وزارة الصحة
Ministry of Health

Protocols on the Safe Use of Contrast Media in Radiology Departments

Version 1.0
2021

وزارة الصحة
Ministry of Health

Table of Contents

1. INTRODUCTION ***3***
1.1 Purpose: 3
1.2 Aim and scope: 3
1.3 Targeted user: are radiology staff. 3
1.4 Ttargeted population: are adult and pediatric, male and female patients who receive intravascular, oral and intracavitary CM. 3
1.5 Methodology: 3
1.6 Updating: 3
1.7 Conflict of Interest: 4
1.8 Funding: None 4
1.9 Abbreviations: 4

2. PRE-PROCEDURAL CONSIDERATIONS ***6***
2.1 Risk Factors and Patient Selection 6
2.2 Informed Consent 9
2.3 Premedication 10
2.4 Preparatory Fasting 12

3. PROCEDURAL CONSIDERATIONS ***13***
3.1 Storing, Handling and Disposing 13
3.2 Warming 14
3.3 Safe Administration 14
3.4 Extravasation 17

4. TREATMENT OF CONTRAST MEDIA REACTIONS ***19***
4.1 Treatment of Acute Reactions 19
4.2 Treatment of Delayed Reactions 19

5. RENAL ADVERSE REACTIONS ***21***
5.1 Clinical Estimation of Renal Functions 21
5.2 Use of Intravenous GBCM in Patients with Kidney Disease 26
5.3 Metformin 28

6. ***MISCELLANEOUS*** *CONSIDERATIONS* ***30***
6.1 Enteric Contrast Media 30
6.2 Pregnancy and Lactation 32
6.3 Pediatric Use of Contrast Media 33
6.4 Ultrasound Contrast Media 36

7. ***Appendix*** ***38***

1. INTRODUCTION

1.1 Purpose:

Contrast media (CM) are essential for accurate diagnosis and are used on a daily basis in most radiological departments. These agents, when administered correctly, are almost always safe, but adverse reactions do occur and can be life-threatening [1].

1.2 Aim and scope:

The aim of these protocols is to standardize and improve the safety of using CM for patients undergoing radiological and medical imaging procedures within Ministry of Health (MOH) facilities, and it will address the following points:

1. Appropriate prescription of CM.
2. Safe administration of CM.
3. Effective recognition and management of CM adverse reactions.

This guideline did not cover the radioactive CM used in nuclear medicine.

1.3 Targeted user: are radiology staff.

1.4 Targeted population: are adult and pediatric, male and female patients who receive intravascular, oral and intracavitary CM.

1.5 Methodology:

In June 2020, a writing team was commissioned by the General Directorate of Radiology and Applied Services (GDRAS) to develop these guidelines. The team examined available relevant clinical practice protocols, including the American College of Radiology (ACR) Manual on CM [2], the European Society of Urogenital Radiology (ESUR) guidelines on contrast agents [3], the Royal Australian and New Zealand College of Radiologists (RANZCR) guideline on iodinated contrast media [4], and the Royal College of Radiologists guidance on gadolinium-based agent administration to adult patients [5].

The team also determined the topics included in these guidelines as well as examined articles published and pertaining to each topic. Databases covered by the search included Pubmed, Medline, Embase, and the Cochrane. All literature relevant to each topic was considered when evaluating the new information and classified according to evidence-based practice criteria [6]. For supporting the recommendation in these protocols, the highest level of evidence was included.

Before publication, the GDRAS assigned another team for the revision of these protocols. Reviewers' feedback was distributed to the writing committee. All feedbacks were assessed and discussed to allow for diverse perspectives and considerations for these protocols. Recommendations were then voted upon to reach consensus.

1.6 Updating:

If, in the view of the GDRAS, new scientific evidence emerges that changes any of the key recommendations in these protocols, revision of the appropriate section of this document will occur accompanied by the date of the revision. Notification to the membership will occur when such revisions take place, depending upon the nature and medical urgency of the revision. Review of the entire protocols

document two years from the effective date will occur regardless of interim revisions to one or more sections of this document.

1.7 Conflict of Interest:

The writing committee members provided a declaration of interest form for all relationships that might be perceived as real or potential sources of conflicts of interest. This form was compiled with the declaration used by the World Health Organization (WHO) [7, 8]. At each committee meeting, each member reports verbally potential conflicts of interest (with actions taken if necessary). Any changes in declarations of interest that arise during the writing period were recorded in the meeting minutes. The development of these protocols was principally funded by the MOH without any involvement from the healthcare industry.

1.8 Funding: None

1.9 Abbreviations:

CM	Contrast media
MOH	Ministry of Health
GDRAS	General Directorate of Radiology and Applied Services
ACR	American College of Radiology
ESUR	European Society of Urogenital Radiology
RANZCR	Royal Australian and New Zealand College of Radiologists
WHO	World Health Organization
LOCM	Low osmolarity contrast media
HOCM	High osmolarity contrast media
IOCM	Iso osmolarity contrast media
ICM	Iodinated contrast media
GBCAs	Gadolinium-based contrast agents
GBCM	Gadolinium-based contrast media
CA-AKI	Contrast associated acute kidney injury
PC-AKI	Post-contrast acute kidney injury
CIN	Contrast induced nephropathy
KDIGO	Kidney disease improving global outcome
USFDA	United State Food and Drug Administration
SFDA	Saudi Food and Drug Administration
NSF	Nephrogenic systemic fibrosis
CKD	Chronic kidney disease
sCr	Serum creatinine
eGFR	Estimated glomerular filtration rate

References:

1. Beckett K.R., Moriarity A.K., and Langer J.M. Safe Use of Contrast Media: What the Radiologist Needs to Know. RadioGraphics 2015; 35:1738–1750.
2. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
3. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.
4. Royal Australian and New Zealand College of Radiologists (RANZCR). Iodinated contrast media guideline, 2018, V2.3.
5. Royal College of Radiologists. Guidance on gadolinium-based agent administration to adult patients, 2019. Available at www.rcr.ac.uk.
6. Melnyk B.M. & Fineout-Overholt E. Evidence-Based Practice in Nursing and Healthcare: A Guide to Best Practice, 2nd edition. Philadelphia: Lippincott Williams and Wilkins, 2010, p. 12.
7. Boyd E, Bero L. Improving the use of research evidence in guideline development: Managing conflicts of interests. Health Research Policy and Systems. 2006; 4(1):1-6.
8. Saudi Arabian Handbook for Healthcare Guideline Development. The Saudi Center for Evidence Based Health Care, verstion1.0, 2014.

2. PRE-PROCEDURAL CONSIDERATIONS

2.1 Risk Factors and Patient Selection

Acute adverse reactions occur within one hour of CM administration and the majority of delayed adverse reactions occur between 3-48 hours after exposure to CM. There are two types of acute reactions, allergic-like and physiologic reactions. Acute adverse reactions can be classified into three categories, mild, moderate and severe (see Appendix A). This classification can be utilized for iodinated contrast media (ICM) and gadolinium-based contrast Media (GBCM) [1-4]. The rate of acute adverse events for low-osmolality contrast media (LOCM) is approximately 0.2%-0.7% and for severe acute reactions, 0.04% [1,5]. GBCM are associated with a very low rate of acute adverse reactions (0.06%–0.09%), and the incidence of acute severe reactions is estimated to be 0.0025–0.005% [6].

Radiologists should consider screening for the risk factors that increase the likelihood of CM adverse reactions.

- **Allergy:** In patients with a history of allergic reactions to CM, if exposed to the same class of CM, the likelihood of having a potential allergic reaction is approximately 5 times greater. Patients with unrelated allergies are at a 2- to 3-fold increased risk of an allergic-like contrast reaction [7-9].
- **Asthma:** The risk of allergic reaction in patients with a history of asthma is moderate and may be more likely to develop bronchospasm. Restriction of CM or pre-medication is not recommended based on a history of asthma alone [8].
- **Renal insufficiency:** Chapter 6 (renal adverse reactions) demonstrates the potential risk of contrast-associated acute kidney injury (CA-AKI) following ICM in patients with kidney disease, as well as the potential risk of nephrogenic systemic fibrosis (NSF) following GBCM in patients with kidney disease.
- **Cardiac status:** The risk of non-allergic cardiac events is modestly increased in patients with severe cardiac disease (e.g., congestive heart failure, arrhythmia, primary pulmonary hypertension). Restriction of CM or pre-medication is not recommended based on these cardiac situations alone [4].
- **Anxiety:** Anxious patients are at increased risk of mild contrast reactions. It is therefore recommended that an anxious patient should be reassured before injection of contrast agent [4].
- **Age and gender:** Middle-aged patients have higher rates of reactions than Infants, neonates, children, and the elderly [7,9]. Female patients have higher rates of reactions than male patients. Restriction of CM or pre-medication is not recommended based on patient age or gender alone [4].
- **Beta-blockers:** The threshold for contrast reactions decreases and its severity increases with using beta-blockers. Also, treatment response to epinephrine decreases. Restriction of CM or pre-medication is not recommended based on beta-blocker use alone. Discontinuing beta blocker medication(s) prior to CM administration is also not recommended [4].

- **Sickle-cell trait/disease:** The risk of an acute sickle crisis may be increased in patients with sickle cell trait or sickle cell disease; however, there is no evidence this occurs with ICM or GBCAs. Therefore, restriction of CM or pre-medication is not recommended based on sickle cell trait or sickle cell disease alone [4].
- **Pheochromocytoma:** There is no evidence that IV administration of ICM or GBCAs in patients with pheochromocytoma raises the likelihood of a hypertensive crisis [10]. Therefore, restriction of CM or pre-medication is not recommended based on a history of pheochromocytoma alone [4].
- **Myasthenia gravis:** The relationship between admiration of ICM and exacerbations of myasthenic symptoms in patients with myasthenia gravis remains controversial [11,12]. Premedication is not recommended based on a history of myasthenia gravis alone [4,12].
- **Hyperthyroidism:** Patients with a history of hyperthyroidism rarely experience thyrotoxicosis following ICM [13]. Therefore, restriction of CM or pre-medication is not recommended based on a history of hyperthyroidism alone. However, ICM should be avoided in patients with acute thyrotoxic crises, because it can potentiate thyrotoxicosis [4]. Furthermore, in patients considering radioactive iodine therapy or in patients undergoing radioactive iodine imaging of the thyroid gland, a washout period is suggested to minimize interaction between radioactive iodine and administration of CM. The ideal washout period is 3-4 weeks for hyperthyroidism patients, and 6 weeks for hypothyroidism patients [13,14].
- **Thyroid function:** In patients with a normally functioning thyroid gland, administration of ICM does not affect thyroid functions [13]. In addition, a single dose of ICM administered to pregnant mother has no effect on neonatal thyroid function [4].

References

1. Katayama H, Yamaguchi K, Kozuka T, et al. Adverse reactions to ionic and nonionic contrast media: a report from the Japanese Committee on the Safety of Contrast Media. Radiology 1990;175(3):621–628.
2. Bettmann MA, Heeren T, Greenfield A, et al. Adverse events with radiographic contrast agents: results of the SCVIR Contrast Agent Registry. Radiology 1997; 203:611-620.
3. Brockow K. Contrast media hypersensitivity--scope of the problem. Toxicology 2005; 209:189-192.
4. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
5. Wang CL, Cohan RH, Ellis JH, et al. Frequency, outcome, and appropriateness of treatment of nonionic iodinated contrast media reactions. AJR Am J Roentgenol 2008;191(2):409–415.
6. Behzadi AH, Zhao Y, Farooq Z, et al. Immediate allergic reactions to gadolinium-based contrast agents: a systematic review and meta-analysis. Radiology 2018; 286(2): 471–482.
7. Beaty AD, Lieberman PL, Slavin RG. Seafood allergy and radiocontrast media: are physicians propagating a myth? Am J Med 2008; 121 (2):158 e1-4.
8. Boehm I. Seafood allergy and radiocontrast media: are physicians propagating a myth? Am J Med 2008; 121 (8): e19.
9. Callahan MJ, Poznauskis L, Zurakowski D, Taylor GA. Nonionic iodinated intravenous contrast material-related reactions: incidence in large urban children's hospital--retrospective analysis of data in 12,494 patients. Radiology 2009; 250 (3):674- 81.
10. Mukherjee JJ, Peppercorn PD, Reznek RH, et al. Pheochromocytoma: effect of nonionic contrast medium in CT on circulating catecholamine levels. Radiology 1997; 202 (1):227-31.
11. Mehrizi M, Pascuzzi RM. Complications of radiologic contrast in patients with myasthenia gravis. Muscle Nerve 2014; 50 (3):443-4.
12. Somashekar DK, Davenport MS, Cohan RH, et al. Effect of intravenous low-osmolality iodinated contrast media on patients with myasthenia gravis. Radiology 2013; 267 (3):727-34.
13. Van der Molen AJ, Thomsen HS, Morcos SK. Effect of iodinated contrast media on thyroid function in adults. Eur Radiol 2004; 14 (5):902-7.
14. Silberstein EB, Alavi A, Balon HR, et al. The SNMMI practice guideline for therapy of thyroid disease with 131I 3.0. J Nucl Med 2012; 53 (10):1633-51.

