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Streamlining Radiologist Workflow for Multidisciplinary Conferences: A Web-Based System to Represent Radiology

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Abstract
Radiologists are an integral component in patient care and provide valuable information at multidisciplinary tumor boards. However, the radiologists' role at such meetings can be compromised by technical and workflow limitations, typically including the need for complex software such as picture archiving and communication system (PACS) applications which are difficult to install and manage in disparate locations with increasing security and network limitations. Our purpose was to develop a web-based system for easy retrieval of images and notes for presentation during multidisciplinary conferences and tumor boards. Our system allows images to be viewed from any computer with a web browser and does not require a stand-alone PACS software installation. The tool is launched by the radiologist marking the exam in PACS. It stores relevant text-based information in a MySQL server and is indexed to the conference for which it is to be used. The exams are then viewed through a web browser, via the hospital intranet or virtual private network (VPN). A web-based viewing platform, provided by our PACS vendor, is used for image display. In the 28 months following implementation, our web-based conference system was well-received by our radiologists and is now fully integrated into daily practice. Our method streamlines radiologist workflow in preparing and presenting medical imaging at multidisciplinary conferences and overcomes many previous technical obstacles. In addition to its primary role for interdepartmental conferences, our system also functions as a teaching file, fostering radiologist education within our department.

Keywords Multidisciplinary conference · Tumor board · Workflow · Education

Background

In the modern era of patient-centered, value-based healthcare, multidisciplinary clinical care conferences are the standard for safe and effective patient management, particularly for complex or otherwise challenging cases [1]. Specialists from many divisions meet to discuss the relevant clinical, imaging, and pathologic findings for a particular patient and disease entity and then arrive at a consensus as a group for the next steps in patient management; such practice has led to improved patient outcomes [1]. In many instances, medical imaging plays a critical role in the diagnosis, surveillance, and assessment of treatment response [2]. At these meetings, radiologists provide key value by describing complex cases, offering interpretations of outside studies and reducing repeat imaging, thereby helping to guide clinical decisions [3]. Despite this integral and nearly ubiquitous need, there is not a standardized method for presentation, and the quality of imaging presentation can be somewhat variable [1].

Furthermore, radiologists' preparation for such meetings has historically required significant effort with technical and workflow challenges [4]. Typically, a list of cases is compiled by the clinical service. The radiologist has to view this list, possibly printed on paper, and locate relevant studies, imaging findings, and key images or sequences. Further notations are typically required to document the context of the case and any relevant clinical history or questions. PACS does not commonly provide robust enough features to document this metadata, so it can be done on paper which can easily be lost; or electronically, which requires operating a separate portable device; or less reliably by memory. At the multidisciplinary meeting, the radiology exams are commonly viewed using stand-alone PACS software that is installed and maintained

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on a computer at the meeting location. Frequently, at least in our experience, interdisciplinary meetings are held in a wide variety of conference rooms and locations with computers that are under different information technology jurisdictions; it can be very challenging to install, manage, troubleshoot, and upgrade complex software such as PACS across this variable landscape. To address this problem, Halsted et al. created a web-based teaching file, where still images from radiology and other disciplines could be uploaded for use at multidisciplinary conferences [5]. This system, however, was limited to preselected key images and did not allow for full-feature viewing of radiology exams.

Our purpose was to develop a web-based system that could be run on any computer with a web browser and network connectivity, conveniently grouping cases and pertinent information in a single easily accessible web page, to simplify presentation and allow quick image retrieval with minimal technical challenges during multidisciplinary conferences.

Methods

Institutional review board (IRB) exemption was obtained. We developed a web-based conference system for streamlining radiologist workflow for multidisciplinary conferences. Our departmental server receives real-time Health Level 7 (HL7) order and report data from our radiology information system (RIS) (Siemens). An instance of the Mirth Connect HL7 engine (Mirth Corporation) filters the data, which is then stored in a MySQL (Oracle) database with associated metadata. An Apache web server (Apache Software Foundation) is also installed on our department server to allow for end-user retrieval of the relevant data. Authentication of the user is performed with our institutional Active Directory (Microsoft) system as well as a local lightweight access directory protocol (LDAP) server (OpenLDAP) for local group and access control purposes. A C#/.NET (Microsoft, Inc.) plug-in was integrated into our radiology workflow application (Medicalis, Corp.) (Fig. 1). A radiologist can open an exam, select the desired conference from a list, and submit free-text clinical and imaging notes into our department server. The context of the case, including user, patient, and exam metadata, is stored along with the user-designated conference within a MySQL database. The associated imaging report, stored in a preexisting database, is joined and displayed within the web application using patient and exam unique identifiers.

