

## Keeping Abreast of Breast Imagers: Radiology Pathology Correlation for the Rest of Us

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### Background

Breast imagers are expected to correlate pathology results of their biopsies and determine if these are concordant with imaging findings. Other subspecialties correlate pathology results less rigorously, particularly for diagnostic, non-interventional examinations though correlation in this setting can provide rich and meaningful feedback at all levels of experience. Such an explicit expectation does not currently exist for other subspecialties though they perform similar diagnostic and interventional procedures, but it can be useful for ensuring quality of procedures and for continuing educational feedback. Whenever a biopsy is performed, the adequacy of a sample to render a diagnosis is a key quality measure. Even in the case of a non-interventional diagnostic examination, if the pathologic diagnosis does not appear consistent (concordant) with contrast enhancement multidetector computed tomography (ceMDCT) or magnetic resonance imaging (MRI) lesion characteristics, this should prompt further evaluation and, possibly, further workup with biopsy. Alternatively, if the pathologic diagnosis is accurate and was not initially considered in the imager's report, this serves as direct educational feedback that has the potential to improve report quality. Ideally, pathologic results should be seamlessly integrated into the imager's daily workflow in all subspecialties across the department to provide better patient care and better feedback regarding the adequacy and concordance of image-guided biopsy samples and the accuracy of differential diagnoses rendered on diagnostic imaging studies. Having a repository of pathology-proven cases in a dashboard also has the potential to enhance and encourage the formation of accurate teaching files, as well as educational publications in the form of case series or "case of the day" submissions.

### Case Presentation

Each night we retrieve all pathology results from our clinical database where the patient had any radiology exam or procedure performed within 60 days prior. We exclude plain film dictations as these tend to be lower yield in generating differential diagnoses as compared to cross sectional imaging. Radiographs also tend to decrease the specificity of our algorithm as a routine pre-procedural chest radiograph is generally not as appropriate to display on the radiologist's dashboard as the chest CT preceding and prompting the lung biopsy. We also excluded lower extremity ultrasounds as these very infrequently have meaningful pathology follow-up and their inclusion resulted in false-positive matches in our first iteration.

Our methodology is novel and distinct compared to prior work in that we annotate our radiology and pathology reports with a limited subset of anatomical concepts from the RadLex ontology which allows us to provide pathology results on diagnostic as well as interventional examinations (1). We first annotate our pathology reports using an instance of the National Center for Biomedical Ontology (NCBO) Annotator hosted locally on a virtual machine. Radiology reports for the same patient are similarly annotated. We found that our false positive rate improved if we excluded the "clinical history" section of radiology reports. If any of the two most frequent concepts found in the pathology report are found in the radiology report, we consider this a relevant match. A subset of matched radiology/pathology reports were reviewed and verified for accuracy by a second-year radiology resident.

Matches are presented to the radiologist through our web-based radiology-pathology dashboard. Users can select a custom date range, can view the radiology reports with correlative pathology reports, view those interventional procedures that may not yet have correlative pathology results, and provide feedback on the presented matches (Figure 1). Feedback categories include Concordant meaning the pathology result is expected given the interventional or diagnostic findings, Discordant meaning the pathology result is unexpected and that further workup may be warranted, and Irrelevant meaning the presented correlative pathology result is completely irrelevant (e.g. a lung biopsy result presented for a CT of a lower extremity). The first two categories help us identify those results that may need further workup. The last category is intended to help us identify nonsensical matches and to then refine our matching algorithm to present more meaningful results.

Figure 1

The screenshot shows a web interface for 'Radpath'. At the top left, there is a 'Radpath:' label followed by a redacted area. To the right is a 'Logout' button. Below this, there are two date input fields: 'From' with the value '2015-07-01' and 'To' with the value '2015-09-12', followed by a blue 'Go!' button. To the right of the date fields is a 'Filters:' section with five colored buttons: 'Concordant' (green), 'Discordant' (yellow), 'Irrelevant' (pink), 'Biopsy' (dark blue), and 'Diagnostic' (light blue).

Again, the benefit of our algorithm is feedback for both diagnostic studies and for procedures. For example, a rib lesion diagnosed on a chest CT as a chondroid neoplasm, is confirmed by biopsy (Figure 2).

Figure 2

The screenshot displays a dashboard for a specific match. At the top right, the date '07-09-2015' and the text 'Pathology Tissue Request' are visible. Below this, there are three tabs: 'Concordant' (highlighted in green), 'Discordant' (yellow), and 'Irrelevant' (pink). The main content area is split into two columns. The left column contains radiology report text, and the right column contains pathology report text. The match is confirmed as 'Concordant'.

