Safe Transfer and Management of Critically Ill Adult, Paediatric and Neonatal Patients requiring MRI Scanning

Clinical Guideline

For Use in:	MRI scanning
By:	NICU medical and nursing staff, ITU/HDU medical and nursing staff, Operating Department Practitioners, Anaesthetists, Radiologists
For:	Adult, paediatric and neonatal patients who are either infusion dependent, oxygen dependent, ventilator dependent, monitoring dependent or any combination of these.
Division responsible for document:	Trustwide
Key words:	MRI, Transfer, Critical Care, Neonatal Intensive Care, Paediatric
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Assessed and approved by the:	Clinical Guidelines Assessment Panel (CGAP) If approved by committee or Governance Lead Chair's Action; tick here ☑
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To be reviewed by:	Philip Hodgson, Christopher Denson-Smith.
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Version No:	V2.2
Compliance links: *(is there any NICE related to guidance)*	None
If Yes - does the strategy/policy deviate from the recommendations of NICE? If so why?	N/A

This guideline has been approved by the Trust's Clinical Guidelines Assessment Panel as an aid to the diagnosis and management of relevant patients and clinical circumstances. Not every patient or situation fits neatly into a standard guideline scenario and the guideline must be interpreted and applied in practice in the light of prevailing clinical circumstances, the diagnostic and treatment options available and the professional judgement, knowledge and expertise of relevant clinicians. It is advised that the rationale for any departure from relevant guidance should be documented in the patient's case notes. The Trust's guidelines are made publicly available as part of the collective endeavour to continuously improve the quality of healthcare through

sharing medical experience and knowledge. The Trust accepts no responsibility for any misunderstanding or misapplication of this document.

Version History:

Version	Date	Author	Reason/Change
1	July 2018	Philip Hodgson and Christopher Denson-Smith	New Document
2	March 2019	Philip Hodgson and Christopher Denson-Smith	Reviewed, minor amendments
2.1	June 2022	Philip Hodgson and Christopher Denson-Smith	Reviewed and amended
2.2	September 2022	Philip Hodgson and Christopher Denson-Smith	Reviewed, minor amendments Formatting updated throughout document

Distribution Control

Printed copies of this document should be considered out of date. The most up to date version is available from the Trust Intranet.

Contents

1. Definitions of Terms Used / Glossary (if applicable)

Anaesthetic Area	Space between CT1 and MRI1 suites used for anaesthesia
MRI	Magnetic Resonance Imaging
NIBP	Non-invasive blood pressure
RF	Radiofrequencies
(S)ODP	(Senior) Operating Department Practitioner
SpO2	Pulse oximeter reading
MRI Scan Room	Inner room containing MRI scanner
MRI Control Room	Outer room where Radiographer controls the MRI

2. Objective/s

The safe transfer and scanning of adult, paediatric and neonatal patients who are either infusion dependent, oxygen dependent, ventilator dependent, monitoring dependent or any combination of these.

Please note –
Another Trust guideline exists for the transfer and MRI scanning of NICU babies who are not oxygen-, ventilator- or infusion dependent): 'Safe Transfer of Stable Babies from the Neonatal Unit to the Magnetic Resonance Imaging (MRI) Unit'.

3. Rationale

Safety of both patient and staff members when working within the MRI suite requires an understanding of the unique risks posed in this clinical area and vigilance at all times. This is especially true of critically ill patients who are connected to ventilators, infusions and invasive monitoring devices.

The medical literature and mainstream media are littered with examples of staff error and inexperience leading to injury and even fatalities.

4. Broad recommendations

No staff member should work (or feel pressured to work) in the MRI suite in Norwich without prior training and orientation. All MRI suites and their equipment are different and training in other centres may not necessarily equip a staff member to deliver safe patient care within our MRI suite.

Medical staff who are not familiar with the layout, equipment and potential risks of MRI scanning should not take (or be delegated) a lead role in the transfer of ventilated and/or infusion dependent patients to the MRI suite.

