Medication Errors Occurring in the Radiologic Services Department

ABSTRACT

An estimated 300 million radiologic procedures are conducted per year in the United States. In cardiac catheterization laboratories, radiology, and other diagnostic departments, medications such as contrast media are administered, rates are adjusted for intravenous (IV) fluids, and IV access lines are flushed. In addition to specific medications that are used in radiology, high-alert medications such as IV sedatives, vasopressors, and blood coagulation modifiers are given in this setting. Nearly 1,000 event reports submitted to the Pennsylvania Patient Safety Authority specifically mentioned medication errors that occurred in care areas providing radiologic services. The administration of wrong drugs and unauthorized drugs was the most commonly reported medication error, followed by wrong-dose errors. While contrast agents and radiopharmaceutical products were cited in almost a quarter of all medication error reports, a majority of the drugs listed are used across the spectrum of patient care settings, not just in radiology. Many of these drugs are high-alert medications. Further qualitative analysis of events classified as wrong-rate medication errors in these areas shows no radiologic medications. Over half of these wrong-rate events involved high-alert medications. Strategies to address these problems include conducting organizational examinations of the medication-use processes in radiology areas to uncover risks that could lead to harmful errors, proactively addressing the plan for the management of the patient's infusion therapy while they are undergoing a radiologic procedure, and including radiology staff when evaluating and validating the level of training and competency to perform medication administration or related tasks. (Pa Patient Saf Advis 2009 Jun;6[2]:46-50.)

Radiologic services are provided in a variety of inpatient and outpatient settings but most commonly involve cardiac catheterization, radiology, and nuclear medicine services. These services use medical imaging, such as radiography, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, positron emission tomography, and ultrasound. Radiologic procedures are fairly common, accounting for 300 million procedures per year in the United States, and 20% of these involve one or more medications.[1] The complexity of radiologic procedures; the use of high-alert medications such as intravenous (IV) contrast agents, sedatives, vasopressors, and blood coagulation modifiers; and the risk of communication failures during handoffs can contribute to errors in this setting.[2] In cardiac catheterization laboratories, radiology, and other diagnostic departments, healthcare practitioners working in the radiology department may administer medications such as contrast media, adjust rates of IV fluids, and flush IV access lines, potentially increasing the risk for errors.

A 2005 U.S. Pharmacopeia (USP) report on medication errors in radiology[1]—that pooled error reports to MEDMARX® from 2000 to 2004—revealed that, while medication errors in radiologic services are not more prevalent when compared to other settings, they do have more potential to cause harm. Twelve percent of the medication errors reported by USP in radiologic services resulted in patient harm ("harm" defined as National Coordinating Council for Medication Error Reporting and Prevention [NCC MERP] harm category E or higher) compared to 1.7% of all medication errors. This report suggested that medication errors in radiology are seven times more likely to harm patients, compared to errors in other settings.

The USP report identifies three ways in which radiologic service areas uniquely may lead to harmful errors compared to other settings:

1. The amount of time a patient spends undergoing a radiologic procedure is very brief compared to the time he or she will spend in the primary inpatient care area.
2. As a patient is being transferred to and from a radiologic care setting, the opportunity for miscommunication and lack of access to patient information sets the stage for errors to occur. Because the care provided to the patient is very much focused on a particular procedure, drugs that were administered pre-examination, or those to be continued postexamination, may not be given sufficient attention.
3. Certification and training requirements for radiologic staff can vary by setting, state regulations, and institutional policies. Frequently, staff directly dispense and administer medications; however, there is no true standard on how much or what kind of medication-use training they receive. In cardiac catheterization laboratories, radiology, and other diagnostic departments, staff administer medications such as contrast media, adjust rates of IV fluids, and flush IV access lines. Errors with any of these tasks carry the potential to cause harm to patients.[1]

A paper published in the *American Journal of Health-System Pharmacists* in 2002 further discusses reasons why radiologic services may be more prone to harmful errors.[3] The paper comments on how imaging drugs are supposed to be administered by a radiologic staff member under the supervision of a radiologist or other physician. In reality, these medications are sometimes administered without a radiologist ever actually

seeing the patient or the patient's medical record. Additionally, there is sometimes no written prescription and no written documentation on a patient's medication administration record when these drugs are administered. Because of this, there is very little opportunity for a pharmacist's involvement in reviewing the orders and screening the patient for allergies, drug-drug interactions, or drug-disease state warnings before the medication is administered.

