Radiologic Resident Education

Improving our PRODUCT:

A Quality and Safety Improvement Project Demonstrating the Value of a Preprocedural Checklist for Fluoroscopy

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Rationale and Objectives: To implement a preprocedural checklist in gastrointestinal (GI)/genitourinary (GU) fluoroscopy suites to assist radiology residents in performing studies with optimal fluoroscopic technique with a goal to lower radiation dose delivered to patients and operators.

Materials and Methods: We introduced a preprocedural checklist in the form of a mnemonic to first-year resident fluoroscopy operators. The checklist was augmented by teaching sessions at the fluoroscopy tower. Fluoroscopy time (FT) was collected for GI/GU fluoroscopy studies performed by first-year residents who did not use the checklist (year 1) and compared with FT from first-year residents who used the checklist for one full academic year (year 2). Residents in both groups were surveyed to assess their knowledge of radiation safety at the end of their respective radiology 1 (R1) academic years.

Results: A total of 778 examinations were analyzed from year 1, and 941 total examinations from year 2. After implementation of the checklist, mean FT for all studies decreased by 41.1 seconds ($P < .0001$) in year 2 residents. Multivariate linear regression confirmed that year of examination was the strongest independent predictor of FT when other covariates such as resident age, gender, and experience and patient age and gender were included. Radiation safety knowledge was similar in both groups but self-reported confidence in safe fluoroscopy tower operation increased slightly in year 2 ($P = .144$).

Conclusions: A visual preprocedural radiation safety checklist in GI/GU fluoroscopy was associated with a reduction in mean FT and may contribute to a culture of radiation safety awareness.

Key Words: Resident education; checklists; radiation safety; quality improvement; fluoroscopy.

Since the 1980s, the US population's exposure to medical ionizing radiation has more than doubled (1). Increased use of computed tomography is the largest source of the increase with smaller contributions from nuclear medicine, interventional fluoroscopy, and conventional radiography and fluoroscopy (2). Although controversy exists over the degree of risk associated with medical radiation, there is a general consensus in the radiology community that steps should be taken to limit unnecessary exposure. Examples include advocating for the use of the ALARA principle urging radiologists to perform studies delivering a dose of radiation that is "as low as reasonably achievable," (3) and the development of the *Image Wisely* and *Image Gently* guidelines by the American College of Radiology and the Society of Pediatric Radiology, respectively (4,5).

Inspired by leaders in medical checklist development (6) and following on from recent efforts to incorporate checklists within radiology departments (7,8), we designed a preprocedural checklist for fluoroscopy studies to optimize safe fluoroscopy tower operation with the goal of reducing radiation dose. Our hypothesis is that the use of the checklist will decrease radiation dose delivered to patients and operators (as measured by fluoroscopy time) and will promote the awareness of radiation safety in gastrointestinal (GI) and genitourinary (GU) radiology in our department. The purpose of this study was to operationalize the checklist, assess qualitative and quantitative changes in radiation dose awareness among first-year resident fluoroscopists, and track intraprocedural fluoroscopy times as a surrogate measure of radiation exposure for patients and operators.

MATERIALS AND METHODS

Study Design

After formal Institutional Review Board exemption, a prospective cohort study with retrospective collection of fluoroscopy time data was performed between July 2011 and June 2013. This study period included two consecutive first-year

Acad Radiol 2015; 22:400–407

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http://dx.doi.org/10.1016/j.acra.2014.09.004

resident cohorts. The first resident cohort (year 1) served as a standard of comparison, or baseline, group and the second resident cohort (year 2) served as the intervention group. The intervention was the introduction of a visual preprocedural checklist. Our outcomes were fluoroscopy time and resident awareness of safe fluoroscopy tower operation in the intervention group.

