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Common patterns in 558 diagnostic radiology errors

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Abstract

Introduction: As a Quality Improvement initiative our department has held regular discrepancy meetings since 2003. We performed a retrospective analysis of the cases presented and identified the most common pattern of error.

Methods: A total of 558 cases were referred for discussion over 92 months, and errors were classified as perceptual or interpretative. The most common patterns of error for each imaging modality were analysed, and the misses were scored by consensus as subtle or non-subtle.

Results: Of 558 diagnostic errors, 447 (80%) were perceptual and 111 (20%) were interpretative errors. Plain radiography and computed tomography (CT) scans were the most frequent imaging modalities accounting for 246 (44%) and 241 (43%) of the total number of errors, respectively. In the plain radiography group 120 (49%) of the errors occurred in chest X-ray reports with perceptual miss of a lung nodule occurring in 40% of this subgroup. In the axial and appendicular skeleton missed fractures occurred most frequently, and metastatic bone disease was overlooked in 12 of 50 plain X-rays of the pelvis or spine. The majority of errors within the CT group were in reports of body scans with the commonest perceptual errors identified including 16 missed significant bone lesions, 14 cases of thromboembolic disease and 14 gastrointestinal tumours. Of the 558 errors, 312 (56%) were considered subtle and 246 (44%) non-subtle.

Conclusion: Diagnostic errors are not uncommon and are most frequently perceptual in nature. Identification of the most common patterns of error has the potential to improve the quality of reporting by improving the search behaviour of radiologists.

Key words: diagnostic error; quality improvement; radiology.

Introduction

Errors in diagnostic radiology have long been recognised with Garland's pioneering articles dating back to 1949.[1,2] Error rates of 30% have been replicated in the setting of abnormal radiology studies with rates of 3.5–4% reported in daily practice where there is mixture of abnormal and normal cases.[3] The Royal Australian and New Zealand College of Radiologists and the Royal College of Radiologists have encouraged radiologists to participate in meetings where cases involving radiological error are discussed.[4,5] Errors can be made at various stages in the imaging cycle, from the clinical question through the request, patient preparation, image acquisition and processing, radiologist reporting and communication of results.[6] An error that occurs at the detection phase of image reading when an abnormality is not appreciated is a perceptual error or false negative and is by far the commonest type of error. Less commonly, an abnormality, which is reported as present but is later shown not to be present, is a false positive error. An error that occurs at the interpretation phase, which results in an incorrect diagnosis being given to an abnormal finding or rarely to a normal finding, is an interpretative error and these typically result in under- or overcalling disease (false negative or false positive errors, respectively).[4,7] Review of cases where error is felt to have arisen has potential educational benefit with

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evidence that error rates can be reduced.[8] A retrospective review of cases referred to our discrepancy meetings was undertaken to evaluate for identifiable recurrent errors or themes which could provide learning lessons and guide reporting radiologists to areas worthy of additional review.

Methods

Since 2003 we have held regular departmental discrepancies meetings attended by consultant radiologists and trainee radiology registrars with 558 referrals over 92 months. Our institution is a 910-bed teaching hospital in South Auckland, New Zealand serving an estimated population of 485 000 people with approximately 180 000 radiology examinations performed in 2010. The hospital provides medical care for all specialties apart from cardiothoracic and neurosurgery, and imaging services are comprehensive apart from nuclear medicine. Magnetic resonance imaging (MRI) became available at our institution in October 2007 having been previously provided by an outside institution. Procedural errors were not included in this review, and mammographic audit is undertaken regularly as a separate component within the radiology department.

Radiologists referred cases of suspected error to the chairperson at their own discretion on the basis of potential significance or educational benefit. Referrals were made voluntarily by radiologists who recognised a discrepancy on reporting or reviewing images, or as a consequence of discussion at multidisciplinary meetings. Discrepancies reported by clinicians were also referred to the chairperson. All the cases were reviewed retrospectively on the picture archiving and communication system (PACS), and diagnostic errors were classified as per Pitman as either perceptual, which is a failure of detection, or interpretative, which is an error in diagnosis.[4] Recorded details included patient age, clinical indication (if available), modality, location of error, and the misses were coded by consensus by a simple majority of those radiologists attending the discrepancy meeting as subtle or non-subtle. Mass lesions overlooked were analysed as to site and size.

