

# Antenatal MRI - Hints and Tips for Radiographers, Technologists and Students

Antenatal MRI is not commonly performed. This document is designed to be a 'work in progress' where others can add additional information. The aim is to develop evolving guidance that can inform all radiographers, technologists and students on the latest techniques and best practice on antenatal MRI. Please post any further information/hints and tips you may have on the MRI Buzz Facebook Group and where appropriate it will be added to this learning resource with your name.

## Achieving patient compliance

For successful antenatal scanning it is always worth remembering that you are dealing with two patients: the baby (fetus) in the womb and the mother. For clarity throughout the document, the mother is often referred to as 'the patient'.

Often the patient is extremely anxious. She may be aware that the scan is being done to check for abnormalities which could indicate the physical and/or mental life chances of her unborn child. It pays to be aware that sensitivities are running high and that there may be a need to emphasize to the mother and her partner, if present, that no harm will come to the baby due to the scan itself. An appreciation and empathy for their situation will help to serve everyone's needs. If they feel unhurried and any pre-conceived ideas or concerns, they may have, are addressed, this sets the tone for gaining their trust and confidence. If the patient is relaxed her baby may too, leading to potentially less movement, improving scan quality.

Patient preparation begins before the patient arrives in the form of the pre-appointment information. The appointment letter should be as informative as possible perhaps with quality images of the scanner. Providing links to websites where the noise of a scanner can be heard or where they can learn more about MRI can be helpful for anyone who has never had a scan before. If staff are alerted by referrers, phoning anxious patients to allay their fears, can save a wasted scan slot and encourage patient compliance. If the patient is extremely nervous, a pre-appointment visit can be suggested to show them what to expect.

## Permitting a partner or friend to remain with the patient during the scan

If the patient would like to have their partner or another adult with her during her scan this should be permitted. It may make a huge difference to the patient if she has someone beside her in the scan room to reassure her. She will feel less alone and comforted by seeing a familiar face and a hand to hold. Once screened, a seat should be provided for the partner next to the scanning table so that they can be as close to the patient as possible to hold their hand, stroke their head or foot, or whatever they can reach so that she knows they are there, even if she cannot see them. Physical contact can ease the stress of the situation. The partner can sit at the other end of the bore (exit) if it's easier to see the patient's face that way. If necessary, prismatic spectacles or a mirror can be placed above the patient's head so that she can see out. For anyone who needs to keep their eyes shut to tolerate the scan, a blindfold should be offered. Having a patient entertainment system which includes being able to watch DVDs is ideal for distraction. The patient will have a 'call button' but

constant communication from the scan operator to the patient is required during the scan to check that they are ok throughout the duration and to reassure them that all is well.

### Reassurance that there is little acoustic concern for the fetus

Reducing patient anxieties may mean reassuring the patient that the noise of the scanner will not damage or have any detrimental effects to her baby's hearing. Studies indicate that there is, 'no significant excess risk of neonatal hearing impairment after exposure of the fetus to 1.5 T MR imaging during the second and third trimesters of pregnancy'<sup>1</sup>. This may be because, 'The sounds available to the fetus are dominated by low-frequency energy, whereas energy above 0.5 kHz is attenuated by 40 to 50 dB'<sup>2</sup>. As the amniotic fluid and maternal tissues filter out most high-frequency sounds, it has been estimated that the frequencies reaching the baby are reduced by 20 to 30 dB even at 33 to 35 weeks of gestational age<sup>3</sup>. The maturation of the baby's ears also means that the fetus is unlikely to be able to detect sounds until after 23 weeks with full maturation of the ears not until about 35 weeks.

### Performing the scan is potentially stressful for the radiographer/technologist too

MRI can help with parental decisions and antenatal counseling. A scan diagnosis helps to inform some tough choices that may be required to be made by the patient. The results may help to prepare the family for a certain outcome. They may be offered options such as a termination if the scan results are devastating. The results become a matter of life or death, so undertaking the scan can be stressful for all concerned, including the staff. Antenatal MRI scanning is not routine and the results tend to be relayed to the patient as soon as possible after the scan as the outcome may be critical. This can affect the staff dealing with the patient. The scan operator may know the diagnosis before the patient and anticipate the news they are about to receive. Conversely, the scan also has the potential to change the diagnosis of a complex condition for the better. This could prepare the family in terms of preparation for the baby, e.g. in terms of any special needs or preparing for surgery/intensive care as soon as the baby is delivered.

### Patient preparation before entering the scan room

Maternal fasting or any patient preparation is not usually required. Some units may ask the patient to avoid caffeine because of its stimulant effects, which may influence the baby too, so likely best avoided. Some units may sedate the patient which may also sedate the baby in the hope of producing images containing fewer motion artifacts.

