Satisfaction of Search in Chest Radiography 2015

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Rationale and Objectives: Two decades have passed since the publication of laboratory studies of satisfaction of search (SOS) in chest radiography. Those studies were performed using film. The current investigation tests for SOS effects in computed radiography of the chest.

Methods: Sixty-four chest computed radiographs half demonstrating various "test" abnormalities were read twice by 20 radiologists, once with and once without the addition of a simulated pulmonary nodule. Receiver-operating characteristic detection accuracy and decision thresholds were analyzed to study the effects of adding the nodule on detecting the test abnormalities. Results of previous studies were reanalyzed using similar modern techniques.

Results: In the present study, adding nodules did not influence detection accuracy for the other abnormalities ($P = .93$), but did induce a reluctance to report them ($P < .001$). Adding nodules did not affect inspection time ($P = .58$) so the reluctance to report was not associated with reduced search. Reanalysis revealed a similar decision threshold shift that had not been recognized in the early studies of SOS in chest radiography ($P < .01$) in addition to reduced detection accuracy ($P < .01$).

Conclusions: The nature of SOS in chest radiography has changed, but it is not clear why.

Advances in Knowledge: SOS may be changing as a function of changes in radiology education and practice.

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

Laboratory studies have demonstrated a satisfaction of search (SOS) effect in chest radiography, with reduced accuracy in detecting native abnormalities on chest radiographs in the presence of simulated pulmonary nodules (1,2). Various abnormalities were missed when a pulmonary nodule was present (SOS condition), but detected when the nodule was absent (non-SOS condition). The original experiment on SOS effects in chest radiography (1) was conducted 25 years ago and the most recent replication (2) 15 years ago. Both of those studies demonstrated a reduction in detection accuracy as a function of SOS. The practice of radiology has changed significantly in the last 2 decades. Film has given way to digital imaging. The utilization of computed tomography (CT) and magnetic resonance (MR) examinations has dramatically increased, and advanced imaging is often the preferred initial examination. Resolution and quality of those modalities have improved significantly. There have been corresponding changes of emphasis in the training of radiologists.

The purpose of the current investigation was to test for SOS effects in computed radiography (CR) of the chest. A new set of test cases acquired with CR were read by a new sample of resident, fellow, and faculty radiologists. Results of the earlier studies (1,2) were subjected to additional analyses of decision thresholds to better understand current results.

MATERIALS AND METHODS

Experimental Conditions

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 assessed with and without the addition of a digitally added simulated pulmonary nodule. 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.

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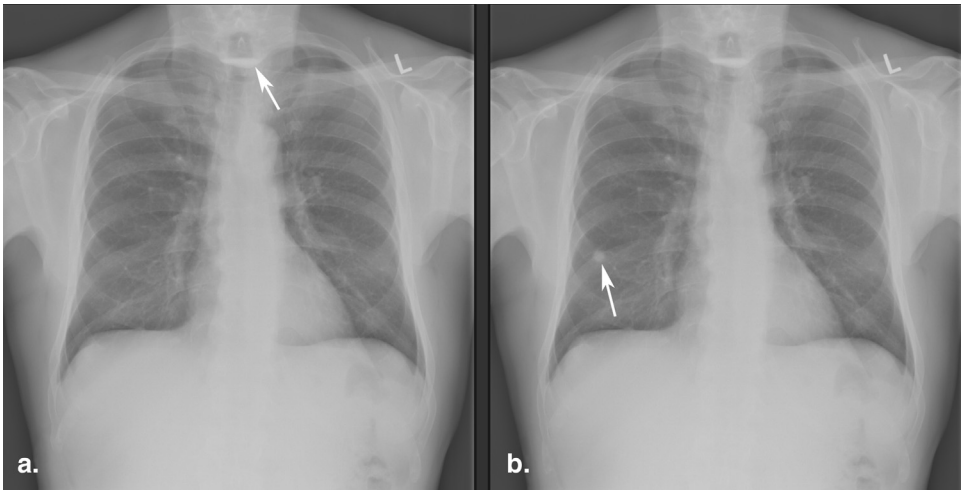

Figure 1. Constructs for the experimental conditions. The non–satisfaction of search (SOS) condition presents without a pulmonary nodule **(a)** and the SOS condition presents with a pulmonary nodule **(b)**. The same native abnormality, a Zenker's diverticulum with residual barium, appears in both **(a)** (*white arrow*) and **(b)**. A simulated pulmonary nodule has been digitally placed in b (*white arrow*). In all other respects, the two images are identical.

Cases and Readers

Sixty-four new CR chest cases were obtained from clinical studies with approval by our local institutional review board. Verification of the lesions and 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 studies to ensure patient confidentiality. Thirty-three cases presented subtle, native abnormalities (Table 1) and 31 had no native abnormalities. The versions for the SOS treatment condition were generated by adding simulated pulmonary nodules to the original 64 examinations (described in the following sections).

The observers saw each case twice in sessions separated by about 2 months to reduce the likelihood that the study images and the responses to them would be remembered. The presentation of non-SOS and SOS trials were intermixed to counterbalance the effect of whether examinations were seen for the first or second time by ensuring that effects of repeated presentation were equal in both treatment conditions. Each session had 64 examinations. Half of the cases presented in each session contained a single added nodule (a different nodule and nodule placement for each case) and half did not. Thus, in the course of the two sessions, each examination appeared twice, once with and once without an added nodule. If the examination appeared with an added nodule in the first session, it appeared without in the second session, and vice-versa. Within each session, examinations were presented in a random order.

Twenty radiologists from the University of Arizona who had no prior knowledge of the examinations used in the experiment agreed to participate in the experiment and included: 2 senior faculty members, 8 fellows, 4 fourth-year residents, 3 third-year residents, and 3 second-year residents. None of these participants was an author of this report. All were given and signed an informed consent document approved by their institutional review board for human subject use. Each radiologist received $200 for his or her participation.

Simulation of Pulmonary Nodules on Chest Radiographs

The use of simulated pulmonary nodules in perception research in diagnostic radiology has a long history (3). It is one of the few abnormalities that it is possible to simulate on x-ray or CR images with any degree of realism. The methods developed at Henry Ford Hospital (4) allow better simulation of lung nodules than have been available before. This work informed our own approach.

Pulmonary nodules were simulated using Gaussian distributions of gray scale levels to simulate x-ray attenuating lesions and placed in the 64 cases, with and without the native abnormalities. One author who is a medical physicist (M.T.M.) developed an algorithm to place simulated nodules in computed radiographs allowing an operator to select the position and to adjust the radius, contrast, and kernel density. The operator was directed to place and adjust the nodules by an author who is senior faculty radiologist (E.A.F.) with the goal of producing natural-appearing pulmonary nodules on the radiographs. Because the method of creating the nodules differed slightly from the method used to display the cases, a second opinion was sought from independent radiologist authors with extensive experience reading chest radiographs (A.T.L., B.H.T., B.F.M.). Adjustments to the gain were made and reviewed again. This iterative review and improvement process relying on radiologists' judgment was similar to that used in the original demonstration of SOS in chest x-ray (1).

We checked realism and level of detectability using prereaders who where residents at a different university (not readers participating in the reported experiment). These readers reported on the examinations with added nodules using a free response format in which they described findings in their own words. None of these reports gave any indication that the nodules looked other than native. Likewise, using the somewhat different reporting scheme of the experiment