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BAMRR news

THE NEWSLETTER OF
THE BRITISH ASSOCIATION OF MR RADIOGRAPHERS

IN THIS ISSUE:

welcome

from your BAMRR PRESIDENT

Dear BAMRR Members.

I hope you are all well and staying safe.

I knew it was going to be a challenging year the moment I fell off the stage at the BAMRR conference in Bournemouth, my first day as President !!!

But who could have imagined the monumental changes that were about to occur. Not only a global pandemic but also a call for renewal of the social justice system.

We now live in a constantly changing world which not only affects the way we live but also the way we work. All of you are now altering your working methods in response to these changes.

I am proud to say that the BAMRR Board have embraced those changes and also adapted their way of working on the Board for our members.

This is reflected in many ways.

Our Board Meetings are now virtual, saving lots of money and time on travelling. It took a little getting used to as Board members joined the meetings from various work and home locations, It was lovely to see inside each other's homes, especially as one member had a litter of adorable puppies to show us. I am sure someone was in a broom cupboard at the back of an MRI department somewhere in the UK and am positive not everyone was completely dressed from the waist down. But nevertheless, the meetings still took place as we frantically searched for methods to adapt and help our members in this time.

We very sadly had to postpone all of the courses planned for 2020 but we will honour all the places booked and hope to return in full force next year.

Our Manchester conference in October can also sadly not go ahead in its planned format, but, we are working together with the BIR to bring you a virtual conference instead and hope that many of you can attend. Details will appear on the website soon.

I cannot express enough how proud I am of all the Board members who, despite the difficulties we all have faced, continue to work and plan for BAMRR. I am also very proud and grateful to all you members who stay with us during this time.

Stay safe and look forward to seeing you all on the other side

Eileen Wilson
BAMRR President

from your EDITOR

Welcome to the autumn 2020 BAMRR News.

No study days…no interest groups…no conferences… not in the loop

Symposium or training day…..education's gone away!

God bless BAMRR News!

Viva BAMRR News!

Long live BAMRR News!

C'est magnifique, BAMRR News…

Sorry about that, I got all 80's TV-retro there for a moment.

Things sure have changed though, but it is great to see us all fighting back where we can. Not least the fact that we at BAMRR will be holding our annual conference on-line this year on Oct 3rd from 1-5pm, so please attend. It is free to members! Look out for the flyer on the website for provisional agenda and registration instructions.

Our own BAMRR Policy Meetings have also temporarily moved to be web-based too. I even had to order myself a webcam. From my point of view these have been a very successful way of keeping things on track, but do seem to suffer somewhat compared to face-to-face meetings when there are a larger number of attendees all trying to contribute. At the last one there was so many of us my screen looked like an episode of Celebrity Squares - ooops, there I go again, showing my age.

So finally, lockdown has not only changed our work, but our home life too. I play in a band and we had to cancel some gigs as well as being forced to stop rehearsaing. So what did I do with my time? Well, here's one more 80's retro link for you to enjoy. And it is very much MRI related!! Enjoy…

https://www.youtube.com/watch?v=Gw77XOprPQk

Matthew Benbow
BAMRR Editor

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WELCOME from our sponsor GUERBET

Guerbet wishes you a warm welcome to the Autumn edition of BAMRR News.

Guerbet wishes you a warm welcome to the Autumn edition of BAMRR News.

In November 2015 we completed the acquisition of the "contrast media and delivery systems" (CMDS) business of Mallinckrodt. The new entity brings together 2,500 employees creating a global leader specializing in contrast media and imaging solutions and services (ISS).

We continue our committment to supporting continuous professional development for MR Radiographers. Throughout the year, in partnership with Radiologists/Radiographers who are passionate about sharing their knowledge, we organise and support teaching courses which are informative and relevant. Please visit our website www.guerbet.co.uk to find out more about the events we hold or sponsor.

Do not hesitate to get in touch on 0121 733 8542 or uk.info@guerbet-group.com if there is something you would like to tell us. As always, we welcome your comments and suggestions as we are here because of you.

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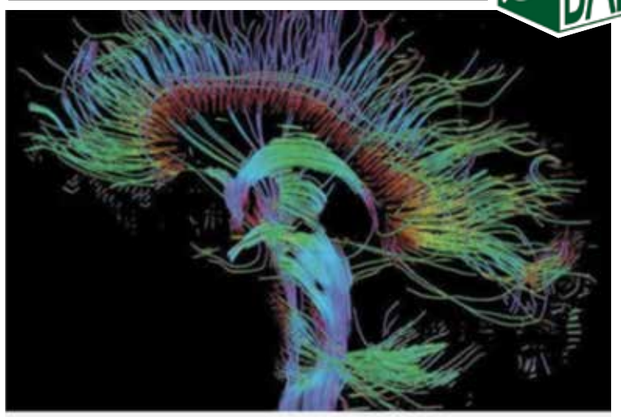
BAMRR



Saturday 8th May

at the
Millennium Gloucester Hotel, London

A full day of talks including scanning of implants, compressed sense, prostate and cardiac imaging, whole body DWI, Neuro oncology, safety implications of 3T and radial sequences, further details are on the website.

Now available for booking via the website
bamrr.org.

BAMRR Policy Board Members, Autumn 2020

The co-ordination of the Associations activities is overseen and undertaken by an elected Policy Board. The board currently consists of the following who are members of BAMRR and working in different regions of the UK.
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Considerations before resuming outpatient MRI services during a pandemic; practical steps to optimise patient and staff safety

Barbara Nugent BSc(Hons) PgC (MRI) DCR(R) MRSO (MRSC™)

MRI Specialist Radiographer and founder of MRI Safety Matters® and CT Training Matters

The cancellation of elective MRI scanning was part of government lockdown measures designed to expand capacity for an expected surge in COVID-19 cases. Such interventions also reduced the likelihood of nosocomial spread of the disease. With the easing of restrictions comes pressure to swiftly resume routine scanning sessions again. Sharing expertise when criteria for infection control during this pandemic is still evolving is warranted.

Barbara Nugent, radiographer and founder of MRI Safety Matters®, has worked with leading MRI and patient safety professionals to consider steps that might help to protect health care workers (HCWs) and patients from contracting COVID-19 in an outpatient setting. July's RAD Magazine article offers practical steps to consider to try to reduce the spread of infection during this crucial time in healthcare.

Maintaining the recommended safe distance from patients and colleagues is not possible when scanning. Identifying infected cases is problematic. A multitiered approach, which filters out the potentially infected before they reach the unit is required. The complex nature of MRI presents further challenges to cleaning, disinfecting and decontaminating a scan room. The type of respiratory personal protective equipment (PPE) worn needs to be checked for MRI safety. None is currently labelled for MRI safety conditions. A new classification system of respiratory PPE with interim testing results is included. The measures and information to review and consider include:

- Health surveillance and temperature checks of everyone entering a healthcare facility
- Universal mask-wearing and PPE to include eye protection for HCWs
- Weekly testing of HCWs for COVID-19
- Classification of MR safety tested respiratory PPE
- Tools and barriers to ensure physical distancing
- Segregation of HCWs in case one team needs to be isolated
- Decontamination procedures with consideration of the emergency gas extract venting system
- Cleaning/disinfection guidance
- The importance of workplace and personal risk assessments
- Ways to enable vetting, reporting and virtual meetings off-site

It is hoped that such measures can help to reduce infection rates and optimise service efficiency. The proposals are based on evolving guidance from many sources. Local assessments are required to enable adopting those measures that are needed and can be supported. The resource can be accessed through RAD's scientific articles page: https://www.radmagazine.co.uk/scientific-article/considerations-before-resuming-outpatient-mri-services-during-a-pandemic-practical-steps-to-optimise-patient-and-staff-safety/.

Testing Methodology from Dr Ian Cavin Regional MRSE (MRSC™) NHS Lothian

The rapid deployment of personal protective equipment (PPE) for staff working, and patients undergoing MRI examinations, during the SARS-CoV-2 pandemic, necessitated a simple and straightforward methodology for carrying out MRI safety testing of FFP3 (filtering facepiece) respirators. Ideally, sites with the required skilled personnel and equipment, could carry out testing to the American Society for Testing and Materials (ASTM) International's standard F2503 for the marking of devices; namely, "Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment". However, this is beyond the scope and remit of most MRI facilities. Therefore, adopting an expedient, robust and reproducible approach is required.