Once in the unit and changed, the patient should be asked to empty their bladder just before their scan. A gravid (pregnant) uterus adds pressure to their bladder and anxiety, or stress incontinence can also make the patient have less control than normal. It is also a good idea to have a cold drink available in the scan room with a straw attached so that the patient can quench their thirst easily without having to sit up. Knowing that the staff have gone to the

<sup>1</sup> Reeves et al, Neonatal Cochlear Function: Measurement after Exposure to Acoustic Noise during in

Utero MR Imaging. Radiology, Dec 2010 Vol 257 Issue 3

<sup>2</sup> Gerhardt & Abrams. J Perinatol. 2000 Dec;20(8 Pt 2):S21-30

<https://www.nature.com/articles/7200446>

<sup>3</sup> Hepper PG, Shahidullah BS Development of fetal hearing Archives of Disease in Childhood - Fetal and Neonatal Edition 1994;71:F81-F87

effort of providing this helps the patient to feel 'KEPT' - experiencing **K**indness, **E**mpathy, **P**atience and that you have all the **T**ime in the world for them (**see more about the concept of 'KEPT' in a future presentation on achieving patient compliance by Barbara and Lubna**).

#### Patient position on the scan table - tilting the patient to avoid IVC compression

After about the 20 weeks gestation, lying supine puts significant weight from the gravid uterus on the inferior vena cava (IVC). The IVC carries blood from the lower body back to the heart. Total blood volume and cardiac output increases in pregnancy but pregnancy leads to high venous pressure in the lower limbs decreasing blood return to the heart. There is also a greater risk of obstruction of the IVC when pregnant because the uterus compresses the iliac veins.<sup>4</sup> Lying an expectant mother on her back can lead to increasing pressure in the IVC leading to decreased cardiac output as the venous return in the vena cava becomes obstructed. By positioning the patient on her side may avoid this sudden rise in venous pressure. A study looking at leaning patients right or left for their MRI scan<sup>5</sup> concluded that a '30° left tilt' was the best position to use, on average, with the biggest reduction of gravid uterine compression of the IVC compared to supine or a right 30° tilt<sup>6</sup>. If positioned on her side, a pillow is placed between the patient's knees. The pillow helps to make her feel more comfortable, prevent lower limb contact and maintain this tilted position. If the patient insists that they cannot lie on their side, her decision to lie supine should be respected. She will have a 'call button' to alert the operator if she feels unwell and should always be closely monitored visually by her partner and the scan operator.

#### Patient positioning in the scan bore for comfort and safety

It is kinder to the patient to position them feet- first into the scanner. This can lead them to feel less restricted or claustrophobic. The patient feels more in control if they can see where their body is being moved to. Moving feet forward rather than their head forward also prevents them trying to crane their neck to see where they are heading.

Vendor dependent, a standard receive- only abdominal/pelvis surface coil(s) is/are placed over the abdomen and pelvis. Remember that the baby may be in a low position nearer the symphysis pubis so make sure coils are positioned low enough. No bare skin should ever touch a surface coil, so care is required to pad appropriately. The coils and straps should be positioned/ fixed very gently with extra padding placed between the patient and the coil if this adds to their comfort. Coils should be checked to ensure they are intact with no loose connections.

To prevent RF burns from the transmit body coil (behind the body coil/magnet bore walls), manufacturer's padding should be used to ensure the patient does not touch the sides of the bore. A larger body habitus makes this a priority as well as the usual prevention of avoiding skin- to- skin contact and conductive flesh loops forming. Prevent clasped hands, folded arms and crossed legs.

<sup>4</sup> <https://www.phlebology.org/chronic-venous-disease-during-pregnancy/>

<sup>5</sup> <https://journalfeed.org/article-a-day/2019/lean-left-ivc-compression-in-pregnancy>

<sup>6</sup> Fujita N, Higuchi H, Sakuma S, Takagi S, Latif MAHM, Ozaki M. Effect of Right-Lateral Versus Left-Lateral Tilt Position on Compression of the Inferior Vena Cava in Pregnant Women Determined by Magnetic Resonance Imaging. *Anesth Analg*. 2019;128(6):1217-1222. doi:10.1213/ANE.0000000000004166

The bore fan should remain fully on to reduce heating effects and improve airflow through the bore. The acoustic protection of the headphones should be confirmed and where necessary, earplugs should be fitted too. A head sponge with a head shaped cavity can be placed beneath the patient's head to fit the headphone nearest the table (if patient on their side). If there are beanbag type patient positioning aids (with the polystyrene type beads within it), these are ideal for such positioning as they are very soft and can be made to fit the headphone shape very easily.

