

Opinion Paper

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Towards better metainterpretation: improving the clinician's interpretation of the radiology report

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Abstract: How the clinician interprets the radiology report has a major impact on the patient's care. It is a crucial cognitive task, and can also be a significant source of error. Because the clinician must secondarily interpret the radiologist's interpretation of the images, this step can be referred to as a "metainterpretation". Some considerations for that task are offered from the perspective of a radiologist. A revival of the tradition of discussing cases with the radiologist is encouraged.

Keywords: radiology; diagnostic error; incidental findings; physician communication.

Introduction

When, as a clinician, you receive a patient imaging report from a radiologist, how you interpret the text has a major impact on the patient's care. In the chain of events from ordering the test to taking action for the patient, this is a crucial cognitive task. It can also be a significant source of clinical error. In this essay I shall outline some tips for thinking about the report, and suggest ways to guard against error. Because we are discussing the clinician's interpretation of the radiologist's interpretation of the images, I will refer to it as a metainterpretation.

It is worthwhile to pause for a moment and consider what is happening when you begin to interpret a radiology report. It is a block of text generated by a complex process beginning with the technical acquisition of the images, through the perception by the radiologist of image findings, and onward through the radiologist's interpretation of those findings. The images themselves are lost in the

process, and along with them sometimes very important information, certainly whatever unremarked subtleties that may have existed there. For this reason, as a radiologist I never rely upon another radiologist's report alone unless I have no choice. Nevertheless, clinicians routinely must use the report to convert the pre-test probability of a diagnosis into a post-test probability. This road can be hazardous if traveled alone.

Metainterpretation: an example

A 24 year old man presented to the emergency department with intractable abdominal pain. CT showed adenopathy in the abdomen (Figure 1a). The radiologist read this as "probable lymphoma." The patient was also discovered to have acute hepatitis C. Work-up was headed towards a lymph node biopsy. He and his partner were very demanding that his pain was not being relieved and continually insisted on more pain medication. He had a history of opioid abuse, and was on methadone maintenance. Drug-seeking behavior was suspected. The liver consultant attributed the adenopathy to hepatitis, and suggested the patient be followed with a visit in 2 months after a repeat CT scan. The team was under the impression that the adenopathy could not account for the pain. So the patient was discharged.

A few weeks later he returned with uncontrolled pain. The adenopathy had increased and he now had extensive small bowel wall edema (Figure 1b and c). Surgery revealed extensive venous infarct. Most of his small bowel was resected. The adenopathy turned out to be anaplastic large cell lymphoma. He died a year later from his lymphoma after enduring short bowel syndrome and many other complications.

The clinicians failed to understand that, while adenopathy can indeed be seen with hepatitis, nodes in that disease are typically scattered around the porta hepatis and nearby regions. Bulky mesenteric adenopathy is not a feature of hepatitis. Also, the intense abdominal pain did not fit well with the diagnosis, but was discounted apparently because it was thought to represent drug-seeking

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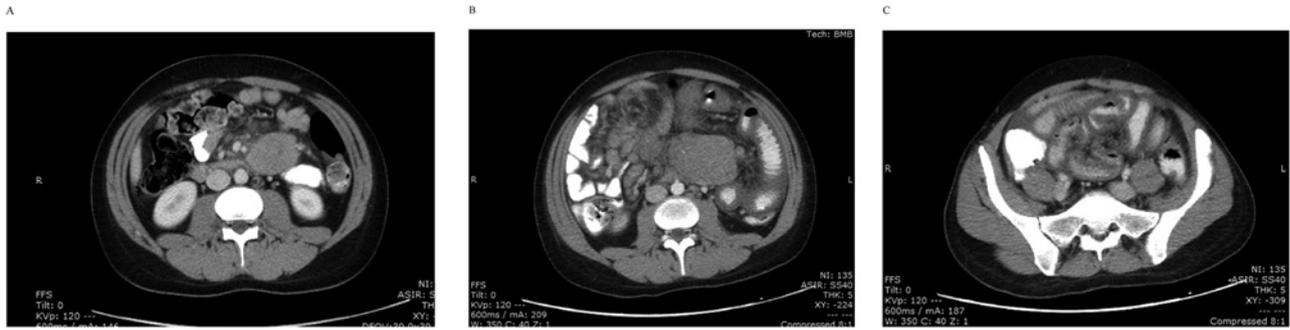