A named (and available) Consultant must be identified and documented by experienced trainees when performing such duties.

All requests for non-elective MRI scanning of critically ill patients should usually be coordinated through the 'emergency theatre booking system'. At the discretion of the requesting Critical Care or Neonatal Consultant, they and/or a suitably trained and equipped team from within their unit may also take responsibility for the transfer and scan. This decision should be

documented. Irrespective of the decision made, it is essential to ensure that an appropriately MRI trained Anaesthetist/Intensivist/Neonatologist and Operating Department Practitioner (ODP)/ Critical Care Airway technician are in attendance throughout.
Currently, there is no emergency MRI service for ventilator dependent or anaesthetised patients outside normal working hours. However, scans may occasionally be feasible depending on the skill mix of out of hours staffing in radiology, critical care, anaesthetics and theatres.

Apart from the tracheal tube itself and non-transduced in-situ arterial and venous lines, no equipment currently used within our critical care or neonatal intensive care units is safe to enter the MRI scan room.

The use of MRI specific monitoring, oxygen delivery equipment, anaesthetic machine and ventilator are mandatory within the MRI suite, but all require specific training and expertise to operate safely and must never be operated by untrained personnel.
Medical and nursing staff transferring the patient to and from the MRI suite must remain in the MRI control room or anaesthetic area throughout the scan.

5. Background

Safety of both patient and staff members when working within the MRI suite requires an understanding of the unique risks posed in this clinical area and vigilance at all times.

The medical literature and mainstream media are littered with examples of staff error and inexperience leading to injury and even fatalities.

The immense strength of the MRI magnet should never be forgotten or underestimated. The magnetic field remains at full strength even when transferring the patient before and after their scan.
Any object containing ferrous material that is accidentally carried through the scan room door can act as a missile and cause life changing injuries.

There are no known or expected harmful effects on humans exposed to the magnetic fields encountered in our MRI suites. This includes those that are pregnant. However, any patient or staff member may have an object, implant or device within them or about their person whose position and/or function could be changed on entering the magnetic field. This can be life threatening. Any concerns should be raised with the MRI radiologist who may need to seek additional advice about implantable devices and objects by consulting specific databases such as MRIsafety.com. Therefore it is imperative that potential issues are highlighted before transferring the patient to the MRI Suite.

6. Staffing Issues

In addition to the patient, Medical and Nursing staff who will need to enter the MRI scan room must also be formally cleared as being ‘MRI safe’ by the MRI duty radiographer. It is suggested that this is done prior to transferring a patient to the MRI suite.

The Consultant Paediatric Anaesthetists in Norwich have the greatest experience in caring for unconscious patients in the MRI environment and can often offer telephone advice if needed.

Contact (via switchboard) should only be made well ahead of the proposed transfer.

Currently, there is no emergency MRI service for ventilator dependent or anaesthetised patients outside normal working hours. However, scans may occasionally be feasible depending on the skill mix of out of hours staffing in Radiology, Critical care, Anaesthetics and Theatres.
The MRI radiographer must ensure that a current risk assessment checklist is always completed on both the patient and staff members before they enter the MRI scan room. However, once this is completed, it is attending medical and nursing staff that have the responsibility for safe management of:

a) Equipment and personal belongings
b) Monitoring
c) Infusion management
d) Ventilation
e) Patient wellbeing and safety
f) Their own wellbeing and safety

7. Equipment and personal belongings

Apart from a tracheal/ tracheostomy tube and non-transduced in situ arterial and venous lines. No equipment currently used within our critical care or neonatal intensive care unit is MRI safe.

