Developing an Automated Database for Monitoring Ultrasound- and Computed Tomography-Guided Procedure Complications and Diagnostic Yield

Jason N. Itri · Lisa P. Jones · Woojin Kim ·
William W. Boonn · Ana S. Kolansky · Susan Hilton ·
Hanna M. Zafar

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Abstract Monitoring complications and diagnostic yield for image-guided procedures is an important component of maintaining high quality patient care promoted by professional societies in radiology and accreditation organizations such as the American College of Radiology (ACR) and Joint Commission. These outcome metrics can be used as part of a comprehensive quality assurance/quality improvement program to reduce variation in clinical practice, provide opportunities to engage in practice quality improvement, and contribute to developing national benchmarks and standards. The purpose of this article is to describe the development and successful implementation of an automated web-based software application to monitor procedural outcomes for US- and CT-guided procedures in an academic radiology department. The open source tools PHP: Hypertext Preprocessor (PHP) and MySQL were used to extract relevant procedural information from the Radiology Information System (RIS), auto-populate the procedure log database, and develop a user interface that generates real-time reports of complication rates and diagnostic yield by site and by operator. Utilizing structured radiology report templates resulted in significantly improved accuracy of information auto-populated from radiology reports, as well as greater compliance with manual data entry. An automated web-based procedure log database is an effective tool to reliably

track complication rates and diagnostic yield for US- and CT-guided procedures performed in a radiology department.

Keywords Procedures · Complications · Diagnostic yield · Tracking · Automated

Introduction

Monitoring outcomes for ultrasound- (US) and computed tomography- (CT) guided procedures is an important component of maintaining high quality patient care that is promoted by various professional societies and accreditation organizations. Joint Commission guidelines define criteria for assessing the competency of licensed practitioners for re-credentialing, which include evaluation of technical skills such as complication rate, and outcomes such as diagnostic yield of procedures performed by individual practitioners [1]. The Society of Interventional Radiology (SIR) recommends reviewing outcomes such as complications and effectiveness, including diagnostic yield, on a regular basis to ensure that practitioners performing diagnostic and interventional procedures have adequate procedural training, skill, and experience [2, 3]. The American College of Radiology (ACR) accreditation program for computed tomography (CT) requires accredited facilities to have a quality assurance program that evaluates complication rates, diagnostic accuracy, including diagnostic yield, and outcome of CT-guided interventional procedures [4]. Although US-guided procedures are not specifically mentioned in the ACR US accreditation program, facilities are required to monitor, analyze and report complications and adverse events related to US examinations [5]. In addition to providing competency-based metrics of professional performance, monitoring outcomes of image-guided procedures can also be used to

J. N. Itri (✉)
Department of Radiology, University of Pittsburgh Medical Center,
200 Lothrop Street, Presby South Tower, Suite 4896,
Pittsburgh, PA 15213, USA
e-mail: itrijn@upmc.edu

L. P. Jones · W. Kim · W. W. Boonn · A. S. Kolansky · S. Hilton ·
H. M. Zafar
Department of Radiology, University of Pennsylvania Hospital,
3400 Spruce Street, Philadelphia, PA 19104, USA

reduce variation in clinical practice between individual physicians by ensuring standards of practice are achieved and identifying deficiencies in order to develop effective remediation programs. Through these activities, monitoring metrics provides opportunities to engage in practice quality improvement, and contribute to developing national benchmarks and standards [6].

Using procedural outcomes as a competency-based metric for physicians in a radiology department has several advantages over other professional assessment measures, including peer review. Procedural outcomes such as complication rates and diagnostic yield are less influenced by the subjective nature of peer review, in which there may be a lack of objective data to use as the reference standard. Peer review is often performed on a randomly selected subset of imaging studies, resulting in review of cases in which there is no discrepancy. Subsequently, a substantial number of secondarily reviewed imaging studies are required to detect deficiencies in radiologists' interpretive skills [6]. Finally, peer review requires time and effort from all radiologists in the department and may not be built into daily workflow in an efficient manner. Procedural outcomes, on the other hand, can be clearly defined and occur in sufficient quantities to detect deficiencies in an individual physician's technical performance. Moreover, automated monitoring of procedural outcomes requires little time and effort on the part of the radiologist.

