
Preface

This manual is dedicated to all residents past and present who have donated their time and effort to the advancement of radiology trainee interests. The manual represents the work of many individuals who have contributed their expertise and resources toward producing a product that will hopefully be of great use to all radiology residents, fellows, and young radiologists. This work has gone through many revisions since the idea was originally conceived and will continue to reflect changing conditions and practices in the years to follow.

Residents and fellows are in a unique position given the fact that they are, by definition, trainees. The individuals contributing to the advancement of resident issues are not paid for their efforts nor do they receive many academic accolades for their time spent on resident interests. The

importance of their efforts is, however, paramount in the overall scheme of organized medicine and radiology. To these residents I say congratulations and thank you for a job well done.

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The use of contrast material is vital to the practice of radiology. A radiologist is expected to learn to use contrast material in a safe and effective manner. Contrast material is used to enhance the conspicuity of lesions various organs, tissues, and potential spaces. Special formulations and volumes of contrast are administered in various ways, depending on the clinical situations, as is outlined below. The radiologist must select

the appropriate type, concentration, volume, and mode of delivery of contrast for each clinical setting. Certain types of contrast carry increased risk for patients, in certain clinical settings. The radiologist must weigh the risks and benefits of contrast administration and choose appropriately. Guidelines for various situations are outlined in the following sections.

1 GI FLUOROSCOPIC CONTRAST

There are two major techniques of fluoroscopic bowel opacification: single-contrast and double-contrast. In single-contrast studies, dilute contrast is used to distend the lumen. Lesions are then seen as profile abnormalities, or as filling defects with compression. The fluoroscope is set to a higher kilovoltage (110–120 kVp) than is used in double-contrast studies. In the latter, the mucosa is coated with thick barium contrast, and the lumen is distended with air. Lesions are coated, and good distention is vital. The fluoroscope is set to a relatively lower kilovoltage (90–100 kVp).

There are two major types of fluoroscopic bowel contrast: *barium suspensions* and water-soluble, iodine-containing *contrast preparations*. Barium preparations can be used with both single- and double-contrast techniques. Water-soluble contrast is used only with the single-contrast technique. If there is a risk of aspiration, barium is preferred, as water-soluble contrast is hyperosmolar and may cause alveolar edema. Alternatively, a low-osmolar nonionic water-soluble agent (such as Optiray 160[®] or Omnipaque 180[®]) could be considered if a risk of aspiration exists. If there is a risk of bowel perforation, water-soluble contrast is preferred, as barium extravasation is irritating and produces foreign body granulomata and subsequent adhesions.

Adult Esophagram/Upper GI

Thick Barium (i.e., EZ Barium)

The patient can only drink thick barium by cup, not through a straw. Thick barium is good for upright, double-contrast esophagus, stomach, and duodenal views.

Thin Barium (i.e., Barospense Barium)

The patient can drink through a straw. It is good for prone right anterior oblique drinking esophagus images. It does not coat the esophagus as well as thick barium but has a faster small bowel transit time. Thin barium is useful for evaluation of the small bowel. For evaluation of the small bowel only, the radiologist may skip thick barium and go straight to thin to speed the transit of contrast through the small bowel. Owing to suboptimal coating with the thin barium, the stomach is less well assessed.

Nonsterile Hypaque Iodinated Contrast

A water-soluble contrast material that comes in a *nonsterile* powdered formulation. It is usually mixed with tap water at 20% for fluoroscopy, or 2% for CT and is adequate for single-contrast evaluation of the stomach, duodenum, or colon. This contrast is suboptimal for examination of the small bowel because the contrast is hyperosmolar, draws fluid into the bowel, and dilutes the column of contrast, making it difficult to see. It is often requested by surgeons to evaluate possible small bowel obstruction, as barium may get impacted and desiccated proximal to an obstruction and may spill into the peritoneum if surgery is necessary. As the contrast passes through the small bowel, however, the hyperosmolarity draws fluid into the bowel lumen, diluting the contrast material. This can make evaluation

of distal small bowel obstructions extremely difficult, if not impossible.

GastroView Iodinated Contrast

A water-soluble contrast material that comes in *sterile*, premixed bottles and is similar to 20% Hypaque.

Esophotrust Barium or EZ Paste Barium

Thick barium paste is used to evaluate the esophagus. Similar products are available from different manufacturers. One can mix this with applesauce or put it on graham crackers.