A Look at the Numbers

Little information in the literature specifically mentions medication errors that occur in the radiologic setting. According to the previously mentioned USP MEDMARX® report, the most common type of medication error in radiologic services was improper dose or quantity, followed by unauthorized (defined as medications that were not authorized by a legitimate prescriber and administered) or wrong-drug use, and drug or dose omission.[1] Analysis of data submitted to the Pennsylvania Patient Safety Authority (see Table 1) from June 2004 through the end of January 2009 reveals that the most common types of reported events include wrong drug, dose omissions, and "other." However, when event types are combined to match those that appear in MEDMARX®, the combination of wrong drug and unauthorized drug (n = 200; 20.3%) comes first, followed by wrong dose (overdosage and underdosage) (n = 144; 14.6%) and drug omissions (n = 133; 13.5%).

A breakdown by harm scores shows that most events (97%) were reported as Incidents (NCC MERP harm scores of A to D), but 88% (n = 866) of the reports show that the event reached the patient (harm scores of C to I) and 2.9% (n = 29) were reported as Serious Events.

Table 1. Most Common Event Types Assigned to "Imaging Services" and "Cardiac Invasive" (n = 985)

EVENT TYPE	TOTAL	% OF TOTAL REPORTS (N=985)
Wrong drug	141	14.3%
Dose omission	133	13.5%
Wrong dose/ overdosage	105	10.7%
Wrong rate (intravenous)	61	6.2%
Unauthorized drug	59	6.0%
Extra dose	54	5.5%
Documented allergy	50	5.1%
Wrong dose/ underdosage	39	4.0%
Prescription/ refill delayed	34	3.5%
Other	125	12.7%

Medication errors in radiologic services may involve misuse of a number of different drugs. In fact, data submitted to the Authority suggests that these errors are more likely to occur with the types of drugs that are *not* for use exclusively in the radiology setting (e.g., heparin, insulin). Table 2 identifies the top 15 most common drugs mentioned in reports associated with the radiologic unit. While the general category of "contrast agents," which represents both IV and oral contrast, as well as radiopharmaceutical products (i.e., technetium products) represents 24.7% of all reports, a majority of the drugs listed are used across the spectrum of patient care settings, not just in radiology. Furthermore, many of these drugs are high-alert medications. When combining the medications listed into their respective class of medications, 28.3% of all medications mentioned are considered high-alert medications, excluding IV contrast agents (which are also high-alert medications). (See Table 3.)

In-Depth Look at Medication Errors in Radiology

Among reports submitted to the Authority, the most common type of medication error was wrong drug (n = 141; 14.3%) (see Table 1). Forty (28.4%) of the wrong-drug errors involved mix-ups of the various

Table 2. Top 15 Medications Involved in Medication Errors in the Radiologic Care Area (n = 567)

MEDICATION	TOTAL	% OF TOTAL REPORTS (N = 985)
Contrast*,†	168	17.1%
Radiopharmaceuticals	75	7.6%
Heparin infusion†,‡	45	4.6%
Eptifibatide (Integrilin®)†	41	4.2%
Insulin†	40	4.1%
Hydration§	25	2.5%
Sodium bicarbonate	23	2.3%
Bivalirudin (Angiomax®)†	23	2.3%
Nitroglycerin	22	2.2%
Heparin bolus†,‡	21	2.1%
Cefazolin	18	1.8%
Morphine†	17	1.7%
Heparin flush‡	17	1.7%
Alteplase (Activase®)‡	14	1.4%
Unknown	18	1.8%