2.2 Informed Consent

Although IV injection of CM have a documented low incidence of adverse events, obtaining consent for all CM procedures is an ethical duty, regardless of the nature of the agent used and the incidence and severity of possible adverse events. Informed consent with appropriate documentation must follow local health facility policies and procedures. For children, the patient's legal representative or, the patient's parent(s) or legal guardian, represents the patient in the consent process [1].

- **Informed consent for emergency procedures**

The scope of the emergency exception to the informed consent requirement when a patient needs immediate medical care and is unable to give informed consent [1].

1. When a delay in treatment would jeopardize the health of a patient and the patient is unable to give informed consent.
2. If the patient is unable to consent and has a legally authorized representative who is available to consent, the treating physician must obtain the informed consent of the representative.
3. When informed consent cannot be obtained from the patient or the representative, the physician treating the patient should determine the immediacy of the need for treatment.
   a. A physician may provide any treatment or perform any procedure immediately required to prevent serious disability or death or to alleviate great pain and suffering.
   b. During the course of an operation or a procedure, a physician may perform any procedure that becomes necessary because of a condition discovered or arising during the operation or the procedure that presents an immediate threat to the life or the health of the patient.
4. The emergency exception to the requirement of informed consent does not extend to a conscious, competent adult patient, otherwise able to give his or her own informed consent, who has refused to consent to a treatment or a procedure.
5. The need for immediate treatment is documented in medical record, including all information establishing the nature, immediacy, and magnitude of the problem and the impossibility of obtaining consent. Any consulting physicians should enter their findings and recommendations in the record. All notes should show the date and time that the determinations were made.

References

[1]. American College of Radiology. ACR-SIR-SPR Practice parameter on informed consent for image-guided procedures, revised 2016; Available at: https://www.acr.org/-/media.

2.3 Premedication

Premedication has been widely used to prevent reoccurrence of immediate hypersensitivity reactions after ICM. However, the evidence for its efficacy and correct patient selection remains scarce and various strategies are being used when a patient has experienced a prior immediate hypersensitivity [1]. In addition, pretesting (intradermal skin testing with CM) has not been shown to be useful in predicting the likelihood of adverse reactions [2].

There are no studies evaluating the efficacy of premedication prior to oral CM or GBCAs administration in high-risk patients. Premedication strategies in these patients are based on extrapolated data from patients receiving intravascular ICM. Although premedication has not been confirmed to prevent or reduce the incidence of all adverse reactions (or reactions-related death), premedication may be considered for patients who have had a prior allergic-like or unknown-type of contrast reaction to the same class of CM [3,4].

A contrast reaction that occurs despite premedication is called a “breakthrough reaction”. Breakthrough reactions occur in a small number of high-risk patients. When they do occur, they usually are of similar severity to the initial reaction. A patient who has had an allergic-like reaction to CM despite steroid premedication can be reinjected in the future after being pre-medicated again, if clinical circumstances require reinjection. Many such patients will not have a repeat reaction, and if a repeat reaction occurs, it will most likely be of the same severity as the previous breakthrough reaction (e.g., mild subsequent breakthrough reaction if the previous breakthrough reaction was mild) [5].

A history of severe contrast reaction is considered a relative contraindication for receiving the same class of CM. In emergency situation, performing contrast-enhanced examination to a high-risk patient in the absence of premedication may outweigh the benefits of prophylaxis. This decision is best made jointly by the radiologist, referring physician and the patients (if feasible) [4].

Recommended Regimens

Elective and accelerated premedication regimens are shown in table 1. [4]

Table 1: Elective and accelerated premedication regimens [4].

Option	Medication	Dose	Route	Timing
A: Elective premedication				
1	Prednisone	50 mg	PO*	7 hours, and 1 hour before CM administration
	+ Diphenhydramine▲	50 mg	IV, IM or PO*	1 hour before CM administration.
B: Accelerated premedication *(in decreasing order of desirability)*				
1	Methylprednisolone sodium succinate, or hydrocortisone sodium succinate	40 mg 200	IV IV	immediately, and then every 4 hours until CM administration (each)
	+ Diphenhydramine▲	50 mg	IV	1 hour before CM administration.
	Or			
2	Dexamethasone sodium sulfate	7.5 mg	IV	immediately, and then every 4 hours until CM administration
	+ Diphenhydramine▲	50 mg	IV	1 hour before CM administration
	Or			
3	Methylprednisolone sodium succinate, or hydrocortisone sodium succinate	40 mg 200	IV IV	1 hour before CM administration (each)
	+ Diphenhydramine▲	50 mg	IV	1 hour before CM administration.

* Hydrocortisone (200 mg IV) can be used to substitute oral prednisone for each oral dose if a patient is unable to take oral medication.
▲ If a patient is allergic to diphenhydramine, the anti-histamine portion of the regimen may be dropped or an alternate antihistamine without cross-reactivity may be considered.

References

1. Schrijvers R, Demoly P, Chiriac AM. Premedication for Iodinated Contrast Media Induced Immediate Hypersensitivity Reactions. Curr Treat Options Allergy 2019; 6:538–553.
2. Trcka J, Schmidt C, Seitz CS, et al. Anaphylaxis to iodinated contrast material: nonallergic hypersensitivity or IgE-mediated allergy? AJR Am J Roentgenol 2008; 190 (3):666-70.
3. O'Malley RB, Cohan RH, Ellis JH, et al. A survey on the use of premedication prior to iodinated and gadolinium-based contrast material administration. J Am Coll Radiol 2011; 8 (5):345- 54.
4. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
5. Mervak BM, Davenport MS, Ellis JH, et al. Rates of Breakthrough Reactions in Inpatients at High Risk Receiving Premedication before Contrast-Enhanced CT. AJR Am J Roentgenol 2015; 205 (1):77-84.

2.4 Preparatory Fasting

Fasting is not recommended before administration of low- or iso-osmolar non-ionic ICM or of GBCAs [1]. However, fasting may be useful in the following situations [2,3]:

- To visualize the gallbladder.
- Help visualize the gut wall (transit, entero-scan) or its vicinity (pancreas).
- Facilitate specific actions requiring sedation or general anesthesia.

Practical considerations:

- No treatment should be discontinued before the examination on the grounds of fasting.
- No fasting is necessary prior to most examinations. If a fast has been prescribed for imaging technical reasons, it will include solids, liquids and tobacco. It should not exceed 6 hours and the examination has to be done as quickly as possible [4].
- If a fast has been prescribed prior to general anesthesia for radiological reasons, the recommendations for fasting are the same ones as for any anesthesia. The prescription is to be done by the anesthesiologist during the anesthesia consultation [4]:
  - Ingestion of clear liquids up to 2 hours before (water, smooth fruit juices, tea, weak dark coffee, sodas). The beverages must be alcohol-free and the quantity ingested is less important than the clearness of the liquids.
  - Light meal no more than 6 hours before.
  - No smoking.

References

1. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.
2. Practice guideline for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedure. A report by the American Society of Anesthesiology Task Force on preoperative fasting. Anesthesiology 1999; 90:896-905.
3. CAS guideline to the practice of anesthesia. Can. J. Anesth.2000; 47:22-4.
4. Prescribing fasting before a radiological examination requiring the use of iodinated contrast media. Available at: http://www.sfrnet.org/data/upload/files/a7e7222e420ac736c1256b6c0044cb07/contrast%20media%20prescribing%20fasting.pdf. Accessed October 12, 2019.

3. PROCEDURAL CONSIDERATIONS

3.1 Storing, Handling and Disposing

a. Storing

CM are delivered to radiology department through pharmacy (or medical supply) in stock. In the radiology department, CM should be stored in a secured area at room temperature, away from direct sunlight, and away from radiation sources. CM are to be rotated as new orders arrive with new stock placed at the rear of the storage. CM are to remain stored in original packaging until being placed in a CM warmer or used [1].

CM warmers should not be used for long-term storage of CM. Follow the manufacturer's directions regarding storage. The responsible practitioner should check the warmer daily to ensure that the warmer is functioning properly. A log should be kept to monitor daily temperature. The ideal temperature is 37° (range between 36°C to 46°C). If the warmer is out of compliance, all contrast are removed from that warmer. A sticker with the date should be place on each contrast bottle prior to placing in the warmer. The responsible practitioner should check for expiration dates once a month. Low turnover CM which risks being kept in the CM warmer for longer than 30 days should be clearly labelled with the date placed in the CM warmer [1].

CBAHI requirements that concern look-alike/sound-alike medications and labeling recommendations, also should be apply to storing CM [2]. Documenting and tracking CM as medications also is critical during the storage phase, as drugs expire, are recalled or if they are improperly stocked [3].

b. Handling:

Only appropriate staff should be allowed to access the storage area. Also, CM should be removed from its packing carton then stored no higher than 18 inches from the ceiling. The health care facility should identify ergonomic stressors in the workplace and assess work tasks that increase risk for injury. Common injuries include carpal tunnel syndrome, back pain and tendonitis [3].

c. Disposing

The safe handling of contrast agents and packaging does not stop after administration. Radiologic technologists and other health care facility personnel must handle discarded bottles. Contrast glass bottles are considered a type of sharp, even if intact, and must be disposed of in puncture-proof containers. Furthermore, contaminated glass be disposed of as hazardous waste [4].

References

1. Royal Australian and New Zealand College of Radiologists (RANZCR). Iodinated contrast media guideline, 2018, V2.3.
2. CBAHI, National Hospitals Standards. 3rd Edition 2015.
3. Morrison G, Teresa G. Odle, B.A. Safety Considerations in Contrast Media Handling and Administration. ASRT. Meeting held: April 23, 2007; Albuquerque, NM.
4. Stevens CM. Regulatory compliance associated with contrast media. Radiol Manage 2005; Novmber-December: 16-27.

3.2 Warming

a. Warming of ICM

*Situations in which external warming of ICM (*37°C*) may be needed or beneficial* [1-4]:

- High rate (> 5 mL/second) IV LOCM power injections.
- Injections of viscous ICM (e.g., iopamidol 370, and other CM with a similar or higher viscosity).
- Direct arterial injections through small-caliber catheters (5 French or smaller).
- Intravascularly injected arterial studies in which timing and peak enhancement are critical features.

Situations in which external warming of ICM may be not needed or beneficial [1-4]:

- Low rate (≤ 5 mL/second) IV LOCM power injections or hand injections.
- Injections of ICM with a relatively low viscosity (e.g., iopamidol 300, and presumably other contrast media with a similar or lower viscosity).
- Direct arterial injections through large-bore catheters (6 French or larger).
- Intravascularl injections in which peak opacification and timing are not critical (e.g., routine portal venous phase chest/abdomen/pelvis CT imaging).

b. Warming of GBCAs

GBCAs are administered at room temperature (15 to 30°C) and according to package inserts, should not be externally warmed for routine clinical applications [1-4].

References

1. Brunette J, Mongrain R, Rodes-Cabau J, et al. Comparative rheology of low- and iso-osmolarity contrast agents at different temperatures. Cath and Cardiov Interv 2008; 71:78-83.
2. Roth R, Akin M, Deligonul U, Kern MJ. Influence of radiographic contrast media viscosity to flow through coronary angiographic catheters. Cathet Cardiovasc Diagn 1991; 22(4):290-294.
3. Davenport MS, Wang CL, Bashir MR, et al. Rate of contrast media extravasations and allergic-like reactions: effect of extrinsic warming of low-osmolality iodinated CT contrast media to 37oC. Radiology 2012; 262:475-484.
4. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020**.**

3.3 Safe Administration

a. General Considerations

CM should be prescribed by radiologists and a formal record of the decision should be made before administration (see Appendix B). Injection methods vary depending on vascular access, differential diagnosis and type of imaging procedure. The mode and method of delivery, either by hand or by power injector, also vary by procedure. A radiologist, radiologic technologist, or nurse may administer contrast

media depending on the local facility policy. Bolus or power injection of IV contrast material is superior to drip infusion for enhancing body structures. It is necessary to have stable IV access. Unless it is proven to be safe (e.g., heparin), the mixture of CM and blood or any drug should be avoided. To avoid potential complications, communication with the patient is required at all times prior to, during, and after a CM injection [1].