Results

All of the cases referred for presentation at the discrepancy meeting occurred in the perception or interpretation phase of the imaging cycle. A total of 558 errors were reviewed and classified as perceptual 447 (80%) and interpretative 111 (20%). The patients' age ranged from 0 days to 94 years with a mean of 51 years. In 36 patients the same error was made on two or three occasions, and two errors occurred in the same report in 17 patients. Modalities included 246 plain radiographs, 241 CT scans, 31 ultrasound, 28 MRI, 12 fluoroscopic

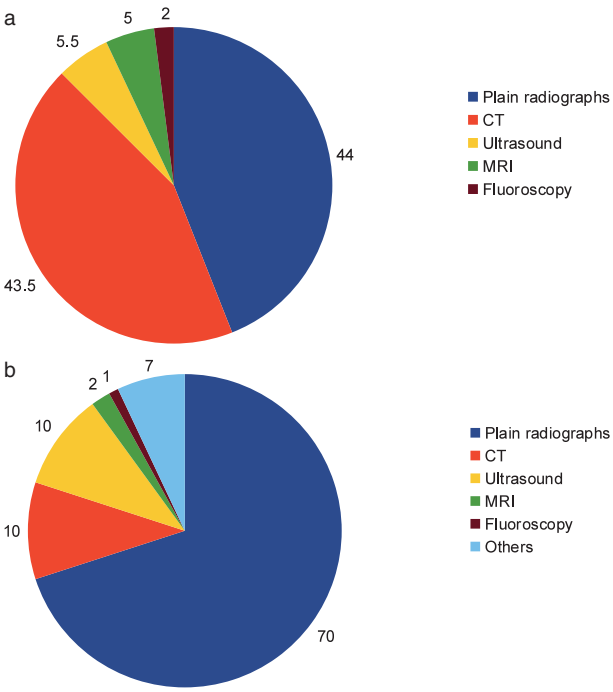

Fig. 1. (a) Percentage of referrals by modality. (b) Percentage of department workload by modality.

examinations with plain radiographs and CT scans accounting for 44% and 43.2% of the total cases retrospectively (Fig. 1).

Of the 246 plain radiograph diagnostic errors, 120 cases (49%) occurred on chest X-ray (CXR) evaluation, the majority of which were perceptual errors (81%) with missed lung nodules being the most common error arising in 37 cases (40% of this subgroup). Figure 2 demonstrates the distribution of the missed lung nodules. Lung nodules ranged in size from 9 to 40 mm (mean 20 mm) in diameter, and in five patients the miss occurred on two separate occasions. The commonest CXR perceptual misses are listed in Table 1. Misinterpretation of CXR occurred in 27 cases which resulted in under-reporting of pathology in 17 cases, predominantly of neoplastic disease mistaken as benign pathology such as infection. Radiologists' reports of axial skeleton plain radiographs of the spine and pelvis in 50 cases missed 21 fractures (42%), including four missed cervical spine fractures of which C2 odontoid peg fractures occurred in three elderly patients aged over 80. In this group metastatic bone disease was overlooked in 12 cases (24%). In the appendicular skeleton missed fractures accounted for the majority (54%) of the perceptual errors. Interpretative errors occurred in 10 cases of the skeleton; seven under calls and three over calls, which included three cases of incomplete evaluation of spine fractures and two cases of misinterpreted metastatic bone disease.

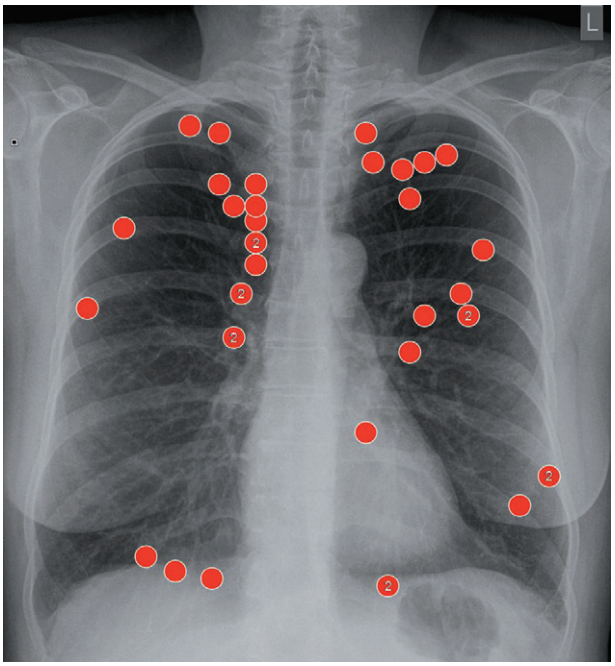

Fig. 2. Distribution of missed lung nodules on chest X-ray. The number '2' denotes nodules that were missed on two occasions.