* Includes both intravenous (IV) and oral contrast

† High-alert medications

‡ Reports mentioning heparin were subdivided into these respective types of therapy (i.e., IV infusions, bolus doses, flushes)

§ Includes IV solutions such as dextrose 5%, sodium chloride 0.9%, and other solutions used to replenish fluids

formulations of technetium, a radiopharmaceutical widely used as a diagnostic aid. Its applications include imaging procedures of the brain, myocardium, lungs, thyroid, and bone. Technetium has numerous uses in nuclear medicine, and it is available in more than 60 different products. Some examples of trade names include Cardiolite®, Myoview®, and Technoscan®. These products can be easily confused, especially if they appear on preprinted order forms and/or pharmacy labels due to the similarity of their generic names.

There were 23 wrong-drug reports involving contrast agents (16.3%). This means that 44.7% (n = 63) of wrong-drug reports involved medications specific to that setting. In most cases, the result of this mix-up does not lead to patient harm; however, it may lead to the rescheduling of the intended test and result in increased cost and loss of productivity.

The second most commonly reported type of medication error was drug omission (n = 133; 13.5%). Unlike reports of wrong-drugs, omissions did not primarily involve radiologic medications. In fact, the most common medications listed included insulin and heparin infusions, such as in the following example:

> *The patient has been in radiology since early this morning. Apparently, the insulin pump was disconnected before the patient's arrival in the radiology department. No report was given by sending nurse. After several hours passed, the radiology technicians made the nurse from the unit aware that the patient would be in the radiology department a while longer. The patient's companion alerted me in the early afternoon to the fact the patient had an insulin pump and it has been disconnected since this morning, so a blood sugar was obtained. The blood sugar registered over 250. The floor nurse was notified of the patient's status and that the radiology department does not carry insulin.*

This example reported to the Authority demonstrates a bigger problem, which is the effect any procedure may have on a patient's current drug therapy. This is especially true when patients are on medications that require the use of an infusion pump, including high-alert medications such as heparin, eptifibatide, alteplase, or insulin, and the therapy has to be temporarily stopped for the procedure (e.g., MRI, CT scan). Errors may occur when the infusion pump is restarted by radiology staff or if the pump is off for a prolonged period of time. Also, any breakdowns in communication or retrieval of important patient information (e.g., allergies, laboratory values, conditions) to radiology staff may impact the intended radiologic procedure or lead to administration of an inappropriate drug to the patient.

Table 3. High-Alert Medication Classes, Other than Intravenous Contrast, Listed in Medication Error Reports (n = 279)

HIGH-ALERT CLASS	TOTAL	% OF TOTAL REPORTS (N = 985)
Anticoagulants, etc*	146	14.8%
Opiates†	48	4.9%
Insulin	40	4.1%
Ionotropics‡	19	1.9%
Antiarrhythmics§	10	1.0%
Moderate sedation**	8	0.8%
Adrenergic agonists††	8	0.8%
Totals	**279**	**28.3%**

* Anticoagulants (e.g., therapeutic unfractionated heparin, enoxaparin, eptifibatide), direct thrombin inhibitors (e.g., argatroban, lepirudin, bivalirudin), thrombolytics (e.g., alteplase, reteplase), and glycoprotein IIb/ IIIa inhibitors (e.g., eptifibatide)

† Narcotics/opiates, intravenous (IV), transdermal, and oral (including liquid concentrates, immediate, and sustained-release formulations)

‡ Inotropic medications, IV (e.g., dopamine, dobutamine, milrinone)

§ Antiarrhythmics, IV (e.g., lidocaine, amiodarone)

** Includes both moderate sedation agents, IV (e.g., midazolam) and oral agents for children (e.g., chloral hydrate)

†† Adrenergic agonists, IV (e.g., epinephrine, phenylephrine, norepinephrine)

