Electronic Workflow for Imaging in Clinical Research

Rebecca A. Hedges · Danielle Goodman · Peter B. Sachs

Published online: 3 April 2014
© Society for Imaging Informatics in Medicine 2014

Abstract In the transition from paper to electronic workflow, the University of Colorado Health System's implementation of a new electronic health record system (EHR) forced all clinical groups to reevaluate their practices including the infrastructure surrounding clinical trials. Radiological imaging is an important piece of many clinical trials and requires a high level of consistency and standardization. With EHR implementation, paper orders were manually transcribed into the EHR, digitizing an inefficient work flow. A team of schedulers, radiologists, technologists, research personnel, and EHR analysts worked together to optimize the EHR to accommodate the needs of research imaging protocols. The transition to electronic workflow posed several problems: (1) there needed to be effective communication throughout the imaging process from scheduling to radiologist interpretation. (2) The exam ordering process needed to be automated to allow scheduling of specific research studies on specific equipment. (3) The billing process needed to be controlled to accommodate radiologists already supported by grants. (4) There needed to be functionality allowing exams to finalize automatically skipping the PACS and interpretation process. (5) There needed to be a way to alert radiologists that a specialized research interpretation was needed on a given exam. These issues were resolved through the optimization of the "visit type," allowing a high-level control of an exam at the time of scheduling. Additionally, we added columns and fields to work queues displaying grant identification numbers.

The build solutions we implemented reduced the mistakes made and increased imaging quality and compliance.

Keywords Clinical research · Imaging informatics · Workflow · Electronic medical record

Introduction

Imaging for clinical research currently represents 7 % of cross-sectional imaging studies performed at the University of Colorado Hospital and supports over 500 clinical trials. Erickson et al., have described the components of a clinical research imaging workflow [1–3]. The transition from paper to a digital electronic health record system (EHR) has forced every sector to reevaluate their workflow, including the complex radiology research infrastructure. Initially managed on paper, we had to reinterpret the way research needs were to be facilitated, communicated, and executed in a digital format. The clinical and research patients share the same radiology resources and basic workflow. Currently, the hospital is 2 years in to the implementation of an EHR which encompasses five hospitals, only one of which is involved in research. With the implementation of the EHR, all routine clinical imaging was ordered electronically; however, research orders remained on paper and were manually entered into the EHR. This transferred the inadequate paper system into a digital format (Fig. 1).

The specific factors that needed to be accounted for by the new workflow included:

1. The research workflow needed to be functional for the central, academic hospital without disrupting operations at the four other community hospitals in the health system that are not involved in research.
2. A communication method was needed that would allow radiology schedulers, radiology technologists, and

R. A. Hedges · P. B. Sachs (✉)
Department of Radiology, School of Medicine, University of
Colorado Anschutz Medical Campus, Mail Stop L954, 12401 E.
17th Ave., Aurora, CO 80045, USA
e-mail: peter.sachs@ucdenver.edu

D. Goodman
Department of Information Technology, University of Colorado
Hospital, Mail Stop L, Aurora, CO 80045, USA

Fig. 1 Workflow diagram of paper driven process

Fig. 2 Workflow diagram of electronic process in the EHR

Fig. 3 Order questions for research in the EHR

radiologists to be alerted that a given patient or exam is part of a research study. Many of our research studies require services that are more complex than our standard practice. These could include non-standard imaging series, longer scan times, specialized interpretations, or imaging on specific equipment. Further complicating this issue is the number of parties involved in carrying out a research study. The first point of contact for research exams is the scheduling team who controls where and for how long a given exam will take place. Radiologists, when protocoling studies, need to direct clinical research exams back to the technologists to perform per protocol. Subsequently, the technologists determine what parameters are used for a given exam, image the patient, and then assign the images to a specific radiology section for review. Finally, the radiologist interprets the images. Each party needs to be aware of the research requirements so any errors made at the first point of contact can be corrected down the line.

3. An automated method of scheduling the exam on the appropriate resource had to be devised. Many studies must be performed on a specific scanner because the protocol requires all acquisitions on the same resource for consistency or because we have a special series loaded on a specific resource. This step is extremely important because the hospital will not be reimbursed for imaging that was not done per protocol and more importantly, the subject generally has to be brought back for repeat imaging.
4. We needed to include a means of controlling whether or not an exam bills a professional fee. Some of our radiologists collect salary support for their participation and review of images on clinical trials in lieu of traditional professional reimbursement. Other trials include limited imaging sequences that do not require review by a radiologist and do not incur a professional fee.
5. The exams that do not receive interpretations by radiologists must also auto-finalize in picture archiving and communication system (PACS) when the exam is ended by the technologist so that they do not drop to a radiologist's interpretation work queue.
6. As part of the re-engineering of clinical research imaging workflow, the Department of Radiology also began a new

program providing specialized research interpretations for oncology clinical trials. These Response Evaluation Criteria in Solid Tumors (RECIST) reads involve a standardized measurement and reporting technique that is incorporated in the more comprehensive, clinical read. This added research service presented some of the same challenges as described above for the overall research build, namely, the issue of notification. This service only affects radiologists and so the schedulers and technologists are not implicated in this specialized read.