Based on Joint Commission guidelines, Society for Interventional Radiology recommendations for image-guided procedures, and ACR requirements for CT accreditation, our departmental Clinical Effectiveness and Quality Improvement (CEQI) committee determined in early 2010 that each section should be reporting complication rates and diagnostic yield, by site, for all US- and CT-guided procedures on a quarterly basis. In an effort to ensure that all members of the chest and abdominal sections who perform procedures are technically competent and qualified, leadership from both sections determined that complication rates and diagnostic yield should also be reported by operator so that individual performance could be compared with aggregate data.

The objective of this article is to describe the development and successful implementation of an automated web-based software application that monitors procedural outcomes for US- and CT-guided procedures in our department. The article will discuss auto-population of relevant procedural information from the Radiology Information System (RIS) and radiology report, user interface and capabilities, integration into daily workflow to reduce redundancy in data entry, audit and reporting functions, and accuracy of auto-population and manual data entry. In addition, we will review challenges encountered with the design and implementation of this application and how these challenges were managed.

Populating the Procedure Log Database

The procedure log software application was developed using the open source tools PHP: Hypertext Preprocessor (PHP) and MySQL, a relational database management system (Fig. 1). The “scheduled” PHP querying script accesses a mirrored Structured Query Language (SQL) RIS (RIS; GE Centricity® RIS-IC, GE Medical Systems, Waukesha, WI) database every morning and identifies all US- and CT-guided procedures scheduled for the current day using the corresponding exam code and exam status. When a relevant examination is identified, the PHP script accesses the mirrored database to query the unique study ID number, accession number, patient information, exam modifier, modality, subspecialty, patient location, ordering physician, date and time of order entry and other relevant studies from the RIS (Fig. 1). The study information queried from the RIS database is stored in two MySQL tables (called “logbasic” and “pathology”) on a separate dedicated server. The information for every US- and CT-guided procedure scheduled over a 5-day span can be viewed using the procedure log software via a “Scheduled” hyperlink on the web-based front-end application. For same-day procedures, there is an “add-on” script that can be run manually from within the procedure log database.

The “finalized” PHP querying script identifies all studies in scheduled status every 24 h and accesses the RIS database to determine if the study has been finalized. This script uses the unique study ID numbers for scheduled exams in the “logbasic” MySQL table to search the RIS database for the same exam in final status, subsequently querying the provider information, final report, and date and time that the study was completed. After a study has been changed from scheduled to finalized status in the “logbasic” table, another PHP script extracts the final report and uses regular expression to identify specific text strings indicating that the procedure was performed for “guidance only” or “complications only” (Table 1) and updates the relevant fields in the “logbasic” table. Subsequently, each final report is searched for the text strings indicating “site” and “immediate complication,” and the associated fields in the “logbasic” table are auto-populated.

The “guidance only” and “complications only” fields were created in response to the large volume of US-guided procedures in which we provide US guidance to faculty endocrinologists for thyroid biopsies, faculty urologists for prostate biopsies, and faculty nephrologists for renal transplant and native kidney biopsies. Although radiologists provided dictated reports for these procedures, they are performed by faculty from the respective departments and are only monitored by radiology nurses when performed in the radiology department. The “complications only” category is also used for CT colonography procedures, as complications are tracked but pathology and diagnostic yield are not routinely available.

