Original Investigation

Impact of Patient Photographs on Radiologists' Visual Search of Chest Radiographs

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Rationale and Objectives: To increase detection of mislabeled medical imaging studies, evidence shows it may be useful to include patient photographs during interpretation. This study examined how inclusion of photographs impacts visual search.

Materials and Methods: Ten radiologists participated. Average age was 43.00 years and average years Board-certified was 9.70, with 2 residents, 1 general, 2 abdominal, 4 cardiothoracic, and 1 pediatric radiologist. They viewed 21 portable chest radiographs with and without a simultaneously acquired photograph of the patient while visual search was recorded. Their task was to note placement of lines and tubes.

Results: Presence of the photograph reduced the number of fixations (chest radiograph only mean 98.68; chest with photograph present 80.81; photograph 10.59; $p < 0.0001$) and total dwell (chest radiograph only mean 30.84 seconds; chest radiograph with photograph present 25.68; photograph 3.93; $p < 0.0001$) on the chest radiograph as a result of periodically looking at the photograph. Overall viewing time did not increase with addition of the photograph because time not spent on the radiograph was spent on the photograph. On average, readers scanned from the radiograph to the photographs about four times during search. Men and non-cardiothoracic radiologists spent significantly more time scanning all the images, including the photographs. Average preference for having photographs was 6.10 on a 0–10 scale, and neck and chest were preferred as areas to include in the photograph.

Conclusion: Photographs may help with certain image interpretation tasks and may help personalize the reading experience for radiologists without increasing interpretation time.

Key Words: Photographs; radiographs; patients; visual search; safety; errors; wrong-patient events.

INTRODUCTION

The Institute of Medicine's Committee on Quality of Health Care in America estimated that as many as 98,000 people die each year from medical errors (1). In radiology, a potential source of error is the *wrong-patient error*, which happens when a patient's radiograph is incorrectly filed under a different patient's folder in the Picture Archiving and Communication System (PACS). For example, one Pennsylvania study demonstrated that 196 of 652 (30.1%) error events in radiology in 1 year that resulted in serious patient harm were wrong-patient errors (2).

To minimize such identification errors, The Joint Commission in its National Patient Safety Goals outlines the requirement of including at least two patient identifiers when providing care, treatment, and services. These identifiers may include the individual's name, an assigned medical record number, telephone number, or other person-specific identifier, such as date of birth or social security number (3). However, when mobile or portable radiographs are obtained in high-stress environments outside of the radiology department, such as in the emergency department or in the intensive care unit (ICU), where patients often cannot accurately provide identification information due to sedation, intoxication, alteration in consciousness, or inability to communicate for other reasons, the setting is ripe for wrong-patient errors to occur (4).

The face, an intrinsic yet externally visible identifier, has been proposed as an adjunct to aid in reducing such wrong-patient errors while radiologists are interpreting radiographs (5). To test this idea, a device that simultaneously and automatically acquires photographs at the time of radiograph acquisition has been developed (5). In two observer studies, one with 10 recently board-certified radiologists (6) and another with 90 radiologists with varying years of experience and specialties (7), the detection rates of simulated errors with and without the presence of concomitantly obtained photographs were recorded. In both studies, photographs paired with

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radiographs significantly increased the detection rate of wrong-patient errors, without a substantial increase in interpretation time.

However, on a post-interpretation survey, up to 20% of the subjects felt that the photographs were distracting, and 42% felt that they spent more time or may have to do so because of the photographs (6,8). Objectively, the average interpretation time of about 60 seconds per radiograph did not change with introduction of a photograph, and was consistent with other studies measuring chest radiograph interpretation times (9). Neither of these previous studies did anything more than record total viewing time, so it is not possible to determine why reading time did not differ when a photograph was available during interpretation.

