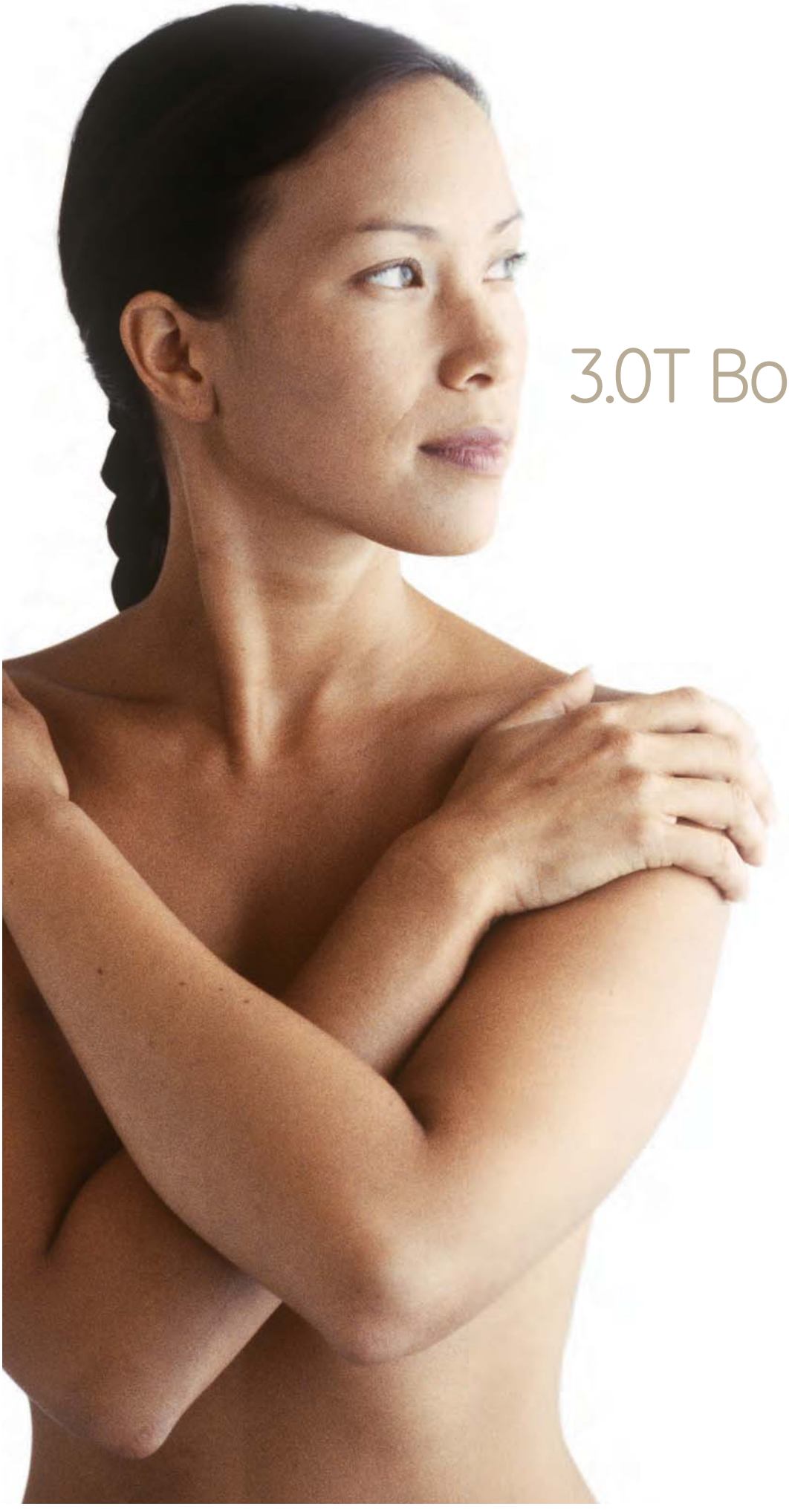


3.0T Body Imaging:

More Than a Pretty Picture

Imaging that helps inform management decisions

The last decade has seen a number of developments that transformed body imaging, including the introduction of 3.0T scanners and parallel imaging. The introduction of 3.0T scanners increased the available signal-to-noise ratio (SNR); however, it also resulted in increased artifacts such as dielectric effects, chemical shift, and magnetic susceptibility.

