Impact of Interactive e-Learning Modules on Appropriateness of Imaging Referrals: A Multicenter, Randomized, Crossover Study

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Abstract

Purpose: Health care expenditure on diagnostic imaging investigations is increasing, and many tests are ordered inappropriately. Validated clinical decision rules (CDRs) for certain conditions are available to aid in assessing the need for imaging. However, awareness and utilization of CDRs are lacking. This study compared the efficacy and perceived impact of interactive e-learning modules versus static versions of CDRs, for learning about appropriate imaging referrals.

Methods: A multicenter, randomized, crossover trial was performed; participants were volunteer medical students and recent graduates. In week 1, group 1 received an e-learning module on appropriate imaging referrals for pulmonary embolism; group 2 received PDF versions of relevant CDRs, and an online quiz with feedback. In week 2, the groups crossed over, focusing on imaging referrals for cervical spine trauma in adults. Online assessments were administered to both groups at the end of each week, and participants completed an online questionnaire at the end of the trial.

Results: Group 1 (e-learning module) performed significantly better on the pulmonary embolism knowledge assessment. After the crossover, participants in group 2 (e-learning module) were significantly more likely to improve their scores in the assessment of cervical spine trauma knowledge. Both groups gave positive evaluations of the e-learning modules.

Conclusions: Interactive e-learning was significantly more effective for learning in this cohort, compared with static CDRs. We believe that the authentic clinical scenarios, feedback, and integration provided by the e-learning modules contributed to their impact. This study has implications for implementation of e-learning tools to facilitate appropriate referrals for imaging investigations in clinical practice.

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BACKGROUND

Diagnostic imaging (DI) expenditure in Australia is increasing at approximately 10% per annum. DI procedures account for 15% of services billed to the Australian government through Medicare, Australia's national public health insurance system [1]. Although some of this increase relates to aging of the population and technologic advances, a proportion of DI is acknowledged to be inappropriate. "Inappropriateness" in this context may be defined as not contributing to either change in decision making or improved patient outcomes, because of one of the following reasons:

- The wrong test was performed.
- The patient characteristics and/or clinical situation did not warrant testing, owing to the low pretest risk of serious pathology.
- The timing of a test(s), or the order in which a series of tests was performed, was suboptimal.

The consequences of inappropriate use of imaging, for patients and the health care system in general, are far reaching but often unappreciated by health care professionals and patients, who are focused on the episode of care [2,3].

As much as one third of imaging has been suggested to be inappropriate, according to the above definition [2,3]. Nigrovic et al [4], in a multicenter study of 40,113 children

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who went to emergency departments with head injury, found that the use of CT scanning was reduced by up to 57%, compared with children matched for hospital and injury severity, if a period of observation occurred before the decision was made to perform imaging [4]. Further, Schachar et al [5], in a retrospective case review of 2,101 pediatric patients with blunt head injury, reported that application of any one of three validated tools for risk assessment of head-injured patients (New Orleans Criteria, Canadian Head CT Rule, NEXUS II criteria) would have resulted in at least 10.9% fewer patients receiving CT scanning.

Jones et al [6] reported high levels of inappropriate investigation of patients for possible pulmonary embolism (PE) when clinical risk assessment did not precede performance of "screening" blood tests, and inappropriateness was reduced with an educational intervention. Smith et al [7], in a random audit of 100 patients with possible PE at a Canadian emergency department, found that most had not had pretest risk assessment to determine whether they needed any investigation for PE. Goergen et al [8] found that implementation of a structured pretest risk-assessment strategy reduced inappropriate referrals for imaging for patients with suspected deep vein thrombosis or PE in three Australian emergency departments.

Validated clinical decision support tools (or clinical decision rules [CDRs]) allow patients with certain clinical conditions to be assessed regarding their need for imaging. These tools involve the evaluation of clinical findings that are known, based on evidence, to increase the likelihood of serious pathology or positive findings on imaging. Lack of pretest risk assessment of patients, with use of validated tools, is an important cause of inappropriate imaging [4-7].

Packaging and presentation of decision aids is vital to successful implementation, and attention to these details can make or break attempts to promote utilization [9,10]. In addition, medical curricula do not cover use of evidence-based CDRs to assess patients' risk before referring them for imaging; inappropriate utilization results in part from this lack of exposure.

To address this issue, the Royal Australian and New Zealand College of Radiologists (RANZCR), with funding from the Australian Government Department of Health, developed a suite of interactive web-based e-learning modules designed to be implemented early in the career of health care professionals. Ten e-learning modules have been developed, relating to clinical conditions associated with: (1) acknowledged high rates of inappropriate imaging; (2) significant adverse patient outcomes if misdiagnosed; and (3) validated high-quality CDRs.

The topics covered by the modules are:

- Introduction to CDRs for imaging—what they are and how to use them;
- Acute head trauma (separate adult and pediatric modules);
- Acute cervical spine trauma (separate adult and pediatric modules);
- Suspected PE (pregnant and nonpregnant patients);
- Suspected lower-limb deep vein thrombosis;
- Acute low-back pain;
- Acute ankle trauma (separate adult and pediatric modules).

Cook et al [11] found that interactivity and feedback in e-learning are associated with improved learning outcomes. Hence, the aim of the current study was to evaluate the educational impact of interactive web-based modules on suspected PE and adult cervical spine trauma, and in comparison with "static" portable document format (PDF) decision support flowcharts for the same conditions (Fig. 1).

METHODS

Participants

Medical students from three Australian medical schools; non-Australian medical graduates enrolled in an Australian educational program to prepare them for an examination enabling general medical registration in Australia; and first-year interns at a university teaching hospital, were asked to self-select for enrollment in this study. Two of the three universities (Monash University and the University of New South Wales) conduct 6-year undergraduate medical programs. The other medical school (University of Sydney) provides a 4-year postgraduate program for students entering with bachelor degrees. At all three institutions, only senior medical students were recruited.

Students and interns were invited to participate via an e-mail sent to their entire cohort. This e-mail contained a participant information statement explaining that the study involved taking part in a randomized crossover trial of e-Learning Educational Modules for Appropriate Imaging Referrals. They were provided with instructions about how to register with our web-based learning management system administrator (C—learning Pty Ltd., (Melbourne, Victoria, Australia). Consent to participate was considered to have been given by registration of the individual on this system. As a recruitment incentive, an iPad mini (Apple Inc, Cupertino, California) was awarded to one randomly selected participant at each institution who completed all aspects of the trial.

Study Design and Procedure

A total of 216 students volunteered for the trial (98 men and 118 women). To ensure an equivalent baseline understanding of CDRs, including their genesis and application,