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Template-Driven Computed Tomography Radiation Dose Reporting:

Implementation of a Radiology Housestaff Quality Improvement Project

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Rationale and Objectives: Radiation exposure from medical imaging has received increasing attention in recent years. Ongoing calls to report radiation doses received during radiology studies as a means of recording cumulative exposure and identifying rare over-exposures have culminated in the State of California passing a mandatory reporting requirement effective July 1, 2012. Herein we describe a radiology housestaff-led quality improvement project to track radiation dose reporting a full year prior to state reporting mandates using a template-driven reporting system and our results over the first 12 months of its implementation.

Materials and Methods: Effective July 2011, all radiology trainees were instructed to use a standard computed tomography (CT) report template that included a CT dose measurement derived from dose information routinely displayed on our picture archiving and communication system. Consecutive reports from July 1, 2011, to June 30, 2012, of patients who underwent CT examinations at our institution were then retrospectively reviewed. Compliance of each study with the reporting requirement was assessed based on the presence or absence of a radiation dose statement within the finalized report.

Results: A total of 36,217 eligible consecutive CT reports were identified within the review period. Of these, 91.9% reported the radiation dose for the examination, greatly exceeding the initial goal of 80% compliance with the dose reporting requirement.

Conclusion: Successful reporting of CT radiation doses resulted from template-driven reporting, readily accessible calculation tools to facilitate dose calculation, and minimization of reporting burden on the radiologist a full year prior to state regulatory mandates.

Key Words: Computed tomography; dose reporting; quality improvement.

The use of computed tomography (CT) in clinical medicine has dramatically increased since its inception in the 1970s, and its subsequent integration into routine patient care is widely considered among the most important advances in medicine. CT now accounts for approximately 15% of all medical imaging and up to 70% of the total medical radiation dose in the pediatric population (1,2). Despite the tremendous importance of CT as a diagnostic modality, there is rising awareness of the potential risks of radiation-induced carcinogenesis (3,4) with numerous reports in the literature estimating the incidence of malignancy resulting from CT imaging (4,5). A few high-profile examples of severe overexposure have further heightened awareness of medical radiation among providers and the public at large (6,7).

The response to rising radiation exposure from imaging has been multifaceted. The American College of Radiology and other radiologic societies have initiated pediatric and adult specific dose reduction campaigns (*Image Gently* and *Image Wisely*, respectively) in addition to Society of Pediatric Radiology–sponsored As Low As Reasonably Achievables conferences, American College of Radiology accreditation programs, and the American Society of Radiologic Technologists professional development course titled “Pediatric Body CT: Techniques and Tactics.” Parallel efforts to decrease unnecessary medical imaging include recent efforts by the US Food and Drug Administration, which in 2010 launched the Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging (8,9).

One response to concerns over radiation exposure has been a push for radiation dose reporting. Although reporting does not directly reduce exposure, documenting cumulative exposure may raise awareness among patients and referring clinicians of the doses being received, leading to improved discretion during radiology ordering. Moreover, mandatory reporting should

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allow for immediate recognition of rare, unintended overexposures, allowing for immediate correction.

On September 29, 2010, Governor Arnold Schwarzenegger signed into law California Senate Bill (SB) 1237 regulating CT radiation dose reporting practices in California. Motivated by several incidents of radiation overexposure on CT scanners and underreporting of these events, the California State Legislature enacted legislation to require documentation of radiation dose in CT scans as well as disclosure of radiation-related errors. Effective July 1, 2012, California SB 1237 requires all computed tomography studies in California to report computed tomography index volume (CTDI vol) and dose length product (DLP) electronically to the PACS as well as in the patient's record. Although recent reports have described progress toward the automated integration of the CT dose into the final dictated report (10,11), differing radiology information systems, differences among scanner manufacturers, and the lack of information technology hardware and software infrastructure makes implementation of these systems expensive, cumbersome, and time-consuming. In this article, we describe our experience at a large tertiary academic medical center with the implementation of a radiology housestaff-led quality improvement project to incorporate the final radiation dose (as a dose-length product [mGy-cm] or as the effective dose [mSv]) in the final radiologic report.

MATERIALS AND METHODS

Dose Reporting

In preparation for compliance with SB 1237, radiology housestaff representatives and departmental leaders discussed potential mechanisms for dose reporting. Summary screens generated from the CT scanner software listing the dose in CTDIvol and DLP were already routinely saved to PACS with each study. A template-driven mechanism for incorporating the dose into reports was selected.