Figure 1: Young patient with abdominal pain. (A) 24 years old man with persistent abdominal pain and new diagnosis of hepatitis C. Bulky adenopathy is centered in the mesentery, with haziness of the surrounding mesenteric fat. This is not the pattern of adenopathy in hepatitis. He was discharged without biopsy. (B) A few weeks later he returned with uncontrolled abdominal pain. Mesenteric adenopathy had increased. (C) There was now small bowel wall thickening indicating edema. Surgery revealed extensive venous infarct of the small bowel. Lymph node biopsy showed anaplastic large cell lymphoma.

behavior. But pain can accompany certain conditions manifesting as mesenteric adenopathy. There is no record to suggest that the clinicians reviewed the images with a radiologist. It is unknown whether any looked at the images themselves.

An important point here is that complex imaging data reduced to a few words or simple concept can be dangerous. In this case the word was “adenopathy”. But not all adenopathy is alike. Details matter, patterns matter. Nonradiologists must be careful in their metainterpretation of radiology reports, especially when derived by looking at the images by themselves, or not looking at all. By way of contrast, few clinicians would rely upon their own interpretation of pathology slides. When new ideas arise about the possible diagnosis after the radiology exam, and those ideas may significantly impact care, the radiologist should be reconsulted.

Factors to consider in reading reports

Many factors determine whether a radiology test is accurate and will contribute meaningfully to the care of the patient. The report must be read with several important questions in mind:

- Was the appropriate test ordered?
- Were proper clinical history and indications provided to the radiologist?
- Was the exam technically adequate?
- Has comparison with old studies been done?
- Might there be radiologist perceptual error at play?
- Does the radiologist’s interpretation make sense?
- What exactly is the nature of the “incidental” findings?

- What actions might be considered based on this report?

We will touch on each of these questions in turn, then discuss how to proceed when the answers are unclear.

To select the correct radiology test, clinicians depend upon their experience and judgment, but also on habit and tradition. Sometimes there is good data to support these choices, and sometimes not. Examinations are not always appropriate for the clinical question, which has led to U.S. government mandates to “aid” clinicians by use of “decision support” software [1]. Yet clinicians have always had the option to confer with other physicians most knowledgeable about imaging, i.e., radiologists. Better communication at this point has untapped potential to improve care, and one would hope would be accepted by the government as an alternative to using software.

The clinical history is crucial to the radiologist who often needs to judge where to place his or her threshold to call an abnormality, and who may profit from a pretest differential diagnosis to best direct their attention [2–4]. Results of diagnostic tests are best understood in a Bayesian framework [5] for which a sense of the pretest probability of disease is necessary. Yet the provided indications are most often just a few words and salient facts are not always included [2]. The radiologist report is to be read in precisely the light of the history you have given. You cannot assume that the radiologist has spent time in the medical record to obtain more information, though good radiologists do that when needed. If you have not told the radiologist you are worried about something, he or she might not be thinking about it.

Technical adequacy is often entirely overlooked by clinicians. They are not in a good position to judge it, so must rely upon the radiologist. If the radiologist makes no

comment, the adequacy is usually good, since ensuring it is a major role of the radiologist that goes unremarked by others. But this is a subtle area, and radiologists seldom go into detail in the report about their reservations about exam quality. In a situation where a major decision is to be made, and if any question whatsoever arises about quality, reassurance from the radiologist should be sought.

