Interventional Radiology Workflow Management in the Electronic Medical Record

Geralyn Gassert · Janette Durham · Michael Cain · Peter B. Sachs

Published online: 15 January 2014
© Society for Imaging Informatics in Medicine 2014

Abstract The electronic medical record (EMR) has significantly improved efficiency in many areas of radiology workflow. Following implementation of an electronic protocol selection process for cross-sectional imaging at the University of Colorado Hospital, the interventional radiology (IR) division desired to have a similar tool. Evaluation of the IR workflow demonstrated the need for a multilayered solution, which accounted for consultation, physician review, authorization and scheduling, pre-procedural nursing evaluation, physician rounding, and resource allocation and prioritization. This paper outlines the rationale for and components of this process.

Keywords Electronic medical record (EMR) · Workflow · Interventional radiology

The implementation of an electronic medical record (EMR) can result in measurable improvements in efficiency by standardizing the collection of information, reducing lost or missing information, eliminating communication errors, and reducing cost. The adoption of an institutional EMR and radiology information system (RIS) necessitates the development of a solution that melds institutional practices with model systems and national best practice guidelines. For the system to succeed, the user must be satisfied, which typically means the system is adapted to the specific workflow of the user. These principles apply to the management of interventional radiology (IR) workflow, as well [1].

At the University of Colorado Hospital, prior to implementation of a new EMR, a team of radiologists, information technology analysts, and radiology administrative staff designed an electronic process to protocol interventional radiology consultations. The goal was for the physician to review enough of the patient's clinical data and imaging to determine if the requested study was appropriate to schedule. This process mimicked the in-place paper process for physician review of consultations, with an electronic data collection form (Fig. 1). A hypertext markup language (HTML) report was created that included in its header patient name, sex, age, medical record number, encounter number, allergies, and language [2]. The body of the display included diagnosis, problem list, medications, and relevant laboratory evaluation. The chart could be accessed for more detailed review, but the report was designed to avoid this additional step. Review of the consultation request and the HTML report would permit a quick decision concerning the appropriateness of the examination, the specific exam to be scheduled, and the necessary additional resources required, including the type of anesthesia, ancillary imaging guidance, and specific room and physician requests. It also identified medications, allergies, and laboratory parameters that needed to be addressed prior to the procedure. The review was planned to occur at a picture archiving and communication system (PACS) workstation, so imaging could be part of the review.

Immediately after go-live, it became apparent that implementation of this process was premature. Due to the timeline that clinics went live on the EMR, half of the outpatient orders were still arriving on paper. Staff tasks were not integrated, and the tools for scheduler and physician communication were not built. The project was shelved, and the protocol process remained paper driven for the next year.

In the meantime, an electronic protocol workflow for cross-sectional imaging was designed and implemented in diagnostic radiology, an effort that has been undertaken elsewhere, as well [3–6]. This provided a knowledge base to reattempt deployment of an electronic solution in IR. Unlike the process

G. Gassert · M. Cain
Department of Information Technology, University of Colorado
Hospital, Aurora, CO 80045, USA

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

IR Protocol

Change order as follows:

Procedure Priority: Duration:

Location: Room:

Specific Equipment:

Specific Physician:

Patient Disposition:

Sedation:

Schedule interpreter? ☐ Yes

2013: © 2013 Epic Systems Corporation. Used with permission.

Fig. 1 Initial physician review template

to protocol an imaging exam, preparing a patient for an invasive procedure requires multiple additional activities. By the time the process was re-engage, the scope had changed to include all workflows from receipt of consultation to the performance of the procedure.

The pre-procedural IR workflow was broken down into the following steps:

- Consultation by a referring physician for a procedure
- Physician review of that consultation for appropriateness
- A request by the scheduler for authorization for payment
- A pre-procedural call to the patient for procedural date scheduling
- A pre-procedural nursing call for review of the patients clinical condition and for delivery of pre-procedural instruction
- A review of the case details by the IR team working on the day of the procedure
- Communication of the final plan back to the hospital staff to determine resource allocation.

For simplification, these steps are referred to as consultation, physician review, authorization and scheduling, pre-procedural nursing evaluation, physician rounding, and resource allocation and prioritization (Fig. 2).

