Learning From Others: A Case Report From the Anesthesia Incident Reporting System

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Review of unusual patient care experiences is a cornerstone of medical education. Each month, the AQI-AIRS Steering Committee abstracts a patient history submitted to the Anesthesia Incident Reporting System (AIRS) and authors a discussion of the safety and human factors challenges involved. Real-life case histories often include multiple clinical decisions, only some of which can be discussed in the space available. Absence of commentary should not be construed as agreement with the clinical decisions described. Feedback regarding this article can be sent by email to **airs@asahq.org**. Report incidents or download the AIRS mobile app at **www.aqiairs.org**.

Case 2020-4: Radiology Contrast Anaphylaxis

A 25-year-old man with a history of developmental delay, anxiety and asthma arrived for a CT scan with contrast under anesthesia at a tertiary care hospital. The patient was recently diagnosed with testicular cancer. However, on the first CT attempt he was unable to lay still due to claustrophobia. The oncology team requested assistance from an anesthesiologist.

The patient was placed on the CT table with monitors, and a propofol infusion was started. Once the patient was sufficiently relaxed, the non-contrast sequences were completed without incident. Contrast was administered through the intravenous line using a power injector. Approximately one minute after the contrast administration, the patient became hypotensive. The anesthesiologist stopped the propofol infusion, opened the fluid line and gave a bolus of phenylephrine. The patient's next blood pressure dropped further, and the anesthesiologist gave a bolus of ephedrine. At this point, the radiology nurse said, "Look how flushed his face is. Is he having an allergic reaction?" The anesthesiologist rushed to give diphenhydramine and hydrocortisone. The patient went into cardiac arrest five minutes after contrast had been administered.

A code was called, and the patient was intubated. The code leader used the emergency checklist to review possible causes ("5 H's and 5 T's"). The differential diagnosis included shock due to anaphylactoid reaction and pulmonary embolus given the patient's history of cancer. After two rounds of epinephrine and high-quality chest compressions, ROSC was achieved. The patient was transported to the ICU. Later that day, the patient regained consciousness and was extubated.

During the post-event debriefing, the anesthesiologist acknowledged focusing on hypovolemia and propofol as the cause of the hypotension without considering other etiologies. Review of the anaphylaxis emergency checklist found that epinephrine should have been given early instead of glucocorticoid and antihistamine.

Discussion

Contrast media is frequently used in a wide variety of imaging procedures. Iodinated contrast is the most common and is used in X-ray and CT scans. MRI scans use gadolinium-based contrast. Anesthesiologists who care for patients undergoing imaging procedures must be familiar with the current literature on contrast reactions and premedication, which is summarized in the American College of Radiology publication "ACR Manual on Contrast Media."[1] Many of the guidelines that follow are summarized from that document.

Life-threatening anaphylaxis from contrast media is not common. The estimated rate of allergic-like reactions with iodinated contrast is 0.6% aggregate and 0.04% severe reactions.

With gadolinium-based contrast, the rate is 0.01–0.22% aggregate and 0.008% severe reactions. A recent European cardiac MRI registry analysis found 0.36% acute adverse events and 0.033% severe acute adverse events.[2] The strongest predictor of an adverse reaction is a prior allergic-like or unknown-type reaction to the same class of contrast. A patient with a prior reaction has five times the risk compared to someone with no prior reaction.

Other risk factors for adverse events to intravenous contrast include asthma, which increases the risk of an allergic-like reaction. However, premedication is not recommended just because a patient has an asthma history. Renal insufficiency increases the risk of non-allergic adverse events affecting the kidneys. Patients with severe cardiac disease may have a higher risk of a cardiac event if a contrast reaction occurs. Finally, patients with anxiety may be at elevated risk of contrast reaction.

If a patient presents for a radiological study with contrast who has a history of an allergic-like or unknown-type reaction from the same class of contrast, the ACR recommends premedication. Ideally, premedication is performed over 12 or 13 hours prior to the study. The two common options

Brand Name	Chemical Name	Structure	Comments
Magnevist®	gadopentetate (Gd-DTPA)	linear ionic	Oldest agent (FDA approved 1988) with historically largest worldwide market share and clinical experience; below average relaxivity; ↑ risk NSF, restricted to intra-articular use in EU
Multihance®	gadobenate (Gd-BOPTA)	linear ionic	Highest relaxivity of all extracellular gadolinium agents due to transient protein binding; 3-5% hepatocyte uptake; competitive inhibitor for cMOAT drugs (tamoxifen, methotrexate, cisplatin); QT prolongation; restricted to liver use in EU
Omniscan™	gadodiamide (Gd-DTPA-BMA)	linear nonionic	Low thermodynamic stability; disproportionately ↑ risk NSF; may interfere with serum Ca++ measurements, lowest rate of reactions; use suspended in EU
Dotarem® Clariscan™	gadoterate (Gd-DOTA)	macrocyclic ionic	Guerbet's patent for Dotarem®, one of the oldest agents with largest market share in Europe, expired allowing entry of GE's copycat Clariscan™ into U.S. market in 2019; strongest Gd binding per Keq
ProHance®	gadoteridol (Gd-HP-DO3A)	macrocyclic nonionic	Lowest osmolality and viscosity of all agents; below average relaxivity
Gadavist®	gadobutral (Gd-BT-DO3A)	macrocyclic nonionic	Highest viscosity due to 1.0M formulation (all others 0.5M); above average relaxivity; marketed as Gadovist® outside the U.S.
Eovist® (USA) Primovist®	gadoxetate (Gd-EOB-DTPA)	linear ionic	Designed for liver imaging; ~50% uptake by hepatocytes after initial extracellular phase; joint renal and biliary excretion; very high relaxivity due to size and transient protein binding; may interfere with serum Fe measurements; QT prolongation

