An Electronic Health Record-integrated Tumor Board Application to Save Preparation Time and Reduce Errors

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Context summary:
What were the time savings for pathologists who used a digital tumor board solution that was integrated with the electronic health record (EHR) to prepare for and present at tumor board?

Over a seven-week evaluation period of a weekly tumor board, pathologists saved over five hours of preparation time when using an EHR-integrated tumor board application compared to standard practice.

Relative to standard practice, the digital solution reduced the potential for case communication errors and augmented tumor board presentations with access to full pathology reports and gross images.

Given the significant time dedicated to tumor boards and the critical care decisions that are made as part of their practice, institutions should consider systems that improve their efficiency and access to information.

ABSTRACT

PURPOSE. Multi-disciplinary oncology meetings, or tumor boards, ensure and facilitate communication between specialties regarding the management of cancer cases to improve patient care. The organization of tumor board and the preparation and presentation of patient cases are typically inefficient processes that require the exchange of patient information via email, the hunting for data and images in the electronic health record, and the copying/pasting of patient data into desktop presentation software.

METHODS. We implemented a standards-based electronic health record-integrated application that automated several aspects of tumor board organization and preparation. We hypothesized that this application would increase the efficiency of tumor board preparation, reduce errors in patient entry, and enhance communication with the clinical team. Our experimental design used a prospective evaluation by pathologists who were timed in preparing for weekly tumor boards using both the new application as well as the conventional method. Additionally, patient data entry errors associated with each method were tracked, and tumor board attendees completed a survey evaluating satisfaction with the new application.

RESULTS. The total time savings for tumor board preparation using the digital tumor board application over the conventional method was 5 hours and 19 minutes, representing a 45% reduction in preparation time ($p \ll 0.01$). Survey results showed that 91% of respondents preferred the digital method and believed that it improved the flow of the tumor board meeting. In addition, most believed the digital method had an impact on subsequent patient care.

CONCLUSION. This study provides further evidence that new electronic systems have the potential to significantly improve the overall tumor board paradigm by optimizing and enhancing case organization, preparation, and presentation.

INTRODUCTION

Multi-disciplinary oncology meetings, or tumor boards, facilitate communication between specialties regarding the management of complex cancer cases to improve patient care.[1–7] These meetings are typically composed of surgeons, oncologists, pathologists, and radiologists.[8] At our institution, the conventional workflow for organizing the tumor board case list involved clinicians sending emails with patient information to their administrative assistant who once a week collates received cases and forwards them to a central tumor board coordinator. This decentralized collection of patient data and the need to switch between different modalities (e.g., email, Word, PowerPoint) to prepare for tumor board is cumbersome and error prone due to the manual entry and re-entry of patient data.

The role of the pathologist at the tumor board is to present the pertinent pathologic findings and help the clinical team interpret them as they relate to the patient, which is a time-consuming task.[9,10] In addition to reviewing the clinical history and pathologic findings for each case, pathologists often show and describe histologic findings, which involves preparing and presenting a live review of glass slides on a digital monitor or creating a PowerPoint presentation with static histologic images.

There has been increased interest in the use of digital tools to facilitate preparation for and discussion during multidisciplinary tumor boards.[11–16] A recent result has shown a reduction in tumor board preparation time for pathologists and several other tumor board participants.[16] Our work focuses only on capturing time savings for pathologists, but describes an application with additional electronic health record (EHR) integration points and an analysis that directly compares conventional and digital methods for the same tumor board case.

In this project, we implemented an application to coordinate tumor board case collection and facilitate case presentation. We then evaluated the application with three main hypotheses: 1) the use of the application (termed the "digital method") would result in reduced preparation time for the pathologist compared to the current method (termed the "conventional method"); 2) the ability to easily present gross images, ancillary studies, and the text of the pathology report using the application would lead to enhanced communication with the clinical team and increased clinician satisfaction; and 3) the application's streamlined case collection would eliminate errors in the communication of patient information to pathology and radiology.