Using readily available equipment, tests, utilising a hand-held test magnet, and subsequently, where safe to do so, exposing the mask or respirator "under test" to the fringe magnetic field of the MRI scanner, in the region, where the attractive force is greatest were conducted. This region is close to where the spatial gradient of the MRI scanner is maximal and is typically at the bore entrance. Noting and observing the behaviour of the respirator in terms of attraction and torque when being held in the hand and deflection or loss of cohesions when being worn correctly was the key test.

Where there was no metal components present the masks were deemed MR SAFE

Where metal components, either magnetic or non-magnetic were present the mask was deemed MR CONDITIONAL.

Where metal magnetic components were present and the mask demonstrated significant attraction, resulting in a loss of cohesion to the surface of the face when being worn correctly the respirator was deemed MR UNSAFE.

Additional testing methodology from Marthe Bergland Jørgensen, Radiographer MRSO (MRSC™) at the University hospital of North Norway, Tromso regarding the surgical masks and respirator that her team tested:

An assessment of translation and torque was made when the facemasks and respirator were introduced into the static magnetic field. An evaluation of the degree of ferromagnetism and whether the masks and respirator could be moved on a patient's face or in any other ways which might create a safety risk was conducted.

Facemasks were placed on a phantom in a head coil on a 1.5 T Philips MRI unit. A standard diffusion weighted echo planar imaging sequence was performed. The type and degree of artefacts were considered. The DWI is very sensitive for inhomogeneities in the magnetic field and will thus show artefacts where other sequences may not. This means that if the DWI doesn't show any artifacts, most other sequences will not either.

Disclaimer: This classification table is for guidance only. The authors performed basic tests on each item, not conforming to ASTM international standards. It is strongly recommended that a local risk benefit analysis should be performed by your local MRI physics, infection control and clinical imaging teams before any facemasks, available locally, are used. None of the MR Conditional masks have been tested on patients in the bore. If the wearer feels that any MR Conditional masks, as described below, do not maintain a secure fit when positioned near the magnet bore then alternative respiratory PPE should be worn.

Table 2. Compilation of respiratory PPE tested in the MR Environment (scan room)

Type	Make & Model	Unofficial MRI Safety Status	Metal (Y/N)	Ferrous (Y/N)	Conditions / Notes	Test Group
Surgical Masks	3M Tie-On Surgical Mask 1818	MR Unsafe	Y	Y	Strong attraction of metal wire of nose bridge, torque on mask close to magnet, lost contact with phantom, potential for local heating and considerable local artefact.	Bergland Jørgensen et al
	Barrier medical face mask REF 4313	MR Unsafe	Y	Y	Strong attraction of plastic-coated metal wire	Quest et al
	Cardinal Health type IIR AT74535UK	MR Conditional	Y	N	Safe for staff use. (Localised artefacts and potential heating if worn by patients)	Quest et al
	Dahlhausen	MR Conditional	Y	N	Safe for staff use. (Localised artefacts and potential heating if worn by patients)	Murray et al
	Hubei Lexin Medical Disposable Medical Mask	MR Conditional	Y	N	Safe for staff use. (Localised artefacts and potential heating if worn by patients)	Bergland Jørgensen et al
FFP2 Respirators	3M Aura 9320	MR Conditional	Y	Y	Minor pull at bore entrance caused 1/2 failed fit-tests.	Quest et al
	Draeger X-plore 1320 Vodour FFP2: MR Unsafe	MR Unsafe	Y	Y	Strong ferromagnetic attraction, torque on mask close to magnet, lost contact with phantom, potential for local heating and considerable local artefact.	Bergland Jørgensen et al
	Halyard Technology 62408	MR Conditional	Y	N	Safe for staff use. (Localised artefacts and potential heating if worn by patients)	Murray et al
	Kolmi	MR Unsafe	Y	Y	Strong ferromagnetic attraction. Lost contact with phantom at bore entrance.	Murray et al
	Nobaprotect 672062	MR Conditional	Y	Y	Safe for staff use (passed fit tests at bore of 2x 3T scanners).	Quest et al
FFP3 Respirators	3M 8833	MR Conditional	Y	Y	Safe for staff use. (Large artefacts and potential heating if worn by patients)	Quest et al, Davies et al
	3M 1873V	MR Conditional	Y	Y	Safe for staff use. (Large artefacts and potential heating if worn by patients)	Quest et al
	3M 1863/3M Aura 1863	MR Conditional	Y	Y	Safe for staff use. (Large artefacts and potential heating if worn by patients)	Quest et al, Cavin et al, Davies et al
	3M 9332+	MR Conditional	Y	Y	Safe for staff use. (Large artefacts and potential heating if worn by patients)	Cavin et al
	Alpha Solway 3030V / 3030V+	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Cavin et al
	Alpha Solway S / S-3V	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Cavin et al
	Alpha Solway AMF-3V	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Manufacturer's website states metal-free
	Alpha Solway C-3V	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Manufacturer's website states metal-free
	BetaFit 3030V	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Cavin et al
	Cardinal Health RFVP 3FV	MR Unsafe	Y	Y	Ferromagnetic nose strip. Do not use in MRI.	Cavin et al, Quest et al
	Easimask FSM18	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Davies et al
	Easimask FSM16	MR Conditional	Y	Y	Considered safe for staff use (weak pull on nose bridge) - not fit-tested	Bacon et al
	Honeywell 5311	MR Unsafe	Y	Y	Ferromagnetic nose strip. Do not use in MRI.	Quest et al
	Kolmi	MR Unsafe	Y	Y	Strong ferromagnetic attraction, torque on mask close to magnet, potential for local heating and considerable local artefact.	Murray et al
	Medline (coned) BWM167/ NON24510V	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Quest et al
	Medline (duckbill) BWM165/NONE24510VF	MR Unsafe	Y	Y	Ferromagnetic nose strip - pulls from face at bore entrance.	Quest et al
	Uvex Silv-Air2312 FFP3 NR D	MR Conditional	Y	N	Safe for staff use (1.5T). Artefacts and potential heating if worn by patients (non-ferrous nose strip).	Summersgill et al
FFP3 Respirators (Re-usable)	3M 7500 Series Half-mask (with 6035 P3R filters)	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Quest et al
	CORPO HF1400 Half-mask (with P3R filters)	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Davies et al
	Gentex PureFlo PF1000 Half-mask (with filter)	MR Safe	N	N	Safe for staff use and for patient use during MRI scans	Quest et al
Powered Air-Purifying Respirators	Gentex PureFlo 3000	MR Conditional	Y	Y	Safe for staff use if always more than 50 cm from bore entrance (1.5T)	Davies et al
	Scott Tornado	MR Conditional	Y	Y	Safe for staff use if always more than 1 m from bore entrance (1.5T)	Davies et al

Acknowledgement and many thanks to the following reviewers: Dr Ian Cavin Regional MRSE (MRSC™) NHS Lothian, Rebecca Quest MRSE (MRSC™) Head of MR Physics Imperial College London, Dr Nigel Davies MRSE Lead MRI Physicist University Hospitals Birmingham

This table along with the latest proposed measures can be seen in September's issue of Imaging and Therapy in Practice www.sor.org/system/files/article/202008/itp_september_2020_lr.pdf

Acknowledgements

Many thanks to the following people for their contribution to this resource: Karen Smith DCR(R) PgC MRSO (MRSC™), MRI Section Head, North West Anglia NHS Foundation Trust; Dr Christina Malamateniou SFHEA PhD MA DIC MAcadMEd BSc (Hons), Director of Postgraduate and Doctorate programme in Radiography, City, University of London; Claire Currie MSc, PgC LTHE, BSc (Hons), MRSO (MRSC™), Lecturer, Glasgow Caledonian University; Rhys Slough MSc BSc MRI Manager, Cambridge University Hospitals NHS Foundation Trust; Liz Ashburner BSc (Hons) Lead MRI Radiographer, Fairfield General Hospital; Wendy Milne DCR(R) MRI Lead Radiographer, Ninewells Hospital, Dundee; Rachel Watt MSc BSc Imaging Modality Services Manager, InHealth; Andrea Michielotto BSc (Hons) MRSO (MRSC™) MRI/CT Specialist Radiographer; Elizabeth Squire HDCR MRSO (MRSC™) Clinical Lead MRI Radiographer, Aston Brain Centre, Aston University ; Marie Glyn-Jones MSc BSc MRI Superintendent, Cardiff and Vale University Health Board; Sally Sandall BSc (Hons) PgC MRSO (MRSC™) MRI/CT Specialist Radiographer, James Paget University Hospital NHS Foundation Trust; Susan Murch DCR(R) MRSO (MRSC™) MRI Superintendent, Golden Jubilee National Hospital; Sohail Bhana MSc MRSO (MRSC™) MRI Superintendent, The Princess Grace Hospital, London; Rebecca Magrath BSc (Hons) MRSO (MRSC™), MRI Specialist Radiographer, George Eliot Hospital NHS Trust; Emily Witten BSc (Hons) MRSO (MRSC™) MRI Lead Radiographer, Spire Parkway Hospital; Pam Mitchell DCR(R) MRSO (MRSC™), MRI/CT Superintendent, University Hospital, Ayr; Professor Paul Bowie Programme Director (Safety & Improvement) NHS Education for Scotland; Dr Avinash Kanodia MBBS, MD, DM, FRCR, MRMD (MRSC™) Consultant Neuroradiologist and Clinical Lead MRI, NHS Tayside.