The Centre for Magnetic Resonance Investigations at the University of Hull (Hull, UK) has been acquiring body MR images since 1994. "The quality of body MR imaging has really benefited from recent technical innovations, such as higher field strengths and parallel imaging; however, we had reached a stage where scanner hardware was the limiting factor," explains Professor Lindsay Turnbull, MD, Scientific Director. "That's why we were so keen to explore the opportunities offered by the Discovery™ MR750 3.0T. With its newly designed 16-rung quadrature body coil, we anticipated a reduction in dielectric effects." Additionally, the Discovery MR750 also provides the industry's most powerful whole-body gradient system and fast reconstruction times, providing greater spatial resolution and volume acquisitions without excessively long reconstruction times. "So, I think you can see why we were so excited about its potential," she adds.

Martin Pickles, PhD, Research Radiographer, agrees, "Our body MR workload is almost exclusively oncology based, and consequently, diagnostic confidence is paramount. Treatment decisions are made based on our imaging studies, including the difference between a patient being offered either curative surgery or palliative therapies.

"We believe that the hardware coupled with new volumetric pulse sequences such as LAVA-Flex and Cube, the imaging protocols we developed, and the assistance of the GE Healthcare Global and European advanced applications teams, have collectively contributed to significantly raising our diagnostic confidence," Dr. Pickles says.

The Discovery MR750 offers improvements in hardware and pulse sequences, which improves ease of use and results in fast scan times to provide improved clinical imaging and enhanced workflow efficiency. "The in-room operator console is a real advantage for body work, particularly since we can monitor the respiratory trace while positioning the patient on the table," explains Julie Pounder, Superintendent Radiographer. "ARC™ is also proving to be a robust parallel imaging technique that does not require the acquisition of an additional calibration scan, while at the same time significantly reducing scan times."

Conclusion

Even though the University of Hull had the new Discovery MR750 for less than a month when these studies were conducted, the results, they felt, were impressive. The increased SNR evident with the Discovery MR750 has been utilized with a good effect in all sequences, but it is most significant in the 3D sequences. The Centre believes the ability to reformat data in any desired plane is a powerful tool, and the acquisition of T2 3D Cube and T1 post-contrast 3D FSPGR sequences increases the examinations diagnostic potential. "Diagnostic and staging accuracy should increase as a consequence, particularly in complex pelvic pathologies," says Dr. Pickles. "Greater use of high-resolution 3D sequences will eventually replace the use of multiple 2D sequences, with the added potential to reduce exam times."

"For body imaging, we have seen a clear distinction between our previous 3.0T scanner and the new Discovery MR750," adds Prof. Turnbull." The ability to acquire volumetric imaging that can be reformatted in any plane within realistic clinical imaging times has increased our diagnostic confidence and resulted in a positive impact on patient management decisions." ■

Clinical cases

Case 1. Prostate

Patient with biopsy confirmed adenocarcinoma of the prostate (Gleason score 6, serum PSA 10 ng/mL). Referred for MR staging and to exclude extracapsular extension, since patient was being considered for radial prostatectomy.

MR revealed a moderately enlarged prostate; benign prostatic hyperplasia was noted throughout the central gland. Hypointense bilateral peripheral zones were noted on T2-weighted (T2w) images. Water only LAVA-Flex, multiphase, 3D volumes revealed type III signal intensity curves bilaterally; however, greater contrast enhancement was noted within the left peripheral zone. There was no evidence of extracapsular extension, pelvic lymphadenopathy, or focal bony abnormality.

Patient management: Radial prostatectomy.