Individual user accounts are governed by a combination of enterprise and local directories. All users of our system must have active enterprise Active Directory accounts. A custom department LDAP server is used for granular control of local groups, such as radiology resident or faculty. Any radiologist is automatically entered as a user of our conference system. Multidisciplinary conferences are managed centrally by our

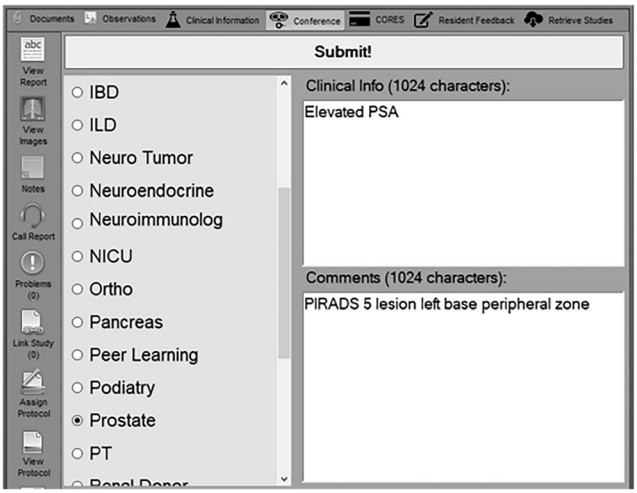

Fig. 1 Screenshot of workflow plug-in to submit cases, with relevant clinical history and imaging notes, for selected conference (prostate tumor board in this case)

Chief of Imaging Informatics, a radiologist, and cannot be modified by other users. These conferences are "public" and are visible to all users within the system. Individual users can create their own personal conferences, which are only visible to themselves.

The conference web page is accessible on any computer with a web browser within our enterprise intranet or through the virtual private network (VPN). The web page displays exam information, radiology report, and notes submitted at the time of case submission, which can be further edited from the web page as needed. Each exam has a link, through which the full study can be launched via a web-based image viewing platform, which is provided by our PACS vendor (Fig. 2). This viewer is a fully functional web-based version of our PACS, capable of displaying the patient jacket, including all priors, with complete tool functionality and all user-specific preferences. Once cases have been reviewed, the radiologist can select those cases to archive from the web interface; the conference system is then reset for the next conference date. Currently, there is no functionality to delete a submitted case; this is intentional so that cases can be recovered if archived in error.

User statistics following deployment, from February 2017 to May 2019, were analyzed. A total number of user log-ons, cases entered, conferences, and times of web page usage were counted.

Results

Our academic flagship hospital is a tertiary referral center for complex cancer and transplant patients; our department has approximately 80 radiologists during any given academic year, including 45 faculty and 35 trainee radiologists. In the