Making HASTE

***Matthew Benbow**, Superintendent Radiographer, Royal Bournemouth Hospital*

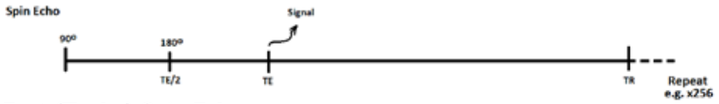
Fast imaging techniques can be useful in situations where the subject is more likely to move. This might include the scanning of restless or confused patients, for cardiac studies, children, or a wide range of abdominal studies. Various sequences have been developed to counter these problems by using ultra short scan times and this includes a method known as 'Single Shot'. Here, enough data is obtained to fill sufficient k-space in one go (in one TR) to create a complete image. In some respects it is a CT-style of MRI, i.e. each slice is acquired in its entirety before moving on to the next position. So how is this done? Let's go back a bit first...

Spin Echo

With standard Spin Echo imaging, one echo is sampled during each TR and one line of k space filled. So for every line of image resolution in the phase direction, one TR is required. The scan time is consequently dependent on image resolution; the higher the resolution, the longer the scan time.

Scan Time = TR x Phase Encodings x Signal Averages

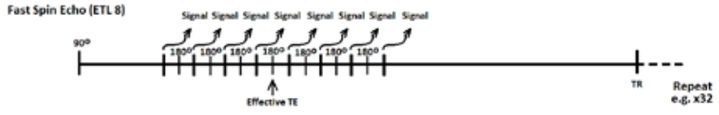
So, if the TR was for example 3000 and the resolution was 320, with one signal average the scan time would be 3000 x 320 x 1 = 960000 milliseconds, or 16 minutes.



Fast (Turbo) Spin Echo

Standard Spin Echo is therefore quite slow, and so Fast (or Turbo) Spin Echo was developed to shorten the acquisition. Here, the first echo is sampled, then the spins are repeatedly refocused with a 180o pulse such that multiple echos are sampled during each TR. Scan times are greatly reduced as each of these refocused measurements fills a line of k-space, i.e. the scan time is divided by the number of refocused measurements in each TR, known as the Echo Train or Turbo Factor.

So with our previous example, if the echo train length was, say 8, the scan time would be reduced to 2 minutes as only 40 TRs would be required to gather all the data and fill k space.



So why is this not used all the time? Well, it is! Especially for sequences where the TR is long (T2, PD) and the scan times would otherwise be unacceptable.

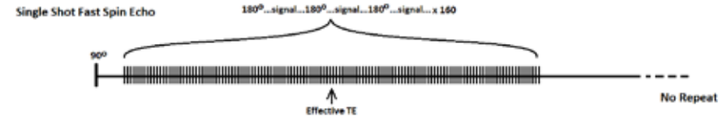
There are a few downsides, but they are minor. The first is that the refocused FID fades somewhat each time it is refocused and so SNR will be reduced slightly with longer echo trains, though rarely noticeably. The second is that whilst it is possible to precisely acquire a desired TE with a single echo (Spin Echo), this is not possible with fast spin echo as each measurement will be sampled at a slightly different time. The echo train is therefore centred about the desired TE and it is accepted that the starting echos will be somewhat earlier than this, and the end echos will be later. This affects the weighting of the acquisition such that the early echos might be a little PD weighted, whereas the later echos will be more T2 weighted but at least you don't have to put a morning aside to scan each patient!

So, what if we take this to the extreme? Instead of filling several lines of k-space in one TR, could we not fill lots? In fact, could we not fill them all?

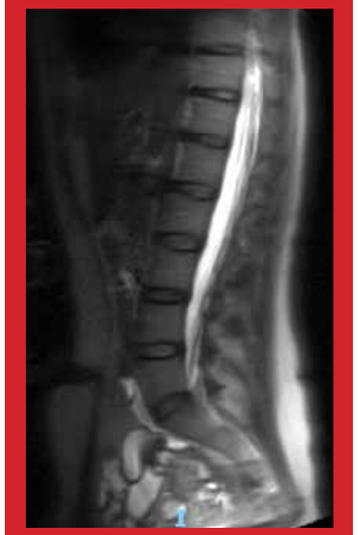
Single Shot

Filling all of k-space in one go seems quite a challenge, so what could help us? Well firstly we could be sensible about the image resolution in the phase direction, being that each line of k space takes time to fill. So instead of 320 in our previous example, let's go for say 256.

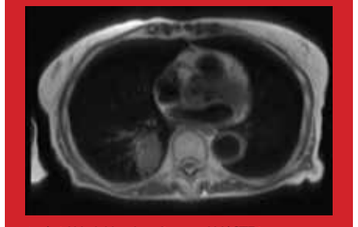
Secondly, we know k-space is largely symmetrical, so instead of acquiring all of it, why not just acquire the top half, and then effectively copy and paste it to the bottom half!? This could half the number of measurements we need to acquire, in this case down to 128. In fact, in reality usually a little over half (5/8) of k space is filled to ensure the important centre portion is well covered, so in the example would actually cover 160 lines. This also has the benefit of preserving some of the SNR loss that will unavoidably occur as a result of scanning a reduced number of phase encodings.



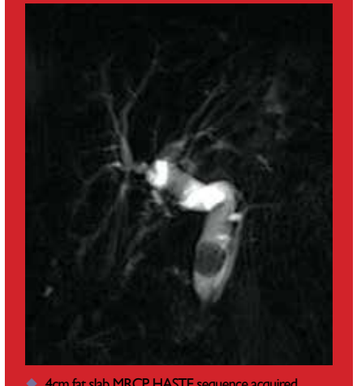
Example Images



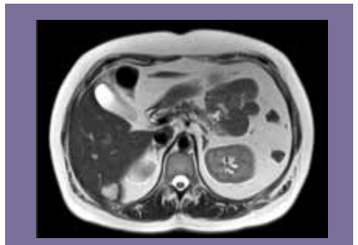
HASTE Localiser – at under a second per image, several slice positions in all three planes can be achieved in around 10 - 15 seconds.



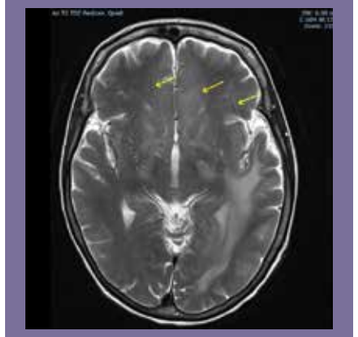
Axial black blood cardiac gated HASTE image showing an incidental lung cancer. 14 images were achievable in a breath-hold.

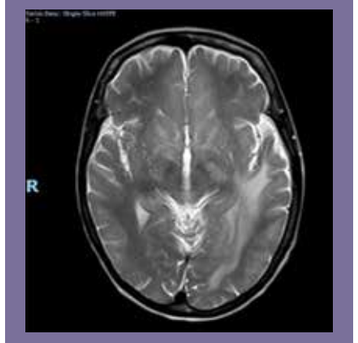


4cm fat slab MRCP HASTE sequence acquired in 2 seconds showing a large calculus in the lower common bile duct.



HASTE sequence with effective TE 80 showing a 23mm haemangioma in segment VI of the liver. 30 slices acquired as 2 breath-held batches of 15, each being 25 seconds long.





