Fool Me Twice: Delayed Diagnoses in Radiology With Emphasis on Perpetuated Errors

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OBJECTIVE. We hypothesized that delayed diagnoses in radiology are not recognized on subsequent radiologic examinations because of multiple types of errors.

MATERIALS AND METHODS. Six hundred fifty-six radiologic examinations with delayed diagnoses were collected from July 1, 2002, to January 31, 2010. Each case was reviewed by two radiologists together, and the diagnostic errors were classified according to our modified scheme with consensus between the radiologists.

RESULTS. There were a total of 1269 errors. The range of days elapsed from the initial error in interpretation to the correct diagnosis was 0–4611 days, with an average of 251 days. The percentage for each type of error was 0.9% (n = 11) for type 1, 9% (n = 110) for type 2, 3% (n = 39) for type 3, 42% (n = 535) for type 4, approximately 0% (n = 1) for type 5, 2% (n = 29) for type 6, 5% (n = 59) for type 7, 2% (n = 20) for type 8, 7% (n = 92) for type 9, 22% (n = 288) for type 10, 0.5% (n = 6) for type 11, and 6% (n = 79) for type 12. The correct diagnoses were not recognized on subsequent radiologic examinations in 196 of 656 cases (30%).

CONCLUSION. Delayed diagnoses were not recognized on subsequent radiologic examinations in about one third of the cases. The most common types of error were underreading, satisfaction of search, faulty reasoning, and location of the finding.

Keywords: delayed diagnosis, diagnostic errors, error in interpretation

DOI:10.2214/AJR.13.11493

Received July 2, 2013; accepted after revision September 11, 2013.

Presented in part at the 2011 annual meeting of the ARRS, Chicago, IL.

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AJR 2014; 202:465–470

0361–803X/14/2023–465

As important technologic advances have been made in the field of radiology within the last two decades, medical imaging has become a crucial component in the decision-making process in the care of patients. Radiologists interpret imaging on the basis of both visual perception and its cognitive interpretation. Mistakes are made in both aspects of interpretation despite the available technologic tools, which may lead to serious consequences for the patient. In the daily radiology practice, the rate of interpretation error is between 3% and 4%; however, of the radiology studies that contain abnormalities, the error rate is even higher, averaging in the 30% range [1]. The problem is further compounded when the error is perpetuated, resulting in a significant delay in diagnosis. Our hypothesis was that delayed diagnoses in radiology are often not recognized on subsequent radiologic examinations and are due to multiple types of diagnostic errors.

Materials and Methods

The Brooke Army Medical Center Department of Clinical Investigation approved this retrospective study. Six hundred fifty-six radiologic examinations with delayed diagnoses at our institution were collected from July 1, 2002, to January 31, 2010. The cases were collected from the department of radiology difficult case conferences and by the authors during the daily interpretation of radiologic examinations. Because the senior author was in charge of conducting the difficult case conference, the radiology faculty and residents were asked to report to him any cases of delayed diagnosis or misdiagnosis that they came upon during their daily clinical practice. Each case was reviewed by two radiologists, and the diagnostic errors were classified in consensus according to our modified scheme (Table 1), which was adapted from previous publications by Smith [2] and Renfrew et al. [3]. Types 6 through 12 errors were added or expanded by the authors from previous reports. Type 6 errors were attributed to improper imaging technique, type 7 errors were due to failure to consult old radiology examinations, type 8 errors were due to inaccurate or incomplete history, type 9 errors were due to the location of abnormality, type 10 errors were related to satisfaction of search, type 11 errors involved complications from a procedure, and type 12 errors were related to satisfaction of report. A type 9 error was assigned when the missed finding was located outside of the main location of interest (e.g., a lytic lesion in a humerus that was not detected on a chest radiograph). Satisfaction of search error was assigned when the interpreting radiologist failed to detect additional abnormalities after the first abnormality was found. Satisfaction of report error was assigned when the interpreting radiologist relied on the previous radiology report and failed to detect an abnormality that was not diagnosed on the previous radiologic examination. When appropriate, more than one type of error was assigned to each case.

Data collected include the number of days elapsed between the initial examination on which the diagnosis was missed and the subsequent examination on which the correct diagnosis was made, imaging technique on which the diagnosis was missed, imaging technique on which the correct diagnosis was made, and whether the diagnosis was missed on subsequent radiologic examinations. Percentages were then calculated according to the total number of errors and on the total number of cases. The errors were also tabulated according to the radiology section, such as musculoskeletal, neuroradiology, body imaging, and so forth.