Comparison with prior radiology studies is vitally important. In my own practice I often make useful new contributions simply by comparing a new study with an old one. The differential diagnosis can be profoundly altered by knowledge of its time course. If a radiologist has not done this it must be regarded as a major quality deficit. The clinician must make an effort to supply the old study in situations where it was obtained elsewhere and therefore unavailable to the radiologist. The competitive practices of hospital systems often deliberately make this difficult, negatively impacting patient care [6].

Perceptual mistakes by radiologists, meaning that the finding is missed or taken to be something it is not, are the cause of up to 80% of reading errors [7–9]. Practicing radiologists are aware that some radiologists are better than others in this regard, but everyone makes these kinds of mistakes to a lesser or greater degree. As Bruno et al. comment, the underlying causes of this type of error remain poorly understood. Findings readily apparent in retrospect can be inexplicably missed. Some worry that the high incidence of perceptual errors is intractable [10].

The clinician usually is not in a position to catch these errors, but nonetheless, looking at their patients' radiology studies is a time-honored practice. Certainly it was a regular practice of the most respected ones here at Yale as I went through training in the 1980s. With the advent of PAC systems, where radiologic images are easily retrieved by any clinician at a workstation, the extent to which this still happens is unclear to me. What I am certain about is that clinicians have largely stopped coming to the radiology department to talk with the radiologist. This has eliminated many second looks by radiologists, so an important element of redundancy has been diminished.

I encourage clinicians to look at their patients' studies, but strongly caution against taking action based on their own interpretation without first talking to the radiologist if the two readings differ in any important way. I often find the clinician's perspective enormously helpful in interpreting difficult cases, but have not been similarly impressed with their ability to directly interpret the findings themselves. Radiologists and clinicians have different skill sets, and both must guard against hubris when operating outside of them.

In making their own metainterpretations, clinicians must parse the radiologist's factual observations from their opinion or interpretation. The radiologist's interpretation is heavily dependent upon the history and change from prior studies, as previously mentioned. If the history is incomplete or incorrect, or the old studies are not available, risk of error increases. Not infrequently, the complete differential diagnosis is not given because it is too long to be helpful. Instead, most radiologists will give the most likely diagnoses. The fact that an alternative diagnosis is not mentioned does not necessarily mean that it would be inconsistent with the findings. This is another point where conversation works better than text on a page, as the former has a profound flexibility that the latter lacks.

When giving a differential diagnosis, I always ask myself whether there are any imaging or history features that are not accounted for. It is too easy to settle on a diagnosis that leaves out one unusual or unexpected finding. Though that finding may seem to be incidental, the question must always be asked how it relates to the presumed diagnosis. If this remains unclear, it may need to be addressed with another test.

Future information can change reports. The same appearance on a radiology study can have different significance when the history changes, whether because of a new test result or a new symptom. The radiologist does not know the future, but by the time of the metainterpretation the clinician sometimes does. This may require going back to the radiologist with the new information to reconsider their reading.

Clearly, the actions you take as a consequence of ordering the radiology examination are a direct result of your understanding of the radiology report. Various terms, even "adenopathy" as we saw in the example above, can be misconstrued or misunderstood.

Perhaps most problematic are terms meant to convey levels of uncertainty [11]. Clinicians are troubled by report terms that do not seem to be fully diagnostic. "Diagnostic of" confers confidence, whereas "consistent with" does not, even though the radiologist's intention in using both phrases may have been the same [12]. In an interesting study by Rosenkrantz et al., terms for a hypothetical liver lesion like "cyst", "benign cyst", "too small to characterize" and so on were ranked similarly in order of concern by radiologists and clinicians. But although radiologists attached no likelihood of malignancy to "cyst" and "benign cyst", clinicians did: 22% would order follow-up imaging for "cyst", but only 2% for a "benign cyst" [13]. One wonders how much unnecessary imaging is done because of this phenomenon. Methods to mitigate this have been proposed, but the problem persists [14, 15].