Nonionic Iodinated Contrast (i.e., Omnipaque)

This is a sterile, nonionic iodinated contrast. It is useful for initial swallows in a patient with a high likelihood of aspiration. If aspirated, it is slightly less damaging to lung tissue. A significant disadvantage is that it has a very bitter taste, and it may be necessary to instill this contrast through a tube placed in the esophagus.

Pediatric Upper GI

EZ Paque Barium or Nonsterile Nonionic Iodinated Contrast (25–30%) if barium is contraindicated.

Be careful with Gastroview in children. It is hyperosmolar and may lower intravascular volume by drawing fluid into bowel.

Enteroclysis

i.e., Entero H Barium

Micropulverized barium preparation, which coats well. It is washed through the small bowel with large volumes of methylcellulose or water.

Double-Contrast Barium Enema

Polybar Barium

Very thick barium preparation with good coating. However, slower moving column of contrast.

AC[®] Barium

Thinner barium preparation with poorer coating, but faster moving column.

Example

An example of a recipe for double-contrast barium enema is 50:50 Polybar/AC. If the patient is less mobile, the radiologist may want to go to 100% AC, to improve the barium flow.

Single-Contrast Barium Enema

Examples of recipes:

1 large can Hypaque[®], mixed to 1200 mL, with water, *or* 4 bottles GastroView, mixed to 1200 mL with water.

Start with 1200 mL and make more if needed, for large-volume colons.

Rectum and Pelvic Floor Examination

EZ Paste Barium

Colostomy Study

100% AC Barium; give glucagon if appropriate.

2 BILIARY CONTRAST

I.e., Sterile Hypaque Iodine (Ionic) Contrast

This comes in *sterile*, premixed bottles at 60% and is useful for opacification of the biliary tree, sinus tracts, and gastros-

tomy tubes, during fluoroscopy. This contrast will be rapidly absorbed from most tissues, including the peritoneum and connective tissues, should it end up there.

3 BLADDER CONTRAST

I.e., Cysto-Conray[®]

This comes in sterile, 500-mL (adult) and 250-mL (pediatric) single-use bottles and is useful for cystograms and vesicoureterograms (VCUGs).

4 INTRAVENOUS CONTRAST

Similar intravascular contrast agents are used for angiography, CT, and intravenous pyelography (IVP). All contain iodine, as the primary element for attenuating the x-ray beam. The older, less expensive contrast agents have iodine-containing molecules that are ionic. Most newer agents are nonionic. Use of nonionic agents is associated with fewer serious contrast reactions and fewer subjective complaints from patients about the injection. The newest agents, in addition to being nonionic, are also iso-osmolar to plasma. These seem to be the safest, best tolerated agents. Various formulations contain different concentrations of iodine. The radiologist can calculate the iodine content of different volumes of various agents. The radiologist should obtain consent from all patients before administration of contrast. When getting consent, one approach is to communicate to patients that “the administration of contrast is a safe and routine procedure. The benefits of using contrast, in general, clearly outweigh the risk. However, there is a small risk (1 in 50,000–100,000) of a life-threatening reaction.

A second important decision to consider is the volume of contrast to use. For older patients, smaller patients, and patients with renal disease, less contrast should be used. Under most nonemergent situations, there is a limit to the amount of contrast used. For CT and IVP, this is generally a single dose per day. For angiography, administration of more contrast is acceptable.

A third important decision to make is the contrast flow rate. This may depend on the size of the needle, the size and strength of the vein that has been accessed, and the desired bolus rate. Higher flow rates are generally better, especially for CT, but be careful not to rupture veins and extravasate contrast. Angiographers must select volumes and flow rates to opacify fully the vessels that have been accessed.

Finally, there are several other factors to consider when administering contrast. One of the most significant complications of intravenous contrast administration is the subsequent development of contrast-induced nephropathy. Intravenous contrast should only be given within the set guidelines of the department. Examples of these of guidelines are described.

Examples of General Guidelines for Patients with Normal Renal Function

If recent creatinine is less than 1.5 mg/dL, then OK to give iv contrast.

If recent creatinine is between 1.5 and 2.0 mg/dL, then give iv contrast if it is necessary to answer the clinical question. You may decrease the volume of contrast administered, as well, from 100 to 75 or even 50 mL. Also, this type of patient may benefit from hydration before contrast infusion.

If recent creatinine is 2.0–3.0 mg/dL, then get referring doctor involved in decision since the patient may get acute, irreversible renal failure and will need follow-up to assess renal function.

