Received:
04 February 2018

Revised:
12 June 2018

Accepted:
18 June 2018

<https://doi.org/10.1259/bjr.20180142>

Cite this article as:

Ivan CV, Mullineux JH, Shah V, Verma R, Rajesh A, Stephenson JA. Peripheral vision: abdominal pathology missed outside the centre of gaze. *Br J Radiol* 2018; **91**: 20180142.

PICTORIAL REVIEW

Peripheral vision: abdominal pathology missed outside the centre of gaze

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ABSTRACT

Radiology misses have been the subject of much debate on both sides of the Atlantic in recent years. There is now greater focus in trying to reduce radiology errors by continuous education and changing the working environment to try and protect the radiologist, and ultimately the patient from potential harm. Duty of candour is a relevant and sensitive area. Developing robust validated reporting pathways within the healthcare structure is very important so as to encourage a “learning from discrepancies” culture and to put the patient and their families at the center of reporting and acknowledging errors in radiology. Having reflected in our daily practice and while writing this pictorial review, we have concluded that during reporting MRI scans, routine assessment of the localizer images, focusing outside the area of interest and having a more structured approach to image interrogation are key actions which may help reduce the number of omissions. We present a myriad of cases where pathology was “missed” outside the center of gaze in relation to the abdomen or outside the abdomen on abdominal MRI, and suggest key high yield sequence related review areas to minimize the chance of missing potentially significant pathology.

INTRODUCTION

MRI is a powerful diagnostic tool. The reporting radiologist uses an arsenal of various sequences to answer a specific clinical question. Reporting MRI requires understanding of each of the sequences employed and should be a systematic process considering the large number of images attached to each study. Review of each MRI sequence could be considered a study in its own right.

MRI images are generally organ or region of interest (ROI) focussed with a wider field of view (FOV) localizer image also acquired. As demonstrated in CT, focussing on individual organ systems related to the clinical history whilst reporting, can lead to visual perception errors.¹ Previous authors have stressed the importance of reviewing the scout image on CT especially as, medicolegally, all images available on Picture Archive and Communication System (PACS) are considered part of the study.² Daffner in 2015 suggested “The CT scout image is the modern equivalent of the edge of the film”,³ providing the advantage of a larger FOV than the dedicated sequences, the MRI localiser is comparable to the CT scout image. In addition to this, MRI,

due to its multiple sequences and potential technical limitations poses additional challenges for radiologists.

METHODS AND MATERIALS

This pictorial review demonstrates a range of abdominal and extra abdominal pathology away from the ROI and often present on only a single MR sequence or single localiser image.

All of the presented cases were identified by the authors, during a 5-year period from a large university teaching hospital (University Hospitals Leicester) which has 60 radiologists and performs >50,000 MRI scans per year. These are a mix of cases reported from within our institution or cases referred for tertiary multidisciplinary team assessment. The findings in all the presented cases were missed on the initial interpretation and, all of the cases were discussed in the gastrointestinal “learning from discrepancy meetings” (LDM). Learning points from each miss were fed back to the radiologist who reported the scan for ongoing education and reflective practice.

Imaging findings

The following “missed” lesions can be divided into three different categories:

- (1) Abdominal pathology “missed” on abdominal MRI investigations.
- (2) Abdominal pathology “missed” on non-abdominal MRI investigations.
- (3) Non-abdominal findings “missed” on abdominal MRI investigations.

Abdominal pathology “missed” on abdominal MRI investigations

Colorectal tumours

Colorectal tumours in our experience are the most common “missed” pathology within the abdomen, this being likely due to the prevalence of colon cancer and radiologists not “running” the colon as they would when reporting CT.

Of note, the vast majority of these scans were reported by subspecialist gastrointestinal and abdominal radiologists, who in the authors’ opinion would invariably not miss a similar lesion on CT. This could be an opportunity for reflection on how we can miss findings on MRI, even when these are within our area of interest and expertise. Close inspection of localizer images on rectal cancer staging MRI is advised to pick-up synchronous primary colonic tumours, particularly in the caecum and sigmoid colon. In addition to the pelvic sequences of a rectal MRI protocol, we routinely perform T_2 weighted imaging (T_2 WI) and diffusion-weighted imaging (DWI) sequences of the liver for further characterisation of low attenuation liver lesions seen at contrast-enhanced CT; the DWI images commonly, radiantly reveal the synchronous non-rectal colonic carcinoma. Lesions in the caecum are often best seen on the coronal localiser images performed prior to the formal liver sequences. We also note post-contrast sequences on multi-phase contrast-enhanced MRI of liver frequently identify a colonic cancer or polyp. As a learning point, the post-contrast and DWI MR liver sequences are especially good at picking up colon cancers due to the avid enhancement and diffusion restriction (Figure 1).