When feasible, histologic diagnosis served as the reference standard. This usually occurred in the cases of neoplasms or diagnoses requiring surgical interventions. In other cases, either CT or MRI served as the reference standard, making the correct diagnosis since the imaging findings were pathognomonic or diagnostic. The correct interpretations were rendered by or reviewed with fellowship-trained radiologists in their specialty.

Results

There were a total of 1269 errors among the 656 cases. The range of days elapsed from the initial error in interpretation to the correct diagnosis was 0–4611 days, with an average of 251 days. The percentage for each type of error as a percentage of the total number of errors (1269) (Fig. 1) was 0.9% (n = 11) for type 1, 9% (n = 110) for type 2, 3% (n = 39) for type 3, 42% (n = 535) for type 4, approximately 0% (n = 1) for type 5, 2% (n = 29) for type 6, 5% (n = 59) for type 7, 2% (n = 20) for type 8, 7% (n = 92) for type 9, 22% (n = 288) for type 10, approximately 0.5% (n = 6) for type 11, and 6% (n = 79) for type 12. Figure 2 shows the percentage of each type of error of the total number of cases; the sum is greater than 100% because many cases have more than one type of error.

The imaging techniques on which the correct diagnosis was initially missed of the total number of cases (n = 656) (Fig. 3 and Table 2) were radiography (n = 354; 54%), CT (n =

TABLE 1: Classification of Errors in Diagnostic Radiology

Type	Cause of Error	Explanation
1	Complacency	Error of overreading and misinterpretation, in which a finding is appreciated but is attributed to the wrong cause
2	Faulty reasoning	Error of overreading and misinterpretation, in which a finding is appreciated and interpreted as abnormal but is attributed to the wrong cause. Misleading information and a limited differential diagnosis are included in this category
3	Lack of knowledge	The finding is seen but is attributed to the wrong cause because of a lack of knowledge on the part of the viewer or interpreter
4	Underreading	The finding is missed
5	Poor communication	The lesion is identified and interpreted correctly, but the message fails to reach the clinician
6	Technique	The finding is missed because of the limitations of examination or technique
7	Prior examination	The finding is missed because of failure to consult prior radiologic studies or reports
8	History	The finding is missed because of acquisition of inaccurate or incomplete clinical history
9	Location	The finding is missed because of the location of a lesion outside the area of interest on an image, such as in the corner of an image
10	Satisfaction of search	The finding is missed because of failure to continue to search for additional abnormalities after the first abnormality was found
11	Complication	Complication from a procedure
12	Satisfaction of report	The finding was missed because of complacency of report, and overreliance of the radiology report of the previous examinations

Note—This classification scheme is a modification of the schemes by Smith [2] and Renfrew et al. [3].

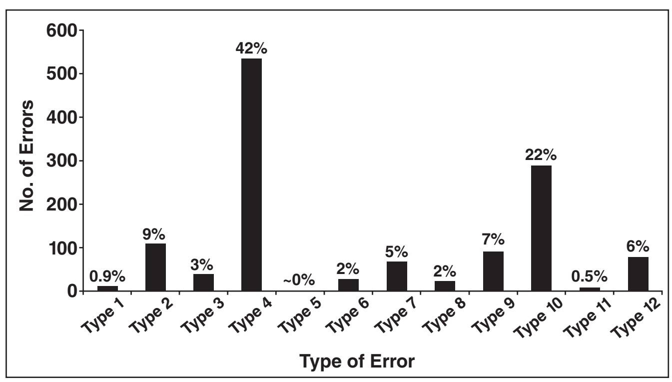

Fig. 1—Number of different types of errors as percentage of total number of errors.

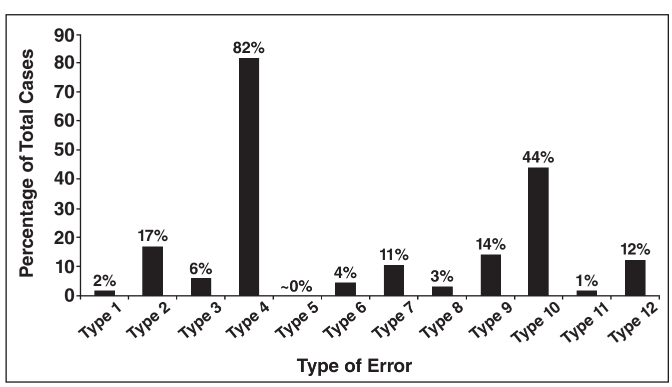

Fig. 2—Number of different types of errors as percentage of total number of cases. Sum is greater than 100% because some cases have more than one type of error.