Consultation

Conversion to an EMR incorporated consultation practices left over from the use of three separate electronic ordering systems and paper orders from a large network of hospital-owned clinics. This resulted in a master order list with many duplicated, incorrectly named, and outdated orders. The first step was to reduce this list to a single set of IR examinations that could be used throughout the process, from scheduling to billing. The complexity of unbundled IR billing necessitated that the technologist had the ability to update the examination at the time of the procedure. Out of a list of coded activities, one main examination needed to be selected to track to the PACS and to the hemodynamic monitoring system that provided the procedural documentation, so that examination naming was consistent for volume and quality reporting. A further requirement was the need to schedule more than one

service at the encounter. It is common in IR to perform multiple discrete services during one encounter—such as central venous access at the time of a biopsy. From a reporting and billing standpoint, it is easiest if both procedures are assigned to a single accession number (RIS/PACS identifier).

Two hundred and fifty distinct procedures were identified. This drove the development of the same number of consultation orders modeled after other orders for radiology services. The advantage of this detailed development was that each request could be associated with appropriate instructions, best practice alerts, and current procedural terminology (CPT) codes. The disadvantage was a text search through a long laundry list for the ordering provider who had little ability to differentiate procedures. In addition, necessary clinical information was missing.

To simplify the process for the ordering physician, a super order was created designated as the “IR OP (outpatient) request.” The super order organized the large number of possible procedure requests into 14 clinical categories that were designed to focus the search. A second layer of drop-down choices was then provided to get the consultation as close as possible to the correct request. Several comment fields were incorporated for clarification of any remaining details. To order a procedure for an inferior vena cava (IVC) filter removal, the ordering provider would only have to enter “IR Procedure” to launch the super order, select IVC filter from the 14 clinical categories, and then select IVC filter removal (Fig. 3). Signs and symptoms, priority, ordering provider pager number, and laterality when appropriate are additional required fields. There are multiple comment boxes to permit individualized information.

On the receiving end, the super order necessitated that every outpatient order which appeared in the system as an order for an “IR OP request” be re-ordered in a more specific manner, appropriate for identification of the study throughout the rest of the process. The IR physician during his review would clarify the exact order to be scheduled, and the scheduler would then make the change. Since the error rate in ordering the correct exam when left to the referring physician working from a text search was already high, this was not much additional work for the scheduling team.

Educating and directing the ordering physician to the super order a year after the system had gone live proved challenging. Ordering by any other methodology than a text search was not

Fig. 2 Initial physician review IR workflow diagram

intuitive, and lumping together two orders was in most other ordering scenarios not possible. Individual examinations needed to remain in the institutional database for the scheduling and billing teams, and savvy physicians could get past any directive to use a super order and find the specific exams in the database of orders. Once specific exam orders found their place in a preference list, it was hard to eliminate them. We have had to link all individual procedures to the super order to prevent the ordering physician from performing a text search for a procedure and then completing a specific order. Currently, we still accept a mix of incoming orders, some specific to the procedure and others through the “IR OP request.” We anticipate a continual rise in the utilization of the super order over time.

2013: © 2013 Epic Systems Corporation. Used with permission.

Fig. 3 Final IR super order

Two additional unanticipated downsides to the super order were discovered. The ability to tie instructions and best practice alerts to a specific exam was compromised. Also, by canceling the original “IR OP request” at the time of rescheduling, the ordering physician received a confusing response in his inbox that detailed the change.

Physician Review for Appropriateness

Appropriateness for many radiology examinations means appropriateness for billing purposes; i.e., the diagnosis will support the procedure. In the IR setting, it means the ordered exam will treat the patient’s problem, is the most likely procedure to do so, and is safe. At the present time, automated appropriateness determination (i.e., clinical decision support [CDS]) is not embedded in this process. This requires a manual review of the patient’s clinical situation and imaging.

In order to develop a communication tool between scheduler and physician, a pre-existing EMR protocol worklist tool was customized. This modified protocol worklist permitted the IR physician to open the physician review tools when a patient was selected from the list, including the protocol template and the HTML clinical summary.