Structured reports, already the standard employed by our department, were modified to include a statement of radiation dose within the report's *Technique* section. A selectable fill-in field was created in which the numeric dose was entered, followed by a descriptive statement including the units of exposure and additional informational resources for interested patients and providers. Radiation dose statements varied based on the type of study being performed and whether the study was being performed simultaneously with imaging of other body parts. For abdominal imaging and pediatric imaging studies, effective dose was chosen as the primary dose metric to maintain reporting continuity with longstanding historical departmental policies regarding dose reporting in these imaging sections. For thoracic, interventional, neurological and musculoskeletal imaging studies, the DLP was selected in lieu of the effective dose as no widely agreed on conversion factors were identified to reliably convert DLP to effective dose.

Our CT scanners report the dose from each series and for the entire imaging session. In cases in which multiple separate body parts were imaged and reported separately, we wanted to avoid reporting of the total dose in multiple separate reports, thereby creating a falsely elevated accounting of the true radiation dose. We elected to not attempt the dividing of this total dose by individual, anatomy-specific series to prevent errors in the calculations and inconsistent usage. Instead, we resolved to report the total dose in only one of the reports and have the remaining reports refer to the report containing the dose. This required establishing a hierarchy of study types wherein the study highest on the list would be responsible for reporting the total dose; abdominal CTs always reported the full dose, as standalone studies or in combination; chest CTs were the most common study type to refer to another report as they were often performed at the same time as an abdominal CT.

Tools to Assist the Radiologist and Implementation

In the cases where radiation exposure was reported as an effective dose, radiologists had the option of using a calculation tool developed in our department and available from each PACS station. The conversion factors were easy to memorize and apply (for abdominal CTs, the effective dose was $0.015 \times$ the DLP). We encouraged reporting to the nearest whole mSv, which enabled many radiologists to calculate the effective dose without the dose calculator.

Prior to the implementation of this new system, a dedicated conference was held for all diagnostic radiology residents and fellows (52 and 41 residents and fellows, respectively, all of whom participated in the quality improvement [QI] project) describing the mechanisms for reporting dose in the templates. In particular, details of more complicated situations (e, multi-body part studies) were discussed at length. The department faculty was also notified of the change via electronic communication. Because nearly all CT examinations are dictated by residents/fellows in the department (with only a very few rare exceptions occurring sporadically), it was decided that given their extremely low dictation numbers, a dedicated conference for the attendings was not necessary.

Study Design

This study was approved by the local Institutional Review Board. Finalized reports for all CT studies performed at our institution between July 1, 2011, and June 30, 2012, were reviewed. The reports were obtained from the radiology information system database (IDXRad version 10.6.0.999; IDX, Burlington, VT [a subsidiary of GE Healthcare]). Compliance with the dose-reporting requirement was ascertained by an automated query of finalized reports to determine the presence or absence of a reported dose and the associated dose statement. Five percent of total studies were randomly selected each month and manually verified to be in agreement with the results of the automated system.

Statistical Analysis

For each day of the study period, the number of studies completed was compared to the dose-reporting rate of the final reports dictated on the same day. Correlation between daily CT volume and daily dose-reporting rate was determined using Pearson's product-moment coefficient.

RESULTS

For the 2011–2012 academic year (July 1, 2011–June 30, 2012), a radiology housestaff-led quality improvement project was implemented with the goal of reporting the radiation dose received on at least 80% of all CT examinations. An average of 3018 diagnostic CT examinations were completed per month across all subspecialty sections (neuroradiology, thoracic and cardiac imaging, abdominal imaging, interventional radiology, pediatric radiology, and musculoskeletal radiology) for a total of 36,217 CT examinations for the study period. On a monthly basis, the percentage of finalized CT examinations reporting the radiation dose received ranged from 85% to 95% with a final total of 91.9% of all reports reporting the dose received, well above our target goal of 80% (Table 1).

The Pearson correlation coefficient (r) between the number of CT studies per day and the dose reporting rate for 366 matched pairs was -0.06 with a 95% confidence interval of -0.16 to 0.05. The coefficient of determination (r^2) was 0.003.

DISCUSSION

Effective July 1, 2012, California SB 1237 requires all CT studies performed in the State of California to report CTDI-vol and DLP electronically to the PACS as well as in the patient's record. The bill was largely motivated by prior incidents of radiation overexposure and emerging evidence regarding the risk of radiation-induced carcinogenesis. Although dose reporting does not directly reduce exposure, documenting cumulative exposure may allow patients and providers to become more aware of the radiation doses delivered during these studies, with the hope that mandatory reporting will encourage appropriate consideration of radiation dose as part of radiology ordering practice and, separately, allow immediate recognition by radiologists of unintended overexposures. Although there has been progress towards the automated integration of the CT dose into the final dictated report, the information technology environment within many academic medical centers and private radiology groups is characterized by diverse and often incompatible radiology information systems, scanner manufacturers, and a lack of proper computer hardware and software support to facilitate automation.