Axial T2 Fast Spin Echo (left) and matching Axial HASTE (right) of a patient with central nervous system lymphoma. The patient was confused and restless, resulting in some movement artefact seen on the fast spin echo (yellow arrows). The HASTE allowed scans to be acquired quickly and without moment issues, however is inherently less sharp. Part of a fast, restless brain protocol – 'CT style' slice by slice HASTE images can either be scanned in one acquisition (in this case 25 x 6mm slices of 256 resolution in 45 seconds) or initiated slice by slice at around 1.8 seconds each.

Helpful Reading

http://mriquestions.com/hastess-fse.html

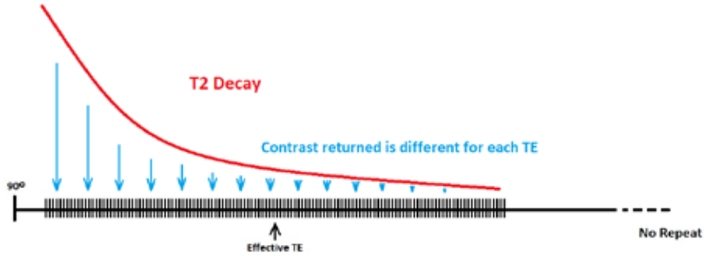
https://www.imaios.com/en/e-Courses/e-MRI/MRI-Sequences/Ultrafast-spin-echo

http://xrayphysics.com/cv_mri.html

https://mrimaster.com/characterise%20image%20%20single%20shot%20tse%20%20.html

Single Shot Image Weighting

As with fast spin echo, but to an even greater extent, the image weighting of each echo across the train will vary - known as k-space filtering. Each point along the T2 curve will have decayed a little more compared to the previous, and so the image contrast returned is slightly different throughout the acquisition. As a result, each image will always contain some degree of PD weighting, with gradually increasing T2. Overall though, image contrast is governed by the middle TE (known as the effective TE) which will always be 'long' and so the result is a T2 weighted scan (though to some degree preparation pulses can be employed to add in a degree of PD and T1 weighting).



Another effect comes from that fact that the differing echos produce signals of intensity that drop with time, i.e. the early echos are strong compared with the later echos which will have decayed. Many of the lines of k-space corresponding to high spatial frequencies are filled with late echoes (weaker intensity due to T2 relaxation) the result of which is image blurring in the phase encoding direction. The longer the echo train, the larger the signal variation, the more blurring will be seen. Parallel imaging in combination with HASTE (e.g. pHASTE, SMASH) has been used to reduce this blurring by reducing the echo train length and hence number of phase encodings required, though the usual associated SNR loss with this technique must of course be accepted.

Sequence Names

Half-Fourier Single-shot Turbo Spin Echo, or HASTE (Siemens)

FASE - Fast Advanced Spin Echo (Canon)

SSFSE (GE)

Single Shot TSE (Philips)

Appearance

Water

HASTE is always T2 weighted due to the long echo train and therefore fluid will return high signal. In fact, the longer the echo train, the more heavily T2 weighted will be the images. The downside with longer echo trains is that SNR is reduced due to the later echos being weaker. For this reason, HASTE is generally only used for anatomy that will offer good inherent SNR, such as body imaging.

Fat

Fat protons interact with neighbouring spins, known as j-coupling. These interactions shorten T2 relaxation, meaning that for standard spin echo, fat actually (and maybe surprisingly) will produce a dark signal. With fast spin echo and HASTE, the repeated rapid 180o pulses disrupt j-coupling, thereby lengthening T2 time and as a result, fat signal returned as bright. The DIET (Delayed Interval Echo Train) sequence has been used to combat this, which utilises careful positioning of the 180o pulse sequences allow j-coupling to occur. Standard fat saturation techniques can also be used.

Flow

For HASTE, the long TE times mean that for most of the echo train, unexcited blood (flow) will have had time to move into the imaged slices and return no signal. So for this reason, HASTE is generally a black blood sequence. On occasions however blood will return higher signal, for example in vessels where flow is very slow, or when the slice acquired coincides with cardiac diastole, i.e. at the point where flow momentarily ceases. For this latter reason, in non-gated HASTE imaging it is not uncommon to observe a variation in the nullification of vessels between neighbouring slices, i.e. some slices may happen to be acquired in diastole (white blood), yet others in systole where flow is higher (black blood).

Uses

HASTE is a T2 weighted sequence.

The unavoidable degree of image blurring means that fine detail structures will not be well demonstrated, so small field of view neurological or orthopaedic applications will not be particularly successful. Similarly, for body applications where higher resolution is needed, e.g. prostate or rectum, standard T2 FSE will always be preferable, though these sequences are of course much longer, and so motion needs to be managed either with antispasmodic drugs and/or good coaching.

Where HASTE comes into its own is when you need to image quickly, yet a compromise in resolution or the use of wider slice widths is acceptable. Liver, pancreas, spleen, MRCP and small bowel imaging all require patient breath-holding and so are examples of where the speed of HASTE is very effective. Then there are scenarios where unavoidable movement needs to be overcome. This includes paediatric studies, confused patients and claustrophobic patients where quick HASTE acquisitions can be 'grabbed' between movements. Also, cardiac examinations have to allow for a beating heart, and so gated, triggered HASTE can be very successfully used to achieve black-blood anatomical images of the mediastinal structures. Finally, it is also a great option when speed is the priority and neither image quality or weighting are important, i.e. localisation (planning) images.

Therapeutic and Diagnostic radiographers working together: The MR-linac experience

Rosie Hales, MR Linac Superintendent Radiotherapy Radiographer,
Christie Hospital and Lee Whiteside, Research Radiographer, Christie Hospital

The Christie NHS Foundation Trust in Manchester began delivering cutting-edge Magnetic Resonance-guided radiotherapy (MRgRT) in May 2019. Radiotherapy delivery on a conventional linear accelerator (linac) is typically image-guided using cone-beam CT (CBCT) imaging. This provides 3D volumetric information sufficient for most treatment scenarios; however, the improved soft tissue visualisation of MR offers huge potential for personalisation of radiotherapy from day to day. This is especially true for treatment sites with multiple sensitive organs ('Organs at Risk', or OARs) in close proximity, such as within the neck, abdomen and pelvis, and those that experience more motion during and between treatments.

MRgRT delivery systems combine an MR scanner and a linear accelerator into a single unified treatment solution (1). The model installed at our institution, the Elekta Unity® MR-linac, incorporates a 1.5T Philips MR scanner around a 7MV Elekta AB linac (2). The treatment delivery process enables MR imaging at multiple time points during the workflow, including during the treatment delivery itself. Furthermore, whilst standard image-guided radiotherapy (IGRT) using CBCT utilises ionising radiation to produce an image, MR-linac imaging adds no additional radiation dose. Due to the field strength there is also the potential for functional MRI, such as diffusion-weighted imaging (DWI) and dynamic contrast-enhanced imaging (DCE-MRI), to incorporate into future image-guided treatments (3).

◆ **Figure 1**: Rosie Hales and Lee Whiteside - photo taken by Christie Communications

The MR-linac workflow enables radiographers to make online decisions and adapt treatment plans. On a standard linac, a team of two therapeutic radiographers set up the patient, image to verify accurate positioning and subsequently deliver pre-planned radiation beams. The introduction of CBCT-guided radiotherapy has increased confidence in tumour localisation; however, delivery is generally planned using a single CT scan taken some weeks prior to the start of a treatment regime. This represents a static snapshot which fails to take into account morphologic changes in patient and tumour anatomy during a course of radiotherapy, for example weight loss, disease progression or regression, and many other unanticipated variations. Conventional IGRT can only correct for positional displacements and delivers the same plan, based on the anatomy as seen on the original CT scan, throughout the course of treatment. MR-linac offers daily online adaptation, presenting an opportunity to truly individualise treatment to daily anatomy, thereby mitigating effects of organ, target and patient motion. This adaptive component represents a change in the complexity of the daily treatment workflow for therapeutic radiographers, as illustrated in Figure 1.

Implementation of the MR-linac service has been a substantial amount of work for the small team of radiographers, physicists and clinicians dedicated to the project. Aside from the changes in day to day workflow, MR physics and safety principles were completely new to most of the team; therefore, therapeutic radiographers on the project were joined by colleagues trained in diagnostic radiography. Multiple MR tutorials and safety screening scenarios were complimented by time spent working in a diagnostic MR department in order to consolidate knowledge before any patients were treated on the MR-linac. Likewise, as a synergistic learning

experience, diagnostic radiographers researching and optimising sequences for use in the treatment workflow have in turn gained knowledge specific to MR in radiotherapy imaging and patient setup. For instance, radiotherapy MR images must be acquired in the treatment position and on a flat-top couch. 3D sequences are preferred due to improved geometric fidelity, and thinner slices with no slice gaps are essential for accurate visualisation of planning target volumes (4). Furthermore, the traditional multichannel body arrays are replaced with a 4-channel array fixed onto a coil bridge suspended above the body to prevent deformation of patient anatomy. There is an additional 4-channel posterior coil located in the treatment table to permit parallel imaging and so keep acquisition times to a minimum.