Fig. 1 Diagrammatic representation of the procedure log software application. Procedures are scheduled and reported into the RIS. The procedure log querying scripts pull relevant study information for all US- and CT-guided procedures performed through the radiology department (excluding interventional radiology) and populate the separate MySQL database. Auto-population scripts extract the site and complication information from each report. Users can access the procedure log

application using any type of internet browser behind the firewall or through VPN access. Individual physician users can enter pathology information and diagnostic yield for each case, and individual nurse users can enter complication information for CT-guided procedures and patient follow-up. Administrators can generate various reports for quality assurance and quality improvement purposes

Reporting US- and CT-Guided Procedures

Biopsy site, complications and diagnostic yield are the three required fields for all US and CT-guided procedures in our department. Because biopsy site is not specified in either the RIS or in the singular exam code used for all US- and CT-guided procedures it cannot be auto-populated using either of these data sources. The US section adapted structured reporting templates in order to auto-populate required database fields with high fidelity. There are a significantly higher number of US-guided procedures performed in our department compared to CT and a greater number of faculty radiologists performing these procedures, leading to a process that proved to be error-prone on initial audits. Two structured templates developed internally within the US section are used to report procedures, both of which include specific fields called “site” and “immediate complications” (Table 2). Each

field has a pick list of options specifying the site biopsied and the type of complication (including none) that match the sites and complications listed in the procedure log database. Using these structured templates to report US-guided procedures ensures that these two required fields are auto-populated in the “logbasic” table accurately. Faculty performing CT-guided procedures currently select site and immediate complications manually from within the procedure log database, but are transitioning to the structured reporting template approach used in the US section.

Initially, faculty had to manually select “guidance only” and “complications only” from within the procedure log application, which led to several procedures being incorrectly categorized. To improve accuracy, we extracted several unique text strings from the current report templates for physicians performing these procedures and upgraded the procedure log application to identify these text strings,

Table 1 Description of procedure designations

Complications and diagnostic yield	Complications only	Guidance only
Thyroid nodule	CT colonography	Thyroid nodule*
Lymph node	Kidney transplant*	Lymph node*
Liver	Native kidney*	Prostate*
Parotid gland		
Retroperitoneal soft tissue		
Adrenal gland		
Pancreas		
Lung Pleura		
Chest wall		
Spleen		
Mediastinum		

The single asterisk indicates image-guided procedures performed in conjunction with endocrinologists (thyroid nodule and lymph node biopsies), urologists (prostate biopsies), and nephrologists (native kidney and transplant biopsies)

allowing the application to automatically catalogue these studies. Once tagged, studies identified as “guidance only” are removed from the audits and analytic reports without requiring entry of complications or diagnostic yield. Studies identified as “complication only” require entry of complication data but not diagnostic yield. Accordingly, “complications only” procedures are included in the audits and analytic reports for complications but do not appear in the audit and analytic reports for diagnostic yield.

Table 2 Description of sites, site modifiers, and complication pick lists

Site	Site modifier	Immediate complications
Thyroid nodule	Right	Hematoma
Lung	Left	Active hemorrhage
Parotid	Bilateral	Pneumothorax
Liver	Axilla	Infection
Retroperitoneum	Neck	Perforation
Adrenal gland	Supraclavicular	Pneumoperitoneum
Lymph node	Retroperitoneal	Arteriovenous fistula
Prostate	Mesenteric	Other
Chest wall	Soft tissue	
Soft tissue	Mediastinal	
Spleen		
Pleura		
Mediastinum		
Colon		
Renal transplant		
Native kidney		
Pancreas		

User Interface

Each user is assigned a username and password based on their unique RIS identification number to login to the application, a role-based access setting to determine which features the user will be able to access, a user designation (resident, fellow, nurse, faculty radiologist, or administrator), and specialty (e.g., chest, abdominal imaging). Each faculty radiologist, resident and fellow has standard physician user access that allows them to manually edit and/or enter biopsy site at the time of the procedure and to enter diagnostic yield after the final pathology results are issued (Fig. 2). In addition to the required fields, the procedure log contains several optional fields including needle type (i.e., fine needle aspiration or core biopsy), needle gauge, number of passes, and whether manual aspiration was used. Because we are a teaching institution, an additional field is designated for the procedure operator labeled as “Procedure performed by”. Options for this field include “both” if both the faculty radiologist and trainee performed direct tissue sampling, “faculty” if the faculty radiologist exclusively performed direct tissue sampling, or “resident or fellow” if the trainee exclusively performed direct tissue sampling under the supervision of a faculty radiologist.