The use of CM in the radiology department must follow the same local facility policy as does the use of other high-alert medications in accordance with CBAHI requirements, including safe prescription, preparation, safe administration and, monitoring patient response [2].

b. Technique

A flexible plastic cannula should be used to administer CM via the power injector. Using metal needles should be avoided whenever possible. The flow rate should be appropriate for the gauge of the catheter. A 20-gauge or larger catheter is preferable for flow rates of 3 ml/sec or greater [3].

The best venous access site for power injection is the pre-cubital or a large forearm vein. If a peripheral venipuncture site must be used, flow rates should be reduced if feasible (e.g., 1-2 mL/sec). It is important to prepare the power injection apparatus carefully to avoid the risk of air embolism or extravasation. To remove the syringe and pressure tubing from the air, normal procedures should be used. Several maneuvers can be performed to confirm the proper location of IV catheter. The catheter can be checked for backflow of blood into the tubing, although backflow is not always noted. A saline test flush can be performed. Direct monitoring of the site during injection is recommended. In all instances, the power injector and its tubing should be positioned to allow adequate table movement [3].

It should not be assumed that all central venous catheter can be injected with CM using power injection. Using power injection of CM through central venous catheters can be performed safely provided that certain precautions are followed. Before connecting to the injector system tubing, the catheter tip position should be tested for venous backflow. Occasionally backflow will not be obtained because the catheter tip is positioned against the wall of the vein. CM can be administered safely if saline can be injected without abnormal resistance. If abnormal resistance or pain is observed, an alternative vein access site should be found. The radiologist should consult the advice of manufacturers for the power injection of CM into certain central venous catheters [1,3].

c. Air Embolism

Small-volume clinically insignificant venous air embolism commonly occurs during or after contrast-enhanced CT. Patients with known risk factors such as right-to-left intracardiac shunt or pulmonary arteriovenous malformation, are reported to be at a higher risk of having neurological deficits from even small amounts of venous air. Great vigilance is recommended in this group of patients to prevent air embolism during administration of intravenous contrast. A small air embolism usually does not require any intervention other than observation. Although accidental injection of 100 cc of air has been reported as fatal, multiple factors such as body position, injection speed, total amount of air injected, and general health status plays a part in fatal cases of venous air embolism. Applying precaution and standard of care when using power injection for contrast enhanced CT will significantly minimize the risk of air-embolism [4,5].

d. **Intra-osseous Injection**

Intra-osseous (IO) catheters allow rapid intravascular access for the administration of fluids and medications in critically ill patients without intravenous access. Humeral placement is the preferred site compared to tibial access, secondary to quick line placement and higher achievable flow rates. High pressures are needed to infuse through IO lines. Prior to an infusion of any substance through IO access, a local anesthetic is needed in non-sedated patients [6].

e. Documentation:

CM prescription and their administration should be documented in the medical record [1,2,3] (see Appendix B).

References

1. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
2. CBAHI, National Hospitals Standards. 3rd Edition 2015.
3. American College of Radiology. ACR-SPR Practice Parameter for the use of intravascular contrast media, revised 2017. Available at https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IVCM.pdf.
4. Sodhi KS, Das PJ, Malhotra P, Khandelwal N. Venous air embolism after intravenous contrast administration for computed tomography. J Emerg Med 2012; 42:450-1.
5. Sodhi KS, Saxena AK, Chandrashekhar G, et al. Vascular air embolism after contrast administration on 64 row multiple detector computed tomography: A prospective analysis. Available at http://www.lungindia.com on Wednesday, September 28, 2016, IP: 81.83.62.154.
6. Baadh AS, Singh A, Andrew Choi A, et al. Intraosseous Vascular Access in Radiology: Review of Clinical Status. AJR 2016; 207:241–247.

3.4 Extravasation

Extravasation of an intravenous contrast media is defined as the accidental release of a variable volume of these solutions, from the intravascular compartment into the tissues, and adjacent soft area compartments. This phenomenon occurs during intravenous contrast media injection with mechanical pump and corresponds to a procedure complication [1].

The incidence of extravasation with the use of ICM is low, occurring in approximately 0.1 to 0.9%, and the incidence of GBCA extravasation is even lower (0.05%), since smaller volumes are used and most often the injection is manual [1-4].

a. Risk factors

Particularly at risk are patients with an inadequate response to pain or unable to communicate effectively. High-risk patients also include patients with atrophic, subcutaneous adipose tissue, limited peripheral vascular status or pathological lymphatic situation, as well as patients after current or ongoing chemotherapy with resulting fragile vascular status and clinically difficult to assess skin color [2,5]. In addition, using of power injector or using CM with large volume, high-osmolar or high-viscosity are associated with an increased risk of extravasation [3,6].

b. Sequelae

Most extravastions are minor (swelling, burning pain or tightness at extravasation site). On physical examination, the site may be edematous, erythematous, and tender. The majority of extravasations recover without significant sequelae. Less commonly, extravasation injury proceed to a severe adverse event, including skin ulceration, soft-tissue necrosis, and compartment syndrome [5,6].

Compared to iodinated contrast, GBCAs have lower toxicity, and extravasation do not cause severe injury due to smaller total volumes of contrast material that are injected [1,4].

c. Treatment

Conservative treatment is adequate in most cases, including limb elevation above the level of the heart, cold compresses, splinting of the affected extremity, and continous careful monitoring. Early (plastic) surgical consultation is recommended in case of severe injury or in presence of progressive swelling or pain, altered tissue perfusion, decrease capillary refill, change in sensation, worsening passive or active range of motion [6,7].

d. Documentation:

Extravasation events and their treatment should be documented in the medical record [6,7].

References

1. Varela C, Sepúlveda P, Prieto J, Pavanati S. Extravasation of intravenous contrast media: What every radiologist should know. Rev Chil Radiol 2015; 21(4): 151-157.
2. Federle MP, Chang PJ, Confer S et al. Frequency and effects of extravasation of ionic and nonionic CT contrast media during rapid bolus injection. Radiology 1998; 206: 637–640.
3. Cohan RH, Bullard MA, Ellis JH et al. Local reactions after injection of iodinated contrast material: detection, management, and outcome. Acad Radiol 1997; 4: 711–718 .
4. Niv G, Costa M, Kicak P et al. Vascular extravasation of contrast medium in radiological examinations: University of California San Diego Health System Experience. J Patient Saf 2014; 10: 105 –110
5. Cohan RH, Ellis JH, Garner WL. Extravasation of radiographic contrast material: recognition, prevention, and treatment. Radiology. 1996;200(3):593-604.
6. Mandlik V, Prantl L, Schreyer AG. Contrast Media Extravasation in CT and MRI – A Literature Review and Strategies for Therapy. Fortschr Röntgenstr 2019; 191: 25–32.
7. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.

4. TREATMENT OF CONTRAST MEDIA REACTIONS

On-site staff should be trained in the rapid diagnosis, treatment, and reporting of adverse contrast reactions (see Appendix B). Emergency equipment and medications needed to treat contrast adverse reactions should be available at the site of CM administration (see Table 2) [1]. The contact phone number of the emergency team should be clearly posted at the site in which CM is to be injected. To ensure that responses to contrast reactions are timely and acceptable, quality assurance and quality management programs are recommended. [1-3].

Most CM reactions are mild and require no treatment. A mild reaction, however, can progress into a moderate or severe reaction. Any patient with a moderate allergic-like reaction should also be monitored for a period of 20 to 30 minutes. In order to minimize the risk of an adverse effect, most mild and all severe reactions require immediate and aggressive therapy [1-3].

The treatment protocols in this document could be used as a guide and the radiology department must follow the local facility protocols or procedures for detecting, managing, and reporting CM adverse reactions.

4.1 Treatment of Acute Reactions

Immediate assessment of patient with a potential contrast reaction should include:

- Patient look (level of consciousness),
- Ability to speak (voice sound),
- Breathing status,
- Pulse, and
- Blood pressure.

This assessment will allow the responding provider to diagnose type and severity of reaction. Once diagnosed, effective treatment can be rapidly and effectively administered (see Appendices C and D) [1]. Activation of the emergency response system to elevate the level of care if needed [1-3].

GBCA acute adverse reactions treatment is similar to that for acute reactions to ICM. Special concern should be taken in MR facilities that patients requiring treatment should be taken out of the magnet so that none of resuscitative equipment becomes a magnetic hazard [1].

4.2 Treatment of Delayed Reactions

Delayed adverse reactions are generally self-limited and requires no or supportive treatment. However, if there are noteworthy associated symptoms, consultation is advised. Drug prophylaxis is generally not recommended for patients who have had a previous contrast medium reaction or those treated with interleukin-2 therapy [4].

Table 2: Equipment and medications for contrast reactions in radiology departments [1].

- Minimum equipment and medications (should be in or close to the room for CM injection):
  - *Equipment:*
    - Access to oxygen.
    - Defibrillator or automated external defibrillator (AED)
    - Blood pressure/pulse monitor.

- Pulse oximeter & Stethoscope.
- *Medications:*
  - Epinephrine IM 1mg/1mL (auto-injector or vials with needle and syringe for use).
  - Inhaled short-acting beta-agonist (inhaler or nebulizer).
  - Anti-histamine.

- Discretionary equipment and medications (may be in or close to the room for CM injection):
  - *Equipment:*
    - Suction: portable or wall-mounted; catheters and tubes
    - Ambu (bag-valve-mask kit); masks for pediatric and adult.
    - Tubing; saline (0.9 percent); IV cannulas and syringes: variety of sizes; tourniquets
    - Needle(s) for IM drug administration.
  - *Medications:*
    - Epinephrine IV 1mg/10mL, 10-mL preloaded syringe.
    - Atropine IV, 1mg/10mL, 10-mL preloaded syringe.
    - Corticosteroid IV.
    - Aspirin PO, 325 mg.
    - Furosemide IV, 20–40 mg (for pulmonary edema) o Labetalol IV, 20 mg (for hypertensive emergency).
    - Dextrose IV, 50% 25g/50mL syringe (for hypoglycemia).

References

1. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
2. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.
3. Rosado Ingelmo A., Doña Diaz, Cabañas Moreno R., et al. Clinical Practice Guideline for Diagnosis and Management of Hypersensitivity Reactions to Contrast Media. J Investig Allergol Clin Immunol 2016; Vol. 26(3): 144-155.
4. Webb JA, Stacul F, Thomsen HS, Morcos SK. Late adverse reactions to intravascular iodinated contrast media. Eur Radiol 2003; 13:181-184.

5. RENAL ADVERSE REACTIONS

5.1 Clinical Estimation of Renal Functions

- Estimated glomerular filtration rate (eGFR), calculated from the serum creatinine, is the recommended method to estimate renal function before contrast agent administration [1-3].
- *In adults* ≥ 18 years the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [4] is recommended to calculate eGFR.

  eGFR (ml/min/1.73 m^2) =

  Female sCr ≤ 62 µmol/l: $144 \times (sCr / 62)^{-0.329} \times 0.993^{Age}$

  Female sCr > 62 µmol/l: $144 \times (sCr / 62)^{-1.209} \times 0.993^{Age}$

  Male sCr ≤80 µmol/l: $141 \times (sCr / 80)^{-0.411} \times 0.993^{Age}$

  Male sCr > 80 µmol/l: $141 \times (sCr / 80)^{-1.209} \times 0.993^{Age}$

  (sCr in µmol/l; age in years)

  All equations x 1.159 if African American race.

- *In children*, the revised Schwartz formula [5] is recommended to calculate eGFR.

I. eGFR (ml/min/1.73 m^2) = 36.5 x length / sCr

(sCr in µmol/l; length in cm)

Note: Neither serum nor plasma creatinine is an ideal indicator of renal function and may miss decreased renal function [1-3].