METHODS

Tumor Board Application

The tumor board application was developed using an information aggregation and organization platform, which has been previously described for integrated cancer reporting.[17,18] The platform was built using web technologies and incorporates real-time interfaces to our Epic (Verona, WI) EHR, Epic Radiant radiology information system (RIS), GE (Boston, MA) picture archiving and communication system (PACS), Epic Beaker laboratory information system (LIS), and Microsoft (Redmond, WA) Active Directory (AD) authentication and authorization system. The Fast Healthcare Interoperability Resources (FHIR) STU3 protocol is used to retrieve reports, labs, histology images, and patient demographics. The Digital Imaging and Communications in Medicine (DICOM) protocol is used to retrieve radiology images. With its broad information access, the platform is intended to support rapid application development by our internal software team, which works in sync with teams from information technology, compliance, and risk management. Additionally, our standards-driven approach allows for implementation with any other vendors supporting FHIR and DICOM.

The tumor board application built on the platform was designed in an iterative fashion with pathologists and tumor board administrators with the goal of using logic to automatically retrieve necessary tumor board case datapoints using basic logical rules. The application provides an administrative interface to create and schedule tumor boards that includes options for email notifications and the distribution of post tumor board summaries. Cases are added to a tumor board by entering a medical record number (MRN), which triggers the system to automatically pull relevant clinical, lab, and imaging data based on rulesets. This data is then transformed into a draft visualization of the patient case that is reviewed by a fellow and adjusted if needed. Example screenshots of the application are shown in Figure 1. Detailed in Table 1, our application also includes several key features, some of which also exist in other tumor board solutions.

Figure 1. a) Digital tumor board platform tumor board list. The tumor board list contains each patient's name, presentation order number, medical record number (MRN), pathology case numbers and diagnosis summaries, brief clinical information, and whether the discussion is related to pathology, radiology, or both. **b) Presentation of the pathology report and microscopic images.** The text of the pathology report is automatically pulled from the laboratory information system and uploaded to case. Microscopic images that were uploaded to the pathology case within the laboratory information system are automatically uploaded to the tumor board case. When clicked, the images open the digital slide within our institution's web-based slide viewer.

Study Design

We selected the musculoskeletal tumor board for our evaluation as it discusses a high volume of

patients, with a mean of 34.6 patients discussed per meeting and a meeting duration of

approximately two to two and half hours. Our study was conducted in two phases. In Phase 1,

use of the application was restricted to pathology fellows, who prep cases and present at tumor

board, for a seven-week period. The fellows received patient data by email and entered it into the

application. In this phase, the application was used to present pathology data at the tumor board

conference. In Phase 2 (a seven-week period immediately following Phase 1), clinicians and

administrative assistants entered patient data directly into the application, negating the need for

email exchange. Users login to the system with there health system credentials and enter the

MRN of a patient they wish to be discussed at tumor board. In addition, users input what they

want to discuss for the case by selecting from a pre-defined list (e.g., imaging review only,

follow-up case, etc.; Figure 1 Action column). A live training session was held for users, and a

video tutorial and standard operating procedure were created for instruction in entering patient

data into the application. Figure 2 provides a swimlane diagram of the conventional

communications in planning and prepping tumor board and Figure 3 illustrates the modified

workflow with the digital method. A detailed comparison of the preparation steps taken in the