Administrators have full access to all finalized procedures performed by any physician user and the ability to generate audits and reports by physician users and nursing using the “Audit” and “Analytic” hyperlinks (see below). Individual physician users can access all finalized procedures that they have individually performed under their “Procedure log” hyperlink, as well as search for procedures performed by other physicians by date, accession number or MRN using the search function under the “Search” hyperlink. Dedicated CT and US nurses hold unique accounts that permit exclusive review and editing of scheduled and finalized procedures specific to their modality under the “Complications” hyperlink including pre-procedure calls, immediate complications, vital sign changes during the procedure, and delayed complications.

Workflow

The majority of US-guided procedures involve superficial sites (e.g., thyroid, neck lymph nodes, etc.). Because of the low rate of delayed complications associated with these procedures, only patients with immediate complications receive a post procedure call. Outpatient post procedure calls are required for all deep intra-abdominal US-guided procedures (e.g., liver, spleen, pancreas, etc.) to document any delayed complications and are performed by the nurse on the following business day. The delayed complication pick list is identical to the immediate complications pick list and includes an option for “none”.

Biopsy QA

[Scheduled](#) | [Search](#) | [Complications](#) | [Nursing Log](#) | [Procedure Log](#) | [Pathology](#) | [QA](#) | [Audit](#) | [Analytics](#) | [Add-ons](#) | [Logout](#)

Guidance only: ☐ Yes ☒ No
 Complications only: ☐ Yes ☒ No
 Click here if procedure not performed: ☐

Accession Number: 9999999 Last Name: TEST First Name: PATIENT
 MRN: 09876653 Modality: ☒ US ☐ CT ☐ MR
 Procedure Code: URBP Procedure: Ultrasound Guidance - Bic Procedure Date (YYYY-MM-DD): 2011-10-26
 Site Specific: Parotid Site modifier: Left
 #1: Needle Type: FNA Gauge: 27 Number of Passes: 3 Aspiration used: ☒ Yes ☐ No
 #2: Needle Type: Gauge: Number of Passes: Aspiration used: ☐ Yes ☒ No
 #3: Needle Type: Gauge: Number of Passes: Aspiration used: ☐ Yes ☒ No
 Attending for Procedure: None Resident/Fellow: None Procedure performed by: Both
 Comment:

Complication Type 1: None Severity: Was case entered into PORTs? ☒ Yes ☐ No
 Complication Type 2: Severity: Criteria for PORTs reporting
 Complication Type 3: Severity: Link to PORTs
 Vital Sign Change: ☒ Yes ☐ No
 Follow up call made: ☐ Yes ☒ No Call Made by: None Call Date (YYYY-MM-DD): 0000-00-00
 If Follow up call was not made, provide reason: Not indicated for superficial bx Was Patient Located: ☐ Yes ☒ No
 Delayed Complication Type 1: None Severity:
 Delayed Complication Type 2: Severity:
 Delayed Complication Type 3: Severity:
 Nursing comment:

Final Report

Targeted ultrasound examination of the left parotid region demonstrated a 2.2 x 1.2 x 1.4 cm hypoechoic cystic mass in the left parotid gland posteriorly without internal vascularity. The risks of the procedure, treatment for any complications should they occur, and alternatives were discussed with the patient and she willingly signed a consent for the biopsy. A safety timeout was done to verify the patient's identity, review any allergies, and confirm the side and site of the procedure. The site was cleaned with alcohol. Following this, an ultrasound-guided fine-needle biopsy of the left parotid cystic mass was performed. A total of 3 passes was made using 27 gauge needles. The Cytopathologist indicated cyst fluid on the first two passes and the third sample was placed into a cup for further evaluation. The patient tolerated the procedure well and post-biopsy scans showed no hematoma. The post-biopsy instructions were reviewed with the patient by our nurse and the patient left the Ultrasound suite in stable condition. COMPLICATION: None. I certify that I have personally reviewed the image and interpretation for this examination and agree with the findings in this report.