References

1. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
2. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.
3. Royal Australian and New Zealand College of Radiologists (RANZCR). Iodinated contrast media guideline, 2018, V2.3.
4. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. Ann Intern Med. 2009;150(9):604-12.
5. Schwartz GJ, Muñoz A, Schneider MF, et al. New equations to estimate GFR in children with CKD . J Am Soc Nephrol. 2009 Mar; 20(3):629-37.

Use of Intravenous ICM in Patients with Kidney Disease

Contrast-associated acute kidney injury (CA-AKI) is any AKI occurring within 48 hours after the administration of CM. The term post-contrast acute kidney injury (PC-AKI) is synonymous with CA-AKI. Contrast-induced acute kidney injury (CI-AKI) is the subset of CA-AKI that can be causally linked to CM administration [1-3].

a. Risk Factors

The most important risk factor for CA-AKI is pre-existing severe kidney disease. The risk of CA-AKI increases with each stepwise increase in CKD stage, approximately 5% at eGFR greater than or equal to 60, 10% at eGFR of 45–59, 15% at eGFR of 30–44, and 30% at eGFR less than 30 mL/ min/1.73 m^2 [2,3]. Additional risk factors include diabetes mellitus, nephrotoxic agents, hypotension, hypovolemia, albuminuria, and impaired kidney perfusion (eg, congestive heart failure) [4,5]. Although multiple myeloma has long been considered a risk factor for CA-AKI, this is not supported by more recent literature [6,7].

There are no confirmed clinically relevant differences in risk of CA-AKI between low-osmolality contrast media (LOCM) and iso-osmolarity contrast media (IOCM) for intravenous applications [8].

Although correlative data link higher doses of CM to greater risk of CA-AKI following intra-arterial administration, no analogous data exist that imply a dose-ranging toxicity for IV administration within the range of clinically administered doses [1].

b. Diagnosis

Kidney Disease Improving Global Outcomes (KDIGO) criteria are recommended for the diagnosis of CA-AKI [4]. Although serum creatinine is an imperfect biomarker for AKI, it remains the most common and practical clinical method of diagnosing AKI [1,2].

Prophylaxis

Patients eligible for prophylaxis includes those with AKI or an eGFR <30 mL/min/1.73 m2 and are not subjected to maintenance dialysis. [3,5]. Prophylaxis is not indicated for the general population of patients with stable eGFR ≥30 mL/min/1.73 m^2, for patients undergoing chronic dialysis, or for patients at risk for heart failure. This eGFR threshold should not be adjusted solely based on concomitant diabetes mellitus [9-12].

When prophylaxis is indicated, isotonic volume expansion with normal saline is the preferred method. The ideal timing, volume, and rate of volume expansion is uncertain. Typical volume expansion regimens begin 1 hour before and continue 3–12 hours after contrast media administration, with typical doses ranging from fixed (e.g., 500 mL before and after) to weight-based volumes (1–3 mL/kg per hour) [1,3]. Longer regimens (approximately 12 hours) have been shown to lower the risk of CA-AKI compared with shorter regimens. However, longer intravenous protocols are generally impractical in the outpatient setting. Oral hydration has not been well studied for patients with eGFR less than 30 mL/min/1.73 m2 or AKI. The risks of prophylaxis (eg, heart failure, other hypervolemic conditions) should be considered before initiation [1,13].

The use of sodium bicarbonate or N-acetylcysteine is not recommended for intravenous CM exposure prophylaxis. In patients with eGFR less than 30 mL/min/1.73 m2 or AKI, cessation of nonessential

nephrotoxic medications (e.g., nonsteroidal anti- inflammatory drugs) may decrease the risk of CA-AKI and is recommended when feasible [1].

c. Screening

Screening based on eGFR should be used to identify patients at potential risk of CI-AKI. Screening based on eGFR is preferred over serum creatinine–based screening [4,14].

A variety of screening data elements have been considered that variably affect the sensitivity and specificity of kidney function screening. A personal history of kidney disease (e.g., CKD, remote AKI, kidney surgery, kidney ablation, and albuminuria) is the most useful element that demonstrates a requirement for kidney function determination. Diabetes mellitus is an optional factor for screening. Patient age and both treated and untreated hypertension are of uncertain utility as independent triggers for kidney function assessment during radiology point of care; they are sensitive indicators and confer a large false-positive rate to the identification of patients with eGFR less than 30 mL/min/1.73 m^2 [1,3,15].

Renal dialysis

Patients with CKD stages 4 or 5 and are not undergoing maintenance dialysis have a relative rather than absolute contraindication to ICM. If contrast media administration is required for a life-threatening diagnosis, then it should not be withheld based on kidney function. If intravenous ICM administration is clinically indicated, then its use should be informed by consideration of the potential risks and benefits as well as alternative imaging strategies. If intravenous ICM is administered in this setting, then should the patient undergo dialysis in addition to standard prophylaxis [1,3].

From an operational standpoint, patients undergoing dialysis who make more than 1–2 cups of urine daily (approximately 100 mL) can be considered nonanuric [4]. Nonanuric patients undergoing maintenance dialysis, whether peritoneal dialysis or hemodialysis, are at increased risk of further loss of residual kidney function following nephrotoxic exposure(s). Although unproven for intravenous ICM, loss of residual kidney function may have adverse quality-of-life and overall survival implications. Therefore, nonanuric patients with residual kidney function undergoing maintenance dialysis are considered similar to patients with AKI or eGFRs less than 30 mL/min/1.73 m2 not undergoing dialysis with respect to the potential nephrotoxic risk of iodinated contrast media (ie, relative contraindication). If loss of residual kidney function is considered clinically important, then the risks, benefits, and alternatives should be considered, and the need for the procedure may require discussion between the referring professional and radiologist [1].

Patient with single kidney

Patients with a single normal or partially functioning kidney (eg, kidney agenesis, nephrectomy, or transplant) should be managed similarly to patients with normal kidney volume (eg, two normal kidneys). In patients with a single normal or partially functioning kidney, clinical risk should be determined based on overall kidney function (ie, eGFR) and clinical circumstances (ie, AKI). The presence of a solitary functioning kidney should not influence decision making regarding the risk of CA-AKI or CI-AKI [3].

d. Nephrotoxic medications

The use of intravenous ICM should not be altered in patients with normal eGFR or mild-to-moderate

reductions in eGFR who have receiving nephrotoxic medications or undergoing chemotherapy. However, monitoring eGFR in patients receiving nephrotoxic medications (e.g., aminoglycosides) or undergoing chemotherapy is important before, during, and after treatment to identify incident nephrotoxicity (e.g., AKI or new eGFR, 30 mL/min/1.73 m^2) [1-3].

In patients with AKI or eGFRs less than 30 mL/min/1.73 m^2, it may be prudent to withhold nonessential potentially nephrotoxic medications (e.g., nonsteroidal anti-inflammatory drugs, diuretics, amino-glycosides, amphotericin, platins, zoledronate, methotrexate) if clinically feasible for 24 to 48 hours before and 48 hours after exposure. Whether to withhold renin-angiotensin-aldosterone system inhibitors, or RAASi, is controversial [1,4,5].

If CA-AKI develops, then nonessential nephrotoxic medications should continue to be withheld until kidney function has recovered. In some cases, withholding a nephrotoxic drug or the delay of an indicated imaging examination while waiting for an administered nephrotoxic drug to be eliminated may carry more risk than the potential risk of CI-AKI. Therefore, decisions regarding the suspension of medications should be individualized by referring and other treating providers [1,3,4].

References

1. Davenport MS, Perazella MA, Jerry Yee J, Jonathan R. Dillman HR, et al. Use of Intravenous Iodinated Contrast Media in Patients with Kidney Disease: Consensus Statements from the American College of Radiology and the National Kidney Foundation. Radiology 2020; 294:660–668.
2. Dekkers IA, van der Molen AJ. Propensity score matching as a substitute for randomized controlled trials on acute kidney injury after contrast media administration: a systematic review. AJR Am J Roentgenol 2018; 211(4):822–826.
3. American College of Radiology. Manual on contrast media. Version 10.3. Reston, Va: American College of Radiology, 2018. https://www.acr.org/ Clinical-Resources/Contrast-Manual. Accessed May 16, 2019.
4. Palevsky PM, Liu KD, Brophy PD, et al. KDOQI US commentary on the 2012 KDIGO clinical practice guideline for acute kidney injury. Am J Kidney Dis 2013; 61(5):649–672.
5. Faucon AL, Bobrie G, Clément O. Nephrotoxicity of iodinated contrast media: From pathophysiology to prevention strategies. Eur J Radiol 2019; 116:231–241.
6. Stacul F, Bertolotto M, Thomsen HS, et al. Iodine-based contrast media, multiple myeloma and monoclonal gammopathies: literature review and ESUR Contrast Media Safety Committee guidelines. Eur Radiol 2018;28(2):683–691.
7. Crowley MP, Prabhakaran VN, Gilligan OM. Incidence of contrast- induced nephropathy in patients with multiple myeloma undergoing contrast-enhanced procedures. Pathol Oncol Res 2018; 24(4):915–919.
8. Eng J, Subramaniam RM, Wilson RF, et al. Contrast-induced nephropathy: comparative effects of different contrast media. Report No. 15(16)-EHC022- EF. Rockville, Md: Agency for Healthcare Research and Quality (US), 2015.

9. Subramaniam RM, Wilson RF, Turban S, et al. Contrast-induced nephropathy: comparative effectiveness of preventive measures. Report No. 15(16)-EHC023-EF. Rockville, Md: Agency for Healthcare Research and Quality (US), 2016.
10. Weisbord SD, Palevsky PM. Prevention of contrast-induced nephropathy with volume expansion. Clin J Am Soc Nephrol 2008; 3(1):273–280.
11. Nijssen EC, Nelemans PJ, Rennenberg RJ, Theunissen RA, van Ommen V, Wildberger JE. Prophylaxis in High-Risk Patients With eGFR, 30 mL/min/1.73 m2: Get the Balance Right. Invest Radiol 2019; 54(9):580–588.
12. Nijssen EC, Rennenberg RJ, Nelemans PJ, et al. Prophylactic hydration to protect renal function from intravascular iodinated contrast material in patients at high risk of contrast-induced nephropathy (AMACING): a prospective, randomised, phase 3, controlled, open-label, non-inferiority trial. Lancet 2017; 389(10076):1312–1322.
13. Van der Molen AJ, Reimer P, Dekkers IA, et al. Post-contrast acute kidney injury. Part 2: risk stratification, role of hydration and other prophylactic measures, patients taking metformin and chronic dialysis patients: Recommendations for updated ESUR Contrast Medium Safety Committee guidelines. Eur Radiol 2018; 28(7):2856–2869.
14. Davenport MS, Khalatbari S, Cohan RH, Ellis JH. Contrast medium-induced nephrotoxicity risk assessment in adult inpatients: a comparison of serum creatinine level- and estimated glomerular filtration rate-based screening methods. Radiology 2013; 269(1):92–100.
15. Too CW, Ng WY, Tan CC, Mahmood MI, Tay KH. Screening for impaired renal function in outpatients before iodinated contrast injection: Comparing the Choyke questionnaire with a rapid point-of-care-test. Eur J Radiol 2015; 84(7):1227–1231.

5.2 Use of Intravenous GBCM in Patients with Kidney Disease

Nephrogenic systemic fibrosis (NSF) is the most serious side effect of GBCM administration in patients with kidney disease. NSF is an extremely rare condition characterized by "pruritic firm, erythematous, and indurated plaques of the skin associated with subcutaneous edema". Patients with NSF can also have systemic involvement of other organs, including muscles and joints, internal solid organs (e.g., lung, liver, and heart) and sclera [1-3].

The interval between GBCM exposure and onset of symptoms attributed to NSF ranges from the same day to approximately 10 years (median, 42 days) [4]. A diagnosis of NSF is made by high clinical suspicion in at-risk patients (renal replacement therapy, AKI, stages 4 or 5 CKD) and confirmed by the characteristic findings on skin biopsy [3].

Saudi Food and Drug Administration (SFDA) recommended that macrocyclic GBCA (e.g., Gadobutrol, Gadoteridol, Gadoterate) should be the first choice for MRI examinations and linear GBCA (e.g., Gadopentetate, Gadobenate, Gadodiamide, Gadoversetamide) should not be used if the alternative is available [5].

The ACR categorizes GBCM into three groups (Table-3) based on their risk association with NSF (group I: highest risk; group II: very low risk; group III: likely very low risk but insufficient confirmatory evidence) [6].

Table 3: ACR classification of GBCM relative to association with NSF [6].