**Radiology Report (Left Column):**

PROCEDURE: CT 4728 - CT THORAX W/O IV CONTRAST  
 DATE OF EXAM: Jul 9 2015 7:15AM

CLINICAL INFORMATION: Left rib fracture in 2006, now with enlarging palpable chest mass.

TECHNIQUE: Axial CT images through the chest were performed without the administration of intravenous contrast. Sagittal and coronal reformatted images were generated and reviewed.

COMPARISON: Outside chest radiograph May 04, 2015.

FINDINGS:

TRACHEA AND AIRWAYS: The central airways are patent.

LUNGS AND PLEURA: No focal consolidation, suspicious pulmonary nodule, pleural effusion, or pneumothorax.

THYROID GLAND: Homogenous appearance of the thyroid gland.

MEDIASTINUM, PULMONARY HILA AND AXILLAE: No bulky mediastinal, hilar, or axillary lymphadenopathy.

CARDIOVASCULAR: Normal heart size without pericardial effusion. Normal caliber thoracic aorta.

UPPER ABDOMEN: Limited noncontrast images through the upper abdomen demonstrates left subdiaphragmatic surgical clips.

SOFT TISSUES: Left anterior eighth rib soft tissue nodule measuring approximately 3.2 x 2.1 cm (series 2, image 111) with internal mineralization/calification centered over the cartilaginous portion of the costochondral junction.

IMPRESSION:

1. Soft tissue nodule with internal calcification centered over/contiguous with the cartilaginous portion of the left eighth anterior costochondral junction, concerning for chondroid neoplasm, like chondrosarcoma. Tissue biopsy is recommended. Location is amenable to image-guided biopsy.

**Pathology Report (Right Column):**

Surgical Pathology Report

Accession Number: [REDACTED]  
 Procedure Date/Time: 07/24/2015 11:00:00 EDT  
 Received Date/Time: 07/24/2015 11:36:00 EDT  
 Verified Date/Time: 07/29/2015 13:17:17 EDT  
 Pathologist: [REDACTED]

Source of Specimen  
 A Left lower rib mass biopsy

Final Diagnosis  
 Left lower rib, mass, CT-guided biopsy:  
 - Mildly hypercellular cartilaginous lesion, favor a chondroid neoplasm (see, "Comment").

Comment:  
 The biopsy shows fragments of chondroid tissue with mildly increased cellularity and some clustering/crowding of lacunae, but no conspicuous cytologic atypia. Although there is no unequivocal evidence of malignancy in this biopsy material, an excisional specimen may be necessary to more fully characterize this lesion.

Hereby I certify that I have personally examined the above specimen and reviewed the report.

The radiologist who made the imaging diagnosis gets direct feedback confirming their findings. The pathology results for a CT-guided bone marrow biopsy confirm both the adequacy of the sample provided, as well as the diagnosis (Figure 3).

Figure 3

The screenshot shows the Radpath interface with the following details:

- Search:** From 2015-04-01 To 2015-09-12
- Filters:** Concordant, Discordant, Irrelevant, Biopsy, Diagnostic
- Report Title:** CT BIOPSY BONE MARROW
- Date:** 04-01-2015
- Procedure:** CT 9422 - CT BIOPSY BONE MARROW
- Date of Exam:** Apr 1 2015 11:09AM
- Indication:** History of AML.
- Final Diagnosis:** Bone marrow biopsy, bone marrow aspirate and peripheral blood smear:
  - Normocellular marrow with maturing trilineage hematopoiesis including adequate megakaryocytes.
  - No morphologic or flow cytometric evidence of increased blasts, consistent with remission of known AML (see, "Note").
- Note:** Biopsy is adequate and normocellular with approximately 70% cellularity. Maturing trilineage hematopoiesis is seen. No blastic groups are identified. Reticulin stain shows focal 1+ increase in reticulin fibrosis. Control stains adequately.
- Aspirate smears:** Aspirate smears are of good quality and confirm the above findings. Erythropoiesis is normoblastic. Myeloid maturation is complete to neutrophil stage. No increase in blasts is seen.
- Peripheral blood smear:** Peripheral blood smear shows normal WBC but decreased platelet counts and with no circulating blasts.