conventional and digital methods is outlined in the Appendix (Tables S1 and S2).
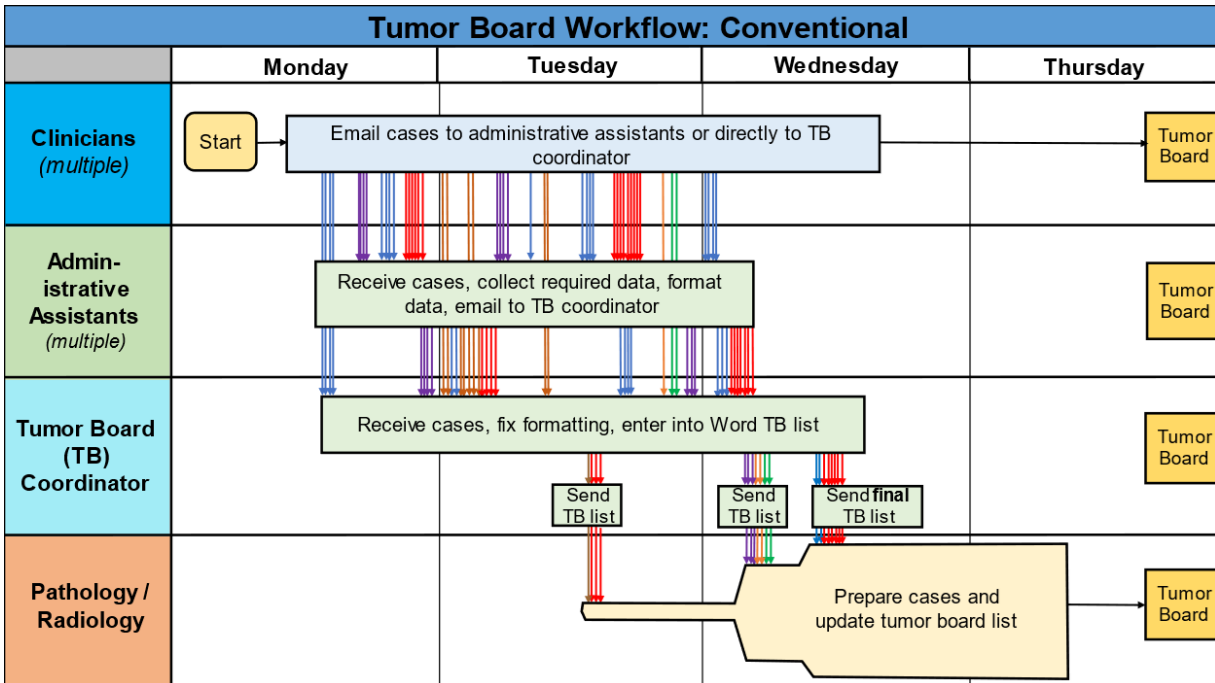
Figure 2. Swimlane diagram of communication of patient data for tumor board between clinicians, administrative assistants, the tumor board coordinator, pathology, and radiology in the conventional tumor board scenario. Each arrow represents discrete transmissions of patient information between participants. Each color represents a unique submitting clinician for each patient. Clinicians have the option to send patient data to an administrative assistant, who then compiles the data and sends to a tumor board coordinator or sends the patient data directly to the tumor board coordinator. The role of the tumor board coordinator is required to organize patient data from all presenting clinicians, format it into a tumor board list MS Word document, and send the list to pathology and radiology by email. (TB: tumor board)
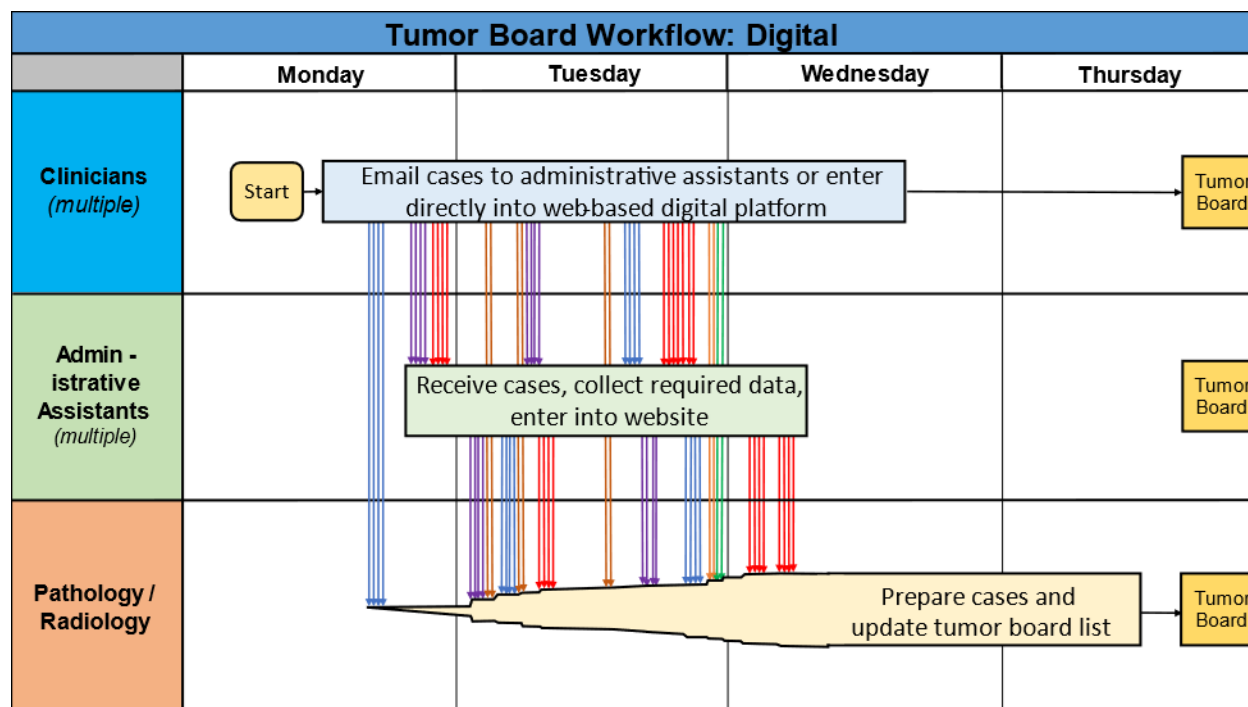
Figure 3. Digital method: Swimlane diagram of communication of patient data for tumor board between clinicians, administrative assistants, the tumor board coordinator, pathology, and radiology in the new digital tumor board scenario. Each arrow represents discrete transmissions of patient information between participants. Each color represents a unique submitting clinician for each patient. Clinicians have the option to send the patient data to their administrative assistant via email, who then enters the data, or enter the data into the tumor board application themselves. In contrast to the conventional workflow (Figure 2), the role of the tumor board coordinator is eliminated as it is performed automatically by the digital application and pathology and radiology have more time for case preparation as there is no need to wait for a tumor board list to be emailed.