200; 30.5%), MRI (n = 75; 11.4%), bone scan (n = 18; 3%), and ultrasound (n = 9; 1.4%). The correct diagnoses were not recognized on subsequent radiologic examinations in 196 cases (30%) of the total number of cases. The imaging techniques on which the correct diagnosis was subsequently missed for the second time were radiography (n = 118; 60.2%), CT (n = 46; 23.5%), MRI (n = 17; 8.7%), nuclear medicine (n = 13; 6.6%), and ultrasound (n = 2; 1%) (Table 2). The imaging techniques on which the correct diagnosis was made as a percentage of the total number of cases were CT (n = 218; 33.2%), MRI (n = 205; 31.3%), radiography (n = 188; 28.7%), nuclear medicine (n = 30; 4.6%), and ultrasound (n = 8; 1.2%) (Table 2). In five cases (0.8%), the correct diagnoses were made at surgery.

The errors were found in the following sections as a percentage of the total number of cases: musculoskeletal (n = 434; 66%), body imaging (n = 96; 15%), thoracic (n = 74; 11%), neuroradiology (n = 43; 7%), nuclear medicine (n = 5; 1%), and ultrasound (n = 4; 1%). Eighty-four of the missed findings (13%) were serendipitous, not expected according to the provided clinical history.

Discussion

Error in imaging interpretation due to human perception has long been established in the literature. In our study, the majority of errors made were errors of underreading (42%), where the finding was simply missed. This is in line with the observation made by Robinson [4] that despite the advances in imaging technology, there is no evidence of a similar improvement in the perception of the human eye and brain. We advocate the use of checklists for different types of radiologic examinations, depending on the body part imaged, to facilitate active search patterns to decrease the incidence of this type of error [5–11]. The World Health Organization's surgical safety checklist has been shown to decrease complication and death rates [8]. Perhaps a checklist approach to imaging interpretation may also decrease error rates in radiology. A checklist for radiologists must include the common diagnoses and misdiagnoses typically seen on that specific radiologic examination of the body part. The second most common type of error, type 10 error (22%), was made when an additional more clinically significant abnormality was missed after the first but less important finding was detected, which is the so-called "satisfaction of search" error. Satisfaction of search errors in musculoskeletal imaging are well documented in the radiology literature [12, 13]. Therefore, it is incumbent on the radiologist to overcome the urge to stop looking after an initial finding is detected by continuing to evaluate the radiologic examination for additional findings using the checklist method.

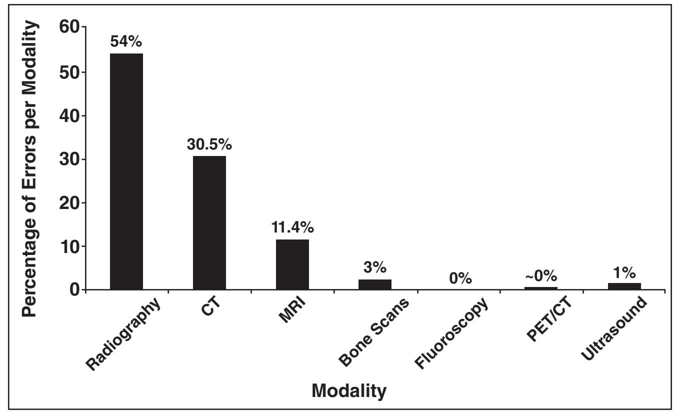

Fig. 3—Percentage of errors based on imaging modality.

Type 2 errors, the third most common type (9%), involved errors due to faulty interpretation, where the finding is seen but attributed to the wrong cause. A contributing factor that we noticed was the lack of expertise in the interpreting radiologist (e.g., fellowship-trained vs non-fellowship-trained radiologists and the number of years of clinical practice). To decrease these errors, the radiologists must be active in maintaining current knowledge through the literature, subspecialty training, and continuing medical education courses. Detailed analysis of diagnostic errors in radiology should be performed according to the classification used in this study. The lessons learned should be shared with colleagues at the departmental monthly difficult case conferences.