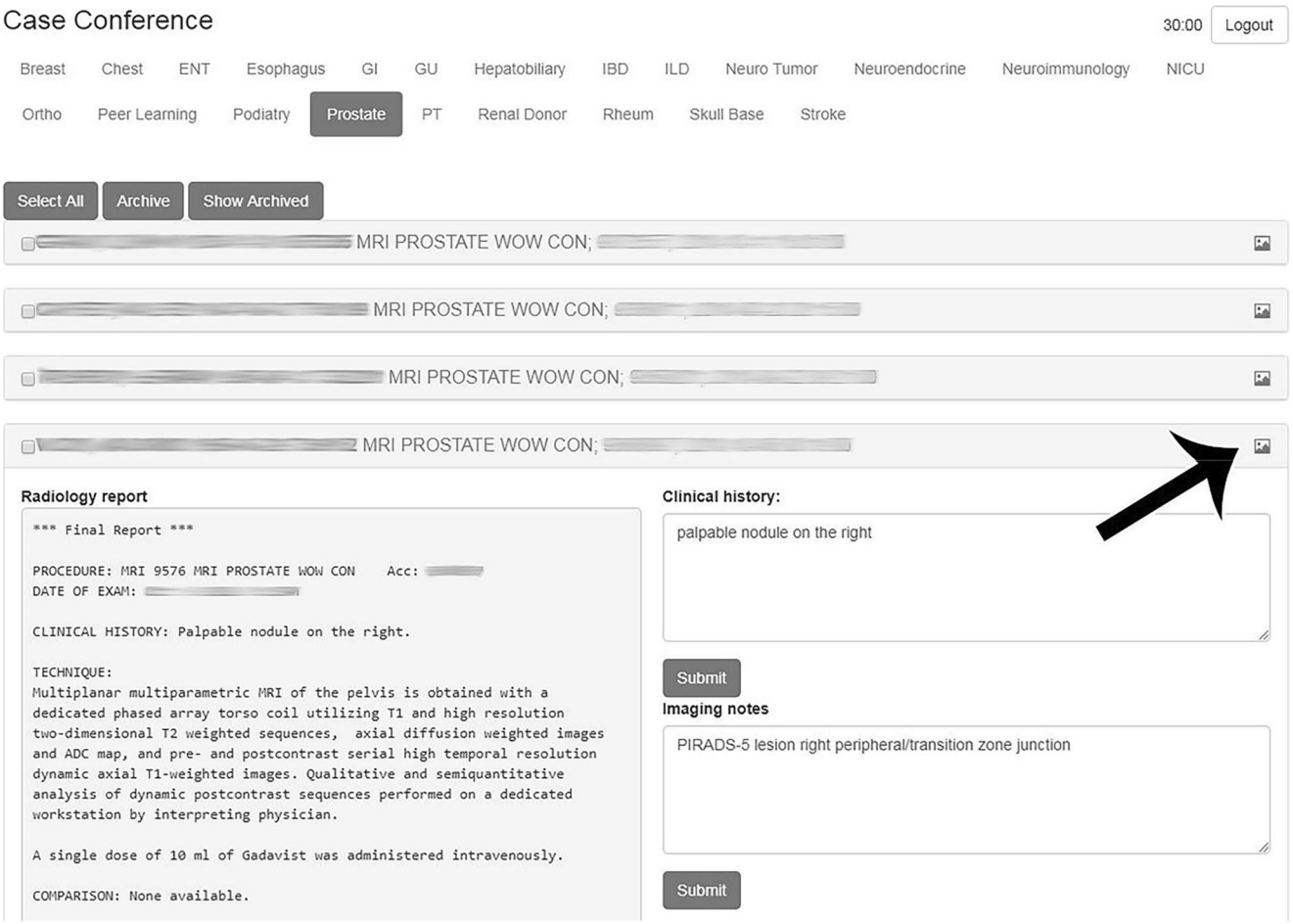

Fig. 2 Example of web-based system, displaying list of cases for our multidisciplinary prostate conference. Picture icon (arrow) launches the in-browser imaging viewer in a separate tab

28 months following initial deployment, 81 users have logged in 2434 times (1–325 times per individual user). Twenty-three department-wide conferences have been added. In addition, 61 user-specific (private) conferences have also been added, to serve as teaching case repositories for small group educational purposes within radiology sections. A total of 4580 cases have been entered fairly consistently over time and up until the present (Fig. 3). The conference web page has been viewed 4628 times. A total of 6009 cases have been reviewed (some more than once), and cases were launched into our fully functional web-based image viewer 6452 times.

Discussion

Multidisciplinary tumor boards or conferences are an integral part in patient-centered, specialized medicine. At many interdisciplinary meetings, medical imaging plays a crucial role, particularly in the diagnosis and assessment of disease processes, which are often complex. The radiologist adds key value in the decision-making and clinical management [2]. Despite this imperative need, tumor board preparation and presentation by the radiologist has traditionally required significant efforts, further hampered by technical and workflow limitations.

Our web-based conference system has several advantages over the typical methods customarily used to present cases at multidisciplinary meetings. It does not rely on dedicated, complex PACS software to be installed locally and managed at disparate locations. It only requires a web browser on our intranet or VPN. In-browser exam viewing allows access to the patient's full imaging study, with all prior imaging exams. Radiology reports and notes from the reviewing radiologists are available in one centralized location which are easily retrievable from any network location, including the VPN if cases must be reviewed outside of our enterprise. Unlike traditional methods, which include paper or electronic note-taking on a separate device, this method is more secure, as it is based in our intranet and utilizes user authentication through institutional Active Directory.