Protocol:

High spatial resolution axial T2w: FRFSE-XL, TR 5280, TE 99.3/Ef, 31.2 kHz, ETL 17, FOV 20x20 cm, 3/0 mm, 384x256, 4 NEX

LAVA-Flex multiphase volumes: 3D LAVA-Flex, flip 12°, TR 4.3, TE 1.3 and 2.6, 166.7 kHz, FOV 34x27.2 cm, 3/-1.5 mm, 320x192, 0.75 NEX, ZIP2

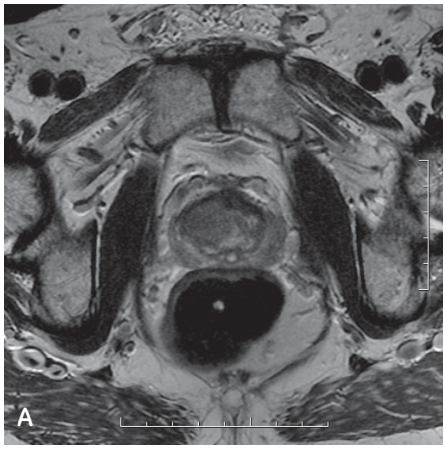


Figure 1a. Axial high-resolution T2w images demonstrating bilateral hypointense peripheral zones.

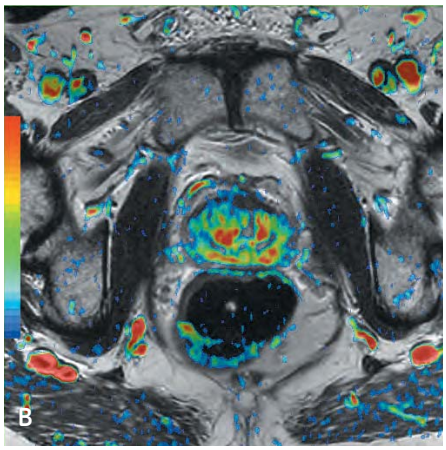


Figure 1b. Positive enhanced integral color map overlaid onto axial high resolution T2w images (Figure 1a).

Case 2. Ovaries

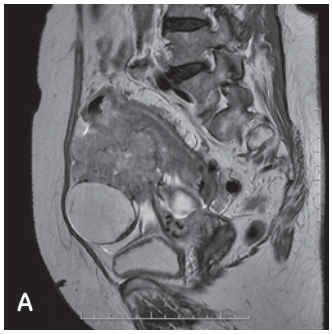
Patient presented with a pelvic mass. Ultrasound revealed a large complex mass and the patient was referred for a MR staging examination.

MRI revealed a poorly encapsulated mass (12 x 12 x 10 cm) with mixed solid and cystic components. Conventional 2D T2w FSE imaging (sagittal, axial, and oblique) suggested involvement of the sigmoid colon. Consequently, 3D T2w Cube was acquired; reformats of the data in several planes demonstrated infiltration of the mass into the bowel wall but no evidence of any mucosal involvement. FIGO stage 2C.

Patient management: Patient referred for neoadjuvant chemotherapy, prior to debulking surgery. Although colo-peritoneal fistulae can occur with bowel involvement, the absence of mucosal involvement on 3D CUBE T2w imaging resulted in the decision not to perform a defunctioning colostomy prior to chemotherapy.

Protocol:

3D T2w Cube: TR 2000, TE 91.9/Ef, 31.2 kHz, ETL 60, FOV 24x24 cm, 1.8/-0.9 mm, 224x224, 1 NEX, ZIP512, ZIP2
Axial T2w: FRFSE-XL, TR 5280, TE 99.3/Ef, 31.2 kHz, ETL 17, FOV 20x20 cm, 3/0 mm, 384x256, 4 NEX



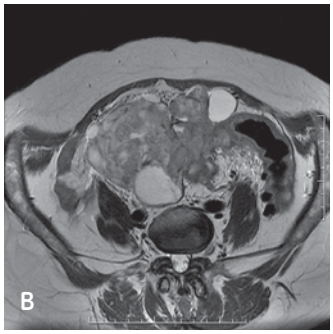


Figure 2a and 2b. T2w images acquired in the sagittal and axial plane revealed a large pelvic mass.