U.S. Trade Name	Generic Name	Structure	ACR Group
Omniscan	Gadodiamide	Linear nonionic	I
OptiMark	Gadoversetamide	Linear nonionic	I
Magnevist	Gadopentetate dimeglumine	Linear ionic	I
MultiHance	Gadobenate dimeglumine	Linear ionic	II
ProHance	Gadoteridol	Macrocyclic nonionic	II
Gadavist	Gadobutrol	Macrocyclic nonionic	II
Dotarem	Gadoterate meglumine	Macrocyclic ionic	II
Clariscan	Gadoterate meglumine	Macrocyclic ionic	II
Eovist	Gadoxetate disodium	Linear ionic	III

Note—Group I: GBCM associated with the greatest number of NSF cases. Group I GBCM are no longer advertised in the United States. Group II: GBCM associated with few, if any, un-confounded cases of NSF. Group III: GBCM for which data remains limited regarding NSF risk, but for which few, if any, un-confounded cases of NSF have been reported.

The joint consensus statements by the American College of Radiology (ACR) and the National Kidney Foundation (NKF) were developed to improve and standardize the care of patients with impaired kidney function who have indication(s) to receive intravenous GBCM. These ACR-NKF consensus statements are summarized in table-4 [5].

Table 4: Major ACR-NKF Consensus Statements on use of intravenous GBCM in patients with kidney disease [7]	
1.	Patients undergoing renal replacement therapy, patients with AKI, and patients with stage 4 or 5 CKD who are exposed to a group I GBCM—especially repeated doses of a higher off-label dose of a group I GBCM—are at greatest risk of NSF.
2.	Risk of NSF differs between GBCM and can be stratified into three GBCM groups (group I: highest risk; group II: very low risk; group III: likely very low risk but insufficient confirmatory evidence).
3.	The risk of NSF increases with larger doses of group I GBCM. The dose-related risk of NSF from group II and group III GBCM is unknown, but in general the lowest diagnostic dose of GBCM should be used.
4.	Group II GBCM should not be withheld or delayed if harm would result from not proceeding with an indicated contrast-enhanced MRI.
5.	Kidney function screening is optional for group II GBCM but is necessary for group III GBCM.
6.	Direct communication between the radiologist and referring provider regarding risk of NSF is not necessary for group II GBCM administration, but it is suggested for group III GBCM administration in patients with eGFR, 30 mL/min per 1.73 m^2 or AKI.
7.	The risk of NSF is very low for a standard dose (0.1 mmol/kg) of group II GBCM, even in patients with eGFR, 30 mL/min per 1.73 m^2 or AKI.
8.	Prophylaxis is not indicated for the prevention of NSF. Risk mitigation strategies can include awaiting kidney function recovery and use of group II GBCM
9.	Dialysis should not be initiated or altered based on group II or group III GBCM administration.
10.	On-label dosing of group II or group III GBCM does not have a clinically important risk of nephrotoxicity.
11.	If multiple urgent group II or group III GBCM doses are indicated, subsequent dose(s) should not be delayed for fear of NSF. If not urgent, delaying the subsequent dose(s). 24 hours or performing inter-current dialysis can promote GBCM clearance.
12.	The above recommendations should not be altered in patients receiving nephrotoxic medications, chemotherapy, or contrast-enhanced CT.
13.	The above recommendations also apply to pediatric patients. The risk of NSF in pediatric patients appears to be low, but data are limited. The Bedside Schwartz equation or the creatinine-cystatin C-based CKiD equation should be used to assess eGFR in infants and children.

References

1. Grobner T. Gadolinium--a specific trigger for the development of nephrogenic fibrosing dermopathy and nephrogenic systemic fibrosis? Nephrol Dial Transplant. 2006;21(4):1104-1108.
2. Marckmann P, Skov L, Rossen K, et al. Nephrogenic systemic fibrosis: suspected causative role of gadodiamide used for contrast-enhanced magnetic resonance imaging. J Am Soc Nephrol. 2006;17(9):2359-2362.
3. Hana Malikova. Nephrogenic systemic fibrosis: the end of the story? Quant Imaging Med Surg 2019;9(8):1470-1474.
4. Attari H, Cao Y, Elmholdt TR, Zhao Y, Prince MR. A systematic review of 639 patients with biopsy-confirmed nephrogenic systemic fibrosis. Radiology 2019; 292(2):376–386.

5. Saudi Food and Drug Administration: recommendations of pharmacovigilance and drug safety consultation committee, 3rd meeting, 6/10/2017.
6. American College of Radiology. Manual on contrast media. Version 10.3. Reston, Va: American College of Radiology, 2018. https://www.acr.org/ Clinical-Resources/Contrast-Manual. Accessed December 21, 2019.
7. Weinreb JC, Rodby RA, Yee J, Wang CL, Derek Fine D, et al. Use of Intravenous Gadolinium-based Contrast Media in Patients with Kidney Disease: Consensus Statements from the American College of Radiology and the National Kidney Foundation. Radiology 2020; 00:1–8.

5.3 Metformin

Metformin is an oral anti-hyperglycemic agent used to treat patients with non-insulin-dependent diabetes mellitus, either alone or in combination with other medications. The risk of developing lactic acidosis in a prone patient is the most important adverse effect of metformin. Metformin is excreted by the kidneys, approximately 90% within the first 24 hours [1, 2].

a. Metformin and ICM

Based on the renal function patients taking metformin are classified into one of the two categories.

Category I

There is no need to discontinue metformin either before or after administration of ICM in patients without signs of AKI and eGFR >30 mL/min/1.73m2, and there is no need to reassess renal function [2,3].

Category II

In patients with AKI or severe CKD (eGFR< 30 mL/min/1.73m^2), metformin should be stopped at the time of (or prior to) the exam and suspended for 48 hours following the exam, and should not be reinstituted unless renal function becomes normal. [2,3].

Although the USFDA recommends withholding metformin prior to ICM exposure for eGFR 30–59 mL/min/1.73 m^2, decision making should be individualized by referring clinicians at this eGFR level because the risk of CI-AKI is sufficiently low [4,5].

b. Metformin and GBCAs

It is not necessary to discontinue metformin after GBCAs when the dose administered is in the recommended range (0.1 mmol/kg of body weight) [2].

References

1. Dunn CJ, Peters DH. Metformin. A review of its pharmacological properties and therapeutic use in non-insulin-dependent diabetes mellitus. Drugs. 1995;49(5):721-749.
2. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
3. Royal Australian and New Zealand College of Radiologists (RANZCR). Iodinated contrast media guideline, 2018, V2.3.
4. Davenport MS, Perazella MA, Jerry Yee J, Jonathan R, et al. Use of IV ICM in Patients with Kidney Disease: Consensus Statements from the ACR and the NKF. Radiology 2020; 294:660–668.
5. United States Food and Drug Administration. FDA revises warnings regarding use of diabetes medicine metformin in certain patients with reduced kidney function. https://www.fda.gov/media/96771/download. Released April 8, 2016. Accessed June 4, 2019.

6. MISCELLANEOUS CONSIDERATIONS

6.1 Enteric Contrast Media

a. Barium contrast media

Barium sulfate is the preferred oral CM for the diagnosis of obstruction (except suspected proximal small bowel obstruction) in most non-acute clinical situations. Leakage into the mediastinum or peritoneal cavity is the most serious complication from the use of barium in the GIT. Mediastinitis can be caused by esophageal leakage. Leak from stomach, duodenal, and small intestinal may result in peritonitis. Leak from the colon carries high mortality. Therefore, it is recommended to avoid barium in patient with suspected or known bowel perforation. In addition, it is also recommended to avoid barium enema in patient with extensive colitis [1-4].

- *Toxicity and adverse reactions*

Direct toxicity resulting from absorption of barium has been rarely reported. Almost always adverse reactions to oral or rectal barium contrast media are mild. Most common symptoms include nausea, vomiting, and abdominal cramping or discomfort. These “reactions” are part of a physiologic response resulting from distention of a viscus. During a double contrast barium enema of colon, vasovagal reactions also may occur [5,6].

Allergic-like reactions to enteric barium are very uncommon. Most of allergic-reactions are mild. Moderate and severe allergic reactions are exceedingly unusual. Life-threatening reactions from double contrast colon examinations, especially those performed following the parenteral injection of glucagon have been reported [3,6].

- *Administration*

In single contrast upper GIT series or small bowel-follow-through (SBFT), the mixture for optimal stability in suspension and bowel wall coating is 60% weight/volume (w/v). The required volume varies with the procedure, anatomy, and the patient’s transit time (for SBFT study). At least 500 ml of 40% w/v barium suspension is suggested for SBFT examinations [6].

For double contrast GI studies high density barium (up to 250% w/v) is used in conjunction with air or effervescent gas. High density barium (85% to 100% w/v suspension) has been recommended for double contrast examinations for colon [6].

- *Colonic preparation cleansing regimens*

Commonly used bowel cathartic agents include bisacodyl tablets and magnesium citrate. The use of magnesium citrate is favored in elderly, patients with renal insufficiency or hypertensive patients especially those being treated with angiotensin-converting enzyme inhibitors [6].

b. Water soluble contrast media

The use of iodinated water-soluble CM is recommended in patients with known or suspected bowel perforation. In addition, it may be preferred before endoscopic procedures of the bowel or in patients with

likely small bowel obstruction in whom timely surgery is anticipated or to confirm the position of percutaneous feeding tube [7].

HOCM are contraindicated for oral administration in patients at risk for aspiration as well as in patients with fluid and electrolyte imbalances, particularly pediatrics or elderly patients with dehydration or hypovolemia. Iso- or low-osmolality CM are safer for these patients [8].

Adverse reactions

Allergic-like reactions can occur after absorption of small volume of enteric water-soluble CM. Presence of mucosal inflammation, mucosal infection, or bowel obstruction can increase the absorbed amount by several fold [8].

- *Administration*

Water soluble CM can be administered safely by mouth or per rectum. Furthermore, High or low-osmolality agents can be used in full strength or diluted form within GI tract. There is no advantage of "IV" LOCM over HOCM (e.g. Gastrografin and Gastroview) for GIT use. However, LOCM agents may reduce risk of pneumonitis in aspiration. Furthermore, the taste of LOCM agents may be more palatable [6,9].

References

1. Ott DJ, Gelfand DW. Gastrointestinal contrast agents. Indications, uses, and risks. Jama 1983; 249:2380-2384.
2. Seltzer SE, Jones B, McLaughlin GC. Proper choice of contrast agents in emergency gastrointestinal radiology. CRC Crit Rev Diagn Imaging 1979; 12:79-99.
3. Gelfand DW, Sowers JC, DePonte KA, et al. Anaphylactic and allergic reactions during double-contrast studies: is glucagon or barium suspension the allergen? AJR Am J Roentgenol 1985;144(2):405–406.
4. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.
5. Savry C, Bouche O, Lefrant JY, Saissy G, Allain P. [Barium sulfate poisoning?]. Ann Fr Anesth Reanim 1999; 18:454-457.
6. American College of Radiology, Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
7. Morcos SK. Review article: effects of radiographic contrast media on the lung. Br J Radiol 2003;76(905):290–295.
8. Eisenberg RL, Hedgcock MW, Shanser JD, et al. Iodine absorption from the gastrointestinal tract during hypaque-enema examination. Radiology 1979;133(3 Pt 1):597–599.
9. Miller SH. Anaphylactoid reaction after oral administration of diatrizoate meglumine and diatrizoate sodium solution. AJR Am J Roentgenol 1997;168(4):959–961.

6.2 Pregnancy and Lactation

a. **Pregnancy**

Intravenous ICM does not affect short-term neonatal thyroid stimulating hormone, however, the long-term effects are unknown [1]. Thyroid function should be tested in neonates during the first week after administration of ICM to mothers during pregnancy [2].

When there is a very strong indication for enhanced MR, the smallest possible dose of a macrocyclic GBCA may be given to the pregnant female. Following administration of GBCAs to the mother during pregnancy, no neonatal tests are necessary [3,4].

b. **Lactation**

When ICM or macrocyclic GBCA is given to the mother, breastfeeding can continue normally [2,3,4].

c. **Premedication of pregnant patients**

It is generally safe to use steroids in pregnancy; however, methylprednisolone carries a small risk to the development of a cleft lip in fetus if used before 10 weeks of gestation. It is not recommended to withhold indicated premedication because the patient is pregnant [5,6].

d. **Management of adverse contrast reactions in pregnant patients**

The management of contrast reactions in pregnant patients is generally the same as in non-pregnant adults [2,7], (See chapter 5 on treatment of contrast reactions).