Incidental findings deserve special mention. They are the bane of existence for frequent users of radiology services. "Incidental" in this context is a treacherous term because of its ambiguity. It is used in two ways. One is to describe an unexpected finding of little or no clinical significance. The other is to describe an unexpected finding of possible or even definite clinical significance. Incidental findings frequently lead to unnecessary worry and further testing (for the first type) and uncertainty and even failure to follow up significant findings (for the second type). The fact that something was unexpected packs the element of surprise, so may seem to the radiologist worthy of note for that reason alone. But in fact all of a finding's importance lies in its clinical significance. Some commentators have suggested that inconsequential findings should not even be mentioned [16].

This problem is particularly acute in instances in which the incidental finding relates to a field of medicine outside that of the ordering clinician. They may feel that someone else is responsible for pursuing further workup or follow-up, but may not communicate that to the relevant parties. This may be more common in situations where multiple caregivers share responsibility. For example, a PET-CT in a patient with squamous cell head and neck cancer showed marked bilateral urinary obstruction from an enlarged prostate (Figure 2). The findings were clearly described by the original radiologist, but there is no record of follow up, and the patient presented 3 months later in renal failure

requiring hospitalization. The oncologist who ordered the scan did not follow through on a non-oncologic problem [17, 18].

Relying on the electronic medical record for any kind of active communication is hazardous unless a specific messaging feature is used, clinician to clinician. A significant finding languishing in the radiology report may never reach another clinician's eyes. The diffusion of responsibility leads to errors. The radiologist must also take responsibility; significant findings must be conveyed to the ordering clinician in a timely way, and the communication documented [19]. Radiologists can do their clinicians a great service by suggesting how to further image or follow-up such findings.

After the metainterpretation

After the clinician has interpreted the radiology report, if ambiguity or uncertainty remains, and important decisions hang in the balance, I strongly encourage speaking with the radiologist. Ideally, every clinician would know a radiologist whose judgment they trust. Even if a particular case is not within that radiologist's subspecialty, he or she is in a much better position than the clinician to route questions to an appropriate colleague. The call for radiologists to function more like consultants is not new [20, 21]. These relationships have

