

Best Practice for Safe and Effective Administration of Epinephrine for the Treatment of Anaphylaxis in the Radiology Department

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THE PROBLEM

Rapid and accurate dosing of epinephrine in anaphylaxis management is critical; it is the most important agent in the treatment of severe allergic reactions to intravenous contrast [1]. Many radiologists and radiology residents lack the critical knowledge and skills necessary to manage patients with anaphylactic reactions to intravenous contrast media [2]. A recent study illustrating this problem reported that one week after a didactic lecture on contrast reaction management, only 31% of radiology residents administered the correct dose of epinephrine during a high-fidelity simulation event, and only 54% identified the correct dose on a prescenario multiple-choice test, illustrating both skills and knowledge gaps [3]. Although relatively rare, adverse reactions to contrast media can be severe, with potentially devastating consequences for patients, providers, and institutions, and thus deserve a timely and error-proof management strategy.

Because epinephrine autoinjectors are designed with premeasured dosing, their use eliminates the need for dose recall and facilitates “rapid and reliable delivery of potentially life-saving antidotes in a time-sensitive, high-stress environment” [4]. Epinephrine autoinjectors have

reported user errors, including sub-optimal length of administration potentially resulting in underdosing. User errors related to the devices combined with cost considerations were primary objections at our institution to replacing an epinephrine vial with an autoinjector for the management of anaphylactic events in the radiology department. However, a recent study evaluating autoinjectors reported that length of duration of epinephrine autoinjection administration does not correlate with the amount of epinephrine absorbed into muscle tissue, eliminating “premature removal of the device” as a potential source of error [5]. Epinephrine autoinjectors have the potential to improve patient safety by decreasing dosing error, and their use has been advocated by the National Comprehensive Cancer Network (NCCN) for the treatment of anaphylaxis in the outpatient setting [6]. A significant number of intravenous contrast reactions occur in the outpatient setting. Therefore, a patient with a severe allergic reaction may receive delayed treatment because the emergency response system often involves community paramedics or emergency medical services rather than an internal code team. Best practice for epinephrine dosing in

the outpatient setting has not been well studied.

In the *ACR Manual on Contrast Media*, the ACR identifies an epinephrine autoinjector—“IM EpiPen® or equivalent”—as an appropriate method of intramuscular epinephrine administration [7]. Several studies have documented suboptimal medical provider use of epinephrine autoinjectors. One group found that only 6% to 21% of pediatricians demonstrated correct use of an autoinjector [8]. Potential sources of user error with the EpiPen include (1) failure to remove the safety cap, (2) inappropriate site of administration, (3) use of the incorrect end of the device, (4) self-administration, and (5) failure to activate the device [4,8,9]. Additionally, because the EpiPen is packaged with two loaded syringes and a near identical empty training device, there have been reports of misuse of the training device [10]. Given the potential for administration errors, the ability of radiologists to properly dose epinephrine with an EpiPen needs to be assessed.

OUR RESPONSE

A quality improvement project at the University of Colorado was initiated to address gaps in accurate physician

dosing of epinephrine in the setting of contrast-related anaphylaxis. An overview of the project is depicted in Figure 1. Key components of the project included replacing a standard vial of 1:1,000 concentration epinephrine with an epinephrine auto-injector (EpiPen; Dey LP, Napa, California) as standard of care for intramuscular epinephrine dosing in the radiology department contrast reaction toolbox. Radiology residents received a single didactic lecture with training in the use of the EpiPen. The lecture was based on the University of Colorado Contrast Reaction Smartcard [11], focused on common user errors, and allowed residents to practice with the EpiPen training device. Additionally, residents received instruction on how to dose intravenous and intramuscular epinephrine from a MinJet (International Medical Systems Limited) 1:10,000 and 1:1,000 standard vial of epinephrine using a tuberculin syringe.