If recent creatinine is greater than 3.0 mg/dL, then don't give iv contrast unless referring doctor insists (and preferably provides written documentation to that effect) This patient may need dialysis after contrast infusion.

Do not administer iv contrast with a concurrent chemotherapy or blood infusion, because if there is a reaction, there may be confusion as to whether the reaction was to the contrast, or the blood, or the chemotherapy agent.

General Rules for Patients with Decreased Renal Function

If recent creatinine is less than 1.7 mg/dL, then OK to give iv contrast.

If recent creatinine is between 1.7 and 2.0 mg/dL, then give iv contrast only if necessary to answer the clinical question.

If recent creatinine is greater than 2.0 mg/dL, then get referring doctor involved in decision and don't give iv contrast unless referring doctor insists.

For a creatinine value to be relevant, it should be less than 2 months old.

Pay special attention to diabetics and other patients with medical renal disease, as well as older men with prostate problems.

If creatinine doubles over a month, renal function has decreased 50%.

If creatinine doubles over 24 h, renal function is essentially zero.

Don't forget that thinner, older patients with poor muscle mass may have a relatively low baseline creatinine. For example, a rise in creatinine from 0.4 to 0.8 mg/dL in these patients may represent a 50% loss of function. A rise from 0.4 to 1.2 mg/dL may represent a 75% loss of function. Keep in mind that the creatinine level is an indirect indicator (albeit the most clinically relevant) of renal function.

If the patient has end-stage renal failure necessitating routine hemodialysis, contrast material does not usually cause difficulties as long as the patient undergoes dialysis promptly after the exam.

Glucophage®

There is no interaction between Glucophage and iv contrast.

The problem is that if the patient develops renal failure acutely because of the contrast, toxic levels of Glucophage can quickly accumulate and result in a lethal lactic acidosis.

Have patient stop Glucophage for 48 h after iv contrast injection. If the patient is at high clinical risk for renal failure, he or she should have renal function checked prior to reinitiating the medication 48 h after the examination. If the patient notices no difference in the pattern of urine production and if the referring clinician agrees that no surveillance is necessary, the patient can subsequently resume oral hypoglycemics after 2 days.

Patients with a History of Contrast Reaction

Find out what type of reaction the patient experienced. Sometimes the patients confuse the feeling of warmth associated with an injection of contrast with a reaction.

For a history of serious iv contrast reaction such as bronchospasm and hypotension, and including hives, one must premedicate the patient with glucocorticoids prior to giving contrast.

Make sure the patient was premedicated appropriately.

Always administer nonionic iv contrast.

EXAMPLE OF PREMEDICATION FOR PRIOR CONTRAST REACTION

Prednisone 40 mg po

–Two doses: 12–18 h and 2 h before exam, *or*

–Three doses: 24, 12, and 2 h before exam.

PATIENTS WITH

Allergy

In patients with a history of asthma or chronic hives, consider using nonionic iv contrast.

Very Poor Cardiopulmonary Function

Such patients should get nonionic iv contrast. They are at increased risk of mortality, should the contrast trigger pulmonary edema.

A Breast Feeding Baby

Previously an absolute contraindication for iv contrast; now considered safe for mothers with breast feeding infants.

Sickle Cell Disease

If the patient is in acute crisis, don't give iv contrast unless referring doctor insists, because of an increased risk of RBC sickling.

Patients not currently in crisis can receive iv contrast, at the discretion of the radiologist.

Multiple Myeloma

Absolute contraindication for iv contrast.

Possible Pheochromocytoma

Need α -blockers accessible prior to the administration of iv contrast.

The administration of contrast to these patients could potentially trigger a hypertensive crisis.

Summary of Contraindications for Contrast

Previous significant contrast reaction

History of anaphylaxis or nontrivial allergy to anything

Chronic urticaria or angioedema

Sickle cell anemia, multiple myeloma, asthma, or significant renal disease

Severe cardiac dysfunction or general debilitation.

Technique for Injection of Contrast

Check the creatinine. Obtain written, informed consent. Apply a tourniquet and gravity to distend veins. Select a contrast agent and draw up the desired volume. Select a type of needle (butterfly or angiocath) and a size (18–23 g). Connect the syringe to the needle, and expel all air from the system. Select a vein, and prep the overlying skin with an alcohol pad. Insert the needle into the vein, and tape down. For most injections done by hand, deliver the contrast as fast as you can push it through the needle while watching the vein for signs of extravasation. Palpate around the vein occasionally. A test injection with 10 mL of normal saline may be done before the injection of contrast material. Test injections are used in some institutions and may possibly reduce the incidence of contrast extravasation.