Cytopathology	Histopathology
Left Parotid FNA - Satisfactory for Evaluation. Parotid, left, 1.3 cm mass, US-FNA: Mucin, few lymphocytes, macrophages and cellular debris present. These findings are consistent with cyst contents.	

Diagnostic Yield: ☒ Yes ☐ No
 Are the imaging findings/recommendation concordant with pathology? ☒ Yes ☐ No
 Tissue Type: Benign

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Fig. 2 Sample biopsy data entry page as viewed under the “Procedure Log” hyperlink. For each scheduled biopsy procedure, a data entry page is generated that auto-populates the patient’s accession number, name, medical record number, modality, and procedure code. This page includes required fields (e.g., site, complication, pathology report, and diagnostic yield) as well as optional fields (e.g., site modifiers, needle type, and gauge, number of passes, who performed the procedure, concordance of

imaging findings/recommendations with pathology results, and tissue type). Every 24 h, the procedure log uses the unique study ID numbers for finalized exams to extract and auto-populate provider information, final report, and date and time of study completion. Following the change of an examination from scheduled to finalized, regular expression is used to identify specific text strings in the report that indicate whether the procedure was performed for “guidance only” or “complications only”

In contrast to US-guided procedures, the CT nurse enters both immediate complications and calls all outpatients who undergo CT-guided procedures the following business day to document any delayed complications. As a final measure, all

faculty radiologists and trainees have the ability to enter delayed complications (e.g., pseudoaneurysm, arteriovenous fistula) on any liver or kidney biopsy performed by another physician by searching for the study in the “Search” hyperlink

using the date of the original procedure, MRN or accession number.

When pathology results become available, typically within three business days, physician users can access the “Pathology” hyperlink to enter cytology results, histology results, diagnostic yield (yes or no), and tissue type (benign, malignant, or indeterminate; Fig. 2). The current system requires users to manually enter each patient’s accession number or MRN into the electronic medical record portal developed at our institution (MedView) to retrieve pathology results which can be copied into the database [7].

Audits and Reports

Each physician user can generate an individual report of all finalized procedures using the “Procedure Log” hyperlink which can be sorted by site, complication, complication severity (i.e., minor and major for any complication other than “none”), and diagnostic yield. In addition, each physician user can perform individual-level audits using the “Audit” hyperlink that identify all finalized procedures reported by that user missing data on biopsy site, pathology, immediate complications, and immediate complication severity (Fig. 3a).

Administrators have full access to all finalized US- and CT-guided procedures, using the “Audit” (Fig. 3a) and “Analytics” (Fig. 3b) hyperlinks, which can be generated for specified time periods. Using the “Audit” hyperlink administrators can use three filters in order to generate reports for all finalized procedures sorted by faculty radiologist compliance with entering procedure information (Fig. 4a), by faculty radiologist compliance with entering pathology information (Fig. 4b) and by modality for nursing compliance with entering complication data (Fig. 5) for CT-guided procedures. Administrators can use the “CEQI report” filter to generate a report by site and by operator of the total number of procedures, immediate complications and rates divided by minor and major, delayed complication rates, overall complication rates, any complications entered into our web-based institutional incident reporting system, and diagnostic yield with the ability to drill down.

User Compliance and Accuracy of Data Entry

The procedure log was implemented on September 1, 2010. Separate dedicated educational sessions were held for the chest and abdominal sections respectively in order to inform users on the necessity of tracking site, complication and diagnostic yield data for CEQI compliance. Faculty radiologists are accountable for the accuracy and completeness of data entered into the procedure log database. Despite faculty recognition of the need to track procedure

outcomes, there were challenges to implementation of the procedure log into daily workflow. Each section adopted a different approach to ensure user compliance with data entry.