According to Cunliffe et al, synchronous carcinomas can be two or more in number, detected pre-, intra- or postoperatively within 6 months. The tumours should be distinctly separate by at least 4 cm in distance.⁴ A review of the literature by Lam et al has shown that synchronous colorectal carcinoma accounts for approximately 3.6% of colorectal carcinomas, and has a slightly higher male to female predominance (2:1). Patients with hereditary non-polyposis colorectal cancer, familial adenomatous polyposis or patients with inflammatory bowel diseases (especially ulcerative colitis) are known to have a higher risk.⁵ When reporting a MRI rectum or liver for colorectal cancer staging particular attention should be paid to the colon, with the aim to identify synchronous colonic lesion (Figure 2).

We have also encountered a number of rectal tumours and polyps overlooked on prostate MRI scans and conversely prostate cancers on rectal MRI. The development cycle of rectal polyps

Figure 1. Ascending colon cancer with spinal metastases on MRI liver. Large ascending colon tumour and left pedicle metastatic lesion with a soft tissue component narrowing the spinal canal. Both the primary and metastatic lesions demonstrate restricted diffusion and enhance on the Fat Sat T1 C + sequence.

may mean that missing a rectal polyp could miss the opportunity for curative resection.

Gastric pathology

The stomach is a notorious area of concern for misses on cross-sectional imaging, with many studies in the literature demonstrating the poor sensitivity of cross-sectional imaging to detect gastric neoplasms.⁶ We found a range of gastric abnormalities from benign polyps to malignant tumours on various abdominal MR investigations (Figure 3). Of note, it has been shown in the medical literature that smooth thickening of the gastric antrum in relation to the proximal stomach of approximately 5 mm on CT is a normal finding. However, the antral thickness should not exceed 12 mm in thickness.⁷

Renal lesions

Renal lesions can be easily missed on non-renal targeted MRI, especially if the coronal localizers are not carefully assessed. Some renal lesions can only be identified on the “bottom slice”, hence can be undoubtedly be missed on the axial sequences. As with colonic malignancies, when available the post contrast enhanced and DWI sequences can be particularly helpful in identifying and assessing renal lesions (Figure 4).

Gynaecological pathology

Ovarian cancers are often known to present at an advanced stage, and in the early stages of development generally have few symptoms. When included in the FOV, an MRI study can represent an additional screening tool of the female pelvis. Symptoms such as bloating and microcytic anaemia can be non-specific and gynaecological pathology may not always be considered during the

Figure 2. Large synchronous primary bowel cancer within the caecum on localiser for staging MR rectum. Large shouldered caecal tumour within the caecum on T_2 weighted coronal localiser. This was subsequently identified on the subsequent staging CT scan. Sagittal T_2 weighted image of a large rectal tumour (right).

clinical assessment (Figure 5). On an informal review of an MRI scan of the liver performed in our institution in female patients, we could see the adnexa on the coronal localiser on more than 25% of studies.

Abdominal pathology “missed” on non-abdominal MRI investigations

Liver and splenic lesions on MR spine

In our practice, we noted that both liver and splenic lesions can often be seen on localisers for spinal imaging. The majority will be benign but further sequences or imaging to differentiate between benign and malignant lesions may be required (Figures 6 and 7).

Primary lesions in retroperitoneal organs on MR spine

The retroperitoneum is often imaged when imaging the spine with MRI, and we suggest close review of the retroperitoneum even when partially obscured with saturation bands (Figures 8 and 9), particular attention should be made to the kidneys and adrenal glands, and for lymphadenopathy.

Figure 3. Lesion within gastric antrum on MRCP. Coronal heavily weighted T_2 imaging shows high T_2 signal thickening of the gastric antrum (yellow arrows). Axial T_2 weighted image showing the circumferential antral thickening (yellow circle). Histology confirmed adenocarcinoma. Note the distended gallbladder and gallstone. MRCP, magnetic resonance cholangiopancreatography.

Figure 4. Renal lesion on MRI liver. Axial T_1 C+ (GD) and following portal venous phase CT reveal a left anterior cortical renal lesion with thick, nodular septal enhancement.