Time Study of Pathology Tumor Board Preparation

During Phase 1, pathology preparation for the weekly clinical musculoskeletal tumor board was performed using both the conventional and digital methods by two pathology fellows. For each weekly tumor board list, each case was completed with both methods. To do so, both fellows performed preparation for every case, but the method by which each case was completed was randomly assigned in a manner that ensured that each fellow completed an equal number of cases using both methods. Each fellow was timed while conducting the tumor board preparation steps. Differences in preparation times were compared using a paired two-sided Wilcoxon signed

rank test. All patients were presented were presented using the new application during the tumor board conference.

Tracking of Patient Entry Errors Submitted to Pathology and Radiology

During Phases 1 (digital presentation only) and 2 (digital presentation and digital case entry), the number of patient entry errors observed in the tumor board list received by pathology and radiology via e-mail sent out by the tumor board coordinator was recorded. These errors were categorized by type, including incorrect patient name, incorrect patient MRN, and entire omission of patients in the communication to pathology and radiology.

Clinician and Radiologist Survey

A nine-question survey regarding the digital tumor board application was administered to all clinicians and radiologists who attended the tumor board in the previous six months. The survey was sent following Phase 2 of the study and the results were recorded and analyzed using basic descriptive statistics.

RESULTS

Time Study of Pathology Tumor Board Preparation

In Phase 1, tumor board preparation was performed for 159 patients using both the conventional and digital methods for seven tumor board meetings. The average number of patients presented at each meeting was 22, with a max of 32 and a min of 17. The conventional method required a total of 11 hours and 36 minutes (average 4 minutes and 23 seconds per patient) and the digital method required a total of 6 hours and 17 minutes (average 2 minutes and 22 seconds per patient). The total time savings for tumor board preparation using the digital tumor board application over the conventional method was 5 hours and 19 minutes. Out of 159 patients, 144 demonstrated a shorter preparation time in the digital method compared to the conventional method (Figure 2). Of the 15 cases in which the digital method took longer, the largest difference