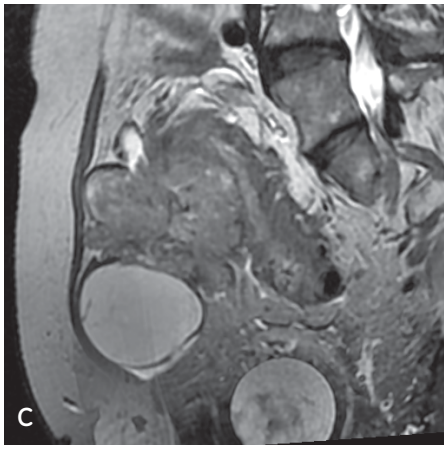


Figure 2c. Reformatted T2 Cube image demonstrating infiltration of the ovarian tumor into the wall of the sigmoid colon.

Case 3. Liver

Patient with known case of ovarian carcinoma, finished second line chemotherapy and referred for assessment of treatment response.

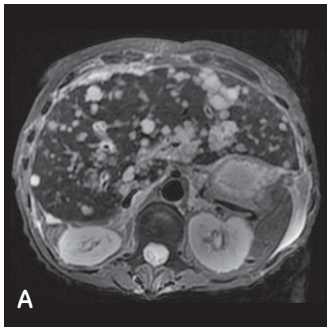
MR revealed extensive disease present within the pelvis, abdomen, and lung bases. Axial T2w fat saturated images of the liver utilizing ARC were acquired with a multiple NEX method as the patient had very shallow respiration. Diffusion-weighted imaging (DWI) was acquired in a breath hold. Both T2w fat saturated and diffusion images demonstrated multiple metastatic deposits in liver and lung bases.

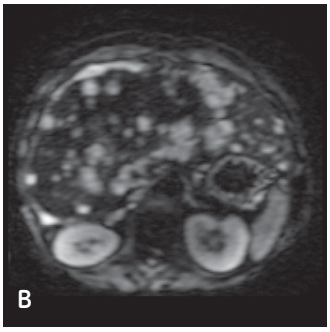
Patient management: In view of the extent of disease present, patient was referred for palliative care.

Protocol:

Axial ARC T2w fat saturated multiple NEX: FRFSE-XL, TR 5040, TE 78.3/Ef, 41.7 kHz, ETL 12, FOV 40x28 cm, 5/1 mm, 256x224, 6 NEX, ZIP512, Fat Sat

Axial DWI: SE/EPI, TR 2000, TE 50.5 FE, 250 kHz, FOV 40x28 cm, 8/2 mm, 80x128, 4 NEX, ASSET, b=0 and 600s/mm^2, applied in SI direction, 18 sec breath hold





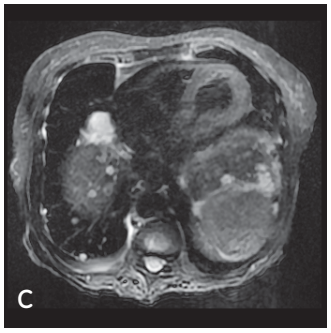


Figure 3a. ARC T2w image acquired with multiple NEX in the axial plane demonstrating multiple liver metastases.

Figure 3b. b = 600 s/mm^2 diffusion image (same slice location as 3a) acquired in one 18 sec breath hold.

Figure 3c. ARC T2w image acquired with multiple NEX in the axial plane demonstrating pulmonary metastases.

Case 4. MRCP

Patient admitted with abdominal pain. Ultrasound demonstrated calculi within the gallbladder referred for MRCP.

Respiratory triggered ARC 2D axial T2w images were acquired through the pancreas and biliary system, as were a respiratory triggered 3D coronal oblique block of heavily T2w images that subsequently underwent maximum intensity projection (MIP) processing. These images demonstrated a number of calculi within the gallbladder; no dilatation of the biliary ductal system was noted.

Patient management: Patient was referred for laparoscopic cholecystectomy.