Eye-tracking has been used for over a century in fields such as neuroscience, psychology, industrial engineering, marketing, and computer science to assess visual attention (10). Since the 1960s it has been used in radiology to study and classify causes and types of errors, the impact of fatigue on search, to characterize the development of medical image interpretation expertise, assess the impact of various technologies on visual search strategies and efficiencies, and develop computer-aided and other decision aids that incorporate search information (11–17). In recent years, eye-tracking studies have extended to whole slide images in pathology and digital photographs in dermatology (18,19). It has not been used to understand the effect of adding a patient photo to the PACS when radiologists are tasked with chest radiograph interpretation reviews.

In the present study, we used eye-tracking to investigate why there were no significant differences in total interpretation time in the two previous studies (6,7) incorporating patient photographs into the radiographic interpretation process. We also surveyed the radiologists after each of the two phases of the experiment using a standardized questionnaire to further explore qualitative viewpoints on the inclusion of photographs during image interpretation.

MATERIAL AND METHODS

The study was approved by the institutional review boards of both Emory University and the University of Arizona. The patient data (radiographs and photographs) were obtained at Emory University and the eye-tracking observer study was performed at the University of Arizona. Informed consent was obtained from the patients or from a family member authorized to provide consent. The study was fully compliant with the Health Insurance Portability and Accountability Act. Patient identifiers (except for the institutional review board approved photographs) were removed from the radiographic images.

Details of how the radiographs and photographs were acquired have been described previously (5–7). The study originally recruited 41 patients, but consent for this additional eye tracking study was obtained from only 21 patients, and, therefore, the current study used data only from these 21 patients.

Radiologists

Ten radiologists (six males and four females) participated in the observer study after providing consent. The subjects were either board-certified attending radiologists or radiology residents at the University of Arizona. Average age was 43.0 years (standard deviation [SD] = 12.5, range 33–76), average years Board-certified was 9.7 (SD = 12.1, range = 0–41), and 2 were in-training (residents). Practice areas of the radiologists included the following: one general, two abdominal, four cardiothoracic, and one pediatric radiology.

Radiograph Review Task Design

The radiologists viewed 21 portable chest radiographs without and subsequently with a photograph of the patient while visual search was recorded. At least 3 weeks passed between sessions to prevent recall bias. A counterbalanced design was not used as viewing the radiographs with the photographs before viewing them without would have revealed the true purpose of the study, potentially impacting their natural search patterns in the radiograph-only condition. Their task was to note placement of tubes and lines. Responses were recorded on a pre-formatted form with the possible tubes and lines noted and checkboxes for indicating proper or improper placement. There were no correct or incorrect answers as this was not a diagnostic accuracy study. However, we did want the observers to perform a task that would require search and that clinically is often a challenge in terms of being able to follow the tubes and lines visually to determine proper placement.

The images were displayed on a 3 MP medical-grade color LCD display (Eizo RadiForce RX340; Eizo Corporation; Ishikawa, Japan) calibrated to the Digital Imaging and Communication in Medicine Grayscale Standard Display Function. Ambient room lights were set at 40 lux. The viewing distance of the observer from the screen averaged 35 cm. A Tobii Pro X2-60 Eye Tracker (Tobii Technology, Inc. Stockholm, Sweden) was used to conduct the study. The Pro X2-60 uses bright/dark pupil tracking with a sampling rate of 60 Hz and has an accuracy of 0.4 deg and precision of 0.34 deg. Prior to the start of an eye-tracking session, observers were calibrated using standard methods (20).

Eye-Tracking Analysis

The eye-position data were analyzed using standard methods (20). Briefly, the accuracy of the system (spatial error between true eye position and computed measurements) is less than 1 degree. The eye-tracker samples eye positions every 1/60 of a second to generate raw x-, y-coordinate eye-position data. Fixations are formed by grouping x- and y-coordinates of the raw data using a running mean distance calculation. Dwell time can be calculated for each fixation, summed across fixations, then associated with a given region of interest or location in the stimulus image. An additional scanning parameter included in the analysis was the number of times the eyes scanned