This merging of professional duties is not simply limited to radiographers. Working on the MR-linac is an interdisciplinary process; for a typical treatment, a mix of clinician, radiographer and physicist/dosimetrist input is required due to the complexity of the adaptive nature and real-time decision-making necessary (5). To reflect the change in staffing mandated by this new technology and the mix of skills and knowledge required, MR-linac therapeutic radiographer-specific competencies have been developed at our institution. Specific guidance on this radiographer profile nationally from the Society and College of Radiographers has been recently published and is helping to validate our work (6). Interdisciplinary learning has been invaluable during the implementation period, and we have no doubt that this pattern will continue as we expand the service in the coming months and years.

1. Liney GP, Whelan B, Oborn B, Barton M, Keall P. MRI-Linear Accelerator Radiotherapy Systems. Clin Oncol [Internet]. 2018;30(11):686–91. Available from: https://doi.org/10.1016/j.clon.2018.08.003
2. Winkel D, Bol GH, Kroon PS, van Asselen B, Hackett SS, Werensteijn-Honingh AM, et al. Adaptive radiotherapy: The Elekta Unity MR-linac concept. Clin Transl Radiat Oncol [Internet]. 2019;(xxxx):1–6. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2405630819300631
3. Datta A, Aznar MC, Dubec M, Parker GJM, O'Connor JPB. Delivering Functional Imaging on the MRI-Linac: Current Challenges and Potential Solutions. Clin Oncol [Internet]. 2018;30(11):702-710. Available from: https://doi.org/10.1016/j.clon.2018.08.005
4. van der Heide UA, Frantzen-Steneker M, Astreinidou E, Nowee ME, van Houdt PJ. MRI basics for radiation oncologists. Clin Transl Radiat Oncol [Internet]. 2019;(18):74-79. Available from: https://doi.org/10.1016/j.ctro.2019.04.008
5. Chin S, Eccles CL, McWilliam A, Chuter R, Walker E, Whitehurst P, Berresford J, Van Herk M, Hoskin PJ, Choudhury A. Magnetic resonance-guided radiation therapy: A review. J Med Imag Radiat Oncol. 2019 pp1-15. doi:10.1111/1754-9485.12968
6. MRI Guided Radiotherapy (2020). The Society and College of Radiographers. London, UK.

4 CPD Points

Virtual Conference October 2020

Saturday 3rd October 1pm-5pm

Free for Members; £25 for non-members

Registration will open soon: Bamrr.org

13:00	Log in Available
13:05	Welcome
13:15	Dr. Sachin Mathur – 'Advanced Neuro-Imaging : Techniques and Clinical Applications' Consultant Neuro Radiologist, Lancashire Teaching Hospital NHS Trust
14:00	Mr. Michael Dubec – 'MR for Radiotherapy' Principle Clinical Scientist (MRI), The Christie NHS Foundation Trust
14:30	Dr. Dhiren Shah and Dr Elise Chua – 'It's not all about bones.... MSK MRI whistle-stop tour' Consultant MSK Radiologist and Radiology Registrar, London North West University Healthcare NHS Trust
15:00	Break with Vendors Interaction
15:20	BAMRR AGM – Members only
15:30	Mr. Cormac McGrath – 'Virtual Reality MRI – The Belfast Children's Hospital Experience' Principle Clinical Scientist (MRI), Belfast Health & Social Care Trust
16:00	Mr. Martin Graves – 'The MR Artefact Gameshow' Consultant Clinical Scientist (MRI), Cambridge University Hospitals
16:30	Mr. Tobias Gilks – 'Safety in MRI' MRSO (MRSE) Founding Principal, Gilk Radiology Consultants, Consultant to Metrasens
17:00	Close & Thanks

MRI Reporting Radiographer Survey Preview

A UK wide survey was recently carried out to try and determine the number of radiographers within the UK that have been trained to report MRI examinations and to also determine the number that are currently in practice. The results of the survey are hopefully to be published later this year but below is a very brief preview of the results.

The first documented course for radiographers to train to report MRI scans was in 2003 and since then it is estimated that approximately 160 radiographers have been trained. This is only a very rough approximation as unfortunately there is no central register of those trained to report. Responses were received from 46 different trusts with 80 radiographers that had been trained or have started their training. 31 of these are in training currently, some of these are already qualified in a different anatomical area and 57 are in practice. The most common areas of reporting are T/L spine and knee, then brain and IAMs, but there are also individual practices out there where radiographers are reporting breast, foot, ankle, orbits, pelvis, wrist and shoulder joints. Further details will hopefully be available soon.

Implant Focus:
The Hydrocephalus Shunt

Cath Mills, BAMRR Safety Co-ordinator

Hydrocephalus is a build-up of fluid in the brain, which can lead to an increase in intracranial pressure in the brain, and if left untreated can lead to permanent damage to the brain tissue. A shunt is a type of implant that provides an alternative fluid pathway for cerebrospinal fluid (CSF) to bypass an obstruction in the fluid compartments of the brain, and acts when CSF absorption is otherwise impaired(1) . Reasons for a shunt to be implanted include malformations, cysts, tumours, trauma, infection, intracranial haemorrhage and idiopathic intracranial hypertension in children, and normal pressure hydrocephalus in adults (9). Each year in the UK approximately 3000 shunt operations are carried out(1), 1660 of these are paediatric (33.5% primary operations and 66.5% are revision surgeries) and 1400 are adult (53% primary and 47% revisions)(2).

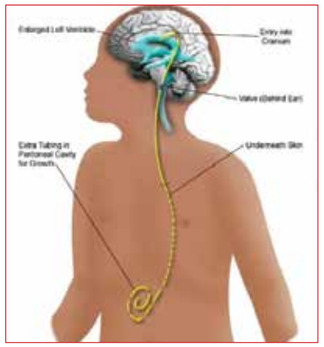
A shunt is basically a tube that redirects CSF from the ventricles within the brain or the subarachnoid spaces around the brain and spinal cord to another body region where it will be absorbed. CSF is constantly made in the brain, so it is important when functions such as CSF production, flow and absorption are affected that a shunt is implanted to restore balance between these physiological functions (3).There are four possible shunt pathways (see table 1.0).

All shunts consist of three components. Firstly an inflow (proximal) catheter which drains CSF from the ventricles or subarachnoid space, the second part is a valve mechanism that controls flow or regulates pressure, and third is an outflow (distal) catheter that runs under the skin and directs CSF to the peritoneal cavity or other suitable drainage site.

Table 1 Common shunt names and pathways

Shunt name	Shunt pathway
*Ventriculo-peritoneal (VP)	Ventricle to Peritoneal cavity
Ventriculo-atrial VA	Ventricle to Right atrium of the heart
Ventriculo-pleural VPL	Ventricle to Pleural cavity
Lumbo-peritoneal LP	Lumbar spine to Peritoneal cavity

*The most common type of shunt is called a ventriculo-peritoneal (VP) shunt(4) (See diagram 1)



There are two types of shunt valve: the difference between the two is that the valve component is either set at a fixed pressure or requires adjustment from an external source outside the body.The shunt systems where the valve requires adjustment from an external source are referred to as a PROGRAMMABLE. Programmable shunts are types of shunts that have a metallic valve that is set in a fixed position by the neurosurgeon using an external device(diagram 2) By setting the valve position it ensures the rate of flow through the shunt is controlled.

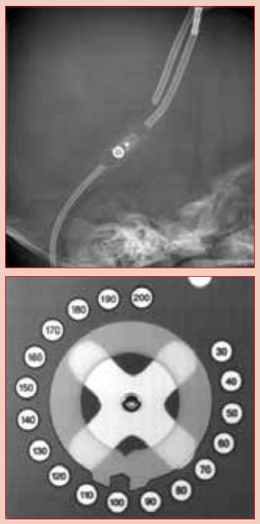


Diagram 2: Radiological identification of valve position and diagram of a Codman Hakim pressure selector.A lateral skull x-ray is required for some models of shunt so that the neurosurgeon can compare the position of the notch against a chart after the valve has been set, enabling the pressure setting to be read and recorded in the patient notes.