In the CT group 195 of the total 241 (81%) errors occurred in body scans and 41 were in head and neck scans. One hundred and sixty-seven perceptual errors occurred in the body group with the most common errors detailed in Table 2. Metastatic bone disease, thromboembolic disease and gastrointestinal tumours occurred most frequently with 14 cases of each, followed by vascular pathology, enlarged nodes or other masses, and lesions in the periphery of the scan. The majority of the cases of missed metastatic bone disease occurred in patients being investigated for either known or suspected malignancy. Solid renal masses ranged in size from 27 to 78 mm in diameter, average 45 mm, with the larger masses being missed on unenhanced CT of the urinary tract. Interpretative errors occurred in 44 of the 241 CT scans which resulted in under-reporting a variety of pathologies in 28 cases with no specific trend.

Table 1. Chest X-ray – most common perceptual errors

Perceptual error	Number
Lung nodules	37
Mediastinal mass or nodes	8
Metastatic bone disease	7
Hilar mass	5
Pneumothorax/pneumomediastinum	5
Fracture	4
Chest wall mass	3
Intraperitoneal air	3

Table 2. Body CT – most common perceptual errors

Perceptual error	Number
Significant bone lesions	16
Metastatic bone disease	14
Fractures	2
Thromboembolic disease	14
Venous thrombosis	10
Pulmonary embolus	4
Gastrointestinal tumours	14
Colorectal	10
Gastric	3
Anastomotic recurrence	1
Vascular pathology	10
Acquired†	8
Congenital	2
Enlarged lymph nodes	10
Liver lesions	8
Pancreatic tumours‡	7
Lung nodules	7
Peripheral lesions	7
Renal masses	6
Peritoneal disease	4

†Two different occasions for two patients. ‡Three different occasions for one individual.

Cranial imaging accounted for 45 of the total number of cases referred with 37 CT and 6 MRI cases. Thirty-six errors were perceptual, the most common of which are listed in Table 3, and nine errors were interpretative. Of the interpretative errors two cases of tumour were misinterpreted as infarct.

Only a relatively small proportion of the diagnostic errors referred were imaged by ultrasound. Of the 31 cases, 21 were interpretative and 10 perceptual with most errors occurring in either assessment of the renal tract or pelvis accounting for 10 and 4 of the total number of cases, respectively.

Forty-six paediatric cases, age 15 years and less, were included in this review with 35 reports performed by general radiologists and 11 by radiologists with a subspecialist paediatric interest. A relatively higher

Table 3. Cranial imaging – most common perceptual errors

Perceptual error	Number
Extra-axial mass	8
Meningioma†	7
Pituitary macroadenoma	1
Thrombosis	7
Dural venous sinus	5
Basilar tip	2
Infarcts	7
Posterior circulation	5
Anterior circulation	2

†The same error occurred on two occasions in two different patients.

representation of cranial imaging (24%) was noted when compared with the adult population (8%).

Of all the 558 errors, 312 (56%) were considered subtle and 246 (44%) non-subtle.

Discussion

Diagnostic errors remain a regular and inevitable occurrence in radiology, and Robinson commented that although technology has made enormous progress in the last century, there is no evidence for similar improvement in the performance of the human eye and brain.[9] With the educational benefit of open format discrepancy meetings, however, it has been suggested that this phenomenon can potentially be reduced.[4,10] Since 2003, we have held regular discrepancy meetings to which radiologists were encouraged to refer any case in which an error was considered to have occurred. Submission of cases is voluntary and interpretation of these results must take into account the fact that it is not a systematic audit of errors and represents a relatively small selection of cases that attracted clinical attention. This process allows us to identify patterns of errors but not establish the rate of error.

Perceptual errors accounted for the 80% of the misses in this review, which is similar to previously published data.[11,12] The explanation as to why these occur remains unclear but is likely related to multiple psychophysiological factors including level of observer alertness or fatigue, workload and speed of reporting, viewing conditions, distraction factors and conspicuity of the abnormality.[4,13] They tend to be sporadic, and interestingly, whilst a lesion can be overlooked on one occasion, it may then be identified on another. This paradox has been likened to the 'Where's Wally' series of books in which Wally the central character dressed in the same instantly recognisable clothes is hidden within a busy page, and once you either spot him or he is brought to your attention, he becomes obvious and easy to find on any other occasion.[4] Unlike any other medical specialties, apart from pathology, not only do we make errors but we store images to allow retrospective review of our misses which in turn has generated unfavourable remarks by politicians and lawyers alike.[14,15] In addition, errors made in previous radiology reports can lead to the tendency of radiologists to replicate the error in subsequent reports, which is referred to 'alliterative bias'.[16] This may have led to the four cases where the same error was replicated on three occasions.