### Typical sequence selection and slice positioning

The duration of the scan is usually less than 20 minutes but can be as short as 10 if the mother is relaxed and the baby relatively still. Efficient pre-planning of any sequence is not always straightforward as the baby could have moved from the previous scan. Planning is provisionally set up but must always be cross-referenced by the most up to date scan.

Obtaining good scout/planning views of the baby is essential to orientate accurately in 3 planes. Fast T2 weighted scans followed by a T1 volume is then performed.

- A large FOV (about 480mm) is initially required to cover the whole abdomen and pelvis to locate the baby and check their initial orientation. Phase oversampling/antialiasing will be required to cover any abdominal tissue, not included in this initial FOV and, if not compensated for, would wrap/fold into the edge of the image in the phase direction as phase wrap/aliasing. This leads to an increased sampling area which will contribute signal to improve the SNR (and time).
- Once the baby is located, a smaller FOV is required to delineate the smaller anatomy.
- Trying to use a large matrix may not be possible due the small anatomy. It's always a challenge to get sufficient signal and sufficient voxels to improve the image resolution (ability to define one object from another) when the area is so small. The larger no. of voxels will increase resolution but reduce SNR. This smaller FOV has less tissue and therefore less protons available than before and each smaller voxel gives off less signal. The lower SNR may be compensated for by increasing the NEX/no. of averages/excitations but this will increase the time of the scan (and patient heating). The SNR will be further increased by expanding the phase oversampling which will ensure that the excess tissue, which was previously in the FOV, is now outside of it but is still contributing to signal. (please note – I would appreciate anyone adding a link or additional text here to better describe relationships SNR/resolution/Matrix/FOV/voxel size/NEX)
- A 4 or 5mm fast T2 weighted type scout is useful to locate the baby's position in 3 orthogonal (at right angles to each other) planes. If the baby moves, a few scouts may be required to plan the subsequent scans accurately. Breath-holds for the scouts can help but may not be necessary (or possible, if too long). These sequences have low sensitivity to motion.
- Always plan the latest scan from the last scan i.e. over the most recent baby position.
- Best to not label the position of the proposed scout plane until you see the images as the plane can move from image to image. It may be best to label all scans retrospectively in case the baby orientates itself differently in each one.

- Plan the scout sagittal images over the coronal abdominal/pelvis view, parallel to the placenta.
- Plan the scout axial images, over the sagittal image, perpendicular to the placenta.
- Check positions in the other 2 planes before starting any scan
- Oblique angles may be required to achieve true axial/coronal/sagittal images.
- For neuro work, the usual landmarks to set up and angle slices in the head are not yet formed or able to be easily visualized, (e.g. no AC-PC line is easily identified). For sagittal head imaging, run the slices parallel to the superior sagittal sinus/falx cerebri on an axial slice. On the resultant sagittal image, position the axial slices to run from the bottom of the frontal lobe/frontal part of the cerebrum to the bottom part of the cerebellum. Coronal slices can be angled on a sagittal image perpendicular to the axial slices or perpendicular to the falx cerebri on an axial image. Always check the slices in other planes, to ensure the slices are orthogonal to each other before scanning and use a sufficient no. of slices to cover all of the brain tissue. For spinal or body imaging, aim to produce a true coronal or sagittal image of the spine but do not take the position of the head as an indicator as the head may be turned but the body/spine/trunk may not be.
- In our unit we had success with using 5mm HASTE sequences (Half-Fourier Acquisition Single-shot Turbo spin Echo imaging, Siemens) but other units may use different sequences. These are fast sequences, <30 secs, giving sufficient anatomical detail with no need for breath-holds. HASTE/SS-FSE is a single-shot technique meaning that data from all of k-space is obtained after a single 90° excitation pulse.
- Other vendors have similar sequences: GE (Single-shot fast spin echo, SS-FSE); Philips (Single-shot turbo spin echo; SSH-TSE; ultra-fast spin echo, UFSE); Hitachi (Single-shot fast SE), and Canon (Fast Advanced Spin Echo, FASE, SuperFASE).<sup>7\*</sup>
- Sometimes 3 quick HASTE scans or an appropriate fast T2 sequence of the head in 3 planes are all that are required for neuro exams
- Other T2 weighted SSFP/FSE sequences, as desired, can also be performed in 3 planes but may require breath-holds.
- Other vendors have similar sequences: GE (FIESTA -Fast Imaging Employing Steady-state Acquisition); Philips (Balanced-FFE - Fast Field Echo).
- T1 VIBE (Volumetric interpolated breath-hold examination, Siemens) a spoiled 3D gradient echo scan is performed with breath-holds to check for a bleed or blood products. These are longer scans and movement may be an issue. The image