For the treatment of hypotension with an obviously gravid uterus, the patient may be placed in the left lateral decubitus position or supine with a leftward tilt using a wedge [2]. If cardiac compressions are required, these are usually best performed in the supine position; in this situation, manual upward and to the left displacement of the uterus is recommended (if there are enough personnel). These tactics reduce the compression of the inferior vena cava [7].

References:

1. Rajaram S, Exley CE, Fairlie F, Matthews S. Effect of antenatal iodinated contrast agent on neonatal thyroid function. Br J Radiol. 2012; 85(1015): e238-242.
2. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
3. ESUR guidelines on contrast agent. contrast media safety committee of the European Society Of Urogenital Radiology, 2018, version 10.
4. Royal College of Radiologists. Guidance on gadolinium-based agent administration to adult patients, 2019. Available at www.rcr.ac.uk.
5. Gerosa M, Meroni PL, Cimaz R. Safety considerations when prescribing immunosuppression medication to pregnant women. Expert Opin Drug Saf. 2014; 13(12):1591-1599.
6. Wang PI, Chong ST, Kielar AZ, et al. Imaging of pregnant and lactating patients: part 1, evidence-based review and recommendations. AJR Am J Roentgenol. 2012; 198(4):778-784.
7. Sikka A, Bisla JK, Rajan PV, et al. How to manage allergic reactions to contrast agent in pregnant patients. AJR Am J Roentgenol. 2016; 206(2):247-252.

6.3 Pediatric Use of Contrast Media

a. **Iodinated contrast media**

Intravascular ICM utilization and associated adverse events are generally similar in pediatric and adults. A few pediatric-specific issues of contrast agents are discussed below.

- *Contrast media osmolality*

Neonates and small children are susceptible to fluid shifts and have a lower tolerance for intravascular osmotic loads than adults. Intravascular administration of HOCM may result in migration of fluid from extravascular soft tissues into blood vessels which will expand blood volume Cardiac failure and pulmonary edema can result if the fluid shift is large; children with pre-existing cardiac dysfunction may be at particular risk [1,2].

- *Contrast media viscosity*

Viscosity is especially important due to the use of small gauge angiocatheters in pediatric patients. If a rapid injection rate is needed through a small angiocatheter using a high viscosity CM, this can potentially result in the failure of reaching desired injection rate and may cause catheter failure of vessel injury. In addition, as temperature increases, viscosity decreases, and this will allow increase in flow rates at lower pressures; this results in fewer adverse events compared to contrast media injected at room temperature [3,4].

- *Other unique issues*

Using a small gauge angiocatheters, unusual vascular access sites and small volumes of contrast media (1.5–2 mL/kg) will complicate the administration of intravascular contrast media to neonates and children. A 24-gauge angiocatheter in a peripheral location was safely power injected with a maximum pressure of 150 psi and a maximum flow rate of approximately 1.5 mL/sec. Hand injection of contrast medium is recommended to minimize risk of vessel injury and extravasation, when access is thought to be tenuous. Verification in advance that any catheter to be utilized for bolus contrast material instillation can tolerate the anticipated injection is commended. Furthermore, it's recommended to ensure that the pressure does not exceed the catheter's pressure rating [5,6].

Attention should be paid to the injection sites, as such neonates and infants cannot effectively communicate the possibility of an injection site complication. Extravasation rates in children is similar to those of the adult. Most extravasations in pediatric resolve without sequelae [6].

- *Physiologic reactions*

Minor physiologic side effects to intravascular CM administration are often of increased importance in children. For example, local warmth at the injection site and nausea, to contrast medium administration, may cause a child to move or cry which may result in the acquisition of a non-diagnostic imaging study, necessitating repeat imaging and additional exposure to radiation and contrast medium [4,7].

- *Allergic-like reactions*

The incidence of allergic-like reactions in pediatric is lower than that in adults patients [3,7]. Although fatal reactions to CM in pediatric are extremely rare, it requires close observation, as they are unable to

verbalize discomfort or symptoms. Recommendations for treatment of allergic-like reactions are similar to adult patient [4] (See chapter 5 on treatment of CM reactions).

- *Premedication*

A sample of premedication is described in the table 5.

Table 5: Pediatric corticosteroid and antihistamine premedication Regimen [4].

	Dosage	Timing
Prednisone	0.5–0.7 mg/kg PO (up to 50 mg)	13, 7, and 1 hours prior to CM injection
Diphenhydramine	1.25 mg/kg PO (up to 50 mg)	1 hour prior to CM injection
Note: Appropriate IV doses may be substituted for patients who cannot ingest PO medication.		

- *Contrast-associated acute kidney injury*

Risk factors for CA-AKI in pediatrics are thought to be similar to those in adults. Strategies described in adults should be considered when using intravascular ICM in pediatric with renal dysfunction [4] (see chapter 6 on renal adverse reactions).

b. **Gadolinium-based contrast agents**

Guideline for intravascular use of GBCAs in pediatric are generally similar to those in adult populations. A few pediatric-specific issues of contrast agents are discussed below.

- *Osmolality and viscosity*

There is a significant range in osmolality and viscosity of GBCAs [4].

- *Physiologic Reactions:*

Physiologic reactions may occur following GBCA administration, including coldness at the injection site, headache, dizziness and nausea. Extravasation is usually of minimal clinical significance because of the small volumes injected [4].

- *Allergic-like reactions*

Allergic-like reactions in pediatric to intravascular use of GBCAs are rare and treated similarly to those reactions to ICM. Using corticosteroid and antihistamine premedication regimens for the prevention of allergic-like reactions to GBCAs in pediatric, are thought to provide some protective benefit [4].

Nephrogenic systemic fibrosis

Follow the same recommendation for adult patients (see chapter 6 on renal adverse reactions). However, due to immature renal function eGFR values in certain premature infants and neonates may be <30 ml/min/1.73 m^2. In these individuals, group II GBCAs should be used [8,9].

c. **Gastrointestinal (GIT) contrast media**

The most commonly used GIT contrast agents in children are barium-based, it can be administered by mouth, rectum, ostomy, or catheter residing in the GIT. It's contraindicated in patients with suspected or known GIT perforation. ICM are preferred in the setting of suspected perforation [10].

ICM within the GIT may cause fluid shifts specifically for neonates or infants of very low birth weight, older children with cardiac and renal impairment. In such patients, low-osmolality or iso-osmolality contrast agents should be considered for upper GIT imaging. Regarding rectal use, higher osmolality contrast agents can usually be diluted. In pediatric who are at risk for aspiration, high-osmolality ICM should be avoided. Aspirated hyperosmolality contrast medium may cause chemical pneumonitis with resultant pulmonary edema [4].

References

1. Standen JR, Nogrady MB, Dunbar JS, Goldbloom RB. The Osmotic Effects of Methylglucamine Diatrizoate (Renografin 60) in Intravenous Urography in Infants. Am J Roentgenol Radium Ther Nucl Med. 1965; 93:473-479.
2. Morris TW HP, Reece K, Katzberg RW. Tissue fluid shifts during renal arteriography with conventional and low osmolality agents. Invest Radiol. 1983; 18:335-340.
3. Vergara M, Seguel S. Adverse reactions to contrast media in CT: effects of temperature and ionic property. Radiology. 1996; 199(8668779):363-366.
4. ACR Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
5. Trout AT, Dillman JR, Ellis JH, et al. Patterns of intravenous contrast material use and corticosteroid premedication in children--a survey of Society of Chairs of Radiology in Children's Hospitals (SCORCH) member institutions. Pediatr Radiol. 2011; 41(21594547):1272-1283.
6. Amaral JG, Traubici J, BenDavid G, et al. Safety of power injector use in children as measured by incidence of extravasation. AJR Am J Roentgenol. 2006; 187(16861567):580-583.
7. Cohen MD, Herman E, Herron D, et al. Comparison of intravenous contrast agents for CT studies in children. Acta Radiol. 1992; 33(1449887):592-595.
8. Thomsen HS. How to avoid nephrogenic systemic fibrosis: current guideline in Europe and the United States. Radiologic clinics of North America. 2009; 47(5):871-875, vii.
9. Weller A, Barber JL, Olsen OE. Gadolinium and nephrogenic systemic fibrosis: an update. Pediatr Nephrol. 2014; 29(24146299):1927-1937.
10. Frech RS, Davie JM, Adatepe M, et al. Comparison of barium sulfate and oral 40 per cent diatrizoate injected into the trachea of dogs. Radiology. 1970; 95(5439432):299-303.

6.4 Ultrasound Contrast Media

Ultrasound contrast agents consisting of microspheres or microbubbles, allow for transient improvement in contrast resolution, increased conspicuity of vascularity, and detection of blood flow. It can be safely injected intravenously or instilled into hollow structures (e.g. urinary bladder) [1].

- *Approved Agents and Uses*

1. Definity® (perflutren lipid microspheres).
2. Lumason® (sulfur hexafluoride lipid-type microspheres; also known as SonoVue®).
3. Optison® (perflutren protein-type A).

Ultrasound contrast agents are approved for echocardiography and liver imaging [1]. These agents also have been used to assess vesicoureteral reflux (voiding ultrasonography), to assess the dynamics of blood flow in tumors, to differentiate between benign cysts from solid masses in the kidney, to detect solid organ injury in trauma patients, to detect and characterize post repair endo-leaks in patients with abdominal aortic aneurysm, to detect bowel wall inflammation in Crohn's disease patients, to discriminate phlegmon from abscess, and to monitor and guide interventions and ablative therapies [1-5].

- *Administration*

Ultrasound contrast agents are approved for IV slow infusion and/or bolus injection. They are typically hand injected using a moderate- or large- bore peripheral IV catheter followed by a saline flush. The maximum volume differs by contrast agent. By avoiding small I.V catheters and using a low mechanical index during imaging the likelihood of bubble rupture can be minimized. No adequate studies regarding the safety of high mechanical index imaging (>0.8), and can cause rupture or microbubble cavitation [1].

- *Pharmacodynamics and Pharmacokinetics*

Intravascularly administered agents generally remain in the blood pool and real-time assessment can be obtained over an approximately 10-minute period. After that, the microbubbles spontaneously rupture and dissolve, and mostly eliminated through the lungs [1].

- *Safety Profile*

In general, ultrasound contrast agents are safe. Clinical evidence of ultrasound contrast agent related events in critically ill patients and patients with acute coronary disease is limited. Most of the adverse reactions are mild and self-resolving (e.g., altered taste, headache, nausea). Severe acute reactions are uncommon and are similar to those after ICM and GCBA [6].

Ultrasound contrast agents have no known renal toxicity in approved doses. These agents are contraindicated for intra-arterial injection and in patients with previous hypersensitivity reaction to microspheres. In patients who have an unstable cardiopulmonary condition, the risk for a serious cardiopulmonary reaction may be increased [1].

Ultrasound contrast agents are not properly examined in pregnant women. While there are no known risks to the fetus, using ultrasound agents should be justified. As the effects of these contrast agents on human breast milk is currently unknown, temporary (~24 hours) pumping and discarding of milk may be considered [1].

References

1. American College of Radiology, Manual on Contrast Media. ACR Committee on Drugs and Contrast Media, 2020.
2. Fernandez-Ibieta M, Parrondo-Muinos C, et al. Voiding urosonography with second-generation contrast as a main tool for examining the upper and lower urinary tract in children. Pilot Study. Actas Urol Esp. 2016;40(3):183-189.
3. Durkin N, Deganello A, Sellars ME, et al. Post-traumatic liver and splenic pseudoaneurysms in children: Diagnosis, management, and follow-up screening using contrast enhanced ultrasound (CEUS). J Pediatr Surg. 2016;51(2):289-292.
4. Miele V, Piccolo CL, Galluzzo M, et al. Contrast-enhanced ultrasound (CEUS) in blunt abdominal trauma. Br J Radiol. 2016;89(1061):20150823.
5. Meloni MF, Smolock A, Cantisani V, et al. Contrast enhanced ultrasound in the evaluation and percutaneous treatment of hepatic and renal tumors. Eur J Radiol. 2015;84(9):1666-1674.
6. ESUR Guidelines on Contrast Agents. ESUR Contrast Media Safety Committee, 2018, version 10.