The initial protocol template was revised to incorporate drop-down menus for specific procedural orders based on the master list (Fig. 4). Updates were provided to clarify laterality, procedure duration, interpreter details, and resource request for ancillary equipment. Comment fields directed to the pre-procedural nursing team were created

IR Protocol

MD PROTOCOL

Schedule as Ordered: ☐ Yes ☐ No

Protocol in Process - Enter Initials:

Change orders as follows:

Ablation: <input type="text"/>	Arterial Intervention: <input type="text"/>	Arteriography: <input type="text"/>
Aspiration / Drainage: <input type="text"/>	Biliary Intervention: <input type="text"/>	Biopsy: <input type="text"/>
Dialysis: <input type="text"/>	GU Intervention: <input type="text"/>	MSK: <input type="text"/>
GI Intervention: <input type="text"/>	Injection / Infusion: <input type="text"/>	Venography: <input type="text"/>
Nerve Block: <input type="text"/>	Lymphangiogram: <input type="text"/>	
Venous Access: <input type="text"/>	Venous Intervention: <input type="text"/>	All Orders: <input type="text"/>

Specify Side: Schedule Guidance: ☐ US ☐ CT

Secondary procedures:

Comments:

Procedure Priority: ☐ Today ☐ ASAP ☐ Routine

Duration: ☐ 30 minutes ☐ 60 minutes ☐ 90 minutes ☐ 120 minutes ☐ 3 hours ☐ 4 hours

Location: ☐ CVC ☐ CT ☐ Endoscopy ☐ OR ☐ PICC

Room: 7 8 9 10 1 2 3

Equipment: ☐ IU 22 ☐ US ☐ IVUS ☐ Microwave ☐ RFA ☐ Angio-jet ☐ EKOS ☐ CO2

Physician #1:

Physician #2:

Patient Disposition: ☐ Inpatient ☐ Outpatient ☐ Extended Recovery > 6 hours ☐ Admit Post Procedure

Analgesia: ☐ None ☐ Sedation ☐ MAC ☐ General Anesthesia

Interpreter required for: ☐ Pre-Procedure only ☐ Duration of procedure

Pre-operative instructions:

Give medication:

Hold medication:

IV Prehydration: ☐ Yes ☐ No

Lab Orders:

Imaging Orders:

2013: © 2013 Epic Systems Corporation. Used with permission.

Fig. 4 Protocol template

to request additional preoperative laboratory or imaging tests and to give instructions to hold or start medications. The HTML report was reorganized and improved to better present information to the user.

Output from the physician review process updates the original consultation request so that the consulting physicians' comments, the IR physician review, and pertinent information from the HTML report are summarized on a rounding report. The rounding report is available to all the workgroups, including physicians, scheduling staff, and nursing team.

The physicians readily transitioned from paper to an electronic documentation process, with the added benefit that information was documented uniformly for every case, simplifying the work of the scheduling team. There remain two obstacles: (1) the inadequate size of the display monitor to organize the worklist, the protocol template, and the HTML report, and (2) the inability to have a two-way connection from the EMR to the PACS. PACS cannot be launched from the EMR. And when PACS opens an imaging study, the EMR is launched in a read-only format, so that the template cannot be completed without closing the imaging. The current solution is the use of a second computer that runs the EMR so that both PACS and the EMR work independently. We have no

immediate plans to integrate the EMR and PACS. The EMR platform is not currently robust enough to support management of PACS and other interfaced components of radiology/IR workflow (i.e., voice, critical results notification).

Authorization and Scheduling

Once the physician review is completed, the physician review template and the original order are available to the schedulers for coding for authorization and scheduling a procedure date. The appointment detail is updated in the rounding report for future use by the nursing and physician team. Since the scheduler has an opportunity to talk with the patient directly at the time of procedure date scheduling, a comment box that flowed to the rounding report was included.

The scheduling staff found this to be a much improved process since paper was often misplaced. Information was now always available to them in the EMR. The learning curve initially slowed their workflow, but they found that there was less chance for error since all information was shared and no one workgroup was missing critical information that another had provided. If the physicians were unable to keep pace with

the electronic protocol worklist, however, the entire process was slowed.

Pre-procedural Nursing Evaluation

Originally, the navigator for the pre-procedural nursing staff was built in isolation from both the physician and the scheduling workflow. After watching them collect all the necessary information about a patient from the chart, so that they could have a knowledgeable conversation with the patient preoperatively, the duplication in work became apparent. Because communication back to the physicians was not possible electronically, they were forced to make written notes for the physician after a call to the patient. Patient arrival time, diet instructions, allergies, important medication changes, current labs, and special patient concerns were all noted on a paper copy of the original order and included in the patient's paper chart. The pre-procedural nursing evaluation template (Fig. 5) was updated to capture aspects of the nursing review that would be updated into the rounding report.