The list of unsafe items that must not enter the scan room includes*:

- Patient trolleys, beds, wheelchairs and incubators
- Anaesthetic Equipment and Difficult Airway Trolleys
- Monitoring equipment temperature probes, ECG electrodes and their connections
- Syringe drivers and volumetric pumps
- Invasive line transducer systems
- Portable ventilators and pacing equipment
- Flexible tracheal tubes, tracheostomies and reinforced/ flexible laryngeal masks
- Oxygen and medical air cylinders
- Resuscitation trolley and all equipment therein
- Laryngoscopes, scissors, clamps (such as on chest drains) and forceps

*this list is not exhaustive, and any equipment or device not listed must be assumed to be unsafe, unless explicitly cleared for use by the duty MRI radiographer.

Such equipment can be employed during transfer to the MRI suite but MUST be left outside the security doors leading into the MRI control and scan room.

Patients should be transferred from their bed or trolley on to the MRI specific trolley prior to

transfer through the scan room door. In view of the above list, only the patient and their tracheal tube and their unmonitored vascular access should enter the scan room.

Ventilator and oxygen dependent patients should be pre-oxygenated outside the scan room to allow for the time it takes to safely establish them on the Aestiva (computer technology) MRI anaesthetic machine ventilator inside the scan room. This is typically 30-60 seconds.

Once formally cleared to enter the scan room, staff should never carry anything about their person or in their uniform that has not been cleared as MRI safe by MRI staff. This includes jewellery, hair accessories, pens, wallets, watches, phones, pagers and ID badges. Staff should always be obsessive and check/pat every pocket and empty both hands, every time they are about to enter the scan room. Objects (however small) have the potential to be accelerated to considerable speeds and cause serious injury.

A test magnet is available in the MRI control room to test the safety of personal items such as jewellery or glasses. If in doubt or not specifically cleared to do so, all such items should never enter the scan room.

8. Monitoring

Replace <u>all</u> transfer monitoring, transducers and electrodes with those used by the '*in vivo'* ™ MRI monitoring system. This should be done outside the scan room immediately prior to transferring the patient onto the MRI trolley.

Non-MRI specific ECG electrodes must never be left on the patient as they will burn the skin. Only MRI 'quatrode' electrodes should be used.

The MRI monitoring system is unlike any others within the Trust and is not intuitive. Staff members unfamiliar with it are strongly discouraged from using it without a suitable period of orientation and training. The Operating Department Practitioner provided by emergency theatres will be familiar with it, but should not be relied upon to operate it *in lieu* of trained medical staff.

The MRI monitoring uses wireless pack technology to transmit SpO_2, ECG data from patient to the main monitor and satellite monitor (that sits in the MRI control room). The main MRI monitor also contains NIBP and a side stream gas analyser. Patient transfer into the scan room may be easier if the NIBP and side stream analyser tubing are momentarily disconnected after initial readings.

To the top right of the monitoring screen(s) is a 'scroll down button' to select the monitoring configuration for specific patient groups. The default setting is 'Sedation' which will need to changed. Selecting 'Paediatric GA (or 'neonatal GA') will auto-format the monitoring to EGG/NIBP/SpO_2 and gas analysis for paediatric/neonatal patients. Selecting 'Adult GA' will do likewise for adult patients.

Specific single use 'wraparound' oximetry probes and smaller quatrode ECG sets are available for neonatal patients.

The safest location to exchange monitoring and/or to transfer the patient between bed and trolley is the anaesthetic area immediately outside the scanning suite. However, the 30 second transfer time into the scan room through the two safety doors should be considered and patients pre-oxygenated appropriately prior to final transfer onto the ventilator in the scan room. This may be critical in patients on high inspired oxygen requirements or and/or reduced functional residual capacity.

Due to space restraints and the need to access the adjacent scan room, only neonatal patients in an incubator should be re-monitored and transferred to the scan room from the area immediately in front of the scan room door. This should only be entertained in consultation with the radiology team.

9. Infusion management

No infusion device can enter the scan room. Infusions can be only continued if the following instructions are followed.

All infusions that can be safely discontinued for the scan duration should be disconnected, labelled and capped off with sterile Luer-lok bungs.

