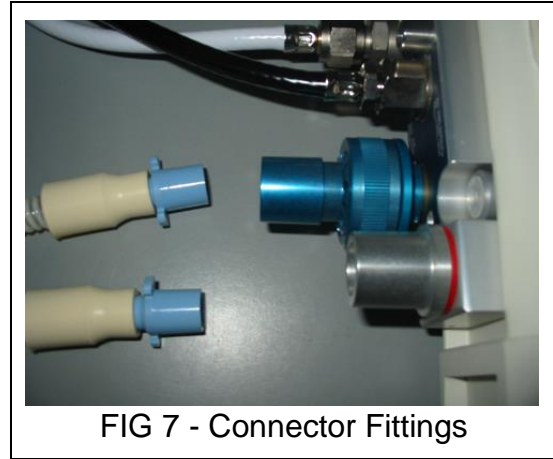


FIG 7 - Connector Fittings

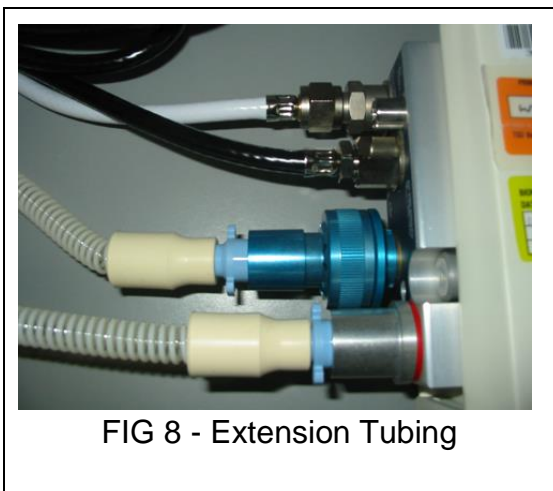


FIG 8 - Extension Tubing

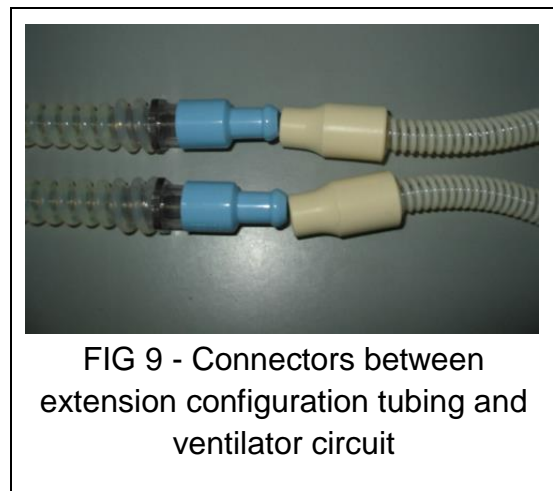


FIG 9 - Connectors between extension configuration tubing and ventilator circuit

Gas Mix

Attach only an oxygen cylinder if the infant is requiring a FiO_2 greater than 0.4. Otherwise attach oxygen and air cylinders.

If oxygen and air cylinders are attached, follow the yellow scale on the oxygen & Air selection (gives 21-70% O_2) (Fig 3).

If only an oxygen cylinder is attached, follow the white scale on the oxygen & air selection (gives 50-100% O_2) (Fig 3).

The oxygen air indicators will be "white".

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 O_2 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.

Rate

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

Function Selection and Turning on the Ventilator

- Turn on the ventilator by selecting the function required:

- **'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.

Pressure

- Set the required PEEP with the gases attached-look at the level delivered on the manometer to determine the cmH₂O.
- Set the required PIP with gases attached-look at the level delivered on the manometer to determine the cmH₂O.
- Set the airway pressure limit to give a top pressure alarm; consider setting 10 above set PIP.



Alarms


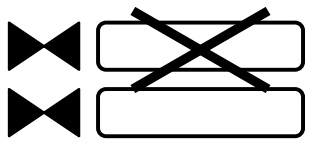
- Occlude the proximal connection port of the patient circuit and check that the manometer gives a required reading during the inspiratory phase.
- Leave the high pressure limit at 30 cmH₂O and set the PIP at 40 cmH₂O then occlude the proximal port and the pneumatic audible alarm should sound, as well as the high inflation pressure visual alarm.
- After 60 seconds initial silenced period, the electronic audible alarm will operate if an alarm condition persists.