Type 9 error was the fourth most common (7%), where the finding was in the periphery of the location of interest. This may be due to "tunnel vision" or "scrolling error." In cross-sectional examinations such as CT or MRI, we found that many of the findings missed in this category were found in the first or last image of a series of images. In viewing a series of images in cine mode, the first and last images may not have received sufficient attention from the interpreting radiologists. With an increase in the complexity of radiologic examinations, the number of images produced, and radiologist workload, this type of error poses significant challenge. Recently, this phenomenon has been termed "inattentional blindness" or "gorilla in the midst syndrome." Researchers from the Visual Attention Laboratory at Harvard Medical School inserted a gorilla figure, 48 times the size of the average pulmonary nodule, into one of the CT images of a chest CT examination. The radiologists were asked to perform a familiar lung nodule detection task. At the end of the exercise, 83% of the radiologists reported that they did not see the gorilla, even though eye-tracking technology revealed that the majority of these radiologists had looked directly at its

TABLE 2: Percentage per Modality Involved in the Initial Miss, Subsequent Miss, and the Correct Diagnosis Made

Modality	First-Time Miss	Second-Time Miss	Correct Diagnosis
Radiography	354 (54)	118 (60.2)	188 (28.7)
CT	200 (30.5)	46 (23.5)	218 (33.2)
MRI	75 (11.4)	17 (8.7)	205 (31.3)
Bone scan	18 (3)	12 (6.1)	26 (4)
Fluoroscopy	0 (0)	0 (0)	2 (0.3)
PET/CT	2 (0.3)	1 (0.5)	4 (0.6)
Ultrasound	9 (1.4)	2 (1)	8 (1.2)
Surgery			5 (0.8)
Total	656 (100)	196 (100)	656 (100)

Note—Data are no. (%) of cases.

location [14]. In all cross-sectional examinations, the radiologist needs to pay careful attention to the first and last image in a series of images. Scout or localizer images, corners of an image, and areas of an examination that are typically not in the forefront of a radiologist's attention also fall into this category. For example, musculoskeletal pathologic abnormalities are frequently underappreciated on chest radiographs.

Type 12 errors were fifth most common (6%). These were errors that were perpetuated from one study to another because of reliance on the prior radiology report. Smith [2] called this phenomenon alliterative error, the influence that one radiologist can exert on another. He stated that if one radiologist fails to detect and report a radiographic abnormality, there is an increased chance that a second radiologist will also miss the same abnormality [15]. Alliterative errors occur more frequently when radiologists read the reports of previous examinations before looking at a new radiologic examination. As human beings, we may have the tendency to be agreeable with our peers and trustful of their interpretation. To overcome this error, radiologists must perform their own interpretation before reading the previous radiology reports.

Type 7 errors were next (5%), where a missed finding could have been avoided if the interpreter had consulted the prior comparisons. Some of the contributing factors that we observed included examinations taken at other institutions, teleradiology services employed by our institution not having access to prior examinations, and failure of our institution's PACS server to retrieve the prior examinations at the time of the radiologic interpretation. The 2010 Revision of the American College of Radiology standard for communication in diagnostic imaging states, "Whenever possible, previous reports and images should be available for review and comparison with the current study" [16]. The radiology literature has shown the value of previous radiologic examinations in interpreting current studies [17, 18]. More important, at least one jury found a radiologist negligent for failing to compare new radiologic examinations with previous studies [19]. Type 7 error potentially has its greatest impact on teleradiology services, which may not have access to all previous radiology examinations and electronic medical records. Every attempt must be made to retrieve and review all prior pertinent radiologic examinations before rendering a final interpretation.

The opportunity for comparison can be missed without a thoughtful search of all the patient's examinations. The radiologists can be biased by the comparison examinations that the PACS automatically selects for the given study. For example, studies such as PET/CT or abdominal radiographs may be overlooked as potential sources for comparison in interpreting radiographs of the pelvis and hips. Similarly, a lung mass that was not detected on a shoulder radiograph may be more evident on a comparison chest or cervical spine radiograph. Past juries have found radiologists negligent for failure to compare a new chest radiograph with all previous chest radiographs [20]. Whether future juries will find radiologists negligent for failure to compare a new radiologic examination with all previous pertinent radiologic examinations is unknown. However, the American College of Radiology's practice guidelines for chest radiography state, "Images should be compared with prior chest examinations and/or *other pertinent studies* that may be available" [italics added by authors] [21]. With the availability of PACS, radiologists no longer have an excuse for failing to make direct comparison with prior radiologic examinations. Therefore, teleradiologists must insist that their teleradiology service providers have access to their patients' radiologic records.

