Technical Report

RadPath: A Web-based System for Integrating and Correlating Radiology and Pathology Findings During Cancer Diagnosis

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Rationale and Objectives: The current paradigm of cancer diagnosis involves uncoordinated communication of findings from radiology and pathology to downstream physicians. Discordance between these findings can require additional time from downstream users to resolve, or given incorrect resolution, may adversely impact treatment decisions. To mitigate this problem, we developed a web-based system, called RadPath, for correlating and integrating radiology and pathology reporting.

Materials and Methods: RadPath includes interfaces to our institution's clinical information systems, which are used to retrieve reports, images, and test results that are structured into an interactive compendium for a diagnostic patient case. The system includes an editing interface for physicians, allowing for the inclusion of additional clinical data, as well as the ability to retrospectively correlate and contextualize imaging findings following pathology diagnosis.

Results: During pilot deployment and testing over the course of 1 year, physicians at our institution have completed 60 RadPath cases, requiring an average of 128 seconds from a radiologist and an average of 93 seconds from a pathologist per case. Several technical and workflow challenges were encountered during development, including interfacing with diverse clinical information systems, automatically structuring report contents, and determining the appropriate physicians to create RadPath summaries. Reaction to RadPath has been positive, with users valuing the system's ability to consolidate diagnostic information.

Conclusions: With the increasing complexity of medicine and the movement toward team-based disease management, there is a need for improved clinical communication and information exchange. RadPath provides a platform for generating coherent and correlated diagnostic summaries in cancer diagnosis with minimal additional effort from physicians.

Key Words: Integrated reporting; Cancer diagnosis; Clinical workflow.

INTRODUCTION

Cancer is one of the leading causes of death in the United States (1). Pathology and radiology form the basis of cancer diagnosis, yet the specialties remain isolated, reporting findings independently and often having only minimal communication. The combination of these factors may result in radiologic-pathologic discordance, defined as a discrepancy between imaging and histologic findings (2). Radiologic-pathologic correlation is utilized in various imaging specialties as a tool to assess the utility of new imaging modalities, to gauge interpretive performance, and to identify radiographic features corresponding to histologic findings (3–8). However, correlation in these instances takes place for research or quality assurance purposes, and is generally not a normal part of radiologist or pathologist workflow.

Radiologic-pathologic discordance can be problematic for the ordering clinician, who is left with the task of reconciling the diagnostic conflict (9). The process of resolution may encompass a spectrum of actions depending on the specific findings, but examples include (1) contacting both the radiologist and the pathologist for clarification of findings; (2) concluding that the computed tomography (CT)-guided biopsy retrieved tissue was not representative of the lesion of concern;

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or (3) accepting the histologic findings as the final diagnosis and mistakenly interpreting an inadequately sampled lesion as benign. Such actions may lead to a false-negative conclusion in which cases of high radiographic suspicion of malignancy are misdiagnosed as benign, leading to delay in diagnosis with subsequent higher treatment costs and worse clinical outcomes (10,11). A recent study found a nearly 20% discordancy rate in mammography biopsies, with over 1.2% resulting in delayed diagnosis of a carcinoma (12). Extrapolated nationally, this type of discordancy was projected to result in 9969 missed diagnoses of malignant disease. Other studies have found similar results in breast imaging with false-negative rates of image-directed core biopsies estimated to be between 1% and 9% (13–17).

In 2010, costs from the diagnosis and treatment of cancer were estimated to be $124.6 billion, and are expected to rise 39% to $173 billion by 2020 (18). Opportunities to lower costs in oncology may be realized through a variety of measures, including the establishment of multidisciplinary care teams and improvements to care coordination (19,20). Such team-based care requires enabling technologies that more effectively exchange information between providers (21), and succinctly highlight salient data points and educational information as the number of diagnostic tests grows with the realization of precision medicine (22). A system that more effectively integrates diagnostic findings could also reduce ambiguous conclusions impacting clinical care. In 2008, a pilot study of 106 breast cancer screening patients at the University of Kansas Medical Center found that a weekly audio-video conference between radiologists and a pathologist affected treatment plan decisions in over one-third of discordant cases (23). The radiologists and the pathologists came to an agreement on a treatment recommendation for each case and subsequently generated a "concordancy report" that was then sent to the ordering physician.

The goal of our project was to create a web-based platform for cancer diagnosis that is incorporated with the electronic medical record (EMR) and enables new methods of communication and coordination for oncology care teams. Current EMR systems are encounter driven, and offer little support for integrating the contents of separate clinical reports over time. The proposed system was designed to overcome two problems with current workflows: (1) a lack of communication between radiology and pathology resulting in discordant diagnostic conclusions, and (2) the amount of effort required for a downstream clinician (e.g., surgeons and oncologists) to locate and review information when determining a diagnosis and when developing a treatment plan. To address these problems, the system retrieves clinical reports and diagnostic tests, and joins them in a compendium highlighting the most important contents from each data source. An associated workflow ensures that diagnostic conclusions are correlated and further action steps (if necessary) are suggested. In this paper, we present a methodology for creating integrated reports, followed by a corresponding implementation in lung cancer diagnosis, a process where achieving radiology-pathology concordance is challenging (24). Usage statistics and user satisfaction scores obtained over a 12-month period are presented for the described system.

MATERIALS AND METHODS

System Architecture

Before development, a team of clinicians and informaticians collaborated to develop a methodology for selecting, prioritizing, synthesizing, and presenting information in an integrated diagnostic report. As described in detail in Figure 1, the team divided the task into multiple steps. The process begins with determining the information systems containing the relevant clinical documents, followed by the specification of the actual reports (e.g., pathology reports). Next, diagnostic elements within the reports (e.g., pathology final diagnosis) are targeted for integration based on their diagnostic salience. Given the diagnostic area, existing clinical data, and clinical workflows, report creators may consider what new information can be synthesized and can be added to the report to further the diagnostic process and provide actionable guidance for the referring clinician. Finally, a discussion regarding how the information elements should be accessed and organized for presentation will help to guide the eventual design and implementation of the interactive report. Across the various steps, designers should be aware of how data from a source may be modified over time (e.g., an amendment) and how such modifications may affect the integrated report. Additionally, there are legal requirements that must be adhered to at federal, state, and institutional levels, especially if new diagnostic information is synthesized.

Following the previously mentioned process, the *RadPath* system was designed as a web-based application using the Java-based Grails framework, with support for modern web browsers (IE8+, Firefox, and Chrome). This design enables RadPath summaries to overcome the constrained representations required by our EMR, which does not allow for the rich presentation of, and interaction with, textual elements and key images from radiology and pathology studies. Furthermore, RadPath summaries have the additional flexibility of being created and being viewed on any device with a web browser. The application has data feeds from several of our hospital's information systems: (1) a Digital Imaging and Communications in Medicine (DICOM) feed for retrieving images and reports from our General Electric (Fairfield, CT) Centricity radiology picture archiving and communication system (PACS) and radiology information system; (2) a structured query language stored procedure for retrieving reports, test results, and images from our Sunquest (Tucson, AZ) laboratory information system; and (3) a connection to our hospital's single sign-on server for user authentication and authorization. Additionally, the system utilizes a custom Health Level 7 (HL7) interface that communicates RadPath results to our Epic (Verona, WI) EMR in the form of hyperlinks, which may be clicked to display the specified RadPath summary in a web