CXR errors occurred in 22% of all cases with miss of a lung nodule, average diameter 20 mm, in 40% of this subgroup. Quekel *et al*.[17] found that 19% of lung cancers presenting as a nodule on chest radiographs were missed with a median diameter of 16 mm, and commented that higher rates between 25 and 90% have been reported in the literature. The value of comparison with previous imaging, including the oldest CXR if available, cannot be underestimated as a risk management tool for reducing diagnostic error.[18] Clinical information can have a positive impact on accuracy leading to a fall in error rate but it can potentially cause an increase in false positive rates,[15] and it is important to avoid 'framing bias' by initially viewing the images prior to reading the clinical details.[7] This will ensure that the radiological impression is not unduly influenced by the supplied clinical information.

Relative to the overall department workload CT scans are disproportionately over-represented. This is probably due to multiple factors including the regular review of cross-sectional imaging at multidisciplinary meetings, when additional clinical information is brought to the attention of the radiologist. CT scanning not only generates a large number of unexpected significant findings such as bowel neoplasms and thromboembolic disease but also the 'incidentaloma' – an unexpected mass or lesion (most often benign) which often requires further evaluation as to its significance with resultant increased imaging and radiation.[19] McCreadie and Oliver[10] highlight eight CT lessons learned on review of 256 errors discussed in a similar manner at departmental discrepancy meetings. Their recurring false negative errors included: failure to appreciate unexpected bowel or pancreatic malignancy, incidental pulmonary emboli, abnormality of vascular structures, bone lesions, omental disease, incidental abnormality on targeted examinations and lesions on the periphery of the field of view. False negative errors occurred in 61% of the series and CT scans accounted for 62% of the referrals with only 9% due to plain radiograph diagnostic error. The eight most common reported CT misses accounting for 63% of the false negatives were not dissimilar to our series, but in our review these represented only 35% of all the CT errors. Horton *et al*. have also examined misdiagnoses in CT reports of the abdomen and recommend the regular use of alternative windows to increase lesion conspicuity and use of multiplanar and/or three-dimensional reconstructions.[20]

In contrast to CT, only 28 cases of discrepancy on MRI were referred. This may be due to two factors: first, that MRI was outsourced to another off-site provider until November 2007; and second, all the MRI scans are double read. Double reading is one well-established method of reducing radiological error.[21]

Recent literature has suggested that errors are more common in young and elderly patients.[22] As our review is a random sample of the department workload we can not extrapolate this data further as to prevalence in different age groups but of note an error in a paediatric patient occurred more frequently if the reporting radiologist did not have paediatric subspecialist interest and cranial imaging accounted for 24% of these referrals.

'Satisfaction of search' is a well-recognised phenomenon and describes the situation in which the detection of

one radiographic abnormality satisfies the 'search for meaning' and results in premature termination of the search.[15] Renfrew *et al*.[12] reported 11 of 182 errors due to satisfaction of search, and in our series it occurred in 17 cases.

In this retrospective review we have endeavoured to identify recurring themes or common misses in order to highlight them as sites that merit extra review. Reviewing a series of cases over a period of time allows the recognition of patterns of what may be considered in isolation as one-off or 'special' errors but with sufficient numbers these can be appreciated to represent 'common' causes. For example, we have changed our practice to make available on PACS coronal reconstructions of all CT examinations. No attempt was made to grade the severity of errors because an imaging finding alone at a point in time, often with an incomplete medical history, is highly subjective and it was decided collectively that this was inappropriate. The major limitation is the voluntary submission of cases leading to an inevitable selection bias.

This form of discrepancy meeting is an important part of the quality improvement framework of our department which is seen by the radiologists as a valuable educational exercise. Anecdotally our radiologist colleagues report that the meetings have changed their behaviour by identifying review areas. The purpose is not to measure the individual or service rate of error and it is not used to identify poor performers. It encourages radiologists to be open regarding errors and promotes discussion regarding the causes of error. It has been noted in the aviation industry that a similar process of voluntary reporting of near misses is an important part of the cultural change which enables quality improvement.[23] The Radiology Events Register is an Australasian voluntary reporting and analysis project which has been collating data since 2006 and now contains records of over 4000 incidents submitted by a range of staff groups.[6,24] A systematic peer-review process can provide quantitative service and individual feedback.[25]

Conclusion

Diagnostic error in radiology remains a regular and probably inevitable occurrence. In this study the most common misses are highlighted in an attempt to direct the reporting radiologist to those areas worthy of additional review with the aim of reducing error rates.

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