We admit that the classification of the types of errors reflects the authors' own interpretation and bias because we cannot read the minds of the original interpreting radiologists. Although most errors fit into only three categories (type 2, 4, and 10), we think that detailed classification of the errors may yield clues to how the errors were made and offer preventive measures to decrease future errors. The other types of errors are small but still significant enough to keep in mind when interpreting images.

In about one third of the cases, the delayed diagnoses were not recognized on subsequent radiologic examinations (Table 2), which was similar to the error rate reported in Garland's classic study on the accuracy of diagnostic procedures, recently reviewed by Dr. Berlin [1]. Simply stated, in 100 abnormal radiologic examinations, 33 abnormal findings were not detected on subsequent radiologic examinations. In Garland's classic study, he concluded that experienced radiologists will miss radiologic evidence of disease on about 30% of chest radiographs [1]. However, this is not the individual radiologist's error rate because he or she interprets correctly the remaining chest radiographs with no radiologic evidence of disease. Radiologist error rate has been well documented in the literature to average 3.5–4% [1, 22, 23]. Similarly, in the present study, the errors reported were not an individual radiologist's error rate, because we did not have the radiologists' total number of interpreted examinations. We did not collect this information because determining a radiologist's error rate was not the goal of our research.

Radiography was the most common technique in which the abnormal findings were not detected on initial and subsequent examinations, followed by CT, MRI, bone scan, and ultrasound, respectively. The dominant role of radiography was probably due to selection bias rather than subtlety of the findings. Although in some cases the radiographic findings were subtle, in most of the cases, the radiographic findings were clearly evident in retrospect. The radiologists simply missed the findings or did not know the significance of the findings. In these cases, the diagnoses were correctly made on either MRI or CT, and in the retrospective review of the radiographic examinations the errors were then identified. This may reflect the lack of training and experience in the interpretation of radiographic examinations in the current generation of radiologists who have more clinical experience with cross-sectional imaging techniques than radiography. This observation is supported by the resident data collection that the Accreditation Council for Graduate Medical Education requires of every radiology resident. Radiology residents are required to report a case log of the radiologic examinations that they interpret annually. The specific examinations listed on the Accreditation Council for Graduate Medical Education website include Chest X-Ray, CT Abdomen/Pelvis, CTA/MRA, Image Guided Biopsy/Drainage, Mammography, MRI Body, MRI Brain, MRI Lower Extremity Joints, MRI Spine, PET, and US Abdomen/Pelvis (Hoskins J, oral communication, 2013). Of 11 categories, only two (18%) were radiography (chest x-ray and mammography); eight categories (72%) were cross-sectional imaging techniques. Radiology residents are not required to report their clinical experience in the interpretation of radiographic examinations of the extremities and abdomen. Therefore, training in the interpretation of radiographic examinations must be reemphasized in radiology resident education. The imaging modality in which the abnormality was correctly identified was highest with CT (33%), followed closely by MRI (31%) and radiography (29%).

The section where the delayed diagnoses occurred the most was musculoskeletal (66%), followed by body (15%), thoracic (11%), and neuroradiology (7%). This was due to selection bias because the senior coauthor was a fellowship-trained musculoskeletal radiologist who identified these cases during daily service on the musculoskeletal service.

There are two major weaknesses in this study. First, our study is a retrospective study with its inherent biases. Second, selection bias results in the large number of cases in the musculoskeletal section and the large number of radiographic examinations. However, we think that the results remain valid and valuable to practicing radiologists.

Another limitation of this study is the determination of the significance of the diagnostic errors. Failure to detect neoplasm is clearly clinically significant. Failure to detect a pneumothorax on a chest radiograph is significant, but it may not be clinically significant if the patient is asymptomatic or the pneumothorax was subsequently detected on a chest CT or follow-up chest radiograph without adverse outcomes. Is failure to detect any fracture clinically significant? Flexion teardrop fracture of the cervical spine requires internal fixation, whereas avulsion fracture of the spinous process fracture does not. One may argue that failure to detect any fracture is significant because it helps to explain the patient's symptoms, leading to prompt treatment and to reducing morbidity. In a recent report on malpractice claims related to musculoskeletal imaging, failure to report fractures accounts for 93.5% of the claims for alleged diagnostic errors [24]. Is failure to detect a normal variant clinically significant? It depends on the patient's symptoms. It is well known that normal variants can be painful [25, 26]. More importantly, medical malpractice claims have been initiated alleging the radiologist's failure to detect os acromiale and os trigonum [27, 28]. Because of the complexity of this question and, more importantly, the lack of clinical information, we elected not to determine the clinical significance of the diagnostic errors. We were more interested in classifying the types of diagnostic errors in hopes of finding steps to decrease their occurrence in the future.