These process improvement changes needed to occur in such a way that patients and ordering physicians not involved in research saw no change in their workflow.

Methods and Results

The solution involved manipulation of several different aspects of the ordering and scheduling process (Fig. 2).

1. At order entry, a physician has to complete several “order questions” such as “Immediate read required?” or “Has the patient had a reaction to CT contrast?” The original paper order contained only one question regarding research: “Billable to grant? If yes, Grant number” (Fig. 3). As much of research imaging is covered by insurance, this question was not accurately capturing all patients participating in a clinical trial. We changed this question to “If research protocol, enter grant number” followed by a separate question regarding billing: “Is this billable to a grant?” This change allowed us to capture all research needs. Schedulers, radiologists, and technologists can all view responses to this question easily in their work queues (Figs. 4, 5, and 6). Utilizing our previously reported electronic protocol selection process [4], the radiologists can route these exams back to the technologists. At the time of imaging, the radiology technologists can then select the correct protocol for each study based on the examination ordered and the supplied grant number. These protocols are built into the imaging resource.
2. Initially, specialized exam codes were created that researchers could select from the EHR. Instead of “CT

Fig. 4 Scheduler work queue with grant protocol number specified

Routine		NO	GK64	CT CHEST/ABD/PELV W CONTRAST [IMG1428]
Routine			GO14	US DOPPLER [IMG2088]
Routine				DIGITAL SCREEN BILAT MAMMOGRAM [IMG605]
Routine		NO		MR BREAST BILAT W/WO CONTRAST [IMG1143]
Routine		NO		PET/CT WHOLE BODY (FDG) [IMG1799]
Routine		NO		IR AORTIC ANGIOPLASTY

Fig. 5 Information presented to radiologist at time of image study protocol selection

Ordering Clinic:	MELANOMA OP
OK to be altered by radiologist:	No
Grant #:	GO02
Sched Inst:	Schedule for 9/30/13. Perform per GO02 protocol.
Signs, Symptoms and/or Diagnosis: (e.g. cough)	melanoma
Clinical Question: (e.g. eval for pneumonia)	please assess baseline disease status. RECIST v1.1
OK to be altered by Radiologist	No
Is the Patient Pregnant?	No by patient report or testing
If research protocol, enter Grant number:	GO02
Study billable to grant?	No

© 2013 Epic Systems Corporation. Used with permission.

CHEST WITHOUT CONTRAST” these research exam codes included the hospital assigned grant ID number (G-number) in the title: e.g., “CT CHEST WITHOUT CONTRAST—GO02/Melanoma Clinical Trial” allowing individuals at each step of the workflow to identify the research study. This created a significant downstream problem. As we began discussing resolutions to this issue, the announcement was made that four other hospitals would be integrated into our EHR but would not be doing clinical research. The grant database could not be made public as it is shared among all five hospitals and inappropriate selection of research-specific imaging studies could occur. To prevent selection of expired or invalid

grant imaging, the database is maintained regularly by analysts and our professional research assistant (PRA). The final workflow employs a scheduling convention called a “visit type.” Every exam code used in the hospital has a visit type which defines the basic logic for scheduling. The room, equipment, and exam duration can all be controlled through manipulation of the visit type. Our EHR analysts build specialized visit types for non-standard research studies. They have the same CPT codes and exam names as their clinical equivalents but the exam duration and specific resource have been altered. In practice, the scheduler sees the grant number in their work queue and then selects the correct grant visit from a

Fig. 6 Technologist work queue with grant protocol number specified

P	Class	S	Time	ARRIVAL	MRN	Patient	Accession #	EAP	Grant Protocol	Procedure
			6:30 PM					MR		MR ABDOMEN
			12:30 PM					MR		MRI pituitary w wo
			8:15 AM					MR		MRI pituitary w wo
			11:30 AM					MR		MRI cervical spine
			7:30 AM					MR		MRI pituitary w wo
			11:45 AM					MR		MRI cervical spine
			10:15 AM					MR BRAIN		MRI Brain MS
			2:00 PM					MR	g195	MR ABDOMEN

© 2013 Epic Systems Corporation. Used with permission.