Our method differs from the web-based teaching file system described by Halsted et al. in that it allows display of the complete exam with full-feature viewing features of our PACS [5]. The use presented by Halsted involves uploading

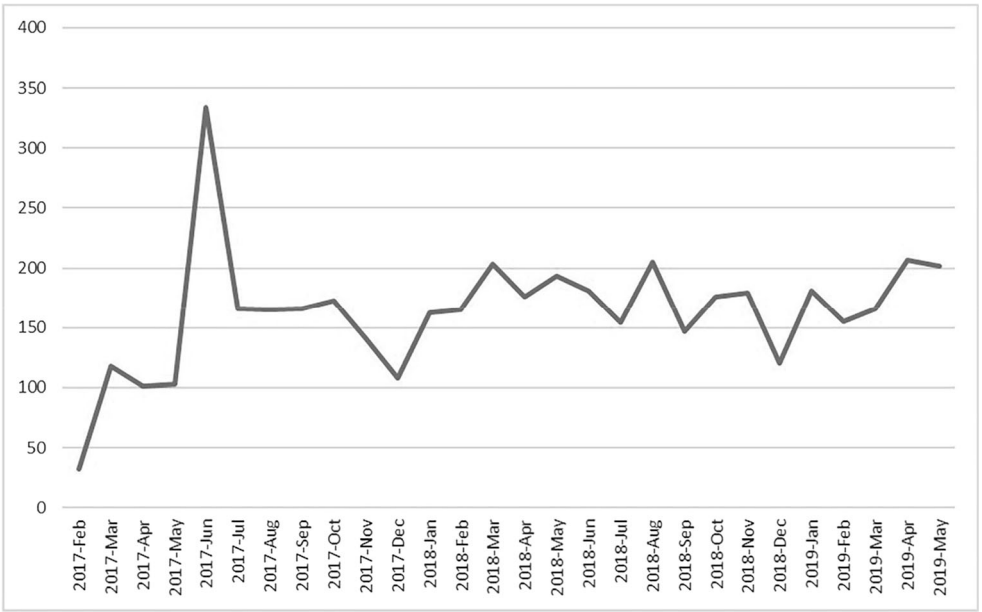

Fig. 3 Number of cases entered into the conference system per month since initial deployment in February 2017

snapshots of imaging from radiology and other specialties, including oncology, surgery, and pathology, into a teaching file. While their system highlights storage of images across multiple disciplines, our system is designed for ease of use for the radiologist, without requiring individual image submission – in many instances, the key imaging findings are only evident through scrollable image sets or comparison of multiple imaging studies over time. Our system also bypasses the need for additional storage of images, as they are accessed from our institution's preexisting radiology server.

Following initial deployment, our system was well-received by our radiology department. It is fully integrated into our daily practice, as documented by the number of times our system has been and is currently being used. In addition to its primary role for multidisciplinary conferences, our system also doubles as a teaching file. For this purpose, many user-specific conferences have been created, and it encourages practicing and trainee radiologist education within our department.

Our method has several limitations. The cases can only be added through the radiology workflow application from PACS workstations. For this reason, it is difficult to add last minute cases at certain meeting venues. The web-based system is only geared for the radiologist's workflow; imaging or data from other disciplines, such as pathology, are not yet incorporated into our system. There have been recent efforts in incorporating imaging data from other specialties, such as pathology, into PACS [6]; this would enable our system to integrate both radiologic and pathologic imaging data in the application. Although our system does not depend on a standalone PACS software, our instance of the web-based viewer is provided by our PACS vendor. Our tool does not hide protected health information by design as it is intended for patient care discussions and internal radiologist review. This would be a limitation if the system were to be used for educational purposes outside our radiology department.

In our instance, the need for a web-based conference tool arose from prohibitive difficulties in installing, maintaining, and managing PACS applications on multiple computers in disparate locations throughout our enterprise, outside the radiology department's domain. User satisfaction surveys could be useful in further optimizing radiologists' workflow. Areas for future improvement include adding a search and indexing function to help review cases presented at past conferences and for teaching on specific topics, having prior case presentation notes persist for recurring tumor board discussion of the same patient, incorporating tumor board discussion outcomes and data from other disciplines, and creating shared teaching conferences.

Conclusion

Despite the critical role of radiologists in multidisciplinary tumor boards and conferences, the radiologists' workflow has historically been hampered by several technical challenges. An efficient, web-based system of preparing and presenting imaging findings and relevant points in one centralized resource, accessible from any computer with a web browser, streamlines the radiologists' workflow and secondarily serves as a teaching tool for radiology education.

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