From September 1, 2010 through February 28, 2012, faculty radiologists in the chest section were 99.7 % (308/309) compliant with entering the site and 88.7 % (274/309) compliant with entering pathology results and diagnostic yield for CT-guided procedures. The range of compliance with entering sites was 98.8 % to 100 % with two faculty radiologists at 100 % compliance. The range of compliance with entering pathology results and diagnostic yield was 70.4 % to 96.5 % with two of three faculty radiologists above 90 % compliance. We expect compliance to be lower for pathology results and diagnostic yield compared to site and complications since pathology results can sometimes take a week to become available. Nurses were 99.0 % (306/309) compliant with entering complications for CT-guided procedures.

From September 1, 2010 to February 28, 2012, faculty radiologists in the abdominal section were 92.4 % (1,057/1,144) compliant with entering the site and 82.6 % (945/1,144) compliant with entering pathology results and diagnostic yield for US- and CT-guided procedures (Fig. 4a, b). The range of compliance with entering sites was 82.2 % to 100 % with seven of ten faculty radiologists above the 90 % benchmark and six faculty radiologists at 100 % compliance. The range of compliance with entering pathology results and diagnostic yield was 66.7 % to 100 % with five of ten faculty radiologists above the 90 % benchmark and three faculty radiologists at 100 % compliance.

Targeted retrospective review of procedure log data on 210 kidney and liver biopsies performed between September 1, 2010 and July 31, 2011 revealed that the proportion of information entered incorrectly was 4.8 % (10/210) for site, 1.9 % (4/210; immediate or delayed) for complication type, 0 % (210/210) for complication severity, 6.2 % (13/210) for procedures incorrectly tagged as “guidance only”, and 6.2 % (13/210) for procedures incorrectly tagged as “complications only”. All of the procedures with incorrect site and incorrect complication type entered into the database occurred before implementation of the structured templates for “site” and “immediate complication.” Auto-population of these fields from final reports became 100 % accurate provided that the correct exam code was used to schedule the procedure, one of the procedure templates was used to report the exam, and the site and complication fields were filled using a selection from the pick list embedded in the procedure template.

In response to the number of procedures tagged incorrectly as “guidance only” or “complication only,” the procedure log application was upgraded to recognize the unique text strings indicating “guidance only” and “complications only” within final report rather than rely on faculty to manually select these options from within the procedure log application. In addition,

Fig. 3 Sample administrator audit (a) and analytic (b) pages as viewed under the corresponding hyperlinks. Each user is assigned a username and password based on their unique RIS identification number to login to the application, a user designation (e.g., fellow, nurse, and faculty radiologist), a specialty (e.g., chest), and an access setting (e.g., administrator, non-administrator). Administrators can generate audits reports across all physician users (i.e., administrator audits) and nursing (i.e., nursing audits) and can generate analytic reports. Individual physician users can only view audit reports for all finalized procedures that they have individually performed (i.e., individual user audits)

a

Biopsy QA

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Administrator audits

Faculty compliance with procedure information Review

Faculty compliance with pathology information Review

Nurse compliance with complications Review

Nursing audits

Finalized exams without complication type entered into the database Generate List

Complications with severity not entered into the database Generate List

Major complications not entered into PORTS Generate List

Entries without a preprocedure call Generate List

Individual user audits

0 Exams without site specified Generate List

0 Finalized exams without pathology Generate List

0 Finalized exams without complications entered Generate List

0 Finalized exams without complication severity entered Generate List

b

Biopsy QA

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Analytics

CEQI report Review

Section report by faculty member Review

Section report for complications Review

Section report for non-diagnostic yield Review

a URL link to an informational page defining these procedures was placed on the login page of the procedure log, and this information was presented during the following abdominal section meeting.

