Optimum imaging of the pelvis with MRI

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Patient preparation
Once all MR safety checks have been completed, a careful explanation of the procedure helps with compliance along with reassurance if the patient is very nervous. Scanning patients feet first, playing music and speaking to very nervous patients throughout the scan can also help with compliance. As with all types of MR scan, a compliant patient will ensure a high quality diagnostic pelvic scan.

Patients should routinely be changed into a hospital gown for their scan; this ensures there will be no artefacts or any danger of causing skin burns.

All pelvic patients should empty or partially empty their bladder prior to the start of their scan to reduce motion artefacts, if they are specifically for a bladder scan, the bladder should remain partially full by only half emptying it. Patients for bladder scans, who have a catheter in situ, should have the catheter clamped as part of the patient preparation.

If the protocol calls for contrast routinely, a cannula is best sited before the patient is taken into the scan room. This ensures there are no delays caused to busy lists and also so that the patient spends the minimum amount of time in the magnetic field.

Equipment
Pelvic imaging will be optimised by using the most appropriate equipment. A phased array coil or a pelvic coil that wraps around will ensure optimum imaging. These coils receive signal from the patient and then transmit the signal, via small surface coil elements arranged above and below the patient, into separate receivers. They provide an excellent standard of high resolution imaging at small fields of view (FOV) (approximately 200mm) whilst still also achieving a relatively large FOV (approximately 300-350mm and up to 500mm in some systems) and maintaining a high signal-to-noise ratio. These surface coils produce images of such quality that they negate the use of other specific coils such as endorectal coils often used for prostate imaging.

Producing an imaging protocol
A standardised imaging protocol ensures all appropriate areas of the pelvis are covered; it ensures efficient use of the equipment, allows consistent interpretation of the examination and ensures reproducibility of subsequent examinations.

Below is a list of basic rules for pelvic imaging:
1. Use at least two planes, usually orthogonal, to assess full extent and volume of disease.
2. Use at least two weightings, usually T1 and T2, for tissue characterisation.
3. Choose weightings that maximise tissue contrast between pathology and normal tissue. Contrast enhanced or fat saturated imaging can be useful also for tissue characterisation.
4. Choose slice thickness to suit pathology. For example, small volume tumours involving the cervix or prostate will require thinner slices than something like a large pelvic sarcoma.
5. As mentioned, use appropriate coils.

Table 1 summarises some basic imaging parameters.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Slice thickness (mm)</th>
<th>Field of view (FOV) (mm)</th>
<th>Matrix size (Phase x frequency) (mm)</th>
<th>Pre-saturation band</th>
<th>Area covered</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Coronal</td>
<td>6</td>
<td>490</td>
<td>307 x 512</td>
<td>From above renal hilar to below symphysis pubis and from sacrum to symphysis pubis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Transverse (pelvis)</td>
<td>5-6</td>
<td>380</td>
<td>230 x 384</td>
<td>From iliac crests to below symphysis pubis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Transverse (abdomen)</td>
<td>5</td>
<td>380</td>
<td>132 x 256</td>
<td>1-2 slice overlap with pelvic block to above renal hilar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2 Transverse</td>
<td>3</td>
<td>200</td>
<td>256 x 256</td>
<td>Parallel superior and inferior</td>
<td>To cover area of interest and sidewalls laterally</td>
<td>May require two blocks to ensure adequate coverage. Phase encoding from right to left to eliminate ghosting due to respiration</td>
</tr>
<tr>
<td>T2 Coronal</td>
<td>3</td>
<td>200</td>
<td>256 x 256</td>
<td>To cover area of interest and from sacral promontory to perineum and sidewalls laterally</td>
<td>Phase over sampling required</td>
<td></td>
</tr>
<tr>
<td>T2 Sagittal</td>
<td>3</td>
<td>200</td>
<td>256 x 256</td>
<td>Over anterior wall fat</td>
<td>From sacral promontory to perineum</td>
<td>Useful for midline structures. Phase over sampling required</td>
</tr>
</tbody>
</table>

Table 1
Some typical imaging parameters
T2 weighted imaging (T2WI)
T2WI has inherent high contrast within the pelvic organs, demonstrating the internal zonal anatomy of some pelvic structures (figure 1). The muscular layers of the pelvic floor, anal canal and rectal wall, can also be demonstrated with T2WI and, along with T1WI, provide good tissue characterisation aiding accurate assessment of the pelvis. It is useful to obtain these images first in case the patient is unable to complete the whole examination. Table 2 demonstrates the signal intensities of the zones of the uterus, cervix and prostate.

FIGURE 1
Zonal anatomy of the prostate demonstrated with T2WI.