To allow an essential infusion to be kept running whilst patient is being scanned, change any 50mL syringes to 20mLs Luer-lok or ideally smaller (50mL syringes cannot safely be fed through the wave guides in the scan room wall). This should be done prior to transfer. More than one syringe of drug may be needed depending on predicted infusion rates.

Ensure that the infusion line has been extended and primed with active drug so that the line can reach from the patient to outside the scanner room. Five 150 cm infusion extension lines in series will reach. The dead space in this extended line system is around 6mLs. When using long infusion line distances, excess pressure alarms on infusion pumps may be triggered and may need to adjusted or mitigated against by using smaller syringes or avoiding infusion line runs with multiple one way valves or r-locks. This should be checked for prior to transfer. It is essential that the infusion line be clamped momentarily at the syringe end (to prevent siphoning or accidental bolusing of drug) while the freed syringe is passed through the wave guide from inside the scan room to the syringe driver remaining in the control room. With multiple infusions great care must be taken to ensure the correct syringe is replaced in its correct infusion device in the scan control room. The team should be clear as to who is responsible for this and double checking of drugs and infusion rates is strongly advised. Arterial and central pressure monitoring lines should be disconnected for the scan duration, labelled, flushed and capped off with a sterile Luer-lok bungs. No part of their transducer systems and wiring must enter the scan room. MRI specific non-invasive blood pressure cuffs for all ages are available and short cycle times can be used.

10. Ventilation

Like the monitoring systems in MRI, the MRI Aestiva machine and ventilator are unlike any others within the Trust and no staff member (including anaesthetists) should operate it without a suitable orientation session. Specific orientation and care should be taken with regard to the 'Auxillary common gas outlet' status. If selected, no fresh gas will enter the circle system in ventilator modes nor the bag in manual mode.

Most ventilation modes are available via its circle system. In practice, neonatal patients with poor lung compliance may be better served by manual ventilation by an anaesthetist with an Ayres T-piece attached to the selectable auxillary common gas outlet.

If personnel remain in the scan room, they must wear the *in situ* ear protection headphones to remain in contact with the radiographer. In such circumstances, the main monitor should be placed as to be visible at all times.

11. Ensuring patient wellbeing during scan

Radiofrequencies (RF) utilized during scan sequences can cause heating effects that can result in burns to the patient. Non MRI ECG electrodes and wires or objects next to skin are

obvious risks. Arms should always be by the patient's side and not touching each other. Legs should be uncrossed.

Some RF sequences utilized during scan sequences can cause interference with some ECG and oximetry waveforms and values. This can mimic SVT, VT and even VF. Capnography will remain unaffected. If in doubt, get the radiographer to pause the sequence.

RF sequences cause high decibel sound waves that can cause permanent hearing loss in both patients and staff. Ear protection of patient and staff (if remaining in the scan room) must be implemented prior to scanning sequences.

In the event of a cardio-respiratory incident, never carry resuscitation equipment or laryngoscopes into the scan room. Instruct the radiographer to stop scanning and they will help remove the patient to the anaesthetic induction area immediately. Remember, the magnet is still on even when scanning is suspended. It follows that the anaesthetic area outside the scanning suite doors should always be left unoccupied and in a vigilant state for such an event. Likewise other radiology patients or equipment must not impede the exits or occupy the anaesthetic induction area during the scanning of critically ill, ventilated patients.

The nearest Adult and Paediatric Resuscitation Trolley is situated in the adjacent CT/MRI Patient Waiting Area / Bed Bay.

In the event of a life-threatening projectile incident within the room, the magnet would need to be quickly disabled by 'quenching'. **This should only ever be initiated by radiology staff** as it exposes the patient and staff to additional dangers and also result in considerable financial and service loss to the Trust.

The radiology staff will guide staff in the rare event that the magnet has to be quenched. The main principle is that the patient must be evacuated from the scan room as quickly and safely as possible but also ensuring the safety of the staff entering the room to do so.

12. End of scan

The reverse of the above sequences must occur. Please ensure that someone is identified who can return the areas used to a tidy, vigilant state. This should include returning the monitoring and anaesthetic equipment to standby, placing monitoring batteries to the charging device and locking all drugs away.