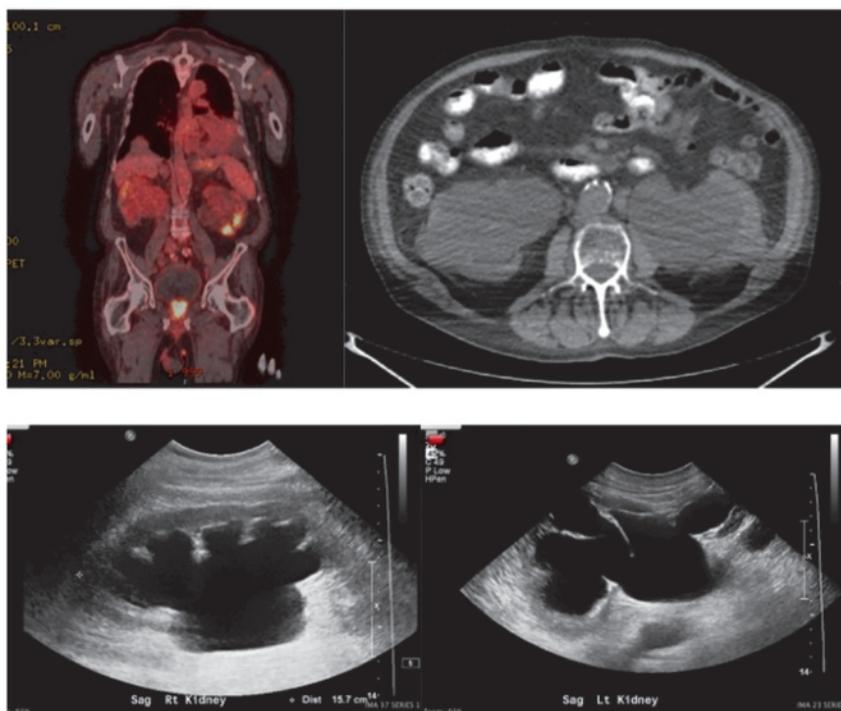


Figure 2: Urinary obstruction by prostatic hypertrophy. A 91 years old male with a history of submental involvement by squamous carcinoma of the skin had a PET-CT (upper row) that showed bilateral urinary obstruction from prostatic hypertrophy. This was reported by the radiologist, but not acted upon by the ordering oncologist, leading to admission three months later in renal failure. The ultrasound images (lower row) show marked bilateral hydronephrosis. The patient recovered most of his renal function after the obstruction was relieved.

withered over the years, but really there are no serious barriers even now to building such a relationship with one radiologist somewhere in your care network. Subspecialists at our hospital frequently have such relationships and I think view them as vital to the high quality of care they can give to their patients. Ideally, the reading radiologist's phone number would be listed on every report [22]. Using those phone numbers (and radiologists cheerfully answering them) should become part of the culture. Tools for better communication via the PACS and electronic medical record are also available [23].

A second review of images by a radiologist tends to decrease error [24–26]. The value likely comes in large part from the better history and more targeted and contextualized questions in this setting, and any new or additional information not available at the time of the original report. Even when the review does not change the original reading, discussion between radiologists and clinicians can have a major impact; in a striking study from Germany by Dendl et al., management was impacted in 37% of the patients even though only 1% of the original (unselected and already subspecialist-read) readings were changed [27]. Dickerson et al. showed that 43% of patients had their surgeons' clinical impression or plan changed by a biweekly conference with the abdominal radiologists, even though major discrepancies from the original report were seen in just 11% [28].

Conclusions

The radiologist interprets the imaging findings in light of the given history. The clinician must subsequently interpret that interpretation in the fuller light of the entire clinical picture. This “metainterpretation” requires great care and skill. Dialog with the radiologist offers rich potential to improve its completeness and accuracy.

