Original Investigation

The Influence of a Vocalized Checklist on Detection of Multiple Abnormalities in Chest Radiography

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Rationale and Objectives: Although a checklist has been recommended for preventing satisfaction of search (SOS) errors, a previous research study did not demonstrate that benefit. However, observers in that study had to turn away from the image display to use the checklist. The current study tested a vocalized checklist to avoid this constraint.

Materials and Methods: A total of 64 chest computed radiographs, half containing various "test" abnormalities, were read twice by 20 radiologists, once with and once without the addition of a simulated pulmonary nodule. Readers used a vocalized checklist-directing search. Receiver operating characteristic (ROC) detection accuracy and decision thresholds were analyzed to study the effects of adding the nodule on detecting the test abnormalities.

Results: Adding nodules induced a substantial reluctance to report the other abnormalities ($P < 0.001$), as had been the case in the most recent study of the SOS effect in radiography.

Conclusions: The vocalized checklist did not reduce nor eliminate the SOS effect on readiness to report further abnormalities. Although useful for organizing search and reporting, particularly among students, a vocalized checklist does not prevent SOS effects.

Key Words: Diagnostic radiology; observer performance; images, interpretation; quality assurance.

INTRODUCTION

Laboratory studies conducted in 1990 and 2000 demonstrated a satisfaction of search (SOS) effect in chest radiology with reduced accuracy in detecting native abnormalities on chest radiographs in the presence of simulated pulmonary nodules (1,2). A more recent study suggested that adding nodules may not always reduce detection accuracy for the other abnormalities, but rather induces a reluctance to report them (3). The authors suggested that this change may reflect changes in the practice and training of radiologists related to the ascendance of three-dimensional imaging modalities.

Checklists have been recommended to counteract SOS errors in radiology (4,5). Using the same radiographs as the 1990 and 2000 papers, a 2006 experiment studied whether self-prompting can prevent reader errors due to SOS (6). A printed checklist was produced as a booklet and contained a page for each case that required the reader to explicitly report on each item on the checklist (e.g., neck, mediastinum; heart/vessels; lungs; pleura; abdomen; bones). The results indicated that there was no SOS effect on detection accuracy; instead, detection accuracy seemed to be reduced even when the added nodule was *not* present. The authors interpreted this finding, suggesting that using the checklist may have interfered with the radiologist's visual search because for some readers, the order of elements in the printed checklist differed from the order they prefer in the clinic. The checklist may have also interrupted the radiologist's search as they had to take their eyes off the display and look at the booklet to follow the checklist.

If the checklist disrupted perception, the problem may not be with a checklist per se, but with how the written checklist was used. Sistrom and Langlotz (7) have identified attributes of the radiology, reporting process that can be improved. They noted that a drawback of point-and-click interfaces is that they require the user to repeatedly look away from the images toward the reporting interface. Sistrom (8) suggested that this problem may explain the detrimental effect on reader performance observed in the 2006 checklist experiment and suggested a follow-up study with a checklist simulating a "talking template." A talking template is a checklist in which

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the checklist items are read out loud to the radiologist who responds verbally to each item. Our goal was to perform Dr. Sistrom's suggested experiment.

MATERIALS AND METHODS

Experimental Conditions

To test whether a vocalized checklist could alter the SOS effect, we used the same two conditions used in previous SOS demonstrations: presentation of each chest radiograph with and without a simulated pulmonary nodule. The detection accuracy for native, subtle lesions was compared to that for those same lesions when a simulated pulmonary nodule was digitally added to the radiograph. This created two cases with the same background anatomy and actual lesions perfectly matched for the two conditions (Fig 1). Simulated and native lesions were not spatially superimposed, and the native abnormalities were physically identical with and without the nodules. The readers were asked to search and report abnormalities in both conditions while a spoken checklist directed them in a patterned search.