For power injection, set the flow rate (dependent on needle size)

<i>Needle</i>	<i>Injection rate (mL/s)</i>
23-g butterfly	Up to 1.5
21-g butterfly	Up to 3.0
20-g angiocath	Up to 3.5
18-g angiocath	Up to 5.0

Do a quick test injection. Deliver the contrast, and palpate the area around the access during injection. An extravasation will not always appear as an enlarging mass; sometimes it may just be a firming of the surrounding tissues. If an extravasation is detected, turn the injector off and then remove needle. Stay nearby for a reasonable amount of time to confirm that no contrast reaction has occurred.

Examples of IV Contrast Agents for CT

Omnipaque 350: 150, 125, 100, or 75 mL

Nonionic. Low incidence of contrast reaction, causes less tissue damage with extravasation. Higher cost.

Ultravist 300®: 150, 125, 100, or 75 mL

Similar to Omnipaque 350.

Examples of IV Contrast Agents for IVP

Ultravist 300/Omnipaque 350: 150, 100, or 75 cc

Nonionic. Lower incidence of contrast reaction. Causes less tissue damage with extravasation. Higher cost. Image quality slightly inferior to Conray 400®, with IVP.

Sterile 60 % Hypaque

Ionic. Slightly lower iodine concentration than Conray 400.

Conray 400

Ionic. Highest iodine concentration. Good image quality. Less expensive. Higher incidence of contrast reaction than non-ionics. Causes more tissue damage with extravasation.

Reno-M-60®

Ionic. Similar to Conray.

5 ORAL CONTRAST FOR CT

Dilute barium, or water-soluble iodinated contrast, is given by mouth to opacify the bowel before CT scanning. This contrast can be made in several ways. One of the most common formulations is 3% Hypaque in water, or clear juice. This can be made by mixing:

- 3 scoops (10 g/scoop) of Hypaque sodium powder in 1.5 L of water or juice
- 2 vials (10 g/vial) Hypaque sodium powder in 1.5 L of water
- Oral contrast material can also be purchased as a ready-to-use barium sulfate suspension (i.e., Prepcat®). These formulations commonly contain 1.5% barium sulfate along with flavoring agents such as sorbitol and citric acid simethicone.

The type of contrast, the volume, and the amount of time needed before scanning varies. For routine body CT scanning, an example of an oral contrast protocol is:

- npo after dinner
- 750 mL of contrast before bed to fill the colon
- 750 mL of contrast 60–90 min before scanning.

The ideal is rarely the reality. In most situations, the patient is given 1.5 L of contrast, over 15–30 minutes, and then scanned 1–3 hours later. For emergent studies, use oral contrast only when indicated and wait as long as is necessary. In cases of trauma, you probably just need to get the study done as quickly as possible. Other special situations are included in *Table 1*.

Table 1
Examples of Oral Contrast Protocols

<i>Area of interest</i>	<i>Contrast type/amount</i>	<i>Waiting time</i>
Entire bowel	1 large cup (1000 mL) of oral contrast	2–3 h
Esophagus	2 teaspoons of esophageal paste contrast	Immediately
Pancreas	2 large cups of water	Immediately
Biliary system	2 large cups of water	Immediately
CT angiography	2 large cups of water	Immediately
Small bowel	1 cup (750 mL) of oral contrast	45–60 min
Terminal ileum	1 cup (750 mL) of oral contrast	90 min
Sigmoid colon	1 large cup (1000 mL) of iodinated oral contrast	2–3 h
Rectum	200–300 mL of contrast via rectal tube	Immediately

6 BLADDER CONTRAST FOR CT

Use diluted bladder contrast (i.e., Cysto-Conray) decreased in concentration to a 3% solution. Instill via Foley catheter via gravity. Can also use Hypaque-60 or Reno-M-60 diluted 1:10 with saline.

7 INTRATHECAL CONTRAST FOR CT

Nonionic, iodinated contrast is instilled intrathecally through a spinal needle prior to CT myelography. Examples of myelography preparations and volumes are as follows:

- 15 mL of Omnipaque 180
- 12 mL of Omnipaque 240
- 10 mL of Omnipaque 300

Ionic contrast is absolutely contraindicated, owing to the risk of seizures and other serious complications. Always double check the contrast administered intrathecally to make sure it is nonionic.

