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Title

Radiographer reporting of neurological magnetic resonance imaging examinations of the head and cervical spine: findings of an accredited postgraduate programme

Abstract

Aim: To analyse the objective structured examination (OSE) results of the first cohorts of radiographers (n = 13) who successfully completed an accredited postgraduate programme in clinical reporting of neurological magnetic resonance imaging (MRI) examinations of the head and cervical spine.

Methods: Forty MRI examinations were used in the OSE which included a range of abnormal cases (prevalence of abnormal examinations approximated 50%) and included: haemorrhage, infarction, demyelination disease, abscess, mass lesions (metastatic deposits, meningioma, glioma, astrocytoma); and disc disease, cord compression, stenosis, ligament rupture, syringomyelia appearances on patients referred from a range of referral sources. Normal variants and incidental findings were also included. True/false positive and negative fractions were used to mark the responses which were also scored for agreement with the previously agreed expected answers based on agreement between three consultant radiologists' reports.

Results: The mean sensitivity, specificity and agreement rates for all head and cervical spine investigations (n=520) combined were 98.86%, 98.08% and 88.37%, respectively.

The highest scoring cases were cases which included astrocytoma, disc protrusion with cord compression and glioma. The most common errors were related to syringomyelia, ligament rupture and vertebral fracture.

Conclusions: These OSE results suggest that in an academic setting, and following an accredited postgraduate education programme, this group of radiographers has the ability to

correctly identify normal MRI examinations of the head/cervical spine and are able to provide a report on the abnormal appearances to a high standard. Further work is required to confirm the clinical application of these findings.

Key words

Radiographer reporting, advanced practice, magnetic resonance imaging, neurological imaging, observer performance

Introduction

Workload continues to rise in diagnostic imaging departments in the United Kingdom (UK), and in England the total number of plain imaging (X-ray), computed tomography (CT) and magnetic resonance imaging (MRI) investigations increased by 12% between 2012-13 and 2015-16, to over 30 million¹. In the same period the number of MRI scans increased by 31%¹, and as a result many departments face significant challenges to meet the escalating demands associated with the timely reporting of these examinations. Sustained increase in MRI examinations means additional reporting capacity is required and new models of care are required to meet the growing diagnostic capacity gap.

Radiographers, appropriately educated and trained, have been providing definitive clinical reports on a variety of imaging examinations since the 1990s; and the role of radiographer reporting, which is now well established within the UK², continues to have an increasing impact on service and cost-effectiveness for imaging services in the UK.^{3,4}

Studies which have investigated the interpretation of plain skeletal examinations by radiographers have demonstrated encouraging findings.⁵ More recent research, related to radiographers' diagnostic performance in the reporting of other more complex investigations, is

also emerging. In particular, this includes research related to the reporting of chest examinations,^{6,7,8} and cross-sectional imaging studies; MRI examinations of the lumbar/thoracic spine and knee^{9,10} and computed tomography (CT) examinations of the head.^{11,12}

Over 120 radiographers have completed the postgraduate certificate (PgC) Clinical Reporting (MRI- General Investigations) programme which aims to prepare radiographers to provide definitive clinical reports on lumbar/thoracic spine and knee investigations, and a growing number (> 10%) of diagnostic imaging departments have confirmed that radiographers contribute to the delivery of MRI reporting services in this way. ^{9,13}

As radiographers can report different MRI body areas and given the significant challenges in meeting the growing diagnostic imaging reporting demands, the progression to prepare radiographers to report other neurological examinations (cervical spine and head) seems a logical extension.

A small number of radiographers (n=13) have also completed a separate PgC programme (accredited by the College of Radiographers) which prepares radiographers to report magnetic resonance imaging (MRI) neurological investigations of the head and cervical spine.¹⁴ The 12-month workplace based programme consists of short, two day, briefing blocks held at the university approximately every two months. Experienced MRI consultant radiologists are involved in the design, management, teaching and assessment aspects of the programme. The assessment schedule includes a case-study, an assignment which requires students to critically reflect on their developing competence in MRI reporting and 500 practice reports, 125 of which must be checked by a consultant radiologist mentor in the students' workplace.