Recognizing the upcoming dose reporting requirement and anticipating the complexity of implementing dose reporting on all finalized studies, a housestaff-led QI project to report CT dose on all diagnostic examinations was conceived, planned, and implemented departmentwide commencing July 1, 2011, for the 2011–2012 academic year. The project as outlined in this article describes the process of implementing a system at a large academic center to report radiation dose in the final radiologic report. The goals of the QI project were twofold: (1) to institute early compliance with a newly passed California law SB 1237 to report the radiation dose on all diagnostic CT examinations and (2) to integrate education of CT radiation dosing into the daily resident workflow environment.

To that end, at the beginning of the QI period, housestaff project QI leaders gave a dedicated resident conference for all diagnostic radiology residents and fellows (52 residents, 41 fellows) describing the mechanisms for reporting dose in the templates. In particular, details of more complicated situations (multi-body party studies) were discussed. The department's faculty was also notified of the change via electronic communication and faculty meetings. Because nearly all CT examinations are dictated by residents/fellows in the department (with only a very few rare exceptions occurring sporadically), it was decided that given their extremely low dictation numbers, a dedicated conference for the attendings was not necessary.

Successful implementation of dose reporting was largely predicated on ensuring the least amount of burden and disruption to the radiologist's daily workflow. This requirement motivated us to leverage our use of structured reports, already the standard employed by our department, to include a statement of radiation dose within the reports' Technique section. Selectable fill-in fields were created to allow for the easy entry of the numeric dose as DLP or effective dose, dependent on the type of study. In instances where a conversion to effective dose was required, radiologists had the option of using a calculator developed in our department specifically for this purpose and readily available from each PACS station. To further increase compliance, the selectable fields in the dose statement were designated as "hard stops" prior to report signing, which when left empty, prompted radiologists to fill in the designated dose fields before finalizing the report.

Month-by-month accounting demonstrated a steady increase in dose reporting over the first 6-month period, likely reflecting the housestaff's initial learning curve and growing

TABLE 1. Total Dose Reporting by Month in the 2011–2012 Academic Year

Month	Not Reported	Reported	Total (%)
July	328	2560	88.6
August	252	3016	92.3
September	238	2742	92.0
October	223	2911	92.9
November	177	2734	93.9
December	172	2660	93.9
January	179	2941	94.3
February	148	2842	95.1
March	165	3061	94.9
April	259	2622	91.0
May	452	2626	85.3
June	329	2580	88.7
Total	2922	33295	91.9

familiarity with the mechanics of radiation dose reporting, culminating in a peak reporting percentage of 95% in February. Interestingly, the reporting rate fell slightly in the last 2 months of the QI period, which may indicate decreased participation by senior residents and fellows at the end of training. Correlation analysis showed no significant link between the total number of studies reviewed on any given day and the rate of compliance with the dose-reporting requirement. This lack of correlation strongly suggests that our systematic approach to integrating dose reporting as seamlessly as possible into the daily radiologist workflow using structured templates, selectable fields, and simple dose calculators did not prove to be an undue time burden.

Finally, a brief retrospective analysis of nonadherent reports failing to provide the radiation dose revealed two common scenarios: (1) dictations not using the standard structured templates and (2) CT-guided procedures. In both instances, we undertook continuing education among residents and fellows alike to use structured reports when available to them and to notify those residents and fellows on procedures to report the dose on nonstandardized reports. We further attempted to encourage compliance by providing the option of manually inserting a dose template (a copy of the dose statement from standard CT reports) into CT-guided procedure reports as well as freehand or other nonstandard reports with relative ease.

CONCLUSION

We have described the planning, implementation, and results of a housestaff-led QI project demonstrating the successful installation of a new systems-based practice in a large academic setting for the reporting of CT radiation dose ahead of state regulatory mandates. Our success can largely be attributed to our structured reporting standard and built-in checks during the report signing process to ensure dose-reporting compliance. We have also described a successful model for housestaff participation and leadership in an academic radiology department and how quality improvement, patient safety, and housestaff education can be effectively incorporated into radiology residency and fellowship training. We hope that our experience will serve as a model for other institutions with an interest in developing and encouraging resident-led quality improvement and patient safety initiatives.

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