Summary of development and consultation process undertaken before registration and dissemination

During its development it has been circulated for comment to:

- NICU Nursing Staff
- Critical Care Nursing Staff
- Critcal Care and Theatre OPDs
- MRI Radiographers
- Consultant Anaesthetists

- Consultant Intensivists
- Consultant Neonatologists

This version has been endorsed by the Clinical Guidelines Assessment Panel Committee.

13. Distribution list/ dissemination method

Email distribution of PDF version of this draft document with 28 day response period.

14. References

Anaesthesia for Magnetic Resonance Imaging. U Reddy, MJ White, SR Wilson. CEACCP Feb 2012
Ensuring Safety for Infants Undergoing Magnetic Resonance Imaging LA. Stokowski. Adv Neonatal Care. 2005;5(1):14-27.
Guidelines for the safe provision of anaesthesia in magnetic resonance units 2019 Guidelines from the Association of Anaesthetists and the Neuro Anaesthesia and Critical Care Society of Great Britain and Ireland S. R. Wilson et al. Anaesthesia 2019. 74,5 638-650

15. Clinical audit standards / monitoring compliance

To ensure that this document is compliant with the above standards, the following monitoring processes will be undertaken:

The audit results will be sent to Philip Hodgson who will ensure that these are discussed at relevant governance meetings to review the results and make recommendations for further action.

Document Name: Safe Transfer and Management of Critically Ill Adult, Paediatric and Neonatal Patients requiring MRI Scanning

Element to be monitored	Lead Responsible for monitoring	Monitoring Tool / Method of monitoring	Frequency of monitoring	Lead Responsible for developing action plan & acting on recommendations	Reporting arrangements (Committee or group where monitoring results and action plan progress are reported to)	Sharing and disseminating lessons learned & recommended changes in practice as a result of monitoring compliance with this document
Compliance with guidelines? Lead staff member Incident reporting	MRI Radiologist scanning Collated by Dr P Hodgson	Audit	Yearly	Dr P Hodgson E Lark	Anaesthetic and Critical Care/NICU CG Meetings	Surgical Division Governance meeting

Appendix A – Suggested Operating Department Practitioner Checks Prior to Patient Arrival

- Confident in the layout, equipment and intended procedure?
- Personally cleared to enter the scan room?
- Remove all personal equipment about your person or on monitor trolley that is MRI incompatible
- Do you have code (or a swipe card) to the doors between anaesthetic area and both MRI control room and main waiting area?
- Anaesthetic machine and induction area anaesthetic apparatus checked (including reserve oxygen cylinder, suction, scavenging and pipeline tug tests)?
- Auxillary Gas Common Outlet is not selected/switched on. (unless specifically requested by the anaesthetist)
- If vapourisers need filling/replacing or a replacement (MRI safe) oxygen cylinder required, the anaesthetic machine should always be wheeled out into the anaesthetic area to carry this out. Apart from new disposable breathing tubing no additional equipment should be added to the anaesthetic machine without it being cleared as MRI safe.
- Switch on all monitoring, trolley first, then main monitor, then satellite. Slide batteries stored in charging unit (in anaesthetic bay) into SpO2 and ECG transmitter boxes (the latter requires 2 batteries) and ensure that bottom of monitor screen shows adequate charge times remaining.
- The 'scroll down button' to the top right of the monitoring screen(s) is changed from the default setting ('Sedation') to either 'Paediatric GA', 'Neonatal GA' or 'Adult GA' to auto-format the monitoring to EGG/NIBP/SpO_2 and gas analysis.
- Specific single use 'wraparound' oximetry probes and smaller quatrode ECG sets are available for neonatal patients.
- Drug cupboard and fridge are opened.(keys are held in the CT Control room). Rescue drugs (atropine, adrenaline, metaraminol, suxamethonium, rocuronium) and IV Hartmanns and IV giving set are present.
- Airway trolley is uncovered and rescue airways (LMA, Airtraq, Guedel airways, tracheal tubes and bougies) and re-intubation equipment checked.
- Resus trolley location is confirmed. This is usually in the bed holding area outside the security doors.
- Radiographer is identified who is can lead check-in and other processes when the patient arrives