Programmable Shunts and MR safety

Programmable shunts are MR Conditional because they contain a magnetic component in the valve that may be affected by external magnetic sources. MR Conditional information given by the manufacturer will provide details of pre and post scan checks that need to be carried out.

Prior to MRI scan the latest manufacturer guidance should be checked to ensure that the correct checking procedure for the shunt is adhered to.The type of guidance differs between manufacturers so it is important to check for the latest information and ensure that local policies and procedures exist to support the safe scanning of patients with these devices.

Advice from the MHRA(2015) about Programmable hydrocephalus shunts:

'The pressure setting of programmable hydrocephalus shunts may be unintentionally changed by the magnetic field associated with MR procedures.This could lead to over- or under-drainage of cerebrospinal fluid and result in deterioration of patient health.

If these patients are to undergo an MR examination then a programmer and a trained clinician should be available to verify the correct setting and to reprogram the device (if required), immediately following the MR procedure.The MHRA recommends that in order to reduce the risk of over- or under-drainage associated with an incorrect pressure setting in programmable hydrocephalus shunts, hydrocephalus shunt implant centres and all MRI departments should develop a policy for identifying, documenting and imaging programmable hydrocephalus shunts.'

Amongst items for inclusion in departmental policies the MHRA recommends 'ensuring that the pre-MRI screening questionnaire specifically asks 'Do you have a hydrocephalus shunt?' and if affirmative, 'Is it a programmable shunt?''.

For the full list of inclusion items see section 4.11.1.4 of The Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use (6).

Advances in technology

Due to advances in technology there are now some programmable shunt models where the valve setting are resistant to being changed by exposure to a magnetic field and manufacturers stipulate that it is not necessary to check shunt setting before or after MRI scan. Examples of this type of shunt are Miethke ProGav, Miethke ProGav 2.0, Miethke ProSa and Sophysa Polaris models.These programmable shunts were not available when the MHRA guidance was issued in 2015 and therefore local policies and procedures should be developed based on manufacturer guidance with the involvement of the MR Safety Expert and MRI manager.

Learning point: it is important to acknowledge that manufacturers may update/change technology in their implants and for that reason it is important to always carry out thorough safety checks via the manufacturer website.

News on shunt related clinical trial

A team at Northwestern University, USA, have conducted a clinical study to test a wireless device known as a 'wearable shunt monitor' on five adult patients who have hydrocephalus.The device is worn like a band aid and uses measurements of temperature and heat transfer to non-invasively detect how much fluid is going through the shunt. Detection of no flow through the shunt would indicate shunt failure meaning this device would potentially reduce time spent by the patient in hospital having diagnostic investigations such as CT or MRI when shunt failure is suspected.The findings of the study will be published later this year (7)

Other resources

Check out up to date shunt safety article and information by Frank Shellock at mrisafety.com(8
Link: http://www.mrisafety.com/SafetyInformation_view.php?editid1=248

Dad gets tattoo of brain shunt after daughter's surgery….Watch this BBC clip to hear why this dad got a tattoo of a shunt on his head (9)
Link to BBC video article
https://www.bbc.co.uk/news/uk-england-birmingham-40962356/embed

UK Shunt Charity

Shine is a registered charity who have been helping families and individuals affected by spina bifida and hydrocephalus since 1966 (10).

Link https://www.shinecharity.org.uk/about-us/about-us

UK Shunt Registry

The shunt registry was created in the early 1990's driven by concerns over unexpected deaths, particularly in teenagers and high rates in infection and shunt revision surgeries. It allowed information sharing between neurosurgery units in the UK with the aim of defining practices, providing accurate pictures of types of shunt used, providing anonymised audit between centres. Read more in their draft report published on the website (2).

Link https://www.sbns.org.uk/index.php/audit/shunt-registry/

References

1. https://radiopaedia.org/articles/programmable-cerebrospinal-fluid-shunt
2. https://www.sbns.org.uk/index.php/audit/shunt-registry/
3. Life with a cerebrospinal fluid (CSF) shunt BMJ 2016;355: https://www.bmj.com/content/355/bmj.i520
4. https://www.hydroassoc.org/docs/FactSheets/FactsheetShuntSystems.pdf
5. Shunt Systems for the Management of Hydrocephalus fact sheet, Hydrocephalus Association https://www.hydroassoc.org/factsheets/
6. MHRA Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use (2015)
7. https://medicalxpress.com/news/2018-10-game-changing-skin-sensor-life-million.html/
8. mrisafety.com shunt article: http://www.mrisafety.com/SafetyInformation_view.php?editid1=248
9. BBC video article https://www.bbc.co.uk/news/uk-england-birmingham-40962356/embed
10. SHINE charity https://www.shinecharity.org.uk/about-us/about-us
11. https://www.sciencedirect.com/topics/medicine-and-dentistry/shunt-failure
12. Shunt Placement and Management, in Neurocritical Care Management of the Neurosurgical Patient, Jason J. Chang, Anthony M. Avellino (2018)
13. https://www.medtronic.com/uk-en/patients/treatments-therapies/hydrocephalus-shunt/strata-valves.html
14. https://www.brainandspine.org.uk/our-publications/our-fact-sheets/hydrocephalus-and-shunt

Collaborative Working to Deliver the £200m Replacement Fund

Neil Emery, NHS Supply Chain

Like a number of equipment areas Magnetic Resonance (MR), Computed Tomography (CT) and Mammography have all seen the pressure of restricted funding, which has resulted in an aged install base. Over the last few years there have been a number of reports, articles and publications highlighting this: reports from the Clinical Imaging Board who represent The Royal College of Radiologists, The Society and College of Radiographers and the Institute of Physics and Engineering Medicine; press releases from AXREM; and more recently information from NHS England and NHS Improvement's data collection exercises and Professor Sir Mike Richard's The Independent Review of Adult Screening Programmes in England. This pressure is amplified when put in the context that the UK are low in the OECD rankings of numbers of CT and MRI scanner per head of population, and that the demands placed on MRI, CT and Mammography services have all increased year on year.

NHS England and NHS Improvement's 2016/17 data collection of NHS Imaging Services in England uncovered a wide variation in the age and specification CT and MR equipment, many of which were over 10 years old. The National Imaging Optimisation Delivery Board (NIODB) noted potential risks to patients, services users, imaging networks and commissioners using a provider service where the majority of CTs or MRs were 10 years or older. In particular:

- Older equipment may require a radiation dose 20-50% higher to deliver the same image quality compared to a scanner less than 5 years old.
- Software upgrades may not be possible which could potentially lead to restricted range of image acquisition, decreased operational productivity or limit patient access.
- Hardware upgrades, for example the table, may not be possible which could lead to a restricted weight limit.

To mitigate these risks the NIODB advised that a CT Clinical Advisory Group (CTCAG) and MR Clinical Advisory Group (MRCAG) should be set up in collaboration with NHS Supply Chain: Large Diagnostic Capital Equipment including Mobile and Services, to produce core specifications for CT and MR equipment which would allow Trusts, Foundation Trusts (FTs) and imaging networks to access value for money, fit for purpose CT and MR equipment and other associated services. Comprised of experts within their field, the Clinical Advisory Groups were tasked with creating a CT scanner able to meet the needs of 80% of a typical caseload and an MRI scanner able to meet the needs of a typical DGH. Once created the specifications will be reviewed periodically to ensure that they address any changes to service need and keep pace with technical innovation.

On 27 September 2019 a major investment in diagnostic equipment for CT and MRI scanners, as well as mammography equipment (imaging and trailers) was announced to the sum of £200m over the next two years. This new funding is part of the government's commitment to ensure 55,000 more people survive cancer each year. It is also part of their commitment through the NHS Long Term Plan to diagnose three-quarters of cancers at an early stage by 2028, through improved screening processes and access to new technology. The specifications created through the Clinical Advisory Groups are now serving as the vehicle for eligible trusts to secure replacement funding.

If you would like to discuss further please contact:

Neil Emery – Senior Buyer, Imaging –
NHS Supply Chain: Large Diagnostic Capital Equipment including Mobile and Services
Neil.Emery@supplychain.nhs.uk

Safety Week Summary

MR Safety week was a great success this year, with many organisations in the international MR community promoting best practice and excellence in MRI safety throughout the week. It took place on 27th July 2020, on the anniversary of the tragic accident where 6-year-old Michael Columbini was killed when a magnetic oxygen cylinder was taken into the MRI scan room by accident.