Infusion Pumps in Radiology

A qualitative review of the medication errors revealed unanticipated results. It would be expected that medication errors that occur in this area would primarily involve problems with medications specifically given for radiologic procedures. However, as indicated in Tables 2 and 3, a majority of the medications involved in errors in radiologic settings were not radiologic medications, such as contrast or radiopharmaceuticals. A review of all the Serious Events (harm scores E to I) classified as wrong-dose/overdose revealed errors involving medications used for moderate sedation as well as heparin, epinephrine, or fentanyl infusions. The following are two examples submitted to the Authority:

> *Patient was consented for MRI with conscious sedation. A registered nurse (RN) administered Versed® (midazolam) and fentanyl IV push prior to MRI. Thirty minutes later, the patient began moving and the RN repeated the dose. Approximately five minutes later, the O_2 saturation was low. The patient was removed from the MRI and an ambubag was used to ventilate patient. Reversal agents were administered without response. CPR was initiated and a code was called; however patient was subsequently diagnosed with anoxic encephalopathy and died.*

> *A pediatric patient in the MRI suite was given 2 mL of 50 mcg/mL [emphasis added] fentanyl solution intravenously instead of 2 mL of 1 mcg/mL [emphasis added] fentanyl solution. Patient developed respiratory distress and cyanosis for which an airway emergency was called. The patient stabilized and was taken to recovery room and subsequently was transferred to pediatric intermediate care for observation.*

In addition, analysis of events classified as wrong-rate medication errors in these areas shows not one radiologic medication, and over half of these events involved high-alert medications. (See Table 4.)

Analysis of the reports to determine which events involved the use of medications given with infusion pumps revealed that 109 of 985 total reports (11%) showed breakdowns that included problems with the use of infusion pumps and the handling of IV lines. These problems include misprogrammed infusion pumps, infusions that were stopped for the radiologic test but not restarted, tubing misconnections, and wrong-patient errors. The following reports illustrate these problems:

The patient arrived to the intensive care unit (ICU) from the cardiac catheterization lab. The report given to the ICU nurse was for dopamine to run at 5 mcg/kg/min. On arrival to the ICU, the dopamine bag was almost empty, with the IV pump set and infusing at 5 mg/min (188 mL/hr).

A patient was sent to ultrasound with an insulin infusion running at 5 units/hour. When the patient returned from ultrasound, the infusion was found to be no longer running and clamped.

Patient arrived at the MRI suite for an abdominal study. A subclavian catheter and tracheostomy were present and all of the ports had similar injection valves. The anesthesiologist connected the injector tubing to the patient's IV site. Contrast and saline were injected, but the scan showed no contrast. Patient was then pulled out of the MRI and discovered that contrast had been injected into tracheostomy cuff with a rupture of the balloon. The patient's SPO_2 decreased slightly with no other changes in vital signs.

An emergency department (ED) patient went to radiology for an x-ray. The patient returned from x-ray with a heparin IV infusing at 12 mL/hour. This patient was not ordered a heparin IV. Following a preliminary investigation, it was determined that an inpatient was in x-ray around the same time the ED patient was in the ED, and for unknown reasons the inpatient's IV was connected to the ED patient. The ED patient was admitted for observation and lab work.

Errors with Patient Information

As mentioned in previous *Pennsylvania Patient Safety Advisory* articles, patient information helps guide the appropriate selection of medications, dosing, and routes of administration.[4] Having complete and accurate patient information, such as past allergic reactions to contrast media, patient weights that would affect the amount of medication (e.g., heparin) to administer, concurrent medications that are contraindicated with contrast, and laboratory values that would affect the type of study to be done (i.e., creatinine clearance) is critical when ordering and performing a radiologic procedure. The probability of renal impairment after a low-osmolality contrast media is administered intravascularly in creases markedly in the patient with chronic renal insufficiency.[5-7] In addition, other nephrotoxic medication should be used cautiously after administration of low-osmolality contrast media.[8] Wrong patient errors can also be averted when key pieces of patient information are available and accessed. A review of the data submitted to the Authority reveals 126 reports (13%) where breakdowns in obtaining and using patient information occurred, including the following case examples:

Patient presented to the ED with abdominal pain and vomiting. A CT scan of the abdomen/pelvis with contrast was ordered. A blood urea nitrogen (BUN) and creatinine (Cr) was ordered prior to the CT scan. The CT scan was performed prior to review of lab result. The patient's creatinine came back at a critical level and contrast should not have been given.