We did not address any particular type of error, such as missed pulmonary nodule, because there have been several published articles on such a topic [29–34]. Also, we do not have a sufficient number of cases for a particular type of error to address this question intelligently. The research study was not designed to address this question either.

All the errors were made by the faculty either working alone or working with residents. We did not include errors made by the residents because they were trainees. We cannot provide error rates for faculty working outside their specialty versus those working within their specialty, because such information was not collected, nor can we assess faculty years of experience and its impact on error occurrence because we do not have information on all the radiologists, some of whom were teleradiologists or radiologists who had left our practice. When interpreting radiologic studies, are subspecialty radiologists held to a higher standard of care than general radiologists? The answer to this question is unclear [35]. Ultimately, that is for a jury to decide. However, Silver and Berlin stated, "...general radiologists who miss subtle fetal abnormalities on sonography and claim malpractice immunity because they are not 'sonographic specialists' cannot escape liability any more than those who miss a subarachnoid hemorrhage on a CT scan and claim malpractice immunity because they are not neuroradiologists" [36]. With the societal and governmental trend of placing increasing expectation and legal obligation on radiologists, we suspect that a jury would expect general radiologists to have the same skills as subspecialty radiologists. Therefore, it is essential that general radiologists and subspecialty radiologists who desire to interpret radiologic examinations outside their subspecialty maintain their skills to the same level as subspecialty radiologists. This would require continuing medical education, including, at the minimum, periodic attendance of annual meetings of the respective societies of subspecialty radiology and selected educational seminars.

In conclusion, nearly one third of delayed diagnoses in radiology were not recognized on subsequent radiologic examinations. Underreading, satisfaction of search, faulty reasoning, and location were the most common types of errors. Seven percent of missed findings were found in the "corner" of the film, and 13% were serendipitous. It is important to analyze and understand diagnostic errors in radiology so that steps can be implemented to decrease future mistakes.

References

1. Berlin L. Accuracy of diagnostic procedures: has it improved over the past five decades? *AJR* 2007; 188:1173–1178
2. Smith M. *Error and variation in diagnostic radiography*. Springfield, IL: Charles C. Thomas, 1967
3. Renfrew DL, Franken EAJ, Berbaum KS, Weigelt FH, Abu-Yousef MM. Error in radiology: classification and lessons in 182 cases presented at a problem case conference. *Radiology* 1992; 183:145–150
4. Robinson PJ. Radiology's Achilles' heel: error and variation in the interpretation of the Röntgen image. *Br J Radiol* 1997; 70:1085–1098
5. Gawande A. *Checklist manifesto: how to get things right*. New York, NY: Henry Holt and Company, 2009
6. Koetser IC, de Vries EN, van Delden OM, Smorenburg SM, Boermeester MA, van Lienden KP. A checklist to improve patient safety in interventional radiology. *Cardiovasc Intervent Radiol* 2013; 36:312–319
7. Martinez Del Pero M, Philpott C. A useful tool: systematic checklist for evaluating sinus scans. *Clin Otolaryngol* 2012; 37:82–84
8. Vaid S, Vaid N, Rawat S, Ahuja AT. An imaging checklist for pre-FESS CT: framing a surgically relevant report. *Clin Radiol* 2011; 66:459–470
9. Stoller D. A comprehensive tutorial in musculoskeletal imaging using the Stoller checklist technique. Stoller website. www.stollermskcourse.com/index.php?option=com_content&view=article&id=110&Itemid=144. Accessed December 18, 2012
10. Getty DJ, Pickett RM, D'Orsi CJ, Swets JA. Enhanced interpretation of diagnostic images. *Invest Radiol* 1988; 23:240–252
11. Weiser TG, Haynes AB, Dziekan G, Berry WR, Lipsitz SR, Gawande AA. Effect of a 19-item surgical safety checklist during urgent operations in a global patient population. *Ann Surg* 2010; 251:976–980
12. Berbaum KS, El-Khoury GY, Franken EA Jr, et al. Missed fractures resulting from satisfaction of search effect. *Emerg Radiol* 1994; 1:242–249
13. Ashman CJ, Yu JS, Wolfman D. Satisfaction of search in osteoradiology. *AJR* 2000; 175:541–544
14. Drew T, Võ ML, Wolfe JM. The invisible gorilla strikes again: sustained inattentional blindness in expert observers. *Psychol Sci* 2013; 24:1848–1853
15. Berlin L. Comparing new radiographs with those obtained previously. *AJR* 1999; 172:3–6
16. American College of Radiology. ACR practice guideline for communication of diagnostic imaging findings. American College of Radiology website. www.acr.org/~/media/C5D1443C9EA4424AA12477D1AD1D927D.pdf. Published 1991. Revised 2010. Accessed November 15, 2013
17. Hunter TB, Boyle RR. The value of reading the previous radiology report. *AJR* 1988; 150:697–698
18. White K, Berbaum K, Smith WL. The role of previous radiographs and reports in the interpretation of current radiographs. *Invest Radiol* 1994; 29:263–265
19. *Jane Blankshain v Dr. Uma D. Gavani and radiolgoists K. S. Vedentham and J Randall Lester,* 95L-4851 (Cook County Ill 1997)