Protocol:

Coronal oblique 3D T2w respiratory triggered: 3D FRFSE-XL, TR set by respiration rate, TE 683.5/Ef, ETL 140, FOV 36x36 cm, 2/-1, 256x224, 1 NEX, Resp. Trig., ASSET, ZIP512, ZIP2

Axial ARC T2w fat saturated respiratory triggered: FRFSE-XL, TR set by respiration rate, TE 88.9/Ef, 31.2 kHz, ETL 12, FOV 40x28 cm, 5/1 mm, 256x224, 4 NEX, ARC, Resp. Trig., ZIP512, Fat Sat

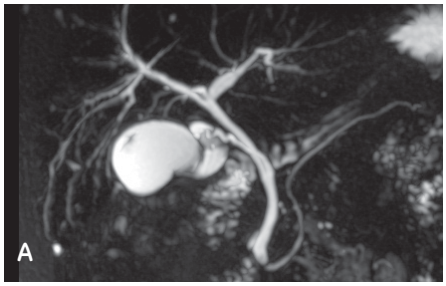


Figure 4a. MIP from respiratory triggered coronal oblique 3D T2w FRFSE-XL depicts the biliary tree and pancreatic duct; note several calculi within the gallbladder.

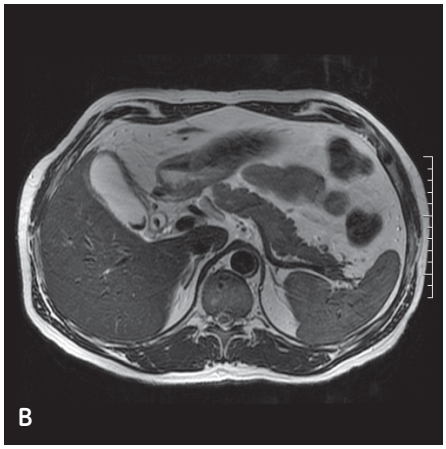


Figure 4b. ARC respiratory triggered T2w FRFSE-XL axial image again demonstrates calculi within the gallbladder.

Prof. Lindsay Turnbull

Lindsay Turnbull, MD, is professor of radiology at Hull-York Medical School and scientific director of the Centre for MR Investigations, University of Hull. Prof. Turnbull received her medical degree from the University of Edinburgh after earning an Honors degree in Pathology and subsequently obtained the FRCR and MD. She is clinical director of the North & East Yorkshire and North Lincolnshire Comprehensive Local Research Network, a member of the regional Experimental Cancer Medicine Centre, and is on the Scientific Advisory committees for Yorkshire Cancer Research, Breast Cancer Campaign and the NHS Health Technology Assessment Diagnostic Technologies and Screening panel.

Dr. Martin Pickles

Martin Pickles, PhD, is a researcher working at the Centre for MR Investigations, University of Hull. Dr. Pickles qualified as a radiographer in 1996 and since 1998 has been working in MRI. In 2003, Dr. Pickles joined the University of Hull where he gained his PhD in breast MRI in 2006. Currently, he is working on a number of oncology 3.0T research projects.

Case 5. Haematosalpinx & hydronephrosis

Patient presented with a one-year history of abdominal pain coupled with a family history of gallstones. Patient initially referred for ultrasound, which revealed an obstructed left ureter. A subsequent CT scan noted an abnormal mass in the location of the left ovary. Patient was referred for MR examination for definitive diagnosis.

Sagittal, axial, and oblique axial T2w imaging of the pelvis demonstrated a right ovary measuring 3 cm which contained a simple cyst (1.5 cm). Enlarged left ovary containing multiple oval shaped structures of low or intermediate signal intensity, which on the 3D LAVA-Flex water-only images were hyperintense with an appearance in keeping with haemorrhagic cysts secondary to endometriomas. A further tubular structure was noted attached to the left ovary in keeping with a haematosalpinx. 3D T2w Cube images were acquired to further understand the relationships between the differing pathologies present. Reformatted images from this sequence revealed the ureter to be obstructed at the level of the superior pole of the ovary. Finally, 2D ARC T2w axial images demonstrated multiple multi-faceted calculi.

Patient management: Patient referred for laser treatment of endometriosis. There is no remaining function of the left kidney so ureteric stenting was not performed.