Experiencing the same advantages and weaknesses apparent to the schedulers, the nurses also appreciated that if the protocol form was filled out to completion, the nurses saved time tracking down a physician to get necessary detailed

information such as laboratory and intravenous hydration orders. They also found that being able to do their work anywhere the EMR was available, not just where the paper chart was stored, was a great advantage. It created a direct method of communication and documentation of pre-procedure medication changes.

Physician Rounding

Each morning, the IR physician team rounds, in order to review the planned cases. Many cases are performed by the first available physician in the first available room, so it is important that the entire team be familiar with the details. In this final step, all the information that is available prior to actually meeting the patient is pulled together. This is the point when the paper chart is reviewed, all the scribbled notes are interpreted, and the actual final plan is assembled.

In a teaching institution, residents are assigned the task of reviewing and presenting the cases at morning rounds. Time necessitates that this is a well-organized presentation. Residents spend significant time the night before in preparation. The lengthy and often unreliable paper trail necessitates that the residents review the printed referral consultation and then dig back in the chart to pull all the pertinent medical

Pre-Procedure Phone Call	
Patient reached?	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="Left message"/> <input type="button" value="ⓧ"/>
Arrival Time	<input type="text"/> <input type="button" value="⌚"/> <input type="button" value="ⓧ"/>
Surgical Consent Signed	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Lab Work Complete	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
NPO Status Reinforced	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Time instructed to stop food	<input type="text"/> <input type="button" value="⌚"/> <input type="button" value="ⓧ"/>
Time instructed to stop fluids	<input type="text"/> <input type="button" value="⌚"/> <input type="button" value="ⓧ"/>
Check in 3rd Floor AIP	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Ride home for sedation	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Patient Status for Procedure	<input type="button" value="Inpatient"/> <input type="button" value="Outpatient"/> <input type="button" value="ⓧ"/>
Anticoagulants?	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Bridging?	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Diabetes melitus?	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Take AM meds as needed	<input type="text"/> <input type="button" value="ⓧ"/>
Patient Knows to Bring Current Medication List	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Last chemo treatment	<input type="text"/> <input type="button" value="ⓧ"/>
Approximate length of stay	<input type="text"/> <input type="button" value="ⓧ"/>
Patient disposition	<input type="button" value="Admitted"/> <input type="button" value="Outpatient"/> <input type="button" value="Extended recover ..."/> <input type="button" value="ⓧ"/>
Contrast allergy?	<input type="button" value="Yes"/> <input type="button" value="No"/> <input type="button" value="ⓧ"/>
Pre-treatment drug	<input type="text"/> <input type="button" value="ⓧ"/>
Items to address on date of procedure	<input type="text"/> <input type="button" value="ⓧ"/>
Phone notes	<input type="text"/>

2013: © 2013 Epic Systems Corporation. Used with permission.

Fig. 5 Pre-procedure evaluation template

information—diagnoses, problem lists, allergies, medication, laboratory evaluation, and results of imaging. They take written notes to guide their presentation at rounds. So for a third time, this information is pulled from the EMR and summarized on a paper that will later be discarded.

Access to the rounding report, updated by the physician, the scheduler, and the pre-operative nursing staff, allows the resident a quick summary of this information in one place (Fig. 6). It includes all the previously written scheduling and nursing notes, an important previous gap in information. Electronic review permits the most recent information, such as labs drawn between nursing review and rounding to be included, and is available to all of the involved workgroups. A potential weakness of this workflow is that it fails if the physician does not read the summation of detail provided on the rounding report.

Activity done procedurally and post-procedurally is not addressed by this process. Post-procedure order sets specific

to like procedures have been built to facilitate standardized post-procedure care. Future orders for longitudinal care, either procedural or clinic, can be entered as orders at the time of procedure completion. These orders trigger the process described in this paper.