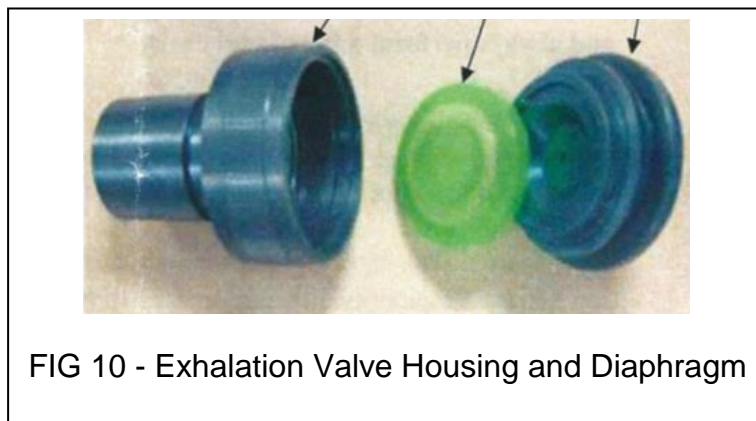
Gas Supply Alarms

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 and air indicator - Fig 3). With low pressure they show **RED**, and with adequate pressure they show **WHITE** (O₂) or **BLACK & WHITE** for the air supply respectively.

Alarm Signals

	<p>High inflation pressure visual alarm - flashed red twice after the high pressure relief valve is used.</p>
	<p>Cycle Indicator- The green light flashed once every time the patient inflation pressure rises through the pre-set threshold pressure: This indicates normal function.</p>

	<p>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.</p>
	<p>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 and Monitoring sections above) the circuit can now be attached to the patient.</p>



Appendix 2

Management of Lines at PCH

To minimise the risk of line sepsis follow the steps below for line changes when taking a baby for MRI.

- Depending on the baby's glucose requirements, and in consultation with the coordinator, using aseptic technique use either CIVAS prepared heparinised saline syringe or make up a new 50ml glucose infusion syringe with heparin and attach 4 primed long extensions. Set aside in the large blue tray and take with baby to MRI. Make up and prime a new arterial line and transducer set if arterial line in situ as the transducer has to come off in MRI. Set aside in the blue tray.
- Using aseptic technique, add 3 long extensions (total of 4 lines) to all infusions; just the same as current practise.
- Do not disconnect or add any extension lines to the TPN line.
- Label all lines carefully in three different places;
 - on the first extension line closest to the syringe on the distal end of this line (this will be the one connecting to baby end after MRI).
 - on the last extension line closest to the baby and
 - on the smartsite/three way tap at the entry to the cannula/central line(Baby's end).
- Record the lipids reading, clamp off, disconnect from baby and discard remaining lipids. One less pump to take.
- On arrival in MRI thread the labelled maintenance fluid line that will be replacing the TPN through the hole in the wall commence at 1 ml /hr if using hep saline or the rate the TPN is running at if using a glucose solution. Using aseptic technique, disconnect all lines EXCEPT TPN. Cap both ends with red combi-stops and feed the lines through the hole in the wall, hand gelling between each line disconnection and threading.
- Cease TPN infusion, clamp and remove from Alaris pump and take the bag of TPN in with the baby to the MRI machine. It will lie on the bed as the baby is having the MRI.
- Accompany baby into MRI, using aseptic technique attach all lines matching the entry and exit labels, including the heparinised saline or heparinised glucose infusion to the y-site on the TPN line.
- When the MRI is completed, using aseptic technique, remove and cap each line again.
- Transfer baby out of MRI.
- Again using aseptic technique reattach all infusion lines matching the entry and exit labels, disposing of all extra extension as you go. Remember to zero arterial transducer once infusion is reconnected.
- Remove the heparinised saline or glucose infusion, discard, and recommence the TPN via the Alaris pump at the correct infusion rate.
- Transfer the baby back to the ward.


Related CAHS internal policies, procedures and guidelines

[MRI Safety eLearning Package](#)

References and related external legislation, policies, and guidelines

1. Monitoring patients during MRI procedures: A Review. Invivo Research INC. 2004
2. Kanal E, Shellock FG: Policies, guidelines, and recommendation for MR imaging safety and patient management: patient monitoring during MR examinations. J Magn Reson Imaging 1992; 2:247-248
3. Joint Commission on Accreditation of healthcare Org: Accreditation manual for MRI. 1993
4. Shellock FG. Crues, JV: Magnetic Resonance; Bioeffects, Safety, and Patient Care. Radiology. 2004; 232: 635-652

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