High-Fidelity Contrast Reaction Simulation Training: Performance Comparison of Faculty, Fellows, and Residents

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Abstract

Purpose: Reactions to contrast material are uncommon in diagnostic radiology, and vary in clinical presentation from urticaria to life-threatening anaphylaxis. Prior studies have demonstrated a high error rate in contrast reaction management, with smaller studies using simulation demonstrating variable data on effectiveness. We sought to assess the effectiveness of high-fidelity simulation in teaching contrast reaction management for residents, fellows, and attendings.

Methods: A 20-question multiple-choice test assessing contrast reaction knowledge, with Likert-scale questions assessing subjective comfort levels of management of contrast reactions, was created. Three simulation scenarios that represented a moderate reaction, a severe reaction, and a contrast reaction mimic were completed in a one-hour period in a simulation laboratory. All participants completed a pretest and a posttest at one month. A six-month delayed posttest was given, but was optional for all participants.

Results: A total of 150 radiologists participated (residents = 52; fellows = 24; faculty = 74) in the pretest and posttest; and 105 participants completed the delayed posttest (residents = 31; fellows = 17; faculty = 57). A statistically significant increase was found in the one-month posttest ($P < .00001$) and the six-month posttest scores ($P < .00001$) and Likert scores ($P < .001$) assessing comfort level in managing all contrast reactions, compared with the pretest. Test scores and comfort level for moderate and severe reactions significantly decreased at six months, compared with the one-month posttest ($P < .05$).

Conclusions: High-fidelity simulation is an effective learning tool, allowing practice of "high-acuity" situation management in a nonthreatening environment; the simulation training resulted in significant improvement in test scores, as well as an increase in subjective comfort in management of reactions, across all levels of training. A six-month refresher course is suggested, to maintain knowledge and comfort level in contrast reaction management.

Key Words: Contrast reaction, contrast, education, simulation, team training, high-fidelity

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INTRODUCTION

Iodinated intravenous contrast material was first administered in the 1920s and remains one of the most frequently administered intravenous medications to improve soft-tissue contrast in radiology [1]. Administration can result in both nonallergic and allergic-like adverse reactions, encompassing a wide spectrum of clinical symptoms ranging from simple urticarial reactions to life-threatening anaphylaxis. The supervising physician is responsible for recognizing the symptoms and providing appropriate management of contrast reactions [2]. Most radiologists have limited experience managing severe reactions, and more than 50% of radiologists do not know the correct dose of epinephrine to administer during a severe reaction [3,4]. This lack of knowledge is a significant problem, especially because a radiologist may be the sole provider during a life-threatening reaction [5].

High-fidelity simulation has emerged as a viable method to educate radiologists about proper contrast-reaction management that is effective and cost efficient [2,6-9]. In addition, such simulation provides an opportunity to

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practice administering medications such as epinephrine, and can serve as a review of basic life-support management [6,10,11].

Using high-fidelity simulation, we instituted a department-wide quality improvement program aimed at increasing patient safety and knowledge regarding management of contrast reactions. The purpose of our study was to assess comfort and knowledge regarding the management of contrast reactions, and reaction mimics, before simulations, at one month and six months after completion of a one-hour high-fidelity simulation session among residents, fellows, and attending radiologists of various experience levels. Assessing the benefits of simulation across all levels of training provides a means to study a population who vary in age and experience. In addition, this type of assessment more accurately reflects actual clinical practice, in which any type of radiologist (trainee or senior faculty) may be called on to respond to a potential contrast reaction.

METHODS

An institutional review board—approved, HIPAA-compliant, quality improvement project was developed for all residents, fellows, and faculty to participate in a program reviewing the management of contrast reactions and contrast reaction mimics. We defined a contrast reaction mimic as a potentially life-threatening event (such as a seizure or hypoglycemic event) that could occur in a radiology department and is unrelated to the administration of intravenous contrast. For our study, informed consent was waived; however, all participants had the ability to request that their specific test results not be included for analysis.

A 20-question multiple-choice pretest was created, based on the ACR 2013 contrast manual, to assess baseline knowledge with Likert-scale questions assessing subjective comfort in managing contrast reactions and perceived effectiveness of simulation-based training, including assessment of group size, simulation training as a learning tool, frequency of simulation training, and use of other forms of simulation training within the department [12]. Participant demographics, level of training, and basic life support/advanced cardiac life support (BLS/ACLS) certification status were recorded (Appendix 1, available online). Testing was completed via participant-specific online links, distributed using e-mail via Qualtrics Labs (Provo, Utah) survey/testing software before, one month after, and six months after simulation session training.

All residents and fellows within our department were required to participate in the simulation training, which included taking a pretest and a posttest. Participation was optional, but was a factor in bonus eligibility, for faculty members. As determined by the departmental leadership, the six-month posttest was optional for all participants, because it was not felt to be a critical component of the overall quality improvement project.

Pre-Simulation Testing

Each participant received an e-mail with a unique link to complete the pretest. Participants were asked to refrain from using any references or sharing answers while completing the test. Once the pretest was completed, participants were able to schedule themselves for a one-hour simulation course via an internal website created by our institution's IT staff.

Simulation Laboratory Procedure

After pre-simulation testing, participants completed a one-hour simulation session designed to practice the management of a moderate-severity contrast reaction, a high-severity contrast reaction, and a hypoglycemic event that mimicked a contrast reaction within our institution's high-fidelity simulation laboratory. A total of 29 simulation sessions were given, each lasting one hour, occurring over 40 days in September 2013 and October 2013 between 8:00 AM and 4:00 PM. Sessions were held on various days of the week and at various times, to facilitate completion for participants.

All sessions were conducted in a high-fidelity simulation laboratory, with groups of eight to ten participants. Groups were a mixture of residents, fellows, and faculty, with two to three people serving as "responders" for each simulation, and the remaining participants watching via video in real time in an adjacent room. In some sessions, radiology nurses were present; if they were not available, the role of a radiology nurse was played by the simulation instructor.

The simulation room was set up as a standardized hospital room at our institution, and all participants had access to a code cart and our department's contrast reaction kit. The kit included the following medications: an albuterol nebulizer, 100 mg hydrocortisone, 50 mg intravenous and/or intramuscular diphenhydramine, 1 mg atropine, 10 ml (1 mg) of a 1:10,000 concentration of epinephrine vial/bristojet, and a 1 ml (1 mg) vial of a 1:1,000 concentration of epinephrine. During the simulation, participants were instructed to interact with the mannequin (SimMan, Laerdal Medical Corp, Wappingers Falls, New York) as if it were an actual