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for premedication are prednisone or methylprednisolone. Prednisone 50 mg by mouth is taken at 13 hours, seven hours and one hour prior to contrast injection. Instead of prednisone, 32 mg methylprednisolone can be given at 12 hours and two hours before contrast administration. If the patient cannot take medication by mouth, hydrocortisone 200 mg I.V. can be used instead of prednisone, with the same dosing schedule. In addition to the corticosteroid, diphenhydramine 50 mg by mouth (or I.V./I.M.) is taken one hour prior to the study. If the study is emergent, or the study cannot be easily rescheduled, accelerated intravenous medication can be performed. The most desirable protocol is methylprednisolone 40 mg I.V. or hydrocortisone 200 mg I.V. given immediately and repeated every four hours prior to contrast administration. Diphenhydramine 50 mg I.V. should be given one hour prior to contrast.

There are some important differences between iodinated contrast and gadolinium-based contrast agents (GBCAs). There are seven different GBCAs currently marketed in the U.S., as seen in the table above.

There has been no systematic study of premedication with corticosteroids and antihistamines in patients with a history of GBCA reactions, and a small study found that premedication was not effective.[3] Some allergists recommend skin testing in patients with a hypersensitivity to a GBCA. There are case reports that patients with a positive skin test for one GBCA do not have a reaction to other GBCAs, suggesting that cross-reactivity is limited. If the patient has a history of an allergic-like reaction to the planned GBCA, it is prudent to consult with the radiologist and investigate alternative GBCAs.

Anaphylaxis may initially manifest with severe symptoms, including hypotension, angioedema, bronchospasm, high peak airway pressures, tachycardia and urticaria. Treatment begins with stopping administration of any medications that may be causing the anaphylaxis. Then, administer epinephrine. Epinephrine stimulates both β1 and β2 receptors. The β1 receptor agonism reverses peripheral vasodilation, while β2 receptor stimulation reduces the release of inflammatory mediators

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from basophils and masts cells and causes bronchodilation. An emergency checklist can be very helpful for guiding treatment of presumed anaphylaxis.

If a patient has an allergic-like reaction to any type of contrast, it is useful to confirm anaphylaxis through mast cell activation by measuring a serum tryptase at the time of the reaction. That value can be compared to a second tryptase level drawn 24 hours later.

It is the responsibility of the anesthesiologist to inform the patient (and parent/guardian if a minor) of allergic reactions that occurred under anesthesia. In addition to documentation and an EMR allergy flag, a letter should be given to the patient detailing what is known about the reaction event. The Australian & New Zealand Anaesthetic Allergy Group has a form letter that can be customized for a particular practice.[4]

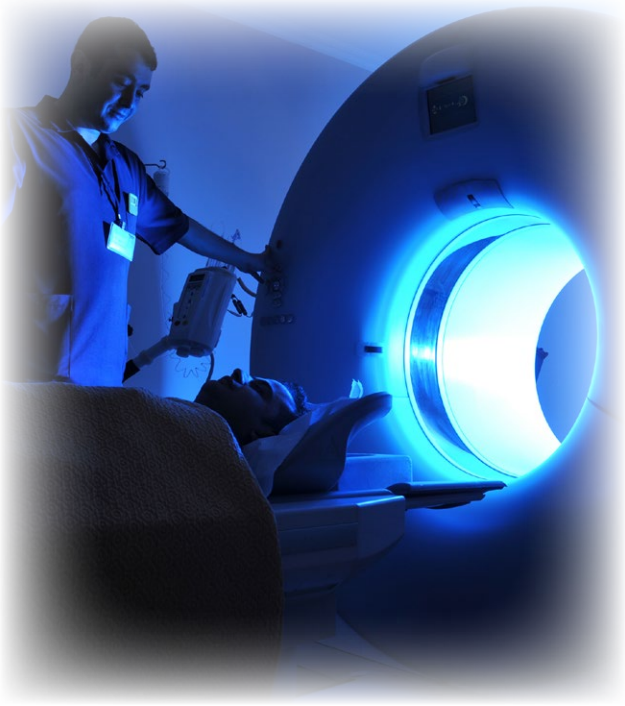
It is useful to apply human factors concepts to learn from this incident. First, the anesthesiology team's natural reaction to an adverse event may be unhelpful and unfair. According to Sidney Dekker, there are a set of common feelings that occur when looking back on an error:

- **Retrospective**: We now have a god-like global perspective, a point of view that the anesthesia team could not have had at the time.
- **Counterfactual**: We look back at the point in time when the patient became hypotensive and we see a critical fork in the road. To the people on scene at the time, this moment passed without seeming at all momentous.
- **Judgmental**: There is an instinct to judge our colleague for making an error we think we would not have made. We overestimate the odds of this outcome having occurred, given the situation before the event.
- **Proximal**: We focus on those who were on scene closest to the patient at the time and ignore other parts of the system that may have reacted differently.

Cognitive errors are more difficult to prevent than technical errors, as we do not know we are making them. For human factors analysis, we try to understand what the actors were seeing (or not seeing) at the time the decision was made.

There is an element of fixation error in this case. The anesthesiologist believed that the patient's hypotension was due to hypovolemia or anesthetic venodilation. This led to the assumption that the situation was under control when it was not. Of all cognitive errors, these may be the hardest to prevent. It is helpful to acquire the habit of "stepping back." Ask yourself, "If I was someone looking to find where mistakes are being made, where would I look?"

A marker of a robust safety culture is the ability to discuss and learn from adverse events. We hope that this case discussion stimulates a conversation about our natural reactions to near misses and errors, and the cognitive biases that are at play.



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