Rectosigmoid lesions on MR pelvis and hips

Pelvic MRI is often reported by a wide range of subspecialist radiologists. In the case of scans performed for musculoskeletal (MSK) indications, we would suggest that MSK radiologist's formally review the rectum and sigmoid due to the prevalence of rectosigmoid cancers (Figure 10).

Other non-target organ findings “missed” on abdominal MRI investigations

Musculoskeletal pathology

MSK pathology can be easily overlooked on non-MSK studies. The localizers provide a larger FOV and usually include multiple vertebral levels. In patients with no known malignancy, bone metastases can significantly change the course of action in cancer treatment. Patients with chronic inflammatory bowel disease historically may have been on long courses of steroid treatment and therefore, prone to avascular necrosis of the femoral head and this is an important review area on MRI of the small bowel. This is less relevant today with the increased use of immunomodulators, but is still often missed (Figures 11 and 12).

Thoracic and vascular pathology

Retrospectively, we have identified pathology such as aneurysms, venous thrombosis, pleural/pericardial effusions and lung nodules. Nodules and masses can stand out if the lungs

Figure 5. Right ovarian mature (cystic) teratoma. Large, fat containing right ovarian mass seen on the coronal T_2 weighted localizer of an MRCP study also subsequently demonstrated on a CT scan. MRCP, magnetic resonance cholangiopancreatography.

Figure 6. Haemangioma on coronal localiser for MR spine. Single image T_2 weighted localiser of MR spine shows a focal high T_2 lesion in Segment 7 of the liver (yellow arrow). Subsequent CT showed peripheral nodular early arterial enhancement in keeping with haemangioma (arrows).

are routinely part of one's review areas during MRI reporting (Figures 13–15).

DISCUSSION

The ethical and medicolegal implications of the subsequent discovery of these “misses” has been discussed extensively in the United States literature largely due to the more litigious healthcare culture.⁸ Until recently, this was a “grey-area” in the NHS but with recent publication of General Medical Council and Royal College of Radiologists guidance on the “professional duty of candour” it is becoming a little clearer.^{9,10} The RCR position statement released soon after the GMC's guidance, forms the basis of our current practice. There is an expectation to document the presence of the “miss” in the radiology report, inform the named consultant responsible for the patient's clinical care and then discuss the cases at our local LDM.¹⁰ It is essential that errors should be discussed in LDMs in a view of quality improvement and continuous learning. These meetings can help decide which of the misses represent “impossible errors”, which are only visible in retrospect or avoidable ones

Figure 7. Splenic lesion on MR lumbar spine. Coronal localiser image showing focal lesion at the splenic hilum (arrow). Subsequent ultrasound shows a poorly echogenic lobulated lesion which was proven to be a metastatic deposit.

Figure 8. Right renal mass on MR spine. (A) Axial and coronal localisers showing a heterogeneous mass in the interpolar region of the right kidney. (B) Coronal portal venous phase CT confirming the heterogeneous mass. (C) Renal mass on coronal contrast enhanced CT images. (D) Renal mass on ultrasound.

where practice can be improved.¹¹ What remains difficult is identifying within the LDM forum, whether the “miss” may have resulted in harm to the patient and if a “candour conversation” should be instigated as discrepancies are often reviewed in isolation without the full clinical picture. An additional complex is that interpretation of a radiologic study is rarely “black and white” and the conclusions are often opinions, therefore, not always binary^{12 13}. There is also an incorrect

Figure 9. Large retroperitoneal mass on MR spine showing multiple spinal metastases. (A) Sagittal T_2 weighted localiser showing lobulated large retroperitoneal mass and focal high T_2 spinal lesions. (B, C) T_1 and T_2 weighted axial images showing spinal metastasis and retroperitoneal mass (star). Note the mass is partially obscured by saturation bands but still visible (arrow).

Figure 10. Sigmoid tumour on MR hip. (A, B) Sagittal and coronal localisers showing abnormal sigmoid colon. (C) Coronal fat saturated planning scan shows high signal tumour in the sigmoid. (D) T_1 weighted axial image showing circumferential thickening with local fat stranding.

assumption that perfection is achievable, and that any error or discrepancy represents a “wrong that must be punished”.^{14,15} In our opinion, the LDM process should focus on an ethos of collective learning along with individual and system improvement, which will ultimately benefit the patient.^{12,16} Radiology departments and hospital trusts should then have separate formal pathways in place for assessing the gravity of a “miss” under their obligations of Statutory Duty of Candour over and above the LDMs. These pathways should include blinded image evaluation, if/when required serious untoward incident review and when required open candour conversations.