Protocol:

3D LAVA-Flex: 3DLAVA-Flex, flip 12°, TR 4.6, TE 1.3 and 2.6, 166.7 kHz, FOV 34x30.6 cm, 1.2/-0.6, 320x224, 0.71 NEX, ZIP23D

3D T2w Cube: CubeT2, TR 2000, TE 91.9/Ef, 31.2 kHz, ETL 60, FOV 24x24 cm, 1.8/-0.9 mm, 224x224, 1 NEX, ZIP512, ZIP2

Axial ARC T2w fat saturated respiratory triggered: FRFSE-XL, TR set by respiration rate, TE 88.9/Ef, 31.2 kHz, ETL 12, FOV 40x28 cm, 5/1 mm, 256x224, 4 NEX, ARC, Resp. Trig., ZIP512, Fat Sat

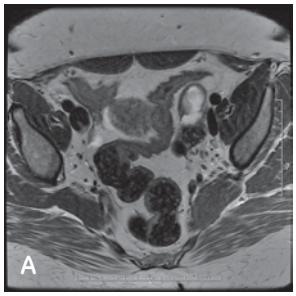


Figure 5a. Axial T2w FRFSE-XL demonstrating left ovary with low signal intensity oval structures and haematosalpinx.

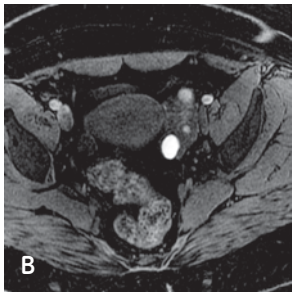


Figure 5b. Axial reformat from 3D LAVA-Flex revealing the hyperintensity signal from the haemorrhagic cysts noted in Figure 5a.

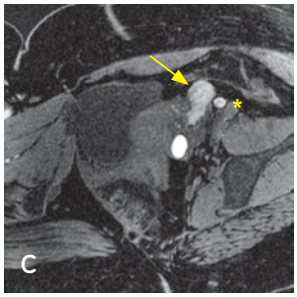


Figure 5c. Oblique reformat from 3D LAVA-Flex again reveals hyperintensity signal from the haemorrhagic cysts noted in Figure 5a. Additionally, the haematosalpinx (arrow) and hydronephrosis (*) are noted.

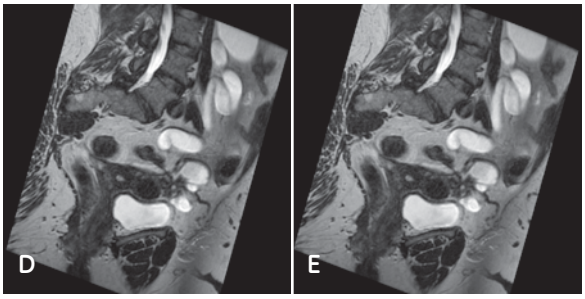


Figure 5d and 5e. Oblique reformats from the T2w Cube revealing the hydronephrosis and haematosalpinx secondary to endometriosis.

Figure 5f. ARC respiratory triggered T2w FRFSE-XL axial image reveals the multi-faceted calculi within the gallbladder.

Case 6. Endometrium & polycystic syndrome

Patient with known case of adenocarcinoma of the endometrium referred for MRI staging of disease prior to treatment.

Sagittal, axial, and oblique axial T2w imaging of the pelvis demonstrated expansion of the normal endometrial strip. The tumor extended into the endocervical canal where it involved not only the mucosa but the underlying stroma; however, no abnormality was noted in the parametrial soft tissues. DWI also demonstrated the lesion that was noted to have a low ADC (1.02 x 10^{-3} mm^2/sec) in keeping with malignancy. No pelvic lymphadenopathy noted on DWI or T2w imaging.

Staging of the upper abdomen revealed extensive liver and renal cysts in keeping with polycystic syndrome; however, there was no evidence of metastatic spread outside the pelvis. FIGO stage 2B.

Patient management: Patient referred for total abdominal hysterectomy and bilateral salpingo-oophorectomy.