Resource Allocation/Prioritization

The final step is getting the information to the staff that is preparing the procedure rooms for a particular case. A status board was developed that follows the progression of cases from the pre-procedural area, to the procedure rooms, back to the recovery area, and to discharge (Fig. 7). This display is transmitted on a large flat screen monitor that is viewable throughout the department. It is pre-populated with limited information about the case, such as the name and medical

<Patient Name> IR Rounding		MRN: <MRN> Description: <Age and Sex>				
Demographics						
Address:	Home Phone:	Work Phone:				
<Patient Address>	<Patient Phone>	<Patient Phone>				
SSN:	Insurance:	Religion:				
<Patient SSN>	<Patient Insurance>					
IR ABDOMEN BIOPSY Imaging		Date: 7/16/2013 Ordering/Authorizing: <Referring MD> Department: <Ordering Department>				
Questions		Associated Diagnoses				
Signs, Symptoms and/or Diagnosis: (e.g. cough)	stage 4 rectal cancer	Rectal cancer [154.1] - Primary				
Clinical Question: (e.g. eval for pneumonia)	right sided subcapsular fluid in previous rx site, cancer?					
Responsible provider pager number:	9999					
Coordinate appointment with ordering clinic?	No					
Allergies (No Known Allergies) Date Reviewed: 07/09/13		Appointment Notes Appointment Notes US guided abdomen bx				
Protocol History Protocolled by: on 7/18/13 at 12:39 PM		IR Pre-Call Data				
Protocol: IR Schedule as Ordered - Yes IR Side: - Right IR Schedule Guidance: - US IR Protocol Status: - Protocolled IR Procedure Priority: - Routine IR Duration: - 60 minutes IR Location: - CVC IR Specific Equipment: - IU 22 IR Patient Disposition: - Outpatient IR Analgesia: - Sedation		Arrival Time: 7/19/13 0815 filed at 07/25/2013 1108 Check in 3rd Floor AJP: Yes [2] filed at 07/25/2013 1108 Ride home for sedation: Yes filed at 07/25/2013 1108 Patient Status for Procedure: -- NPO Status: Yes filed at 07/25/2013 1108 Reinforced: -- Time instructed to stop food: 0001 filed at 07/25/2013 1108 Time instructed to stop fluids: 0730 filed at 07/25/2013 1108 Anticoagulants?: No filed at 07/25/2013 1108 Drug: -- Bridging?: -- Stopped: -- Diabetes: No filed at 07/25/2013 1108 mellitus?: --				
Last Resulted Components						
Date/Time	Result Component	Value	Flag	Reference Range	Units	Lab Status
03/05/13 0400	POTASSIUMS	3.9	-	3.3-5.0 mmol/L	mmol/L	Final result
03/05/13 0400	CREATININE5	0.81	-	0.40-1.20 mg/dL	mg/dL	Final result
02/20/13 0940	ACTPARTIAL	31.2	-	25.4-33.5 Sec	Sec	Final result
02/20/13 0940	PROTHROMB2	13.2	-	11.4-14.4 Sec	Sec	Final result
02/20/13 0940	INTERIATIONIA	1.0	-	0.9-1.1	-	Final result
03/03/13 0359	WHITEBLOOD6	3.9	Low	4.0-11.1 10 ⁹ /L	10 ⁹ /L	Final result
03/03/13 0359	REDBLOODCE5	2.76	Low	4.76-6.09 10 ¹² /L	10 ¹² /L	Final result
03/03/13 0359	HEMOGLOBIN5	9.0	Low	14.3-18.1 g/dL	g/dL	Final result
03/03/13 0359	HEMATOCRIT2	26.3	Low	39.2-50.2 %	%	Final result
03/03/13 0359	PLATELETCOU	131	Low	150-400 10 ⁹ /L	10 ⁹ /L	Final result
03/03/13 0359	MEANPLATELE	8.9	Low	9.8-12.8 fL	fL	Final result
02/27/13 0400	BILIRUBIN10	1.2	-	0.0-1.3 mg/dL	mg/dL	Final result
Lab Orders: No orders found from 7/28/2013 to 7/31/2013.						
Problem List as of 7/30/2013						
Codes	Priority	Class	Noted - Resolved			
154.1, 197.7			11/14/2012 - Present			
197.0, 199.1			1/17/2013 - Present			
Current OP Meds						
Start	Stop	Sig	Ordered			
03/13/13 0000	--	Take 1 tablet by mouth 2 times daily as needed for Anxiety or Sleep.	03/13/13 1224			
--	--	Take 600 mg by mouth 3 times daily. Take with food.	07/23/13 1038			
--	--	Take 4 mg by mouth daily as needed.	07/23/13 1123			
--	--	Take 17 g by mouth daily.	11/14/12 1533			
--	--	Take 5 mg by mouth every 6 hours as needed.	07/23/13 1123			

2013: © 2013 Epic Systems Corporation. Used with permission.