## Outcome

On initial review of 124 matched pathology/radiology (both diagnostic imaging and image-guided procedures) by a second-year radiology resident, the sensitivity of our algorithm was 47%, specificity was 92%, and accuracy was 71%. Of the 5 false positive reports, 3 could be attributed to information in the “clinical history” section of the radiology report that was irrelevant. For example, a patient history of “small bowel transplant” on dictations for a chest radiograph, a lower extremity Doppler, and a pelvic ultrasound report were erroneously linked with a pathology report of a small bowel biopsy. Given the number of irrelevant radiographs and lower extremity ultrasounds discovered on this review, these were excluded from future iterations. With these exclusions applied to a review of 576 matched reports, our sensitivity increased to 60%, specificity increased to 93%, and our accuracy increased to 77%.

One interesting outcome of this real-world application of the RadLex ontology was what we felt could be useful suggestions for new or modified entries. For example, a radiology report of a sinus CT was not successfully matched with pathology results for a sinus biopsy because the term “sinus” is not in the RadLex ontology. Curiously, pleural effusion cytology reports and chest CT radiology reports were not matched because although RadLex does recognize “pleura”, it does not include the term “pleural”. Although CSF and cerebrospinal fluid are essentially synonyms, “CSF” is not in the RadLex ontology, making lumbar puncture cytology results and brain and/or spine MRIs difficult to reconcile. “Disc” and “disk” are not included as

synonyms of “intervertebral disk” which could be useful. “L3-L4” could be included as a synonym of “L3/L4” to account for different ways of dictating intervertebral disc levels. “Renal” could be included as a synonym of “kidney” which would have been helpful when a radiology report refers to a “renal biopsy” but the pathology report only mentions “kidney” as the specimen.

## Discussion

Pathology is the radiologist’s gold standard. In the current climate of quality measures and standards, a seamless, consistent system (i.e. a dashboard) for presenting correlative pathology across the entire range of interventional and diagnostic radiology examinations provides several benefits. First, the imager receives pathology results on images where a novel finding (i.e. a new liver mass) prompts a differential diagnosis. Many times, the radiologist plans to “follow up” an interesting and complex imaging case, but workflow demands and cumbersome electronic medical record query can exhaust even the most dedicated and well-intentioned imager. Our user-friendly platform displays pathologic results for relevant imaging studies and eliminates this practice, ultimately potentially influencing the imager’s receiver operating characteristic (ROC). Second, the procedure-oriented imager should have knowledge of the success rate of their image-guided biopsies and ultimately, if the pathology results are concordant or discordant with ceMDCT or MRI imaging findings. Such consistent feedback achieves two main endpoints: 1) Provides meaningful assessment of the value added of an image-guided biopsy. 2) Alerts the clinician of the need for further evaluation if discordance is discovered.

The potential added benefit of having a dashboard of pathology-proven diagnostic cases is the enhancement of teaching files, as well as potentially encouraging the publication of case-based publications. Other institutions have applied RadLex and natural language processing (NLP) to automating the creation of teaching files (2). However, these methods have only been applied to the radiology report and have not included the “gold standard” of the pathologist’s input. Our study builds and expands on these practices. Having a known diagnoses gives the imager more confidence and credibility in presenting these cases in an educational setting, and in this way enhances the quality of cases presented to trainees.

We present an automated method of correlation for all diagnostic images and interventional procedures. Presentation of these correlates improves clinical understanding, furthers radiology education, and perhaps more importantly, patient care can be improved as discordant pathology results can prompt additional workup via biopsy or further imaging. The added benefit of our study in utilizing the comprehensive lexicon RadLex in developing this radiology-pathology dashboard, was the discovery of potential additions to the current lexicon, such as “lumbar puncture”, “sinus”, “pleural” “CSF” (cerebrospinal fluid), and others described above which might help improve this valuable ontology.

## Conclusion

Automatically presenting radiology pathology correlation for all diagnostic imaging and interventional procedures is an important means for continuing educational feedback, enhancing radiologist competency and confidence, and improving patient care. Application of RadLex to intelligently match radiology and pathology reports allows expansion of correlative pathology feedback beyond interventional procedures to include diagnostic radiology examinations, ensuring that both the proceduralist and the diagnostic imager benefit from the pathologist’s input.

## References

1. Langlotz CP. RadLex: a new method for indexing online educational materials. *RadioGraphics* 2006; 26(6):1595–1597.
2. Do BH, Wu A, Biswal S, Kamaya A, Rubin DL. RADTF: a semantic search-enabled, natural language processor-generated radiology teaching file. *Radiographics* 2010 Nov;30(7):2039-48.

## Keywords

Radlex, Radiology Pathology Correlation, Radiology Education, Dashboard