Three weeks after the didactic lecture, 30 of our 34 radiology residents were individually evaluated during two consecutive high-fidelity simulation scenarios in which epinephrine dosing accuracy from a vial (both intramuscular and intravenous) and with the EpiPen was assessed, as depicted in Figure 2. The simulation events took place at the Work, Education and Life Long Learning Simulation Center, which is affiliated with the University of Colorado Hospital. Radiology faculty members and critical care instructors designed the anaphylaxis scenarios. Simulation scenarios used the Laerdal 3G mannequin with capabilities including cardiac monitoring, tongue swelling, bronchospasm, and stridor. A Work, Education and Life Long Learning Simulation Center simulation expert provided live scripted vocals with prompting by the evaluator.

Each resident individually participated in two consecutive standardized

anaphylaxis scenarios. In the first scenario, a 54-year-old man experienced bronchospasm after receiving iodinated intravenous contrast media and progressed to severe hypotension. Residents were evaluated with a checklist assessing dose and route of conventional intramuscular and intravenous epinephrine administration. Immediately after the first scenario, all residents were debriefed using the University of Colorado Contrast Reaction Smartcard [11] as a guideline and educational tool for elements relevant to conventional vial dosing of epinephrine. Residents then participated in a second scenario using an identical mannequin to simulate stridor in a 54-year-old man after intravenous contrast administration. Residents were asked to administer the EpiPen to the mannequin. EpiPen use was assessed by direct observation using a four-point key action checklist; correct dosing was based on the successful execution of

Is there a Role for an Epinephrine Auto-injector in the Radiology Suite? – An overview of the University of Colorado Experience.

The Problem

- Radiologists lack direct experience in the management of severe contrast reactions.
- Timely administration of epinephrine in this setting is critical.
- Existing studies demonstrate a physician knowledge gap in epinephrine dosing.

The Proposed Solution

- Replacing the vial of 1:1000 epinephrine in the "contrast reaction toolbox" with an EpiPen®/epinephrine auto-injector.
- Hands-on training in the use of the EpiPen® focusing on common user errors.

Assessment/Outcome

- Residents received a didactic lecture in which training in **BOTH** drug delivery systems was provided.
- High fidelity simulation was then utilized to evaluate residents and compare user error with the EpiPen® versus standard vial dosing in anaphylaxis management.

Fig 1. Project Overview.

Resident Education and High Fidelity Simulation Assessment

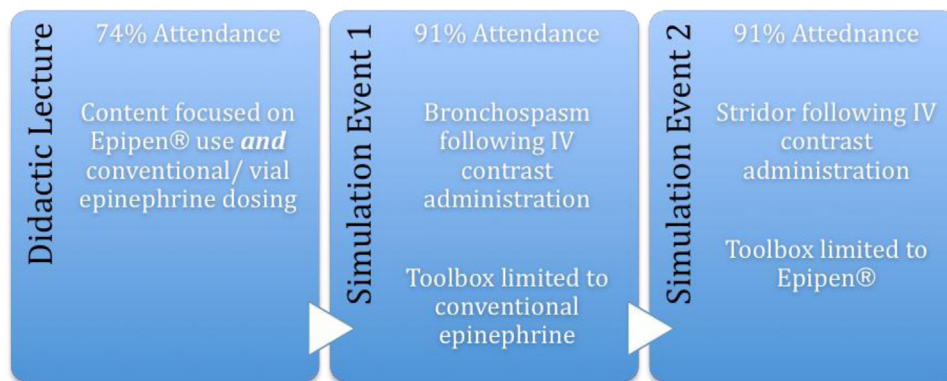


Fig 2. Didactic lecture was given as part of a standard case conference series in the Department of Radiology whereas simulation training and assessment was conducted three weeks later at the WELLS Center. Residents participated in identical sequencing of simulation scenarios and were debriefed separately on performance relative to vial epinephrine dosing and EpiPen use; respectively.

four actions: proper uncapping, use of correct end, proper site of administration, and not self-administering. After each scenario, two observers discussed resident performance and reached consensus. A second resident debriefing focusing on EpiPen use was conducted. Residents were then asked to complete an anonymous survey regarding the experience. Responses were assessed using a 5-point Likert-type scale.

Finally, a three-question electronic survey using SurveyMonkey (SurveyMonkey, Palo Alto, California) evaluating the use of epinephrine autoinjectors in academic radiology departments was administered electronically to 131 active members of the Society of Chairs of Academic Radiology Departments (SCARD) on June 24, 2013. The goal of this survey was to evaluate the prevalence of epinephrine autoinjector use and any occurrences of misuse.