Fig. 6 Rounding report

Fig. 7 Status board

10:30 am <MRN>	<Patient Name> Ir Paracentesis	Patient In Recovery Acetaminophen, Codeine, Iodine, Morphine, Vicodin CARDIAC PRE/POST 35 PROC	Room 9 Paracentesis w/ sedation
<Assigned IR MD>		
8:30 am <MRN>	<Patient Name> Ir Non Neuro Embolization	Patient in Room CARDIAC PRE/POST 31 PROC	Room 10 Transcatheter coiling of splenic artery aneurysm
	<Assigned IR MD>		

2013: © 2013 Epic Systems Corporation. Used with permission.

record, procedure to be performed, the language, and allergies. It includes a comment box for notes.

Critical elements that will otherwise delay a case if omitted are communicated through this tool during the rounding process. Problems with consent, the need for additional labs, requests for specific rooms or resources, the priority, and last minute patient requests can be addressed in this fashion. During rounds, notes to the staff can be sent and received without phone interruptions. Once review is complete, the status board is updated with an icon that communicates the patient is ready.

Future Directions

Designing a system so that data can be mined is critical. Since go-live with our current EMR, data mining has been difficult because of the manpower required to build reporting tools. For us, this started by standardizing terminology for examinations throughout radiology. Analytics tools available within the EMR or as a third-party add-on can easily retrieve data via Health Level Seven (HL7) interface, and we are in the process of setting this up.

Additional future development projects include attaching order specific instructions and best practice alerts (CDS) to procedures in the IR super order (this would provide useful clinical decision support for the ordering physician) and improving the integration with PACS such that patient-specific images could be opened directly from the protocol form in the EMR.

The use of mobile devices for PACS imaging review and EMR work is currently possible, but since they are not integrated, the back-and-forth movement between the two is impractical. Full integration of the EMR and PACS should make this possible.

Conclusions

Electronic IR workflow management is a new process that has recently been implemented at the University of Colorado Hospital. The benefits in simplifying, standardizing, and

aligning the workflow of schedulers, physicians, nurses, and technologists are already apparent. Time spent accessing the medical record to make medical decisions is shortened. One provider's work is available to another with all of the added information gained by two phone encounters with the patient included in the documentation. If orders need to be placed for additional testing, the user is working in the chart and can immediately place an order. Communication back to the referral physician can also be performed easily through the in-basket of the EMR. Communication via phone call or a walk to the scheduling desk are eliminated and replaced with electronic communications that are part of the permanent medical record. The process should be generalizable to large IR practices where scheduling, authorization, nursing communication, and physician review are done by separate parties. Those with the same RIS/EMR as the University of Colorado (Epic) can accomplish this easily with the help of trained analysts. Those utilizing other RIS/EMR solutions will need to consult with their vendors for support.

Acknowledgments The authors wish to acknowledge the significant contributions to the design, implementation, and refinement of this system made by Danielle Decoteau; Dena Keilman, RN; Beth Kujawski; Kimberley Olson, RN; Christine Saetta, RT; Laura Ortiz, RN; and Sandy Scruggs.

References

1. Vasko C: Paperless workflow for interventional radiology: Tufts Medical Center. *imagingBiz Newsletter* February 22, 2013
2. Khorasani R: Can you efficiently incorporate patient-specific electronic medical radiology into radiology workflow? *J Am Coll Radiol* 9(12):862–863, 2012
3. Khorasani R: How IT, tools can help improve current protocolling performance gaps. *J Am Coll Radiol* 8:675–676, 2011
4. Bassignani MJ, Dierolf DA, Roberts DL, Lee S: Paperless protocolling of CT and MRI requests at an outpatient imaging center. *J Digit Imaging* 23:203–210, 2012
5. Medverd JR, Cross NM, Font F, Casertano A: Advanced medical imaging protocol workflow—a flexible electronic solution to optimize process efficiency, care quality and patient safety in the National VA Enterprise. *J Digit Imaging*. Published online: 04 January 2013
6. Sachs PB, Gassert G, Cain M, Rubinstein D, Davey M, Decoteau D: Image study protocol selection in the electronic medical record. *J Am Coll Radiol* 10(2):220–222, 2013