Computed Radiography Examinations

To match the most recent experiment on SOS in chest radiography as closely as possible, we used the same set of cases as the earlier experiment (3). A total of 64 cases consisting of digital chest radiographs (computed radiography) were obtained from clinical studies with approval by the local institutional review board. Verification of the lesions and the disease state was through follow-up studies, surgery, clinical course, laboratory tests, and autopsy reports that were part of the patient medical record. All patient identifiers were removed from the images. A total of 33 cases presented subtle, native abnormalities, and 31 had no native abnormalities. Native abnormalities that were present in the abnormal examinations included: aneurysm (three examples), aortic calcification, asbestosis, bone anomalies, cardiomegaly, cervical ribs (two examples), dilated esophagus, fractures (three examples), free air (two examples), gallstones, gastric bubble, goiter (two examples), hiatal hernia (two examples), middle lobe collapse, Morgagni hernia, pneumonia, pneumothorax (two examples), renal stone, right aortic arch (two examples), thyroid deviation (two examples), tuberculosis, and Zenker diverticulum.

The examinations for the SOS treatment condition were generated by adding pulmonary nodules to the original 64 examinations. The methods used to simulate the pulmonary nodules placed on the computed radiography examinations have been described previously (3). Pulmonary nodules were simulated using Gaussian distributions of grayscale levels to simulate X-ray attenuating lesions and placed in the 64 cases, with and without the native abnormalities. An author who

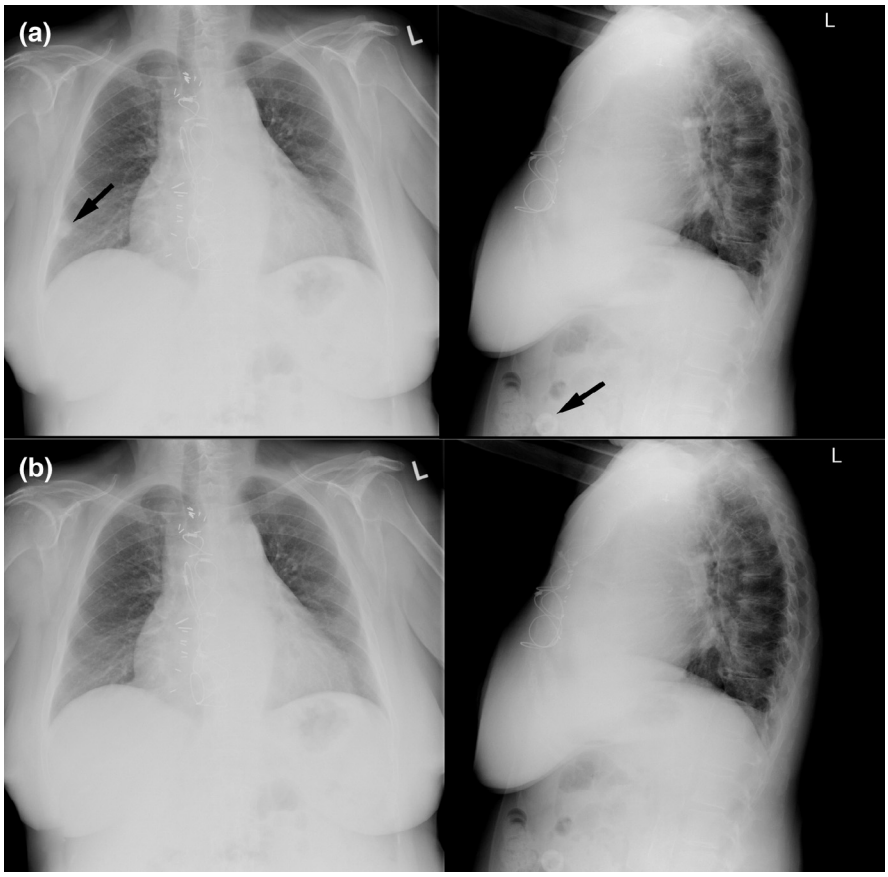

Figure 1. Constructs for the experimental conditions. The satisfaction of search (SOS) condition presents with a pulmonary nodule **(a)** and the non-SOS condition presents without a pulmonary nodule **(b)**. The same native abnormality, a gallstone, appears in both **(a)** (*black arrow*) and **(b)**. A simulated pulmonary nodule has been digitally placed in **(a)** (*black arrow*). In all other respects, the two examinations are identical.