Development and Enterprise-Wide Clinical Implementation of an Enhanced Multimedia Radiology Reporting System

Andrew B. Rosenkrantz, MD, MPA, Yvonne W. Lui, MD, Chandan P. Prithiani, MS, Philip Zarboulas, BS, Fabien Mansoubi, BS, Kent P. Friedman, MD, Dana Ostrow, BA, Hersh Chandarana, MD, Michael P. Recht, MD

THE PROBLEM

The radiology report is the most important means of communication between radiologists and clinicians, often serving as the only communication in the current digital environment [1]. Therefore, it is critical that radiology reports provide clear content that clinicians may efficiently access and understand. However, the standard prose text constituting the traditional report has numerous limitations, including suboptimal characterization of complex abnormalities, inefficiency inherent in clinicians' need to independently access images to visualize described findings, and, most important, potential miscommunication regarding pathology that can affect patient care [1,2].

An alternative approach is to transform the report into an enhanced format complementing text with multimedia elements [3-5]. Remarkably, despite repetitive calls for new reporting approaches [2,4], and descriptions of various software approaches for multimedia reporting dating back more than 20 years [5-9], radiologists continue to overwhelmingly use standard prose. This may relate to technical hurdles to clinical implementation at an enterprise level [3]: systems are needed for the creation and viewing of such reports, which must be seamlessly linked with the PACS and electronic medical record; these systems must identify references to key images within the text, extract and modify such images for incorporation into the report, and generate the enhanced document itself. Systems must be accessible, quick, and easy for radiologists and clinicians to use. Thus, although there is clear value to enhanced reporting, prior initiatives have not achieved successful integration into large enterprise systems or broad incorporation into practice.

We have undertaken an initiative to incorporate an enhanced reporting tool into our practice within a large academic medical center, aimed to be tightly integrated into existing enterprise technologies and to be easy and efficient for radiologists and clinicians to use. Our initial version incorporates embedded images and tabular tracking of lesions across serial examinations. Herein we describe our early experience in the development and enterprise-wide implementation of this enhanced multimedia radiology reporting system.

IMPLEMENTATION OF THE ENHANCED RADIOLOGY REPORT

Two authors (PZ and FM) are employees of Primordial Design Inc., which did not provide financial assistance; the remaining authors had full control over all data.

Our department collaborated with a commercial vendor (Primordial Design Inc.) in the tool's development. Radiologists compose enhanced reports using the same dictation system used for standard reports. During dictation, the enhanced report is automatically created in a separate window using an internally developed lexicon for triggering the inclusion of multimedia elements on the basis of expressions within the standard report; no additional commands are required. The radiologist may view the enhanced report to ensure the accuracy of multimedia elements, while directly editing only the standard report (which leads to automatic updating to the enhanced report).

During dictation, the tool continually scans the report for references to specific images via series and image number. These references serve as hyperlinks within the enhanced report to corresponding images. In addition, a panel within the enhanced report demonstrates thumbnails of referenced images.

The reporting tool also scans the standard report for tags that identify descriptions of lesions. Content regarding these lesions populates a lesion-tracking table that can be used to track lesion size across examinations. Dictation macros were created to insert these tags into the report using a single command. The system then scans the tagged sentence to identify the lesion's size and its series and image reference. The table is populated with location, size, and hyperlinked image reference of tagged lesions. For follow-up examinations, the tool extracts lesion content from the table populated during the previous examination and inserts the lesion's new size and image reference into new columns. Over time, the tool yields a single table that provides sizes of multiple lesions in multiple organs across examinations, with hyperlinks to representative images on each examination.