Fig. 7 Specialized read (RECIST) request highlighted in radiologist reading palette at time of study interpretation

Question	Answer	Comment
Signs, Symptoms and/or Diagnosis: (e.g. cough)	Rising PSA. Baseline for study	
Clinical Question: (e.g. eval for pneumonia)	RECIST 1.1 baseline for study, compare to previous, please measure lesions	
OK to be altered by Radiologist	No	
If research protocol, enter Grant number:	GM63	
Study billable to grant?	No	
Coordinate appointment with ordering clinic?	Yes	
Responsible provider pager number:	3077	
Immediate read required?	No	
If contrast is ordered is patient at risk of decreased GFR?	No known risk	
Has the patient had a reaction to CT contrast?	No	
RECIST read to be performed by Radiology?	Yes	
RECIST by Radiologist?	Yes	

© 2013 Epic Systems Corporation. Used with permission.

Fig. 8 Timeline to develop and implement a fully electronic process for clinical research imaging workflow management

Sept 2011

Mar 2012

Jul 2012

Feb 2013

Radiology goes live on EMR

Grant Question is added to orders

Radiology stops accepting paper orders for clinical exams

Research ordering continues on paper

Grant field appears in scheduling and technologist work lists

Visit type workflow is under development

Visit type is implemented

Radiology stops accepting paper orders for research

- database embedded in their EPIC workflow, thus automatically blocking the study-required equipment resource for the study-required exam length.
3. The visit type also allows control over professional billing. Logic added to the visit type causes a message to populate in the coders work queue: “No process read.” This notifies coders not to bill a professional fee.
 4. A programming point can be added at the visit type level that allows an exam to auto-finalize without hitting a radiologist’s work queue. When the exam is terminated by a technologist, this added programming communicates to PACS that the exam is complete and auto-populates the report with a default message stating the exam is “for research purposes only and the images are not intended for clinical use.”
 5. To accommodate cases requiring a RECIST read, we amended the order questions to include a RECIST request: “RECIST read performed by radiology? (Yes/No).” Principal investigators can order this specialized read when they order the corresponding exam. This request is highlighted in the radiologist’s reading palette when reviewing the exam (Fig. 7).

The error rate for ordering research studies incorrectly prior to the implementation of this process was 2 % with an estimated cost for repeat imaging of \$60,000. After the implementation 18 months ago, the error rate dropped to 0.05 % for an estimated savings of \$45,000. The effect on patient and ordering physician satisfaction is not measurable but subjectively significant.

Discussion

Design and implementation of this workflow at our institution required approximately 12 months (Fig. 8). Hopefully, other institutions can accomplish this more quickly using our experience. We have been unable, after discussion with our vendor, to determine whether others have implemented a similar EHR-based workflow for clinical research. To our knowledge, no similar clinical research workflow process has been reported in the literature.

The research build described above required input from many individuals representing schedulers, technologists, radiologists, and clinicians to ensure that the strategies we

employed would be functional for everyone involved. Overall, these changes have resulted in a more structured, transparent, and efficient process for managing research subjects.

The paper system provided no guidance or structure for ordering physicians. As a result, they submitted orders in a research language that was meaningless to clinical personnel in radiology. The new order question provides a specific directive (“... enter your grant number”) with a limited space for entry. This allows for consistency in reporting research requirements and separates the need for a research exam from that exam’s reimbursement.

In the paper system, acquisition errors were common and costly. If imaging is not done per protocol, the sponsor will not reimburse the hospital and the patient has to return for repeat imaging. With this change, the technologists are receiving consistent information that they trust to be accurate. When they see a grant number associated with a patient, the technologist reviews the loaded protocols on the research designated scanner and initiates the protocol named with the corresponding grant number cited on the request. The new electronic workflow has greatly diminished the number of mistakes in adhering to protocol-required imaging procedures.

An additional unplanned bonus of an electronic workflow is that each step is automatically documented in the background. If we fail to image a subject per protocol, it is easy to go back through the EHR and identify the point of failure. Additionally, the order questions are a reportable field allowing us to evaluate the volume of research moving through the department.

References

1. Erickson BJ, Pan T, Marcus DS: Whitepapers on imaging infrastructure for research. Part 1: general workflow considerations. *J Digit Imaging* 25:449–453, 2012
2. Erickson BJ, Pan T, Marcus DS: Imaging infrastructure for research. Part 2: data management practices. *J Digit Imaging* 25:566–569, 2012
3. Erickson BJ, Pan T, Marcus DS: Whitepapers on imaging infrastructure for research part three: security and privacy. *J Digit Imaging* 25: 692–702, 2012
4. Sachs PB, Gassert G, Cain M, Rubinstein D, Davey M, Decoteau D: Imaging study protocol selection in the electronic medical record. *J Am Coll Radiol* 10(3):221–223, 2013