7. APPENDIX

Appendix A

Classification of acute adverse reactions to ICM and GBCM.

Mild
Symptoms and signs are self-limited without any proof of progress. Mild reactions include:

Allergic-like	Physiologic
Limited urticaria/pruritis	Limited nausea/vomiting limited
Cutaneous Edema	Transient flushing/warmth/chills
Limited itchy/scratchy throat	Headache/dizziness/anxiety/altered taste
Nasal congestion	Mild hypertension
Sneezing/conjunctivitis/rhinorrhea	Vasovagal reaction that resolves spontaneously

Moderate
Symptoms and signs are more obvious and treatment is usually required. Some of these reactions have the potential to become severe if not treated. Moderate reactions include:

Allergic-like	Physiologic
Diffuse urticaria/pruritis	Protracted nausea/vomiting
Diffuse erythema, stable vital signs	Hypertensive urgency
Facial edema without dyspnea	Isolated chest pain
Throat tightness or hoarseness without dyspnea	Vasovagal reaction that requires and is responsive to treatment
	Wheezing / bronchospasm, mild or no hypoxia

Severe*
Symptoms and signs are often life-threatening and, if not properly treated, can result in permanent morbidity or death. Severe reactions include:

Allergic-like	Physiologic
Diffuse edema, or facial edema with dyspnea	Vasovagal reaction resistant to treatment
Diffuse erythema with hypotension	Arrhythmia
Laryngeal edema with stridor and/or hypoxia	Convulsions, seizures
Wheezing/bronchospasm, significant hypoxia	Hypertensive emergency
	Anaphylactic shock (hypotension + tachycardia)

* Severe allergic-like or physiological reactions may cause cardiopulmonary arrest. If the etiology of cardiopulmonary arrest is unknown, allergic-like reactions might be considered the cause.
Pulmonary edema, a rare severe reaction that can occur in patients with either tenuous cardiac reserve or in patients with normal cardiac function, and it may be triggered by allergic or physiological reactions. If the etiology of pulmonary edema in patients with normal cardiac function is unknown, allergic-like reactions might be considered the cause.

Appendix B

Checklist on Compliance with Contrast Media (CM) Protocols

Hospital name: ……	**Date:** ……/……/……

Code	Protocol Item		Description	Compliance	
				Yes	No
1	Safe prescription	1-1.	There is a protocol to ensure a clear and accurate CM prescription.		
		1-2.	The radiologist is responsible for writing the prescription.		
		1-3.	The prescription includes patient information (ID, name, gender, age, diagnosis or indication, current medications, comorbidities, relevant laboratory values).		
		1-4.	The prescription includes CM information (name, dose, frequency, route, exact strength, or concentration, quantity or duration and specific instructions for use).		
		1-5.	The prescription includes name of prescriber.		
		1-6.	The prescription includes date and time.		
		1-7.	CM prescription is kept in the medical record.		
		1-8.	The protocol for safe prescription is implemented.		
2	Screening for risk factors.	2-1.	There is a protocol to identify patients at high risk of adverse reactions.		
		2-2.	This protocol includes history of allergies (same class of CM, other allergies),		
		2-3.	This protocol includes history of asthma		
		2-4.	This protocol includes history of kidney disease (chronic kidney disease, remote of acute kidney injury, kidney surgery, kidney ablation, albuminuria),		
		2-5.	This protocol includes history of diabetes Mellitus & metformin.		
		2-6.	This protocol includes history of nephrotoxic medications.		
		2-7.	The protocol of screening for risk factors is implemented.		
3	Signed informed consent.	3-1.	There is a protocol to ensure patients sharing in making decisions that affect their health and also protect radiologists from the complexity associated with medico-		

			legal issues.		
		3-2.	This protocol includes all intravenous contrast examinations.		
		3-3.	This protocol includes adults and pediatrics patients		
		3-4.	This protocol includes emergency examinations.		
		3-5.	The protocol of signed informed consent is implemented.		
4	Premedication.	4-1.	There is a protocol to reduce the incidence of reoccurrence of adverse reactions to the same class of CM.		
		4-2.	This protocol specifies elective and accelerated premedication regimens.		
		4-3.	This protocol specifies medications in each regimen (medication names, dose, route, and timing).		
		4-4.	The protocol of premedication is implemented.		
5	Safe administration	5-1.	There is a protocol to reduce errors associated with CM administration.		
		5-2.	This protocol defines employees who have the responsibility to administer CM.		
		5-3.	This protocol defines precautions before CM administration (e.g., readiness of the emergency cart, and verification of the expired date).		
		5-4.	This protocol includes adherence to the classic five rights (right patient, right drug, right time,right dose, and right route of administration).		
		5-5.	This protocol includes monitoring the patient's perception of reactions during CM administration.		
		5-6.	The protocol for safe administration is implemented.		
6	Documentation of administration.	6-1.	There is a protocol to promote patient safety and quality of care.		
		6-2.	This protocol specifies data and information to be documented		
		6-3.	The documented data and information include the route, access site, administration devices used, and rate of administration.		
		6-4.	The documented data and information include extravasation events and their treatment (if any).		
		6-5.	The protocol for documentation of administration is implemented.		

7	Reporting of adverse reactions (if any).	7-1.	There is a protocol to ensure providing information that is necessary to mitigate the adverse reactions and prevent them from recurring.		
		7-2.	This protocol specifies types of adverse reactions to be reported.		
		7-3.	This protocol specifies method of reporting.		
		7-4.	The protocol for reporting of adverse reaction is implemented		
8	Treatment of adverse reaction (if any).	8-1.	There is a protocol to ensure timely and effective treatments to CM reactions.		
		8-2.	This protocol defines training required for radiology staff to rapidly identify, evaluate, diagnose and treat adverse CM reactions.		
		8-3.	This protocol defines emergency medications needed to treat contrast adverse reactions.		
		8-4.	This protocol defines required emergency equipment.		
		8-5.	The protocol of treatment of adverse reaction is implemented.		

Appendix C

Treatment of acute adverse reactions to contrast media in pediatrics

Hives (Urticarial)

	Treatment	Dosing
General comment: Observe until hives are resolving. Further observation may be necessary if treatment is administered.		
Mild (scattered and/ or transient)	No treatment often needed; however, if symptomatic, can consider	
	Diphenhydramine *	1 mg/ kg (max = 50mg) PO, IM, or IV: administer IV dose slowly over 1-2 min
Moderate (More numerous/ bothersome)	Monitor vitals	
	Preserve IV access	
Consider	Diphenhydramine *	1 mg/ kg (max = 50mg) PO, IM, or IV: administer IV dose slowly over 1-2 min
Severe (widespread and / or progressive)	Monitor vitals	
	Preserve IV access	
Consider	Diphenhydramine *	1 mg/ kg (max = 50mg) PO, IM, or IV: administer IV dose slowly over 1-2 min

*Note: All forms can cause drowsiness; IV/IM form may cause or worsen hypotension.

Note: it can be difficult to dose medications accurately in neonates and infant also, with respect to IM delivery of epinephrine, Epipen Jr® Package insert does not provide dosing recommendations for children <15kg.

Diffuse Erythema

	Treatment	Dosing
All forms	preserve IV access	
	Monitor vitals	
	O_2 by mask	6-10 L / min
Normotensive	No other treatment usually needed	
Hypotensive	IV fluids: 0.9 % normal saline	10-20 mL/ Kg;
	Or	Maximum of 500- 1.1000 Ml
	Lactated Ringer's	
if profound or unresponsive to fluids	Epinephrine (IV)*	iv 0.1 mL/ kg of 1:10.000 dilution (0.01 mg/ kg); administer slowly into a running iv infusion of fluids; can

alone can also consider		repeat every 5-15 min, as needed; maximum single dose: 1.0 mL (0.1 mg); can repeat up to 1 mg total dose
	or (if no Iv) access available)	
	Epinephrine (IM) *	1M 0.01 mL/ Kg of 1:1.000 dilution (0.01 mg/ kg); max 0.30 mL (0.30mg); can repeat every 5-15 minutes up to 1 mL(1mg) total
	or	
		Epinephrine auto-injector (1:1,000 dilution equivalent) If < 30 kg, pediatric epinephrine auto- injector 0.15 mL equivalent (0.15 mg); If ≥ 30 kg, adult epinephrine auto- injector 0.30 mL (0.30 mg)
	Consider calling emergency response team	

Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administration Also, with respect to IM delivery of epinephrine,. Note: it can be difficult to dose medications accurately in neonates and infants.

Bronchospasm

	Treatment	Dosing
All forms	preserve IV access	
	Monitor vitals	
	O_2 by mask	6-10 L / min
Mild	Beta agonist inhaler	2 puffs (90 mcg/ puff) for a total of 180 mcg: can repeat up to 3 times
	Depending on the completeness of the response, consider calling the emergency response team.	
Moderate	Consider adding epinephrine (IM) *	IM 0.01 mL/ kg of 1:1.000 dilution (0.01 mg/ kg); max 0.30 mL (0.30 mg); can repeat every 5-15 minutes up to 1 mL (1mg) total.
	or	
		Epinephrine auto – injector (1:1.000 dilution equivalent) if < 30kg, pediatric epinephrine auto – injector (Epipen Jr® or equivalent) 0.15 mL equivalent (0.15mg); if ≥ 30 kg, adult epinephrine auto – injector (Epipen Jr® or equivalent) 0.30 mL (0.30 mg)
	or	

	Epinephrine (IV)*	IV 0.1 ML/ kg of 1:10.000 dilution (0.01 mg/ kg); administer slowly into a running IV infusion of fluids; can repeat every 5-15 min, as needed; maximum single dose: 1.0 mL (0.1 mg); can repeat up to 1 mg total dose.
	Depending on the completeness of the response, consider calling the emergency response team.	
Severe	Epinephrine (IV)*	IV 0.1 ML/ kg of 1:10.000 dilution (0.01 mg/ kg); administer slowly into a running IV infusion of fluids; can repeat every 5-15 min, as needed; maximum single dose: 1.0 mL (0.1 mg); can repeat up to 1 mg total dose.
	or	
	Epinephrine (IM)*	IM 0.01 mL / Kg of 1:1.000 dilution (0.01 mg /kg); max 0.30 mL (0.30 mg); can repeat every 5-15 minutes up to 1 mL (1mg) total
	or	
		Epinephrine auto – injector (1:1,000 dilution equivalent) if < 30 kg pediatric epinephrine auto – injector 0.15 mL equivalent (0.15mg); if ≥ 30 kg, adulr epinephrine auto – injector 0.30 mL (0.30mg)
	AND Beta agonist inhaler (May work)	2 puffs (90 mcg/ puff) for a total of 180 mcg; can repeat up to 3 times
	Call emergency response team	

*Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administration, also, with respect to IM delivery of epinephrine,

Note: it can be difficult to dose medications accurately in neonates and infants.

Laryngeal Edema

	Treatment	Dosing
All forms	preserve IV access	
	Monitor vitals	
	O_2 by mask	6-10 L / min
Epinephrine (IV)*		Iv 0.1mL/kg of 1:10,000 dilution (0.01 mg/ kg); administer slowly into a running IV infusion of fluids; can repeat every 5-15 min, as needed;

		maximum single dose: 1.0 ml (0.1mg; can repeat up to 1mg total dose
	Or	
Epinephrine (IM)*		IM 0.01 mL / kg of 1:10,000 dilution (0.01 mg/ kg); max 0.30 mL (0.30mg); can repeat every 5-15 minutes up to 1mL (1mg) total
	Or	
		Epinephrine auto – injector (1:1,000 dilution equivalent) If < 30 kg, pediatric epinephrine auto – injector 0.15 mL equivalent (0.15 mg); If ≥ 30kg, adult epinephrine auto – injector 0.30 mL (0.30 mg)
Call emergency response team		

*Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administration, Also, with respect to IM delivery of epinephrine,

Note: It can be difficult to dose medications accurately in neonates and infants.