When clinicians view a standard report in the electronic medical

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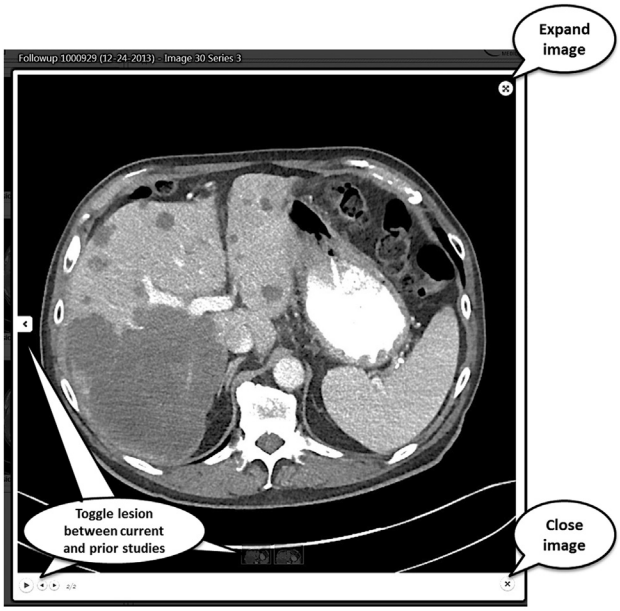

Fig 1. Example of embedded image associated with enhanced report; functionality of buttons is indicated in overlay. The reporting tool automatically extracts images of key lesions on the basis of recognition of series and image references within report text and associates images of such lesions across serial examinations.

record, an alert indicates that an enhanced report is available. Clicking the alert opens the enhanced report in a separate window, including embedded images (Fig. 1) and lesion-tracking table.

EVALUATION

A "Feedback" button at the top of the enhanced report generated a window prompting the clinician to answer 3 multiple-choice questions relating to the tool's ease of use, the value of multimedia elements, and comparison with the standard report. Survey respondents were subsequently solicited by e-mail to provide more in-depth feedback through free-response questions. Feedback regarding report creation was also solicited in a multiple-choice survey of radiologists.

This feedback was obtained as part of operations of the tool's design committee. Our institutional review board indicated that approval was not needed to evaluate feedback results.

FEEDBACK

Clinicians completed 50 multiple-choice surveys, indicating the enhanced report to be easy or very easy to use in 92% of cases, multimedia elements to be valuable or very valuable in 66%, and the enhanced report to be preferable over the standard report in 76% (Fig. 2). On the basis of free-response questions (Table 1), clinicians found multimedia elements to be useful; little extra time was needed to access and use the enhanced reports; the enhanced reports were likely to influence patient care, although not necessarily for all patients and referrers; and the enhanced reports would be used in a broad variety of ways, including to demonstrate findings to patients, enhance patient education, provide content to paste into clinic notes, guide surgical procedures, and save time compared with manually identifying images within the PACS.

Radiologists indicated that the amount of extra time needed to construct the enhanced report was <2 min for 8 of 10 respondents, the enhanced reports correctly captured embedded images and lesion information most of the time for 9 of 10 respondents, the tables were easy to construct for 6 of 8 respondents (two nonrespondents), the tool was disruptive to normal workflow for 1 of 10 respondents, and the enhanced report allowed better communication of findings for all 10 respondents.

DISCUSSION

Our enhanced radiology reporting system was integrated into existing IT infrastructure within a large academic medical center and applied in real time to clinical examinations. Clinicians overall viewed the reports as quick and easy to use, providing useful content, preferable to standard reports, and generally likely to influence care. Clinicians identified various ways in which the system would benefit patients and their own workflow.

Even the most thorough textual descriptions fail to reflect subtleties of images that may become readily apparent upon direct image review [1]. Furthermore, even if the radiologist provides the series and image number, it can still be labor and time intensive for the clinician to load the examination in the PACS and manually identify the image [4]. Given the increasing complexity of radiologic examinations, clinicians may encounter difficulty and give up prematurely. Thus, embedding images directly links the imaging with the report and helps align radiologists' and clinicians' perceptions of abnormalities.

An additional aspect of our system was the table for tracking lesions across examinations. This feature may have particular benefit in oncology patients undergoing drug therapy. Guidelines such as the Response Evaluation Criteria in Solid Tumors require extracting serial measurements in a highly precise fashion. It may be time consuming and confusing, if not impossible, for clinicians to obtain such measurements from nonstructured reports. Even if the same lesions are tracked across serial examinations, these may be described in a different order or using different terminology. The lesion-tracking table in our enhanced report encourages radiologists to describe the same lesions using similar structure and