OUTCOMES

Thirty of our 34 residents (88%) participated in the high-fidelity simulation experience, and of those

participants, 23 (77%) attended the didactic lecture preceding the simulation event. Fifty-seven percent of residents dosed epinephrine correctly using a vial, whereas 90% dosed epinephrine correctly using an EpiPen, yielding a difference in error rate of 33%. The difference in error rate between the drug delivery systems was statistically significant (McNemar test statistic = 8.33, $P = .004$).

All 30 residents were rated on four key actions related to EpiPen use and performed all actions with a high overall accuracy rate (90%). A Fisher exact test was used to compare EpiPen administration performance indicators with lecture attendance. All residents, regardless of lecture attendance, were able to successfully uncapped the device and use the correct end of the EpiPen. There was no statistical difference between lecture attendance and correct standard-of-care vial epinephrine dosing ($P = .70$).

Resident satisfaction levels with the simulation and training experience were high, with 100% of participants rating the experience ≥ 4 out of 5 (excellent or good) on a 5-point Likert-type scale. Ninety-seven

percent of residents stated that the availability of an EpiPen (5 out of 5 on the Likert-type scale) increased their confidence in the management of contrast reactions. However, only 80% of residents stated that the availability of management algorithms in the CT suite increased their confidence in patient management.

The anonymous electronic survey of active members of SCARD had a 25% ($n = 34$) response rate. Thirty-five percent of responding institutions ($n = 12$ of 34) endorsed the use of the EpiPen in the radiology department. Of those institutions that endorsed the use of the EpiPen, 2.9% ($n = 1$ of 34) reported knowledge of adverse events related to faculty member or resident misuse of an EpiPen.

DISCUSSION

Radiology residents achieved more accurate dosing of epinephrine when using an EpiPen compared with standard-of-care vial dosing of epinephrine during simulation training and achieved overall high rates of accurate use of the EpiPen. A 90% accuracy rate with EpiPen

use compares favorably with prior studies reporting a 31% accuracy rate of conventional epinephrine dosing by radiology residents during simulation events [3].

The potential of epinephrine autoinjectors to eliminate physician error in epinephrine dosing must be balanced with device user errors. Our experience suggests that common device user errors can be reduced through education. However, we did not find a statistically significant difference in execution of the key actions for EpiPen use between residents who did or did not attend the lecture.

The NCCN, in addition to the ACR in its *Manual on Contrast Media*, endorses epinephrine autoinjectors, and the NCCN specifically recommends autoinjectors rather than vial dosing to “avoid wrong dose and wrong route errors” [6]. EpiPen autoinjectors are currently used in academic radiology suites, with 35% of responding SCARD members endorsing the use of these devices in contrast reaction management. These national recommendations may parallel increasing physician preference for autoinjectors. Because approximately 79% of allergic-like contrast reactions occur in the outpatient setting, where radiologists may need to treat patients without nursing staff members present, physician preference and skills in direct dosing of epinephrine may play an important role in patient safety [12]. Assessing user error in a high-fidelity simulation

environment was critical to reproducing the stressful environment in which radiologists are asked to manage anaphylaxis and suggests that the results of this study may be applicable to clinical practice, although data were collected for the purpose of quality improvement and were not intended to be generalizable.

Limitations of our experience were related to the joint educational and quality improvement mission of the project, limiting simulation time. The scenario using the EpiPen was shorter and less complex than the scenario involving conventional dosing of epinephrine. Finally, because the EpiPen scenario followed the standard-of-care vial-dosing scenario, some of the differences in user error may be related to familiarity with the simulation.

The use of an epinephrine autoinjector in the outpatient management of anaphylaxis, when accompanied by dedicated physician training, has not been formally studied. Our project suggests that the use of epinephrine autoinjectors may improve patient safety at our institution by reducing medication dose error, therefore delivering the highest quality for patients treated by medical providers who lack extensive practical experience managing anaphylaxis.

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The authors have no conflicts of interest related to the material discussed in this article.

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