Hypotension (minimum normal blood pressure varies for children of different ages)		
	Treatment	**Dosing**
All forms	Preserve IV access	
	Monitor vitals	
	O2 by mask	6–10 L / min
	Elevate legs at least 60 degrees	
	Consider IV fluids: 0.9% normal saline	10–20 mL/kg;
	Or	Maximum of 500–1,000 mL
	Lactated Ringer's	
Hypotension with bradycardia (min normal pulse varies for children of different ages) (Vasovagal reaction)		
If mild	No other treatment usually necessary	

If the patient remains symptomatic, despite the above treatments,	Add IV Atropine	IV 0.2 mL / kg of 0.1 mg / mL solution (0.02 mg / kg); Minimum single dose = 0.1 mg Maximum single dose = 0.6 – 1.0 mg Maximum total dose = 1 mg for infants and children 2 mg for adolescents administer into a running IV infusion of fluids
Hypotension with tachycardia (max normal pulse varies for children of different ages) (Vasovagal reaction)		
If severe (hypotension persists)	Epinephrine (IV)*	IV 0.1 mL / kg of 1:10,000 dilution (0.01 mg / kg); administer slowly into a running IV infusion of fluids; can repeat every 5 – 15 min, as needed; maximum single dose: 1.0 mL (0.1 mg); can repeat up to 1 mg total dose
	or	
	Epinephrine (IM)*	IM 0.01 mg / kg of 1:1,000 dilution (0.01 mL / kg); max 0.30 mL (0.30 mg); can repeat every 5 – 15 minutes up to 1 mL (1 mg) total
	or	
		Epinephrine auto-injector (1:1,000 dilution equivalent) If < 30 kg, pediatric epinephrine auto- injector 0.15 mL equivalent (0.15 mg); If ≥ 30 kg, adult epinephrine auto- injector 0.30 mL (0.30 mg)
	Call emergency response team	

*Note: In hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administration. Also, with respect to IM delivery of epinephrine,

	Treatment	Dosing
	Activate emergency response team	
	Start CPR	

	Get defibrillator or automated electronic defibrillator (AED); apply as soon as available; shock as indicated	
	Epinephrine (between 2 min cycles)	0.1 mL/ kg of 1:10,000 dilution (0.01 mg / kg); administer quickly with flush or IV fluids; max dose of 10 mL (1 mg)
Note: Please also see the booklets for BLS and ACLS.		

Note: It can be difficult to dose medications accurately in neonates and infants.

Unresponsive and Pulseless

Pulmonary Edema

	Treatment	Dosing
	Preserve IV access	
	Monitor vitals	
	O2 by mask	6–10 L / min
	Elevate head of bed	
	Furosemide (IV)	IV 0.5–1.0 mg/kg; over 2 min; maximum = 40
	Call emergency response team	

Seizures/Convulsions

	Treatment	Dosing
	Observe and protect patient	
	Turn patient on side to avoid aspiration	
	Suction air way, as needed	
	Preserve IV access	
	Monitor vitals	
	O2 by mask	6–10 L / min
If unremitting	Call emergency response team	

Hypoglycemia

	Treatment	Dosing
All forms	Preserve IV access	
	O2 by mask	6–10 L min
If patient is able to swallow safely Observe		
	Administer oral glucose	2 sugar packets or 15 g of glucose tablet or gel or ½ cup (4 oz) of fruit juice
If patient is unable to swallow safely		
And IV access is available	Dextrose 50% (IV)	IV D25 2 mL/ kg; IV injection over 2 min
And IV access is not available	Glucagon (IM/SQ)	IM/SQ 0.5 mg if < 20 kg
		IM/SQ 1.0 mg if > 20 kg

Anxiety (Panic Attack)

	Treatment	Dosing
	Diagnosis of exclusion	
	Assess patient for developing signs and symptoms that might indicate another type of reaction.	
	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	If no identifiable manifestations and normal oxygenation, consider this diagnosis	
	Reassure patient	

Reaction Rebound Prevention

	Treatment	Dosing
	Hydrocortisone (IV)	IV 5 mg / kg; administer over 1-2 min; maximum: 200 mg.
	Or	
	Methylprednisolone (IV)	IV 1 mg /kg; administer over 1–2 min; maximum: 40 mg
Note: While IV corticosteroids can prevent a short-term recurrence of an allergic reaction, they are not useful in the immediate treatment of any reaction. However, these should be addressed for patients with severe allergic-like symptoms prior to transport to the Emergency Department.		

Appendix D

Treatment of acute adverse reactions to contrast in adults

Hives (Urticaria)

	Treatment	Dosing
Mild (scattered and/or transient)	No treatment often needed; however, if symptomatic, can consider:	
	Diphenhydramine *	25–50 mg PO
Moderate (more numerous/bothersome)	Monitor vitals	
	Preserve IV access	
	Consider diphenhydramine *	25–50 mg PO
	Or	
	Consider diphenhydramine*	25–50 mg IM or IV dose slowly over 1–2 min)
Severe (widespread and/or progressive)	Monitor vitals	
	Preserve IV access	
Consider	Diphenhydramine *	25–50 mg IM or IV (administer IV dose slowly
* Note: all forms can cause drowsiness; IM/IV form may cause or worsen hypotension· Note: second generation antihistamines cause less drowsiness.		

Diffuse Erythema

	Treatment	Dosing
All forms	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6-10 L/min
Normotensive	No other treatment usually needed	
	Treatment	**Dosing**
Hypotensive	IV fluids 0.9% normal saline	1,000 mL rapidly
	or	
	Lactated Ringer's	1,000 mL rapidly
If profound or unresponsive to fluids alone can also consider	Epinephrine (IV)*	IV 1 mL of 1:10,000 dilution (0.1 mg); administer slowly into a running IV infusion of fluids; can repeat every few minutes as needed up to 10 mL (1 mg) total
	or (if no IV access available)	
	Epinephrine (IM)*	IM 0.3 mL of 1:1,000 dilution (0.3 mg); can repeat every 5-15 minutes up to 1 mL (1 mg) total
	or	
		Epinephrine auto-injector

		(EpiPen® or equivalent) (0.3 mL of 1:1,000 dilution, fixed[0.3mg]); can repeat every 5-15 minutes up to three times
	Consider calling emergency response team	
* Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administered drug.		

Bronchospasm

	Treatment	Dosing
All forms	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6–10 L / min
Mild	Beta agonist inhaler (Albuterol®)	2 puffs (90 mcg/puff) for a total of 180 mcg; can repeat up to 3 times
	Consider sending patients to the emergency department or calling the response team depending on the completeness of the beta agonist inhaler response.	
Moderate	Beta agonist inhaler (Albuterol®)	2 puffs (90 mcg/puff) for a total of 180 mcg; can repeat up to 3 times
	Consider adding epinephrine (IM)*	IM 0.3 mL of 1:1,000 dilution (0.3 mg); canrepeat every 5-15 minutes up to 1 mL (1 mg) total
	or	
		Epinephrine auto-injector (EpiPen® or equivalent) (0.3 mL of 1:1,000 dilution, fixed [0.3mg]); can repeat every 5-15 minutes up to three times
	or	

	Epinephrine (IV)*	IV 1 mL of 1:10,000 dilution (0.1 mg); administer slowly into a running IV infusion of fluids or use saline flush; can repeat every few minutes as needed up to 10 mL (1 mg) total
	Depending on the completeness of the response, consider calling the emergency response team.	
Severe	Epinephrine (IV)*	IV 1 mL of 1:10,000 dilution (0.1 mg); administer slowly into a running IV infusion of fluids or slow IV push followed by a slow saline flush; can repeat every few minutes as needed up to 10 mL (1 mg) total
	or	
	Epinephrine (IM)*	IM 0.3 mL of 1:1,000 dilution (0.3 mg); can repeat every 5-15 minutes up to 1 mL (1 mg) total
	or	
		Epinephrine auto-injector (EpiPen® or equivalent) (0.3 mL of 1:1,000 dilution, Fixed [0.3mg]); can repeat every 5-15 minutes up to three times
	AND Beta agonist inhaler (Albuterol®) (may work	2 puffs (90 mcg/puff) for a total of 180 mcg; can repeat up to 3 times
	Call emergency response team	
* Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administered drug.		

Laryngeal Edema

	Treatment	Dosing
All forms	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6–10 L / min
	Epinephrine (IV)*	IV 1 mL of 1:10,000 dilution (0.1 mg); administer slowly into a running IV infusion of fluids or use saline flush; can repeat every few minutes as needed up to 10 mL (1 mg) total
	or	
	Epinephrine (IM)*	IM 0.3 mL of 1:1,000 dilution (0.3 mg); can repeat every 5-15 minutes up to 1 mL (1 mg) total
	or	
		Epinephrine auto-injector or (equivalent) (0.3 mL of 1:1,000 dilution, fixed [0.3mg]); can repeat every 5-15 minutes up to three times
	Consider calling an emergency team depending on the severity of the reaction and the completeness of the response.	
* Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administered drug.		

Hypotension (systolic blood pressure< 90 mm Hg)

	Treatment	Dosing
All forms	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6-10 L/min
	Elevate leg at least 60 degrees	
	IV fluids: 0.9% normal saline	1,000 mL rapidity
	or	
	Lactated Ringer's	1,000 mL rapidity
Hypotension with bradycardia (pulse < 60 bpm) (Vasovagal reaction)		
If mild	No other treatment usually necessary	
If patient remains symptomatic despite above treatments	Add IV Atropine	0.6 – 1.0 mg; administer into a running IV infusion of fluids; can repeat up to 3 mg total

	Consider calling the emergency response team	
Hypotension with tachycardia (pulse > 100 bpm) (Anaphylactoid reaction)		
If hypotension persists	Epinephrine (IV)*	IV 1 mL of 1:10,000 dilution (0.1 mg); administer slowly into a running IV infusion of fluids; can repeat every few minutes as needed up to 10 mL (1 mg) total
Or		
	Epinephrine (IM)*	IM 0.3 mL of 1:1,000 dilution (0.3 mg); can repeat every 5-15 minutes up to 1 mL (1 mg) total
		or
		Epinephrine auto-injector (EpiPen® or equivalent) (0.3 mL of 1:1,000 dilution, fixed[0.3mg]); can repeat every 5-15 minutes up to three times
	Consider calling emergency team depending on the severity of the reaction and the completeness of the response	
* Note: in hypotensive patients, the preferred route of epinephrine delivery is IV, as the extremities may not be perfused sufficiently to allow for adequate absorption of IM administered drug.		

Hypertensive Crisis (diastolic BP> 120mmHg; systolic BP> 200mm Hg; symptoms of endorgan compromise)

	Treatment	Dosing
All forms	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6-10 L/min
	Labetalol (IV)	20 mg IV; administer slowly, over 2 min; can double the dose every 10 min (e.g., 40 mg 10 min later, then 80 mg 10 min after that)
	and	
	Furosemide (IV)	20–40 mg IV; administer slowly over 2 min
	Call emergency response team	

Pulmonary Edema

	Treatment	Dosing
	Preserve IV access	
	Monitor vitals	
	O2 by mask	6–10 L / min
	Pulse oximeter	
	Elevate head of bed, if possible	
	Furosemide	20–40 mg IV; administer slowly over 2 min
	Call emergency response team	

Seizures/Convulsions

	Treatment	Dosing
	Observe and protect the patient	
	Turn patient on side to avoid aspiration	
	Suction airway, as needed	
	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	O2 by mask	6–10 L / min
If unremitting	Call emergency response team	
	Lorazepam (IV)	IV 2–4 mg IV; administer slowly, to maximum dose of 4 mg

Hypoglycemia

	Treatment	Dosing
	Preserve IV access	
	O2 by mask	6–10 L / min
If patient is able to swallow safely	Oral glucose	Two sugar packets or 15 g of glucose tablet/gel or ½ cup (4 oz) of fruit juice
If the patient does not swallow safely and IV access is available,	Dextrose 50% (IV)	D50W 1 ampule (25 grams) IV administer over 2 min
	D5W or D5NS (IV) as adjunct therapy	Administer at a rate of 100 mL/hour
When there is no IV access available,	Glucagon (IM)	IM 1 mg

Anxiety (Panic Attack)

	Treatment	Dosing
	Diagnosis of exclusion	
	Assess patient for developing signs and symptoms that might indicate another type of reaction	
	Preserve IV access	
	Monitor vitals	
	Pulse oximeter	
	If no identifiable manifestations and normal oxygenation, consider this diagnosis	
	Reassure patient	

Reaction Rebound Prevention

	Treatment	Dosing
	Hydrocortisone (IV)	IV 5 mg / kg; administer over 1-2 min
	Or	
	Methylprednisolone (IV)	IV 1 mg / kg; administer over 1-2 min
Note: While IV corticosteroids can prevent a short-term recurrence of an allergic reaction, they are not useful in the immediate treatment of any reaction. However, these should be addressed for patients with severe allergic-like symptoms prior to transport to the Emergency Department.		