Consistent with other postgraduate programmes in clinical reporting at this university, one of

the final summative assessments for the PgC is an Objective Structured Examination (OSE) which, for this pathway, consists of 40 MRI investigations.

Aim

To analyse the OSE results of the first cohorts of radiographers (n=13) who successfully completed the PgC programme; and to determine radiographers competence to report magnetic resonance imaging (MRI) neurological investigations of the head and cervical spine.

Method

Compliance with the University's Research Ethics and Governance procedures was confirmed and all other relevant guidance followed.¹⁵

Obuchowski¹⁶ acknowledged the importance of the diversity of observers' interpretations and in particular recognised the need to consider the performance of an 'average reader' when measuring observer performance. Accordingly the OSE was constructed using cases (n=40) where there was good agreement between 3 experienced consultant radiologists.

To ensure that an adequate number of cases were available to be selected for the OSE and aware of the variation that exists, even between experienced observers,^{16,17} approximately 100 MRI examinations of the head and cervical spine were randomly selected from archives at two diagnostic imaging departments in Southern England. To ensure compliance with the relevant data protection legislation all identifying information was removed from the images, request details and the initial radiological reports, which were then coded anonymously. Subsequent reports were provided independently by two consultants radiologists blinded to the original report. All the reports were provided by non-specialist consultant radiologists.

Although the specific agreement rates between the consultant radiologists was not calculated, the method adopted had been used previously¹⁷ and the cases in good agreement were selected for inclusion in the OSE.

Based on the file report, and the two subsequent reports, the expected answer (including diagnosis), was then agreed by consensus by the programme team (KP and LP) and one of the consultant radiologist external examiners experienced in MRI reporting, for every examination (n=40) selected for the OSE. The external examiner also confirmed that an appropriate selection of discriminatory cases were included¹⁷. A range of cases were included to adequately test the candidates' knowledge and to demonstrate competence at postgraduate level. The final prevalence of abnormal (Figure 1) to normal (including normal variants) cases approximated 1:1. Mean age of the patients was 46.2 years, and the male to female ratio was 1:1 (20 males, 20 females).

All examinations were viewed on 42 cm monitors with native screen resolution of 1280 x1084, ~1.3 megapixels, consistent with relevant guidance^{18,19} in Digital Imaging and Communications in Medicine (DICOM) format using KPACS software²⁰ to enable manipulation.

Candidates were provided with the patient's details (age, gender, referral source and clinical history) and were asked to make a decision whether the appearances were normal (including normal variants) or abnormal, recording the decision on the pro forma. For the abnormal cases the student was expected to provide key details on the abnormal radiographic appearances and include suggested pathology/ies where applicable, in the form of a free text hand-written report. Credit was also given where candidates made appropriate recommendations related to further imaging.

The responses were compared to the expected answer by one of the programme team and second marked as required by university procedures (KP/LP). If the examination was correctly identified as normal or abnormal, a true negative/positive (TN/TP) fraction was allocated accordingly. If the case was marked as incorrectly normal or abnormal, a false negative/positive (FN/FP) was recorded. Overall sensitivity and specificity rates, and 95% confidence intervals (CI) were calculated, using the Wilson procedure.^{21,22}

In terms of agreement, and as used previously to mark OSE answers, one mark for each normal and a maximum of five marks for each abnormal case was allocated and fractionated⁹ where necessary to reflect the different key aspects that were required in each report. Students were not penalised providing any agreed expected pathology was diagnosed.

All scores were summed and the overall agreement percentage calculated. All sensitivity, specificity and agreement rates were verified by the radiologist external examiner. Consistent with other OSE assessments in this academic programme the pass mark for sensitivity and specificity have been set at 90%.^{6,9,11} Due to the known high variability between expert observers^{23,24}, the pass mark for agreement in this OSE had previously be set at 85%.