Appendix B - Checklist/sequence for attending medical staff immediately before patient transfer through Scan Room doors

		Circle as appropriate	
1	Patient MRI safety questionnaire completed by radiographer?	Yes	No
2	All staff members intending to enter room cleared as 'MRI Safe'?	Yes	No
3	All monitoring replaced with MRI compatible systems and working?	Yes	No
4	All non-MRI ECG electrodes, temperature probes, suction port connectors removed?	Yes	No
5	Flush, label and cap off invasive pressure lines. Remove all transducer systems	Yes	No
6	Identify accessible IV port for safe use during scan. Saline flush to ensure patency	Yes	No
7	Transfer/slide patient sideways onto to MRI trolley. NB:Neonates and infants should only be carried through the scan room door in exceptional circumstances).	Yes	No
8	Check patient and trolley one final time for metal objects	Yes	No
9	Check Monitoring trolley baskets for MRI unsafe objects	Yes	No
10	Tape pilot balloon of tracheal tube, tracheostomy or LMA away from the area being scanned.	Yes	No
11	Ensure ear protection for the patient is in place (foam ear plugs or ear defenders).	Yes	No
12	Identify clearly who is allowed to go into scan room and those who must not.	Yes	No
13	Personnel entering scan room confirm empty pockets, no MRI unsafe jewellery etc	Yes	No
14	Pre-oxygenate to allow for transfer time and connection to ventilator within scan room	Yes	No
15	Path is clear and the doors unlocked.	Yes	No
16	Identify who will take infusion devices to the far corner of the control room (by the cupboard style door to the wave guides) and reload, unclamp and restart infusions.	Yes	No
17	Identify somebody inside scan room who will immediately feed infusion syringes through wave guide tubes. (NB must be 20mL syringes or smaller)	Yes	No

18	Clamp and remove all essential infusions from their infusion devices (which should be labelled with the drug they are infusing)	Yes	No
	TRANSFER ONLY AFTER ALL THE ABOVE CONFIRMED	Yes	No

Appendix C – Anaesthetist Sequence/ Checks once patient within scan room

- Attach patient to ventilator on anaesthetic machine. Turn it to face the scan room window so that ventilator screen, bellows/bag and rotameters are visible from the control room. The anaesthetic machine must not cross the Gauss line marked on the floor. As reassurance, a >300 Gauss indicator with alarm are present on the front of the anaesthetic machine.
- Ensure that any head or neck coils placed by the radiologist do not kink the ventilator tubing and/or obstruct the airway
- Reattach gas side stream analyser and NIBP cuff if they have been disconnected for transfer and ensure both are giving readings.
- Pass infusion syringes one by one through the wave guide tubes and only unclamp their lines once replaced in their original infusion devices on the other side of the window. In the presence of multiple infusions extra care is required to ensure the correct syringe is always placed in the correct driver.
- Ensure monitor within room is facing the window. The MRI monitoring stack can be placed within the Gauss line on the floor if needed.
- Have final check that ventilator tubing will not tug at tracheal tube and that monitoring lines and wires will not be displaced when patient moves in and out during the intended scan sequence. This is especially true of patients in the 'head first' position. The radiologist will always be present in the room during the transfer process to demonstrate this.
- On leaving the room and closing door, ensure that it is not locked. Immediate access may be needed.
- Finally ensure and remain vigilant that the outside anaesthetic bay and transfer area are left ready in case emergency exit of the patient is required (ie ventilation equipment and all drug cupboards and fridge are accessible) and that it remains free from all obstructions (i.e. other patients and/or equipment). It is strongly recommended that one team member polices this while the scans are being obtained