20. Berlin L. Must new radiographs be compared with all previous radiographs, or only with the most recently obtained radiographs? *AJR* 2000; 174:611–615
21. American College of Radiology. ACR-SPR practice guideline for the performance of chest radiography. American College of Radiology website. www.acr.org/~/media/ACR/Documents/PGTS/guidelines/Chest_Radiography.pdf. Published 1993. Revised 2011. Accessed August 18, 2013
22. Siegle RL, Baram EM, Reuter SR, Clarke EA, Lancaster JL, McMahan CA. Rates of disagreement in imaging interpretation in a group of community hospitals. *Acad Radiol* 1998; 5:148–154
23. Borgstede JP, Lewis RS, Bhargavan M, Sunshine JH. RADPEER quality assurance program: a multifacility study of interpretive disagreement rates. *J Am Coll Radiol* 2004; 1:59–65
24. Fileni A, Fileni G, Mirk P, Magnavita G, Nicoli M, Magnavita N. Malpractice claims related to musculoskeletal imaging: incidence and anatomical location of lesions. *Radiol Med (Torino)* 2013 [Epub ahead of print]
25. Lawson JP. Symptomatic radiographic variants in extremities. *Radiology* 1985; 157:625–631
26. Lawson JP. Not-so-normal variants. *Orthop Clin North Am* 1990; 21:483–495
27. *Bey v Neuman, 100 AD3d 581 (NY App Div 2012)*
28. Kaufman, Borgeest, and Ryan, LLP. [Untitled document.] www.kbrlaw.com/news/view/46. Accessed August 17, 2013
29. Austin JH, Romney BM, Goldsmith LS. Missed bronchogenic carcinoma: radiographic findings in 27 patients with a potentially resectable lesion evident in retrospect. *Radiology* 1992; 182:115–122
30. Schofield TD, Youngberg RA. Chest radiograph interpretation and lung cancer: experience at Madigan Army Medical Center. *Mil Med* 1993; 158:297–299
31. White CS, Salis AL, Meyer CA. Missed lung cancer on chest radiography and computed tomography: imaging and medicolegal issues. *J Thorac Imaging* 1999; 14:63–68
32. Quekel LG, Kessels AG, Goei R, van Engelshoven JM. Miss rate of lung cancer on the chest radiograph in clinical practice. *Chest* 1999; 115:720–724
33. Monnier-Cholley L, Arrive L, Porcel A, et al. Characteristic of missed lung cancer on chest radiographs: a French experience. *Eur Radiol* 2001; 11:597–605
34. Manning DJ, Ethell SC, Donovan T. Detection or decision errors? Missed lung cancer from the posteroanterior chest radiograph. *Br J Radiol* 2004; 77:231–235
35. Berlin L. When interpreting radiologic studies, is the standard of care the same for board-certified radiologists, radiology residents, and nonradiology physicians? *AJR* 2012; 199:[web]W523
36. Silver B, Berlin L. Radiologists and obstetric sonography. *AJR* 1996; 167:301–302