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References

1. Moja L, Kwag KH, Lytras T, Bertizzolo L, Brandt L, Pecoraro V, et al. Effectiveness of computerized decision support systems linked to electronic health records: a systematic review and meta-analysis. *Am J Publ Health* 2014;104:E12–22.
2. Fatahi N, Krupic F, Hellstro M. Quality of radiologists' communication with other clinicians as experienced by radiologists. *Patient Educ Counsel* 2015;98:722–7.
3. Loy CT. Accuracy of diagnostic tests read with and without clinical information. *J Am Med Assoc* 2000;292:1602–9.
4. Leslie A, Jones AJ, Goddard PR. The influence of clinical information on the reporting of CT by radiologists. *Br J Radiol* 2000;73:1052–5.
5. Johnson KM Using Bayes' rule in diagnostic testing: a graphical explanation. *Diagnosis* 2017;4:159–67, De Gruyter Publications.
6. Rosenkrantz AB, Smith SW, Recht MP, Horwitz LI. Perceptions of radiologists and emergency medicine providers regarding the quality, value, and challenges of outside image sharing in the emergency department setting. *AJR Am J Roentgenol* 2020;214:843–52.
7. Donald JJ, Stuart A, Barnard SA. Common patterns in 558 diagnostic radiology errors. *J Med Imag Radiat Oncol* 2012;56:173–8.
8. Degnan AJ, Ghobadi EH, Hardy P, Krupinski E, Scali EP, Stratchko L, et al. Perceptual and interpretive error in diagnostic radiology - causes and potential solutions. *Acad Radiol* 2019;26:833–45.
9. Waite S, Scott JM, Legasto A, Kolla S, Gale B, Krupinski EA. Systemic error in radiology. *AJR Am J Roentgenol* 2017;209:629–39.
10. Bruno MA, Walker EA, Abujudeh HH. Understanding and confronting our mistakes: the epidemiology of error in radiology and strategies for error reduction. *RadioGraphics* 2015;35:1668–76.
11. Bruno MA, Petsavage-Thomas J, Abujudeh HH. Communicating uncertainty in the radiology report. *AJR Am J Roentgenol* 2017;209:1006–8.
12. Khorasani R, Bates DW, Teeger S, Rothschild JM, Adams DF, Seltzer SE. Is terminology used effectively to convey diagnostic certainty in radiology reports?. *Acad Radiol* 2003;10:685–8.
13. Rosenkrantz AB. Differences in perceptions among radiologists, referring physicians, and patients regarding language for incidental findings reporting. *AJR Am J Roentgenol* 2017;208:140–3.
14. Hillman BJ. Speaking of language. *J Am Coll Radiol* 2015;12:544.
15. Kabadi SJ, Krishnaraj A. Strategies for improving the value of the radiology report: a retrospective analysis of errors in formally over-read studies. *J Am Coll Radiol* 2017;14:459–66.
16. Pandharipande PV, Herts BR, Gore RM, Mayo-Smith WW, Harvey HB, Megibow AJ, et al. Rethinking normal: benefits and risks of not reporting harmless incidental findings. *J Am Coll Radiol* 2016;13:764–7.
17. Al-Mutairi A, Meyer AND, Chang P, Singh H. Lack of timely follow-up of abnormal imaging results and radiologists' recommendations. *J Am Coll Radiol* 2015;12:385–9.
18. Kim YW, Mansfield LT. Fool me twice: delayed diagnoses in radiology with emphasis on perpetuated errors. *AJR Am J Roentgenol* 2014;202:465–70.
19. Siewert B, Brook OR, Hochman M, Eisenberg RL. Impact of communication errors in radiology on patient care, customer satisfaction, and work-flow efficiency. *AJR Am J Roentgenol* 2016;206:573–9.
20. Gunderman RB, Chou HY. The future of radiology consultation. *Radiology* 2016;281:6–9.
21. Paz D. The radiologist as a physician consultant. *J Am Coll Radiol* 2010;7:664–6.

22. Bilyj B. A direct line to radiologists. American College of Radiology, Imaging 3.0 in Practice, Reston, Virginia, USA; September 2018.
23. Rosenkrantz AB, Sherwin J, Prithiani CP, Ostrow D, Recht MP. Technology-assisted virtual consultation for medical imaging. *J Am Coll Radiol* 2016;8:995–1002.
24. Abujudeh HH, Boland GW, Kaewlai R, Rabiner P, Halpern EF, Gazelle GS, et al. Abdominal and pelvic computed tomography (CT) interpretation: discrepancy rates among experienced radiologists. *Eur Radiol* 2010;20:1952–7.
25. Pow RE, Mello-Thoms C, Brennan P. Evaluation of the effect of double reporting on test accuracy in screening and diagnostic imaging studies: a review of the evidence. *J Med Imag Radiat Oncol* 2016;60:306–14.
26. Lauritzen PM, Andersen JG, Stokke MV, Tennstrand AL, Aamodt R, Heggelund T, et al. Radiologist-initiated double reading of abdominal CT: retrospective analysis of the clinical importance of changes to radiology reports. *BMJ Qual Saf* 2016; 25:595–603.
27. Dendl LM, Teufel A, Schleder S, Rennert J, Stroszczynski C, Mueller-Schilling M, et al. Analysis of radiological case presentations and their impact on therapy and treatment concepts in internal medicine. *Fortschr Röntgenstr* 2017;189: 239–46.
28. Dickerson EC, Alam HB, Brown RKJ, Stojanovska J. In-person communication between radiologists and acute care surgeons leads to significant alterations in surgical decision making. *J Am Coll Radiol* 2016;13:943–9.