was 1min 35sec. These outliers were frequently associated with cases which had multiple gross images attached, which led to increased upload and case generation time. A paired two-sided Wilcoxon signed rank test demonstrated that overall preparation time per case, as well as task-specific times per case, were significantly lower for the digital method compared to the conventional method ($P \ll 0.01$, alpha=0.05).
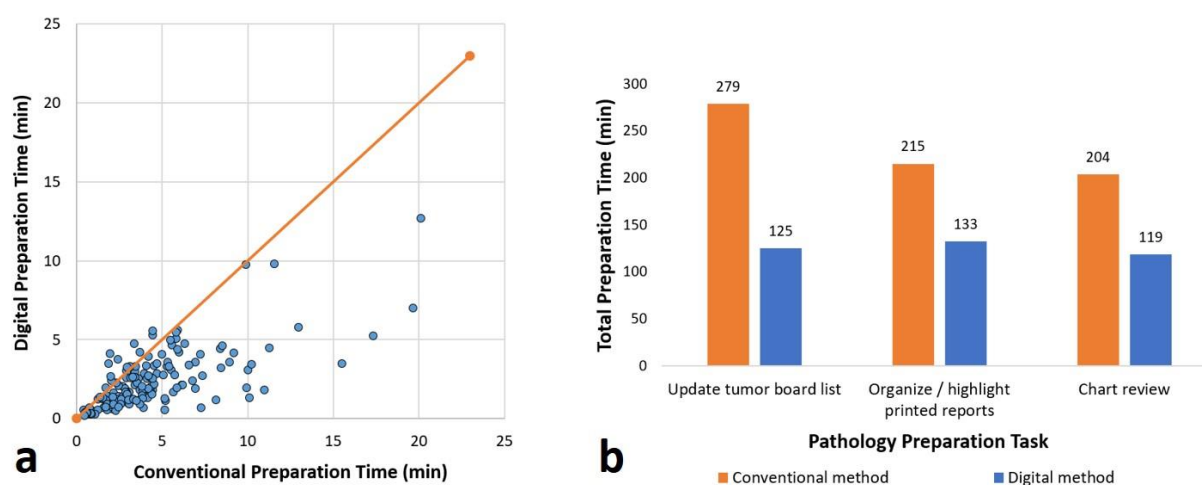

Figure 4. Total (a) and task-specific (b) preparation time for the conventional and digital methods for each of the 159 patients. In Figure 4a, the orange line represents an x=y line. In Figure B, the digital method reduced preparation time in each task category with a 55% reduction for updating the tumor board list, 38% reduction for organizing reports, and 42% reduction for chart review.

Tracking of Patient Entry Errors Submitted to Pathology and Radiology

During Phase 1, there were a total of three patient data errors in the clinical information received by pathology and radiology. These included two medical record number errors, and one patient which failed to appear on the list sent to pathology and radiology despite being sent by clinicians. In Phase 2, there were no data errors in the clinical information received by pathology and radiology.

Clinician and Radiologist Survey

The nine-question survey was sent to ten clinicians (medical oncologists, surgeons, and radiation oncologists) and two radiologists, all of whom completed the survey. 91% (11/12) surveyed preferred the digital tumor board application compared to the conventional method of pathology presentation (median 5, IQR 4-5). 91% felt the application improved the flow of the tumor board meeting (median 4, IQR 4-5), and 75% (9/12) felt it enhanced their understanding of tumor board cases (median 4, IQR 4-5). 67% (8/12) felt that the application had an impact on subsequent patient care (median 4, IQR 4-5). Graphs and additional survey results are presented in the appendix (Figures S1-S3).

DISCUSSION

Reduced Tumor Board Preparation Time

As observed in previous studies, our digital application saves pathologist preparation time for tumor board.[16] Different aspects of the digital application account for the observed reduction in case preparation times. For example, the time required for chart review and manual patient data acquisition was reduced by 41%. The ability of the application to automatically upload the most recently finalized pathology report decreased the amount of manual searching in the EHR. For the latter, navigating to the pathology section in the EHR requires seven mouse clicks, manually pasting an MRN into a field, and several loading steps, while navigating in the digital application requires only two mouse clicks. A large time-savings was also seen in updating the digital tumor board list compared to the conventional method, which required updating a Word document. For this task, the digital method led to a 55% reduction in preparation time.

Our study did not measure the time required for clinicians and administrative assistants who placed patients on the tumor board list. However, it is likely that significant time savings were realized as our application eliminated the need for collecting cases and distributing lists via email, thus removing those tasks from our tumor board coordinator.