Here at BAMRR we published daily releases on our website, giving our members up to date information about Covid in MRI, links to the latest safety resources, podcasts and webinars, and there was also a safety quiz and wordsearch to test our member's safety knowledge! If you missed out you can download all of the information we published via the Safety page of the website.

MR Safety Week
Day 1
MRI Safety & COVID-19 resources

MR Safety Week
Day 2
MRI Safety resources

Check out these websites for more information and resources on MRI Safety...

The British Institute of Radiology focused on raising MR safety awareness by publishing four case studies about real life incidents, where they went wrong and how processes were improved because of lessons learnt. You can download the case studies via the BIR website.

MRI safety information for ward staff

Magnetic Resonance Imaging (MRI) is a reliable and relatively safe diagnostic imaging procedure.

However, the use of strong magnetic fields means there is information that the MRI department needs to know and preparation of the patient is required prior to their arrival to ensure their safety.

Information the MRI department needs to know about the patient

- Details of previous operations and dates of any recent operations
- Details of any implants such as a cardiac pacemaker; a joint replacement such as a hip or a knee; metal screws, clips, rods or pins; shunts; vascular stents; or a cochlear (ear) implant
- Any incidents where metal has gone into the patient's eyes
- Any other known metal in the body such as shrapnel
- Pregnancy status
- Is the patient receiving oxygen therapy
- Any known allergies
- Method of transport
- Any current infection risk
- Do they have hearing aids?

More overleaf…

SCoR THE SOCIETY & COLLEGE OF RADIOGRAPHERS

www.sor.org

The Society of Radiographers focused on raising awareness in non-radiology hospital staff by publishing an information leaflet 'MR Safety information for ward staff'.

Link to poster: https://www.sor.org/news/mri-safety-information-ward-staff

BAMRR NEWSLETTER

Liver MRI

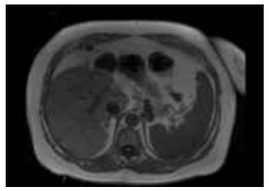
Helen Estall

Consultant Radiographer, University Hospitals Leicester

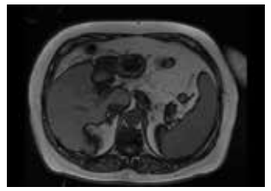
Liver MRI is one of the most common examinations carried out and there are lots of different sequences available. A very brief description of the most commonly used ones are below, with some of the more common pathologies that you may come across.

Sequences

T1 in phase (IP)

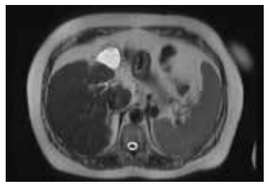


T1 opposed phase (OP)



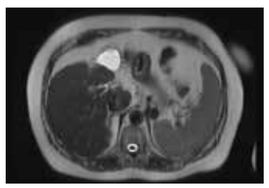
Uses two echoes per excitation pulse simultaneously. It is used to demonstrate intravoxel lipid and is useful for the diagnosis of focal or diffuse fatty infiltration of the liver (steatosis). Chemical shift is useful for lesion characterisation by demonstrating fat within tumours and it can be incidentally useful in characterising adrenal masses as adenomas

T2 tse.



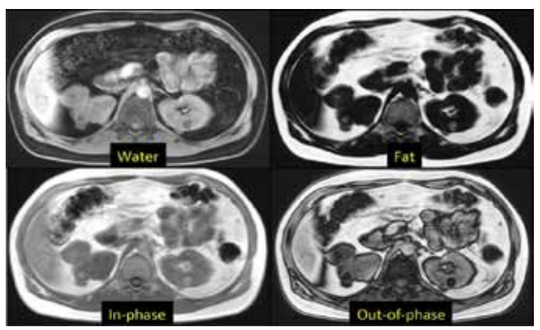
Helpful to differentiate lesions with long T2 relaxation, such as cysts and haemangiomata which show increased signal with increased T2 weighting (longer TE). T2* can be used for parenchymal assessment, eg Iron deposition. A dual TE can differentiate between lesions, for example, Haemangioma, HCC and cysts can be hyperintense on TE 90 images, on the TE180 images, cysts and haemangiomas can remain the same whilst HCC can be hypointense

VIBE/LAVA/fast SPGR



This is an ultra-fast gradient echo RF spoiled 3D T1, useful for the evaluation of soft tissue and vasculature. You will usually have multiple scans at different phases post contrast. Benefits are speed and effective spatial resolution, with T1 sensitivity, making it excellent for dynamic contrast assessment.

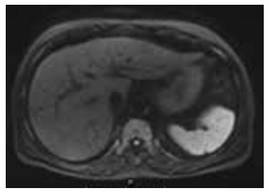
Dixon



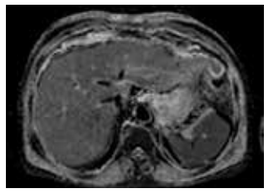
Dixon is based on chemical shift and is designed to achieve uniform fat suppression. The sequence combines three echoes acquired at different TEs to create water only and fat only images, resulting in four separate images as above.

DWI

B1000

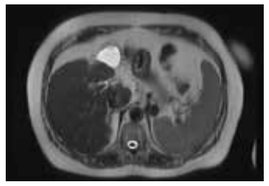


ADC



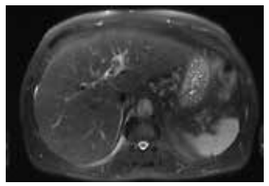
This sequence measures the freedom of water molecules to wander within the tissue, the strength of the diffusion weighting is defined by the b value. DWI is useful for focal liver lesion characterisation and treatment response. As with all DWI sequences, the ADC map is required to confirm that a lesion is due to true restricted diffusion.

True FISP/FIESTA/Balanced FFE/True SSFP



This is a balanced gradient echo sequence, true fast imaging with steady state precession. It is very sensitive to magnetic field inhomogeneities but has low motion sensitivity so is ideal for breath hold images.

HASTE/Single shot FSE/FASE/EXPRESS



A half fourier acquired single shot tse, which is extremely useful in liver imaging as it gives an overview of the liver and differentiates solid from cystic lesions. Fast imaging performed to assess static fluid such as bile. This is an integral sequence when undertaking imaging of the biliary tree as in MRCP.

Contrast

There are 3 types of hepatobiliary contrast, gadolinium or manganese based solutions and superparamagnetic iron oxide.

The gadolinium based agents are taken up by the hepatocytes in the liver and are eliminated through the biliary system. They are designed to distinguish between benign and malignant hepatocellular lesions based on the uptake by functioning hepatocytes, therefore, non-hepatocytic tumours such as hypovascular metastases do not enhance.

MultiHance and Primovist are gadolinium based contrast agents that are only licensed for delayed liver imaging in Europe.

MultiHance is extracellular, the best liver-to-lesion contrast is in the first 90 seconds, approximately 5% is taken up by the liver.

Primovist has maximum liver to lesion contrast at 10-40 minutes, approximately 50% is taken up by the liver.

Superparamagnetic iron oxide particles (Ferumoxide/Ferucarbotran) act as intravascular contrast or blood pooling agents as they do not leak into the interstitium and are taken up by the Kupffer cells. They reduce the T2 relaxation so that the liver appears dark on T2, most liver tumours are usually deficient of Kupffer cells so appear relatively hyperintense.

The Manganese based agent is specifically taken up by hepatocytes as the gadolinium agents, but unlike the gadolinium based agents, the manganese can readily dissociate, leading to increased neurological risks caused by manganese intoxication.

Pathology

It is important to be able to differentiate between liver lesions as some are best left alone and others need surgical resection, for example FNH or hepatoma versus HCC, all of which show arterial enhancement but treatments are very different.

Benign lesions can be split into 3:

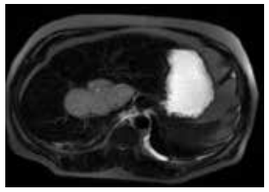
Hepatocelluar – Adenoma and Focal Nodular Hyperplasia (FNH)

Cholangiocellular – Hepatic cysts and Biliary Cystadenoma

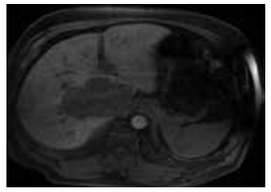
Mesenchymal – Haemangioma, Mesenchymal Hamartoma, Infantile Haemangio-Endothelioma and Lymphangioma, Lipoma, Fibroma, Angiomyolipoma, Leiomyoma

Haemangiomata are the most common solid lesions and usually an incidental finding. They are hypervascular, usually peripheral in location, T1 hypo and T2 hyperintense with peripheral nodular discontinuous enhancement and no mass effect. The enhancement progresses centrally on delayed imaging. If they grow to over 5cm with progressive pain then resection may be considered, otherwise they are left alone.