A total of 13 radiographers sat, and successfully completed the OSE between 2008 and 2012. All the radiographers had a minimum of two years MRI experience and no previous reporting experience on other modalities. Twelve of the radiographers had previously completed the PgC Clinical Reporting (MRI – General Investigations) programme.

Results

The mean performance rates (and 95% CIs) for all students (n=13) and for each anatomical area (head and cervical spine), are shown in Table 1. The mean % sensitivity, specificity and

agreement rates for all head and cervical spine investigations (n=520) combined were 98.86%, 98.08% and 88.37%, respectively.

The mean scores for each anatomical area (head: 4.49/5; cervical spine: 4.07/5) are shown in Table 2.

The highest and lowest mean scores for all cases are listed in Table 3 indicating the key abnormal appearances outlined in the expected answer.

Discussion

The unique nature of the work presented in this study is perhaps limited in that it was conducted in the OSE setting and the relatively small number of cases relates to a small, specialised cohort of radiographers. The mean sensitivity and specificity rates for the radiographers were all high (99.0% and 98%, respectively). The majority of radiographers (9/13) achieved sensitivity and specificity rates of 100% demonstrating they could correctly identify all the abnormal investigations included in the OSE. The remaining four radiographers achieved rates of 95% and successfully passed that element of the assessment for which the pass mark had been agreed at 90%.

This is an encouraging finding as it is important for any practitioner interpreting clinical images as part of their role, to be able to differentiate between normal and abnormal examinations to a high standard and to a comparable level to a consultant radiologist. All the radiographers (13/13) met the 85% pass for agreement, and the mean scores for the head/cervical spine cases were 4.49/5 and 4.07/5 respectively. The mean % agreement rates (88.37%; 86.7%-90.0%) achieved by the radiographers, for the neurological investigations included in this study compares favourably with the rates found in an earlier study, which

reported on the radiographer reporting of MRI examinations of the knee (73.9% - 97.6%) and lumbar spine (77.1% - 96.9%), in an OSE setting⁹.

No studies to date have compared radiographer and radiologist reporting of MRI head or cervical spine investigations although a previous study which included lumbar spine reporting produced encouraging findings. Brealey et al confirmed that 'carefully selected MR radiographers with postgraduate education and training reported in clinical practice conditions on specific MRI examinations of the knee and lumbar spine to a level of agreement comparable with non-musculoskeletal consultant radiologists' (p. 597)¹⁰. In particular, the level of discordance between the lumbar spine reports provided by an index radiologist, and the radiographers (14.6%) or radiologists (19.2%) reports in Brealey's study, was found to be statistically similar ($p=0.279$).

Research related to observer variation or agreement among radiologists in this area of reporting is also limited.

McCarron et al investigated the level of disagreement between general radiologists and neuroradiologists and found that neuroimaging (CT and/or MRI) reports of some patients differed substantially between the general and specialist radiologists²⁴. Primary findings differed in 15.9% of reports and a change in management occurred in 13.4% of cases following the neuroradiologist report. The disagreement for the MRI cases specifically was recorded as 14.4%²⁴. Comparable results were reported by Briggs and colleagues²⁵ who assessed the impact on patient management of formal neuroradiology "second reading" of CT and MRI images initially interpreted by general radiologists and found a major discrepancy rate of 13%. Expert radiologist – general radiologist agreement is similar to that demonstrated by the radiographers in this study (88%).