Protocol:

Sagittal and Axial T2 FRFSE: FRFSE-XL, TR 3260, TE 91.5/Ef, 41.7 kHz, ETL 19, FOV 24x24 cm, 4/1 mm, 448x224, 4NEX

DWI: SE/EPI, TR 4000, TE64.1FE, 250 kHz, FOV 38x38 cm, 5/0 mm, 224x192, 12 NEX, ASSET, b=0 and 600 sec/mm^2, applied in ALL directions

3D LAVA-Flex: Flip 12o, TR 4, TE 1.3 and 2.6, 166.7 kHz, FOV 48x48 cm, 6/-3 mm, 320x256, 0.83 NEX, ZIP2, 16 sec breath hold

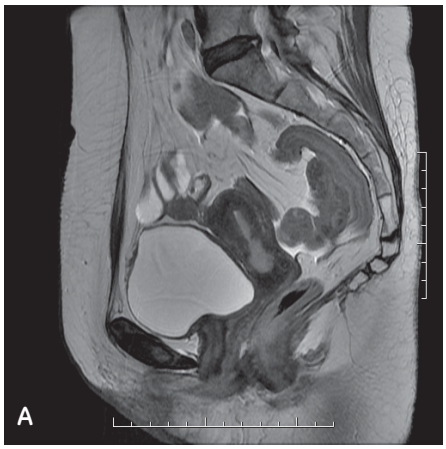


Figure 6a. Sagittal T2 FRFSE-XL demonstrating expansion of the normal endometrial strip.

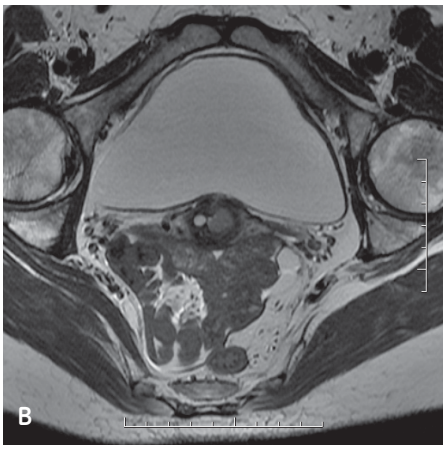


Figure 6b. Axial oblique T2 FRFSE-XL revealing the lesion and an intact sroma ring.

Figure 6c. b = 600 sec/mm^2 diffusion image demonstrating within the endometrium.

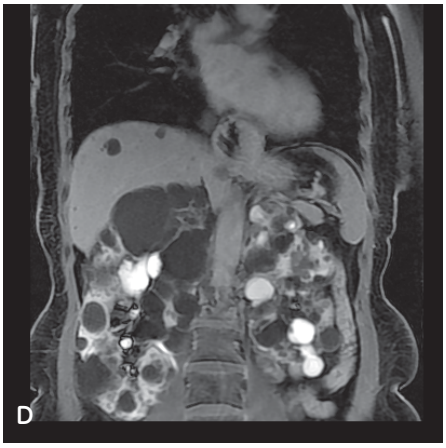


Figure 6d. Coronal 3D LAVA-Flex water only image revealing multiple cysts within the upper abdomen, acquired in one 18 sec breath hold.

Julie Pounder

Julie Pounder is a Superintendent Radiographer working at the Centre for MR Investigations, University of Hull. Julie qualified as a Radiographer in 1994 and has been working in MRI since 1997. Julie gained a PGc in MRI in 2001 through the University of Bradford and has lectured to undergraduates and postgraduates in MRI at Sheffield Hallam University.

About the facility

The Centre for Magnetic Resonance Investigations (CMRI) at Hull University was commissioned in 1992 to jointly house separate NHS and University funded MR systems. The CMRI is funded through an endowment from Yorkshire Cancer Research, but additional revenue is generated by the sale of MR system session time to the NHS for the provision of an extended clinical service. Established research programs are in place for breast, prostatic, and gynecological malignancies, with further extension of activity proposed in other oncological and non-oncological fields.

CMRI has an established reputation in breast imaging with Professor Lindsay Turnbull, MD, who is one of the Principal Investigators in the MRC-funded MARIBS study and the Chief Investigator in the NHS HTA R&D funded COMICE study. Additional breast related studies are in progress, including response to neoadjuvant chemotherapy, DCIS, and optimization of lesion characterization. Other research programs examine prostatic and ovarian malignancies, and bone imaging related to cancer and cancer therapy. The development of surrogate MR biomarkers of tumor response to therapy continues in all areas and is a major theme of the CMRI.

The CMRI is currently expanding into cardiac imaging in conjunction with Professor J. Cleland, Professor of Cardiology, whose major interest is in the pathophysiology and clinical management of heart failure.