Use of CT Dose Notification and Alert Values in Routine Clinical Practice

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Objective: The purpose of this investigation was to assess the impact on workflow of the use of notification and alert values in our practice and to provide baseline data for quality improvement initiatives.

Methods and Materials: Five diagnostic clinical CT scanners were programmed with the notification and alert values recommended by the American Association of Physics in Medicine. Retrospective analysis was performed on log files to assess the frequency of and reason for notification and alert events.

Results: Between February and September of 2012, 11,384 patients were scanned on the 5 systems. One alert occurred because of the use of bolus tracking in a morbidly obese patient, where the prescan cumulative volume CT dose index for the exam exceeded the recommended alert value of 1,000 mGy. Only 1.2 ± 0.6% of patient scans triggered a notification. Notifications were mainly triggered because of bolus tracking and/or large patient size. Protocols triggering notifications most often included CT angiography of the chest for pulmonary emboli.

Conclusion: Because only a small percentage of performed patient examinations triggered a notification or alert event, the impact on workflow of adopting these features was negligible. Evaluation of the logs identified trends in reasons for which notification events were triggered; these primarily included large patient size and bolus tracking. Additionally, specific protocols were identified where adjustment of notification values was deemed necessary.

Key Words: CT, radiation dose, dose check, notification and alert values, patient safety initiatives

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INTRODUCTION

Radiological imaging has greatly benefited patient care. However, there is still a possibility of patients receiving a radiation injury from medical imaging. In 2009, the concern of excess radiation during CT brain perfusion scans was brought to the FDA's attention when 385 patients presented with radiological injury [1]. Considering that over 70 million scans are performed annually in the United States [2], the risk of acute injury is extremely low. Nonetheless, radiation doses must be carefully monitored and controlled to ensure that the lowest doses of radiation necessary to achieve a diagnostic level of image quality are used and to ensure no future deterministic injuries occur [1,3]. To assist in this task, many organizations, including the International Commission on Radiological Protection and ACR, endorse the use of diagnostic reference levels (DRL) [3-5]. DRLs do not represent the optimal radiation dose, but rather they are used to trigger an investigation into the need for possible dose reduction actions. They can be used as a guideline for doses in specific patient sizes under specific scanning conditions [5]. Recently, the National Council on Radiation Protection and Measurement established DRLs to provide a national guideline for imaging physicians to prevent the administration of unnecessary high doses of radiation [6]. However, DRLs are based on large patient populations and are, therefore, poor surrogates for monitoring the appropriateness of doses in specific patients.

After the radiation injuries during CT brain perfusion scans were revealed, the FDA asked all scanner manufacturers to address the issue of inadvertent uses of high dose levels [7]. The Medical Imaging Technology Alliance and the National Electrical Manufacturers Association worked with the ACR and the American Association of Physics in Medicine (AAPM) to develop a method to better protect patients from inadvertent high dose levels [7-9]. In conjunction with key stakeholders, the Medical Imaging Technology Alliance developed a technical standard to help avoid patient injury by

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automatically checking for potentially high dose levels and notifying the CT operator [9]. The AAPM later released a set of recommendations regarding reasonable notification and alert values for clinical use [7]. The values recommended by the AAPM were selected by a group of medical physicists, radiologists, and technologists, as well as manufacturers' representatives. The values were selected to produce relatively infrequent notification or alert events to avoid technologists becoming desensitized to the events. The precise event frequency that is neither too high nor too low is not known, but the consensus of the working group was to aim for an event rate of approximately 5%. The AAPM recommended notification and alert values are given in terms of volume CT dose index ($CTDI_{vol}$) [7]; hence, $CTDI_{vol}$ data from the ACR Dose Index Registry were used to determine the 95th percentile $CTDI_{vol}$ values in an attempt to achieve a 5% event rate.

Notification values are used to trigger a message when a single prescribed scan is likely to exceed the set value. An alert value is used to trigger a message when multiple prescribed scans within one examination are likely to result in a cumulative dose exceeding the set value [7]. When a notification or alert value is exceeded, the user is prompted to verify the scanning protocol and provide a comment before continuing on with the scan. The purpose of notification and alert values is for users to be aware of and to confirm scanning parameters likely to lead to high dose index values before scanning patients. As manufacturers update scanners with software versions implementing notification and alert values, the tool should be integrated into clinical practice. An important aspect of this integration is monitoring of notification and alert event logs so that exam protocols, technologist practices, or the programmed notification and alert values can be adjusted to fit the needs of specific patient demographics and exam types [7]. Our investigation analyzed data from 5 diagnostic clinical CT scanners to better understand the impact on workflow of the use of notification and alert values and to provide baseline data for future quality improvement initiatives.

METHODS AND MATERIALS

The AAPM-recommended notification and alert values [7] were manually programmed into 5 scanners in our practice that were equipped with the necessary software, which is part of the manufacturer's operating software. The software required use of a universal alert value, which was a single value applicable to all scan protocols. The alert value was set at a $CTDI_{vol}$ of 1,000 mGy, based on a recommendation by the FDA. Notification values can be individually set for each series with a scan protocol.

Table 1 [7] lists the notification values used in our practice, which are the same as those recommended by the AAPM. The use of automatic exposure control (AEC) is dependent on the exam protocol. For example, AEC is used almost exclusively in our practice for exams of the torso, but AEC is not commonly used for exams of the head. Therefore, all adult patient head exams, regardless of patient size, were scanned using the default $CTDI_{vol}$ settings, as the AEC system was not used to modify scan parameters on a patient-by-patient basis.

Table 1. Dose notification values recommended by the AAPM

CT Scan Region (Associated with one scan series or scan phase)	$CTDI_{vol}$ Notification Value (mGy)
Adult head	80
Adult torso	50
Pediatric head	
<2 years old	50
2-5 years old	60
Pediatric torso	
<10 years old (16-cm phantom)*	25
<10 years old (32-cm phantom)†	10
Brain perfusion (exam series that repeatedly scans the same anatomic level to measure the flow of contrast media through the anatomy)	600
Cardiac	
Retrospectively gated (spiral)	150
Prospectively gated (sequential)	50

Data were derived from the American Association of Physics in Medicine [7].
AAPM = American Association of Physics in Medicine; $CTDI_{vol}$ = volume CT dose index.
*As of January 2011, GE, Hitachi and Toshiba scanners use the 16-cm-diameter CTDI phantom as the basis for evaluating dose indices ($CTDI_{vol}$ and dose-length product) displayed and reported for pediatric body examinations.
†As of January 2011, Siemens and Philips scanners use the 32-cm-diameter CTDI phantom as the basis for evaluating dose indices ($CTDI_{vol}$ and dose-length product) displayed and reported for pediatric body examinations.

Before scan initiation, if a notification value was exceeded, a window popped up stating that the selected settings resulted in a $CTDI_{vol}$ value that exceeded the notification value assigned. The user was prompted to enter a reason for exceeding the notification value before continuing on with the scan. Alternatively, the user could have canceled the scan and selected new scanning parameters. The consequence of triggering an alert was different than for triggering a notification. When an alert was triggered, a different window appeared, stating the total $CTDI_{vol}$ for the study exceeded the alert value. The user could then cancel the scan and select new scanning parameters. However, if the user elected to proceed, the user was required to enter his or her name and a reason for exceeding the alert value before continuing. Although this information was optional when choosing to continue with the scan when a notification value was exceeded, it was mandatory when an alert value was exceeded. The software can be configured to require that a password be entered to proceed; however, that feature was not enabled for this study.

The scanners chosen for use in this study encompassed the full range of clinical use (Table 2). An analysis