As previously stated the majority (12/13) of the radiographers had completed a reporting programme which included lumbar / thoracic spine. It is interesting therefore that the lowest scoring cases in this study (Table 3) related to the cervical spine. This however may be expected as a number of authors have reported significant variation between observers when reporting MRI examinations of the cervical spine. Braga-Baiak et al,²⁵ for example, found Kappa (K) values ranging from -0.02 to 1.00 in a study which investigated the inter-observer variation between seven radiologists when reporting intervertebral disc abnormalities of the cervical spine. In a study which investigated the classification of structural changes in whiplash injuries²⁶, the pair-wise interobserver agreement (weighted kappa) was found to be fair to moderate (0.31–0.54) and Cook et al found only poor agreement (K = -0.12 – 0.51) when measuring the interobserver variability in cervical stenosis.²⁷ Kuijper et al found Kappa scores, for evaluation of herniated discs, spondylotic foramen stenosis and the presence of root compression, was 0.59, 0.63 and 0.67, respectively, in MRI evaluation of patients with cervical radiculopathy²⁸.

Agreement between experienced observers in MRI examinations of the brain has been found to be similar. In a study which compared experienced neurologists and neuroradiologists, the interobserver overall concordance was good (K >0.6) for classification of postthrombolysis brain haemorrhage using MRI.²⁹ Likeman et al³⁰ investigated the diagnostic accuracy of MRI in a range of pathologically confirmed diseases which cause young-onset dementia and found moderate agreement (K =0.5) between three neuroradiologists. In a study which examined the agreement between sub speciality-trained university-based neuroradiologists, 87.6% (876/1000) neurological examinations were found to be in agreement with the original report.³¹

Conclusion

The aim of this study was to determine radiographers' competence in the reporting of neurological MRI examinations of the head and cervical spine, and overall, the results presented suggest that this small group of radiographers, at the end of an accredited postgraduate programme, can report on the broad range of, with satisfactory accuracy under examination conditions. Although lessons are to be learned from these initial experiences, generally the types of errors made appear to be similar to those made in the practical setting by consultant radiologists of varying experience. Knowledge of these errors, in particular, will help to improve the training programme as part of routine quality monitoring and enhancement processes. A number of the radiographers included in this study are now reporting MRI head and/or cervical spine examinations in clinical practice from a range of referral sources.

Recommendations

In the future it will be imperative to investigate the accuracy of MRI reporting by radiographers more extensively and particularly throughout implementation into clinical practice and in comparison with consultant radiologists.

Radiographers could continue to contribute to the reporting service as part of a sustainable strategy to meet growing demands and diagnostic capacity requirements.

Conflict of interest statement

None

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Figure 1 Range of abnormalities included in the OSE

Head
Haemorrhage – various
Infarction – various
Demyelination disease
Mass lesions
○ Metastatic deposit/s
○ Meningioma
○ Adenoma
○ Astrocytoma
○ Low grade glioma
○ Dysembryoplastic neuroepithelial tumours (DNET)
○ Abscess
Cervical spine
Degenerative disc disease, vertebral endplate (Modic) changes
Intervertebral disc morphology (bulge, protrusion, annular tear)
Cord compression, nerve root involvement, spinal stenosis
Rupture anterior longitudinal ligament
Syringomyelia
Gliososis

Table 1 Mean sensitivity, specificity and agreement rates

Performance measure	Mean	95% CI
Sensitivity	98.86	96.4 – 99.7
Specificity	98.08	95.3 – 99.3
Agreement	88.37	86.7 – 90.0

Table 2 Mean scores by anatomical area

Anatomical area	Mean score per case (Maximum score = 5)	Minimum – maximum scores
Head (n=260)	4.49	4.02 – 4.83
Cervical spine (n=260)	4.07	3.15 – 4.77

Table 3 Highest and lowest scoring cases

Anatomical area	Abnormality	Mean score / 5
Highest scoring		
Head	Astrocytoma	4.83
Cervical spine	Disc protrusion with cord compression	4.77
Head	Glioma	4.75
Lowest scoring		
Cervical spine	Fracture C2	3.15
Cervical spine	Rupture anterior longitudinal ligament	3.19
Cervical spine	Syringomyelia	3.33

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