Benefits, Limitations, and Future Direction

Developing a process to track complications and diagnostic yield for image-guided procedures is a core component of measuring and managing procedural competency for practicing physicians. These outcome metrics can be used as part of a comprehensive quality assurance/quality improvement program to ensure high quality patient care and minimize errors [4]. From a regulatory perspective, procedural complication rates and diagnostic yield are metrics used by the Joint Commission to assess the competency of licensed practitioners for re-credentialing, by the ACR for CT accreditation of facilities, and by the SIR in order to ensure that practitioners

have adequate procedural training, skill and experience. Moreover, these outcome metrics can be used to reduce variation in clinical practice, provide opportunities to engage in practice quality improvement, and contribute to developing national benchmarks and standards [6]. In this article, we have described how we developed and implemented an automated web-based procedure log that reliably monitors complications and diagnostic yield in real time by site and by operator for US- and CT-guided procedures in a radiology department.

The greatest benefit of the database is the ability to accurately quantify procedure volume by site and to measure complication rate and diagnostic yield by individual physician, by modality and by section. These data are relevant on a daily basis to provide accurate statistics on complication rates and diagnostic yield to patients when obtaining consent. These data are also relevant on a quarterly basis in order to benchmark outcomes by section and by user relative to national data and to engage in practice quality improvement. At this time the abdominal section plans to identify faculty

a

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Compliance report for procedure information in AI beginning 2010-09-01 00:00:00

Attending	Total report	Procedure information entered	% Entered	Site entered	% Site entered	Generate list
	9	9	100 %	9	100 %	Review
	12	9	75 %	12	100 %	Review
	14	14	100 %	14	100 %	Review
	29	23	79.3 %	26	89.7 %	Review
	46	42	91.3 %	46	100 %	Review
	135	122	90.4 %	111	82.2 %	Review
	114	99	86.8 %	112	98.2 %	Review
	122	115	94.3 %	122	100 %	Review
	207	193	93.2 %	207	100 %	Review
	456	347	76.1 %	398	87.3 %	Review
Attending	Total report	Procedure information entered	% Entered	Site entered	% Site entered	Generate list

b

Biopsy QA
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Compliance report for pathology information in AI beginning 2010-09-01 00:00:00

Attending	Total	Path entered	Path not entered	% Entered	Generate list
	12	8	4	66.7 %	Review
	456	313	143	68.6 %	Review
	29	22	7	75.9 %	Review
	135	113	22	83.7 %	Review
	114	98	16	86 %	Review
	46	44	2	95.7 %	Review
	207	202	5	97.6 %	Review
	122	122	0	100 %	Review
	9	9	0	100 %	Review
	14	14	0	100 %	Review
Attending	Total	Path entered	Path not entered	% Entered	Generate list

Fig. 4 Sample administrator audit pages for site and pathology as accessed under the “Audit” hyperlink using the “Faculty compliance with procedure information” and the “Faculty compliance with pathology information” filters shown in Fig. 3a

Biopsy QA					
Scheduled Search Complications Nursing Log Procedure Log Pathology QA Audit Analytics Add-ons Logout					
Compliance report for procedure information in AI beginning 2010-09-01 00:00:00					
Modality	Total procedures	Complications entered	No complications entered	% complications entered	Review
CT	482	476	6	98.8 %	Review
US	1267	1257	10	99.2 %	Review

Fig. 5 Sample administrator audit page for compliance with complication entry by modality as accessed under the “Audit” hyperlink using the “Nurse compliance with complications” filter shown in Fig. 3a

radiologists with high outcome metrics (i.e., low complication rates and high diagnostic yield) to generate best practice lists for use by trainees as well as faculty radiologists with lower outcome metrics. As we are a teaching institution, both chest and abdominal sections have discussed using the database to measure variance in outcomes between trainees and faculty radiologists. This could potentially establish outcome standards for trainees and could permit faculty radiologists to identify trainees with deficiencies in order to tailor procedure volume by modality and by site prior to matriculation. From an operation’s perspective, understanding the volume of procedures performed by our chest and abdominal sections can help us to better utilize existing resources and guide expansion of these services.