Table 4. Medications Involved in "Wrong Rate" Medication Errors in the Radiologic Setting (n = 61)

PRESCRIBED MEDICATION	TOTAL
Heparin infusion*	9
Eptifibatide (Integrilin®)*	9
Hydration	7
Sodium bicarbonate	6
Nitroglycerin	4
Alteplase (Activase®)*	3
Abciximab (ReoPro®)*	3
Adenosine	3
Vancomycin	2
Diltiazem*	1
Dopamine*	1
Fentanyl*	1
Bivalirudin (Angiomax®)*	1
Dobutamine*	1
Insulin*	1
Milrinone (Primacor®)*	1
Nesiritide (Natrecor®)	1
Amiodarone*	1
Potassium chloride	1
Pantoprazole (Protonix®)	1
Ceftriaxone	1
Saline	1
Albumin human	1
Tirofiban (Aggrastat®)*	1
Total	**61**

* High-alert medications

A nurse gave a verbal order for a heparin dose to be given IV push and the physician assisting with the heart catheterization did not know that the heparin was already administered. The heparin was administered again. The patient developed a hematoma at the catheter site and required blood products.

A patient received a dosage of IV contrast for a CT scan administered by CT technicians without checking the lab values of the patient's BUN and Cr before administering the contrast. The physician was notified and stated [the intent to] hydrate the patient.

A four-year-old patient underwent a Cardiolite® (technetium Tc99m sestamibi) cardiac imaging scan. A routine audit of the records discovered that the dose was based on 50 kg and not the patient's weight of 50 lbs. Upon internal review, it was discovered that the weight was obtained verbally by the technician and then forwarded to the pharmacy for nuclear medicine. The patient received a one time dose of Cardiolite for the scan based on the 50 kg weight.

Risk Reduction Strategies

Healthcare facilities should identify the error risks currently present in cardiac catheterization laboratories, radiology, and other diagnostic departments and take steps to implement risk reduction strategies. Based on analysis of reports submitted to the Authority and the literature, as well as observations at the Institute for Safe Medication Practices, risk reduction strategies for preventing the types of medication errors observed in radiology include the following:

- Examine the medication-use processes in radiology areas as well as those medications for patients on continuous IV infusions to uncover risks that could lead to harmful errors.[2]
- Patient care units that are transferring patients to the radiology department can proactively address the plan for the management of the patient's infusion therapy, recognizing the potential need to interrupt the infusion during the procedure and how the therapy would be affected by the length of the procedure.
- Some organizations employ nurses specifically dedicated to radiologic services or send a nurse to accompany patients to radiology if they have a high-alert drug infusing.[9] A verbal handoff between the accompanying nurse and the radiology staff, including verification of infusing IV therapy, must occur.
- Adequate supervision by a physician or nurse must be provided where technicians are administering contrast media and other medications. Ultimately, the responsibility for patient safety falls to the licensed medical professional supervising the technician.
- Include radiology staff when evaluating and validating the level of training and competency to perform medication administration or related tasks. Keep technicians in the information loop regarding safe medication administration practices by providing in-service education.[11]
- Organizations need to carefully consider current and recent patient information before ordering, dispensing, and administering any medication in this setting that may affect the procedure. Pharmacists can help in the assessment of patients about to undergo radiologic procedures by providing a continually updated list of drugs that should be withheld before a procedure and the corresponding time intervals.[10] This information should be obtained as part of the preprocedure assessment and communicated to the ordering physician as well as the radiology departmental staff.

Notes

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PENNSYLVANIA PATIENT SAFETY ADVISORY

This article is reprinted from the Pennsylvania Patient Safety Advisory, Vol. 6, No. 2–June 2009. The Advisory is a publication of the Pennsylvania Patient Safety Authority, produced by ECRI Institute and ISMP under contract to the Authority.

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