Error Reduction in Patient Entry

In the seven-week time study period prior to implementation of clinician/coordinator patient entry, there were three patient data entry errors. These included incorrect medical record numbers and a failure to incorporate a patient into the tumor board list by the tumor board coordinator. Due to the simplified case collection method enabled by our application, there were no patient data entry errors by clinicians or patient coordinators using the digital method in contrast to the conventional method in which errors occur due to the asynchronous and inexact nature of email communications. For example, an incorrect MRN can be emailed out on the tumor board case list, whereas this scenario is prevented in our application as the system immediately verifies the case.

Enhanced Communication with the Clinical Team

The ability to efficiently share more information increased attendee interest and potentially enabled a better understanding of cases relative to the baseline scenario, in which pathology reports are typically reviewed by clinicians without the presence of a pathologist. By displaying the actual pathology report text, clinicians were able to review exact terminology and ask questions about specific details they may not have understood. The preference for the new application was not unexpected considering its information richness compared to the conventional presentation format. Somewhat surprising was the observation that most attendees believed the new application had an impact on subsequent patient care, suggesting that the incorporation and presentation of additional information impacts medical decision making relative to the conventional baseline. In particular, the surgeons expressed appreciation for the ability to easily upload and present gross pathology images during the tumor board conference. One surgeon reported that viewing the gross image enabled him to share his surgical technique with his colleagues as well as observe and learn from the technique of others. Another surgeon

reported using the application to show patients pictures of the gross specimen and key microscopic images, which he believed helped him explain the disease and treatment course. However, this and other possible sources of clinical benefit require additional evaluation to confirm.

Additional Improvements to Pathology Tumor Board Preparation

Direct patient entry by clinicians and their administrative assistants enabled additions to the tumor board list to be updated in real time, providing additional time for both pathology and radiology to prepare cases. While not directly measured, the radiology fellows who performed the radiology preparation reported the digital method of transmitting patient data was significantly better. In particular, they cited the ability to receive patient data in real time, which allowed for more preparation time, and the automatic generation of a sortable digital tumor board list, which increased organization of tumor board preparation. They also appreciated the inclusion of clinical questions accompanying a case when submitted via the application, which contrasted with the conventional workflow in which sometimes only a medical record number was shared and it was unclear what the focus of the tumor board discussion should be for the case.

Limitations

The primary limitation of our study is that the application was evaluated within a single tumor board at a single institution, and it is therefore possible that we may not achieve the same time savings elsewhere. However, while there is heterogeneity in how tumor boards function, case collection and pathology presentation are standard features. We believe that our results will generalize to any tumor board where the standard of practice is like the conventional method described in this work. Another limitation is that the fellows performing tumor board preparation

during the time study may work at different paces, which does not provide for a direct comparison on an individual case level basis. This was mitigated by assigning each fellow an equal number of cases in each preparation method. Finally, the seven-week Phase 1 and Phase 2 study periods may not have been long enough to fully characterize the error rates of case entry; however we believe our results are generalizable given the nature of the errors, which were due to incorrect information being shared via email, or emails being not sent or missed.

CONCLUSION

Our work provides further evidence that digital, EHR-integrated applications have the potential to significantly improve tumor boards by enabling more efficient organization, presentation, and preparation, which should ultimately benefit both physicians and patients. We are currently expanding the application to other subspecialty tumor boards within our health system and extending the solution to incorporate more discrete data capture.

Table 1. Key features of the digital tumor board application.

Benefit	Feature
Decrease preparation time	Automatic retrieval and creation of a tumor board report upon entry of a patient's medical record number into the application. The tumor board report includes: • Patient's most recent pathology report • Link to a digital whole slide image from the most recent pathology case • Gross specimen photographs associated with the most recent pathology case • Any available molecular results Ability for clinicians and administrative staff to enter patients directly into the digital application Automatic generation of printable patient list for each tumor board meeting Automatic generation of summaries of relevant pathology findings displayed in the tumor board list
Enhance communication with clinical team	Ability to add additional reports and images from other studies (e.g., FISH and molecular pathology) Continuous access to the current tumor board patient list without need for additional communication (e.g., email) Ability to utilize annotations on digital slides to highlight key microscopic features quickly during tumor board presentation
Reduce in patient entry errors	Reduction of redundant manual entry of patient data in communications between clinicians, radiologists, and pathologists
Miscellaneous benefits	Ability to retain tumor board reports within the application which can be loaded instantly into other tumor board meetings

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