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>Hyperintense</th>
<th>Medium signal intensity</th>
<th>Hypointense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterus</td>
<td>Endometrium</td>
<td>Myometrium</td>
<td>Junctional zone</td>
</tr>
<tr>
<td>Cervix</td>
<td>Endocervical canal</td>
<td>Fibrous stroma</td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td>Peripheral zone</td>
<td>Central zone</td>
<td>Transitional zone</td>
</tr>
<tr>
<td>Seminal vesicles</td>
<td></td>
<td></td>
<td>Seminal vesicle walls</td>
</tr>
</tbody>
</table>

TABLE 2
Signal intensities of zonal anatomy

A small field of view (FOV), ~200mm and thin slices, ~3mm with a matrix of 256 x 256, will provide good spatial resolution. Fast spin echo (FSE) or turbo spin echo (TSE) will reduce scan time and reduce the risk of patient movement. Some systems are able to reduce scan times by utilising parallel imaging techniques which acquire a reduced data set in the phase encoding direction of K-space therefore reducing acquisition times.

T2WI is usually performed in all three orthogonal planes, with the addition of oblique imaging for some pelvic structures such as the cervix, prostate and rectum.

T1 weighted imaging (T1WI)
T1WI gives an overview of the pelvis and abdomen, demonstrating the bones and bone marrow, any lymph node enlargement, hydronephrosis and hydro-ureter. It provides information about the bulk of any tumour present or any fluid such as haemorrhage.

T1WI is usually performed in two planes, coronal and transaxial, using a relatively large FOV, ~400-500mm with a slice thickness in the region of 5-7mm.

Motion artefacts
Motion artefacts from respiration, blood flow, bowel and bladder movement and patient discomfort can significantly degrade image quality. The following are ways to help reduce motion to a minimum:

1. Antispasmodics/smooth muscle relaxants significantly reduce bowel motility in patients (figure 2). Provided there are no contra-indications, routine use is recommended. The effectiveness lasts at least 20 minutes giving enough time to complete the T2 imaging.

2. If the patient has a contra-indication to antispasmodics, the pelvis can be compressed by placing a foam pad over the lower abdomen and then strapping the phased array coil or pelvic coil across. Alternatively, scanning the patient prone are both methods which help to reduce motion artefact in the pelvic organs.

3. Motion artefacts from respiration can also be reduced by using the methods mentioned in point two but in addition, can be eliminated by selecting a breath-hold sequence or by increasing the number of acquisitions to average out the artefact. If the latter is chosen, the scan time can be reduced by using a rectangular FOV. A rectangular FOV can be achieved by applying the phase-encoding in the anterior-posterior direction so that fewer phase-encoding steps are then performed.

4. Ideally, the bladder should be partially full as this will help to lift the bowel loops out of the pelvis. If the bladder is too full, there will be motion artefact from either the bladder itself or patient movement due to discomfort.

5. Artefacts from blood flow in the inferior vena cava (IVC) and aorta can be minimised with the use of presaturation bands, ie superior and inferior and parallel to transverse block.

Contrast enhanced imaging
Due to the inherent high contrast within the pelvis on T2WI, contrast is not used routinely. However, in some circumstances it can be useful, ie to determine the extent of a sarcoma or similar disease or the effects of treatment. It can also be useful in assessing complex ovarian masses and determining whether a mass contains a cystic component. Dynamic contrast enhanced (DCE) sequences can be useful in assessing tumour activity (figure 3). Rapid acquisition, something in the region of one image every two seconds, following a bolus injection of MR contrast agent can be used to investigate malignant lesions of the cervix, endometrium, bladder and prostate. Activity curves (figure 2) can then be created using the scanner’s software, giving information of any abnormal activity at a cellular level.

FIGURE 2
Motion artefact significantly reduced following administration of antispasmodic/smooth muscle relaxant.

FIGURE 3
Dynamic contrast enhanced (DCE), with rapid acquisition, imaging of the endometrium.

Fat suppression/saturation techniques
These techniques rely on the differences in resonant frequencies of water and fat (220 hertz at 1.5T) therefore a saturation pulse set at the frequency for fat will selectively remove the signal contribution from it. These techniques can be used with both T1 and T2 sequences and are useful in distinguishing fat within a lesion (ie ovarian masses and benign teratomas) and extension of any lesion into surrounding fat. They also increase conspicuity of enhancing peritoneal deposits and omental disease.
Spectroscopy

$^1$H spectroscopy has been used recently for examining the cell metabolism of the prostate. The spectra demonstrate the changes in creatine and choline signals and the reduction in the signal from citrate in the presence of tumour (figure 4). Spectral changes have been reported in otherwise normal appearing imaging. It can provide information on disease spread, it can be used to guide biopsies, monitor response to treatment and determine recurrence.

Diffusion weighted imaging (DWI)

Research is currently being undertaken into the use of DWI in recurrent pelvic disease. Diffusion imaging relies on the random motion, known as Brownian motion, of water and other small molecules in tissue. When this motion is exposed to a magnetic gradient it results in irreversible signal loss. If then a strong pulsed gradient is applied to a spin echo (SE) or gradient echo (GRE) sequence during the MR signal evolution, the sequence becomes very sensitive to the diffusion effects. Therefore, in areas of restricted diffusion, ie where there is suspicion of tumour, there is decreased attenuation of the MR signal resulting in a hyperintense area on the diffusion weighted image. As DWI is very sensitive to changes in diffusion, it has the potential to demonstrate early signs of recurrent disease and increase the degree of confidence of the reporting radiologists.

References