Ease of access to the database is critical to facilitate compliance. Because the database is web based and password protected, it can be accessed anywhere within the hospital or remotely using VPN. HIPPA compliance is maintained by only permitting physician users the ability to view procedures they have personally performed and by the elimination of patient identifiers from any audits or analytics generated for section or department review. Storage of the log on a remote server that is backed up every month ensures that the log cannot be misplaced. Finally, the procedure log fulfills ACGME accreditation for residents to maintain a log of all procedures performed.

In order for a procedure log application to work for a radiology department, it must be flexible enough to adapt to the unique needs and requirements of individual sections and modalities while accurately capturing valid outcome metrics. In this context, differences in implementation of the log between the chest and abdominal sections and between US- and CT-guided procedures highlight a core strength of the log. In the upcoming year, the log will be expanded to include the musculoskeletal section in our department and will likely be further tailored within the chest and abdominal sections to reflect evolving evidence regarding factors associated with procedure outcomes. For example, modification of the log for thyroid nodules biopsies is currently under discussion to

capture data regarding the size and composition (e.g., cystic versus solid) of nodules as these have been found to be associated with diagnostic yield [8, 9]. In the chest section, similar modifications have been proposed for lung procedures to document risk factors associated with complications including emphysema, lesion size and lesion depth [10, 11].

The main inherent limitation of the procedure log is error due to manual entry. Such errors, which generally occurred during the initiation period of the database, included several instances of miscoding where the faculty radiologist or nurse selected “guidance only” rather than “complications only”, resulting in omission of several complications (a hematoma and three arteriovenous fistulas). In one case, the nurses entered that there was an arteriovenous fistula but selected “none” under the “immediate complication” pick list. These errors have been mitigated through the use of the “guidance only” and “complication only” texts strings, through education of the faculty radiologists and nurses and also through the use of structured templates for “site” and “immediate complication” in the US section. Similar structure templates for CT-guided procedures would help reduce manual error and increase compliance and are currently being developed. However, structure templates will only auto-populate these required fields within the log if the correct text string is utilized. In other words, if physician dictate using free text rather than the structure template these procedures will be incorrectly coded.

The biggest barrier to compliance from the perspective of physician users is manual entry of pathology data. Auto-population would eliminate the task of manually entering pathology results and would maintain the benefit of reviewing all pathology results and images to determine diagnostic yield, tissue type and concordance with images. At present, plans are under way to modify the procedure log application such that the pathology table will be automatically populated with the pathology report corresponding to the image-guided procedure. Based on our experience to date, we believe that the combination of these two measures will move all faculty radiologists above the 90 % benchmark as it will eliminate the

need to log into the electronic medical record and look up pathology results for each patient individually.

Conclusion

We have created an automated web based procedure log database at our institution that meets department CEQI and chest and abdominal section requirements to reliably track complication rate and diagnostic yield for all US- and CT-guided process by site and by operator. This is accomplished through a joint effort on the part of physician users as well as the dedicated US and CT nursing staff and is tailored to the workflow, volume and variety of procedures performed by these sections and modalities. Auto-population of site and immediate complication fields within the log is feasible using structure templates and has improved compliance for US-guided procedures; similar results can be achieved for CT-guided procedures. Analytic reports generated by the application permit comparison of procedural outcome metrics of individual physician users with national benchmarks and can be eventually be used to develop tools to improve outcomes among both faculty radiologists and trainees, as well as aid in teaching and research.

Take Home Points

- Monitoring complications and diagnostic yield for image-guided procedures are outcome metrics that can be used as part of a comprehensive quality assurance/quality improvement program to reduce variation in clinical practice, provide opportunities to engage in practice quality improvement, and contribute to developing national benchmarks and standards.
- An automated web-based procedure log database is an effective tool to reliably track complication rates and diagnostic yield for US- and CT-guided procedures performed in a radiology department.

- Utilizing structured radiology report templates can result in significantly improved accuracy of information auto-populated from radiology reports, as well as greater compliance with manual data entry.

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