However, there are still a number of elephants in the room in relation to discrepancies which radiologists need to bring to the fore; one is the wide gap between what we as radiologists know to be our discrepancy rate and what both our clinical colleagues and patients believe it to be.¹¹ The second being hindsight bias, which is a very powerful phenomenon in that, once the outcome of an event is known it becomes very difficult to imagine an alternative¹¹ which can cloud judgement in discrepancy review; then, ultimately how can we reduce our error rate?

Perhaps in the future, artificial intelligence and machine learning will help improve the rate of errors we make by providing us with computer assisted interpretation of images. But for the present, there are steps we could take to improve the reporting environment, such as: being provided and obtaining accurate clinical history for a precise report, double reporting high-risk scans

Figure 11. Focal spinal lesion on MRCP. (A) Axial T_2 weighted sequence showing multiple liver metastases and a focal lesion in the superior endplate of a lower thoracic vertebral body. (B) Sagittal localiser from the same study confirmed the lesion is in the superior endplate of T12 (arrow). (C) Subsequent T_1 weighted sagittal image from a dedicated MR showing metastatic lesions at T12 and T1 (arrows). MRCP, magnetic resonance cholangiopancreatography.

Figure 12. AVN in the right femoral head on MR small bowel. (A) T_2 weighted coronal image from MR small bowel showing the classic “Double-line” sign of AVN on the right femoral head. (B) Axial CT shows sclerosis of the right femoral head. AVN, avascular necrosis.

Figure 13. External iliac artery aneurysm on MR prostate. (A) Coronal localiser showing large rounded lesion in the right pelvis. (B) On axial T_1 weighted images, the lesion was continuous with the external iliac artery and later confirmed as an aneurysm (arrows).

where there is high clinical suspicion of malignancy, reducing reporter fatigue or using structured reports in some cases.^{12,17,18}

CONCLUSION

We propose that the MR localiser is the equivalent of the CT scanogram. It is important that all the images sent to PACS are reviewed and suggest that radiologists reporting MRI scans build review areas of the localiser sequences and other non-ROI organs into routine practice, so each organ is individually interrogated as they would when reporting a CT. Some institutions do not routinely send MRI localiser images or CT scout images to PACS. This practice varies between subspecialties within the same institution. Institutions should have an agreed uniform policy. Increasing workload has also reduced the radiologist/radiographer interactions. This has led to radiographers practicing as scanning technicians paying little attention to the scan

Figure 14. Malignant lung nodule on MRCP. Sagittal T_2 W localizer showing a posterior basal left lung nodule. CT scan after 1 year, demonstrates a necrotic lung mass invading through the diaphragm, into the spleen.

Figure 15. Pleural effusion and pericardiophrenic angle lung nodule on MRCP. Sagittal and axial T_2 W localizers and the accompanying CT scan demonstrating a nodule at the posterior cardiophrenic angle (arrows). MRCP, magnetic resonance cholangiopancreatography.

due to time pressures. It is extremely important to address this in institutions and engage with the radiographic staff and involve them in the peer-learning process to improve quality of radiologic practice, thereby improving quality of care delivered to patients.

Our aim has been to increase awareness of potential important omissive errors when interpreting MRI. Interpretative errors in radiology are a complex process depending on many factors, some of which being reader dependent.^{12,19} Reflection on one's practice, feedback from colleagues and LDMs are essential to improve reporting accuracy. This is especially important in our current work environment in which the workload is increasing and MRI investigations are more and more complex. With increasing numbers of sequences available, each MRI sequence could be considered an investigation in its own right. McDonald *et al* have shown that the average number of images requiring interpretation per minute per radiologist has increased to 7-fold from 1999 to 2010.²⁰

Particular attention should be paid to the colon and kidneys. This is especially important when little clinical history is provided. A number of these "misses" were subsequently found to have signs/symptoms related to "missed" pathology at the time of the MRI, which was not included in the clinical history provided with the request.

The time interval between the "miss" and subsequent diagnosis varied between the presented cases, as did the clinical outcome/consequence. In some of these cases, the initial omission did not have important consequences on the patient, whereas in others the initial miss had a significant negative impact on the patient.

The management and reporting of these "misses" continues to be an area of debate in diagnostic radiology due to the inherent risk of error.¹² The 2015 publication of GMC guidance on professional duty of candour has raised many questions about how these "misses" should be managed and reported⁹ and many trusts are still developing robust pathways on how to deal with this sensitive but important area.

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