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<sup>7</sup> <http://mriquestions.com/hastess-fse.html> - \*by comparison, FSE/TSE is a multi-shot technique. This means that although k-space is traversed much more quickly than in conventional SE imaging, data from several separate RF-excitations are still needed to acquire all the data. For example, if 128 lines of k-space were to be sampled, a FSE/TSE sequence with an ETL/Turbo factor of 16 would require  $128/16 = 8$  "shots" to completely collect all the data

quality is usually not good enough to see much fetal anatomy but sufficient to highlight blood

- Other vendors have similar sequences: GE (FAME/LAVA); Philips (THRIVE); Hitachi (TIGRE); Canon (3D QUICK)

### Challenges of antenatal scanning

The further on in the pregnancy the easier it should be to identify any abnormalities e.g. from 25 weeks on but scans can be performed far earlier than this. The main issue is fetal movement which can make image interpretation difficult. The plan is not to get *perfect image quality* but *sufficient image quality* to see any abnormality. Perfection is the enemy of good when scanning a moving target with little signal. Obtaining good resolution and signal is difficult as the target is so small.

There is no guarantee that the scan will be quick if the baby is very lively on the day of the scan so best to factor in at least 30 to 45 minutes between antenatal patients.

Scanning for twins or triplets is especially complicated as they may be lying head to feet or 'dancing' with each other. It is vital that the correct baby is identified in each scan. Ensure each baby is accurately identified as that individual by labelling as 'Baby 1' and 'Baby 2', in each of the 3 orthogonal planes. Where more than one baby is present there is less space in the uterus so less chance that the babies will move too far from their original orientation.

### Scan in 'normal mode' to reduce heating effects

Always scan in normal mode 'Excessive heating is a potential teratogen; because of uncertainties in the RF dosimetry during pregnancy, it is recommended that exposure duration should be reduced to the minimum and that only the normal operation level is used.'<sup>8</sup> According to the IEC 'the instructions for use shall describe that scanning of pregnant patients with the whole body RF transmit coil should be limited to the normal operating mode with respect to the SAR level. 'The MHRA<sup>9</sup> also recommends that pregnant patients be scanned in Normal mode. If there is a need to scan in Controlled mode the decision to do so should be based on a risk-benefit analysis about risks weighed against the clinical benefit to the patient and made at the time by the referring clinician, an MR radiologist and the patient.

Caution is advised in the 1<sup>st</sup> trimester according, 'There is at present insufficient knowledge to establish unequivocal guidance for the use of MRI procedures on pregnant patients. In these circumstances, it is advised that MR procedures may be used for pregnant patients

<sup>8</sup> National Radiological Protection Board. ELF electromagnetic fields and the risk of cancer; report of an advisory group on non-ionising radiation. Documents of the NRPB 12(1), 2001. ISBN 0859514560.

<http://webarchive.nationalarchives.gov.uk/20140722091854/http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/DocumentsOfTheNRPB/Absd1201/>

<sup>9</sup> MHRA: Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use 2015

[https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/476931/MRI\\_guidance\\_2015\\_-\\_4-02d1.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/476931/MRI_guidance_2015_-_4-02d1.pdf)

only after critical risk/benefit analysis, in particular in the first trimester, to investigate important clinical problems or to manage potential complications for the patient or fetus. ”<sup>10</sup>

### Some indications for antenatal scanning

Antenatal scanning is not routine. Good quality ultrasound is normally the first imaging technique for initial diagnosis. Following abnormal findings, MRI may be warranted to provide a more complete diagnosis.

MRI can add additional information about the baby’s central nervous system (CNS) and in many cases, such as with a Chiari malformation, the spine will need to be scanned as well to identify any associated abnormalities (myelomeningocele). Fetal stroke can occur during pregnancy up to 28 days after birth and can be caused by clots breaking off from the placenta and lodging in the baby’s brain or by a blood clotting disorder.

Neuro: fetal stroke; ventriculomegaly; Chiari malformation; Vein of Galen malformation

Spinal: myelomeningocele (spina bifida); spinal defects; diastematomyelia; dysraphism

Thorax: bronchopulmonary foregut malformations; differentiation of diaphragmatic hernia from pulmonary malformation; pulmonary hypoplasia in diaphragmatic hernia

Abdominal: Liver abnormalities - T1 VIBEs are useful here -on such a small piece of anatomy- to see blood.

Other reasons: to look for other pathology and reasons for recurrent miscarriages, the baby failing to thrive (FTT) or to identify where conjoined twins are united.

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<sup>10</sup> International Commission on Non-Ionising Radiation (ICNIRP), Medical Magnetic Resonance (MR) Procedures: Protection of patients. HEALTH PHYSICS 97(3):259-261; 2009  
<http://www.icnirp.org/en/publications/index.html>