Checklist Development

Two third-year radiology residents undertook the task of developing the checklist following a review of the literature describing checklist development in medicine and the aviation industry (6,9,10,14). The goal was to develop a checklist that would be visible at the fluoroscopy tower by resident operators. During initial brainstorming sessions, the authors decided to create the checklist in the form of a mnemonic to improve ease of recollection of the checklist steps. Other concept development points included how many steps to include in the checklist, what level of resident operator to target, and the types of fluoroscopy procedures to be targeted for the checklist intervention. With the assistance of the department physicist and knowledge of the critical steps required in optimizing fluoroscopic technique, a list of seven potential procedure steps of fluoroscopy tower operation was created and then organized into an appealing mnemonic with each letter representing a step in potential radiation dose reduction. The checklist is titled "Improving Our PRODUCT" and is illustrated in Figure 1. The mnemonic PRODUCT stands for the following: pulsed fluoroscopy, remove grid, off pedal, de-magnify, use badge, collimate, tower down. The checklist was reviewed by the department physicist, two GI faculty radiologists, and two fluoroscopy technologists, one with more than 35 years of practical experience, to solicit feedback on appropriateness and ease of use. Suggestions were incorporated into the final product which took the form of a laminated placard posted to the top of the fluoroscopy tower in each of four GI fluoroscopy suites and one GU fluoroscopy suite. The checklist was then disseminated to all GI/GU faculty radiologists to familiarize them with the tool.

The checklist was developed for several purposes: 1) to be used by residents before and during performance of a fluoroscopy study similar to how an aviation checklist is used by pilots; 2) as a teaching tool for fluoroscopy physics principles; 3) to visibly promote our culture of radiation safety in the GI/GU radiology division; and 4) as a component of a division-wide quality improvement project.

To promote commitment to using the checklist, faculty-led weekly teaching sessions at the fluoroscopy tower were scheduled to enhance understanding of basic fluoroscopy physics principles using the checklist as a visual prompt to discuss the effects of grid application, magnification, lowering the tower, changing pulse rate, and collimation on radiation dose. During the teaching sessions, residents were encouraged to physically practice the steps of the checklist to promote incorporation of the checklist steps into their fluoroscopy performance. When possible, the teaching sessions included all members of the fluoroscopy team, including technologists, residents, and faculty, to encourage a team approach to radiation safety and division-wide commitment to radiation dose reduction.

Data Collection

Fluoroscopy time was chosen as a surrogate marker for radiation dose because it is routinely recorded in the radiology information system (RIS) and tracked by procedure through the Common Procedural Terminology codes ascribed to medical procedures. The RIS database also captures the examination date, patient age, patient sex, medical record number, and fluoroscopist performing the study. Data from the RIS were exported in text format and converted to a spreadsheet using standard software (Microsoft Excel; Microsoft Corporation, Redmond, WA). To obtain fluoroscopy times, a spreadsheet containing all data from each resident year was searched for the corresponding Common Procedural Terminology codes for esophagrams, upper GI series, small bowel follow-through examinations, feeding tube placement and repositioning, and contrast enemas.

Fluoroscopy times were retrospectively collected for first-year residents performing GI and GU fluoroscopy between July 2011 and June 2012 before the introduction of the checklist (year 1). This group of residents served as a baseline group. The year 1 residents were surveyed anonymously at the completion of the academic year in June 2012 to assess knowledge and awareness of safe fluoroscopy technique. The self-assessment was composed using a free online survey tool (surveymonkey.com) and was sent to residents through hospital-based e-mail. It consisted of five knowledge-based, multiple-choice questions addressing basic physics principles of fluoroscopy and their application to radiation dose reduction. All of these principles were highlighted by steps in the checklist mnemonic. The second portion of the evaluation included six self-assessment statements evaluating the residents' confidence level in operating the fluoroscopy tower and performing procedures according to the ALARA principle. Residents responded to these specific statements using a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. Fluoroscopy times were retrospectively collected from the RIS for year 1 residents between July 2011 and June 2012.

The next cohort of first-year residents who started radiology residency training in July 2012 were instructed on how and when to use the checklist. This group served as the intervention group (year 2). The year 2 residents used the checklist before performing each fluoroscopy procedure and participated in the weekly faculty-led teaching sessions during their 4-week GI radiology rotation. At the completion of the academic year in June 2013, year 2 residents were administered the same anonymous 11-question self-assessment. Fluoroscopy times were retrospectively collected from the RIS for year 2 residents between July 2012 and June 2013.