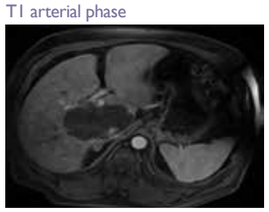
T2



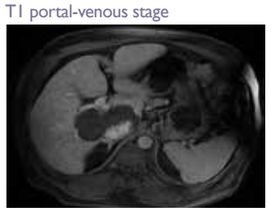
T1 in phase



T1 arterial phase

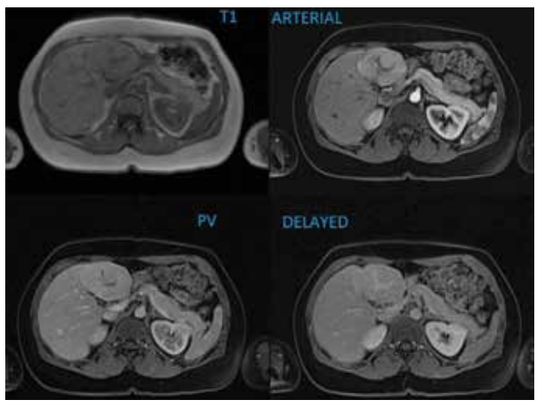


T1 portal-venous stage



FNH are the second most common benign lesion and are usually asymptomatic requiring no treatment. They are usually solitary lesions, but 20% of patients may have multiple. If they are symptomatic then this is usually due to mass effect. They are usually T1 hypo and T2 hyperintense with a central scar. Post contrast with MultiHance they have intense arterial enhancement, isointense on portal-venous and the scar retains contrast on the delayed images. With Primovist, they show arterial enhancement which persists into the portal-venous stage with a small amount persisting into the delayed period.

FNH



◆ Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 50662

Malignant lesions can also be split into 3 types:

Hepatocellular – Hepatocelluar cancer (HCC), Fibrolamellar cancer and Hepatoblastoma.

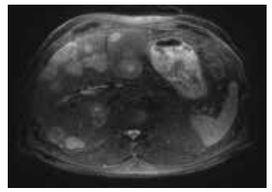
Cholangiocellular – Cholangiocarcinoma and Cystadenocarcinoma.

Mesenchymal – Angiosarcoma, Epitheloid Haemangio-Endothelioma, Leiomyosarcoma and Lymphoma.

Metastases

Metastases are 18-40 times more common than primary liver tumours, multiple primary lesions metastasise to the liver and many benign lesions can be misinterpreted as metastases. MRI is more sensitive then CT and there is variable enhancement depending on size, the primary and which contrast is used. Treatment can be resection, chemotherapy and/or radio-embolisation.

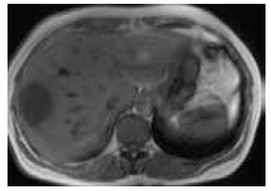
T2 fat sat showing multiple metastases with central necrosis from a prostate primary:



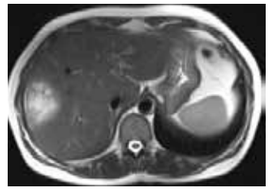
◆ Case courtesy of Dr Roberto Schubert, Radiopaedia.org, rID: 17769

Metastases using hepatocyte-specific contrast:

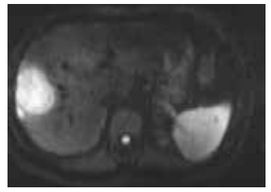
T1



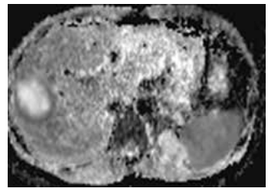
T2



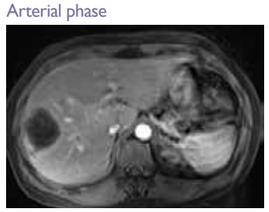
DWI



ADC

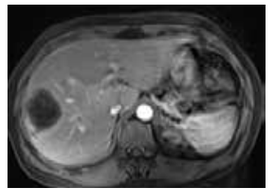


Arterial phase



5 minute delayed

20 minute delayed



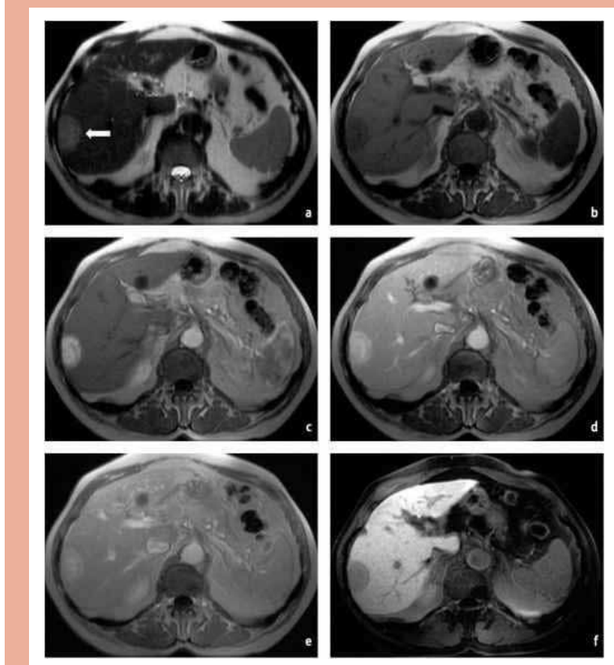
◆ Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 53536

continued on page 18

continued from page 17

HCC is the most common primary malignant liver tumour and has a strong association with cirrhosis. It accounts for 5% of all cancers with a rising incidence due to the increase in patients with hepatitis B and C. The lesion has variable T1 and T2 signal with arterial enhancement and rapid rim wash out, rim enhancement may persist. Treatment can be by resection for small lesions or a liver transplant. Chemotherapy or ablation is considered if surgery is not possible.

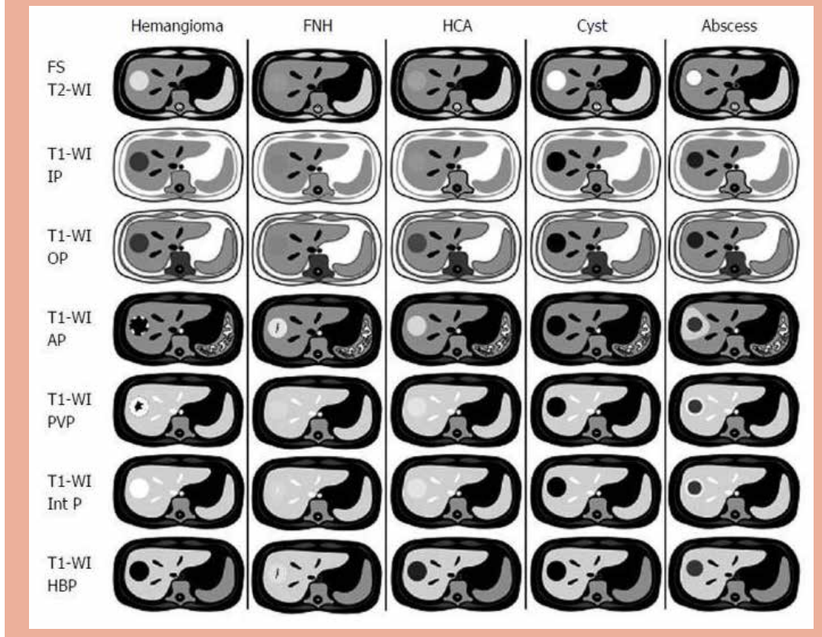
HCC



◆ a – T2, b – T1, c – arterial phase with hypointense rim, d – portal-venous phase with persisting enhancement and rim enhancement, e – equilibrium phase, f – delayed hepatobiliary phase.

https://www.doctorabel.us/mri-of-liver/images/1902_30_251-hepatocellular-carcinoma-and-mri.jpg

There are multiple aids on line which can help differentiate some lesions as per the below:



www.wjgnet.com

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