8 MR CONTRAST

Contrast material is also given for MR examinations. The vast majority of these agents contain gadolinium. The two major categories of MR contrast are the general purpose agents and the organ- or tissue-specific agents. The other categories, including oral MR contrast and the non-[¹H] contrast agents, will not be addressed in this section.

General Purpose Agents

Gadopentetate (Gd-DTPA), *Magnevist*[®] (469 mg/mL)

- Standard dose: 0.1 mmol/kg or 0.2 mL/kg
- Dose range: 0.05–0.3 mmol/kg

Gadoteridol (Gd-HP-DO3A), *ProHance*[®] (279.3 mg/mL)

- Standard dose: 0.1 mmol/kg or 0.2 mL/kg
- Dose range: 0.05–0.3 mmol/kg

Gadodiamide (Gd-DTPA-BMA), *Omniscan* (287 mg/mL)

- Standard dose: 0.1 mmol/kg or 0.2 mL/kg
- Dose range: 0.05–0.3 mmol/kg

Gadodiamide (Gd-DTPA-BMA), *Dotarem*[®] (279.3 mg/mL)

- Standard dose: 0.1 mmol/kg or 0.2 mL/kg
- Dose range: 0.1–0.3 mmol/kg

Gadobenate dimeglumine (Gd-BOPTA), *Multihance*[®] (334 mg/mL)

- Standard dose: 0.05–0.1 mmol/kg or 0.1–0.2 mL/kg
- Dose range: 0.05–0.2 mmol/kg

Note: The hepatic uptake of Gd-BOPTA is 3–5%, and liver enhancement is noted up to 2 hours post injection. This gadolinium-based contrast is therefore useful as an extracellular agent in the first few minutes after injection as well as a hepatic agent when acquiring delayed images.

Organ/Tissue-Specific Agents

T1 AGENTS

Gadobenate dimeglumine (Gd-BOPTA), *Multihance* (334 mg/mL)

- Standard dose: 0.05–0.1 mmol/kg or 0.1–0.2 mL/kg

- Dose range: 0.05–0.2 mmol/kg

- This agent initially distributes in the extracellular fluid and behaves like Gd-DTPA. The hepatic uptake produces sustained T1 enhancement and allows delayed images of the liver to be obtained 1–2 hours later

Gadoxetic acid disodium (Gd-EOB-DTPA), *Eovist*^{*} (181 mg/mL)

- Standard dose: 0.025 mmol/kg or 0.1 mL/kg

- Dose range: 0.025 mmol/kg or 0.1 mL/kg (only approved dose)

- Eovist also shows immediate extracellular fluid distribution, but approximately 50% of this agent is extracted by hepatocytes. Maximum contrast between normal and abnormal hepatic tissue occurs 20–45 min after injection (imaging time range is about 2 h). A substantial portion of this contrast is also excreted in the bile and can be seen as positive contrast enhancement on the postinjection images.

**At the time of publication, Eovist was not yet FDA-approved.*

Mangafodipir trisodium (Mn-DPDP), *Teslascan*[®] (37.9 mg/mL)

- Standard dose: 0.1 mL/kg (5 μmol/kg) infused at 2–3 mL/min up to a total volume of 15 mL

- Teslascan is not a liver-specific agent but is manganese-based and is taken up by tissues that are rich in mitochondria. This agent is taken up in the liver, kidneys, adrenals, pancreas, myocardium, and gastrointestinal mucosa. The manganese produces T1 enhancement in the liver for several hours after the injection, with an optimal imaging window of 20 min to 4 h (abnormal retention of contrast may be further emphasized on 24-h delayed images).

T2 AGENTS

Ferumoxides: *AMI-25*[®], *Feridex*[®], *Endorem*[®] (mean particle size 150 nm)

- Standard dose: 10 mmol/kg or 11.2 mg of Fe/mL (and 61.3 mg of mannitol)

- Dose range: 7.5–15 mmol/kg
- The ferumoxides are administered as a dilute infusion (i.e., with 100 mL D5W) over 30 min to minimize adverse reactions, especially back pain.
- Particles are taken up by the reticuloendothelial cells of the liver, spleen, and bone marrow, with about 80% of the dose reaching the liver in normal patients. Because of the magnetic field inhomogeneity induced by these agents, the liver appears dark on both T1- and T2-weighted images. Optimal images are obtained 30–120 min after injection.
- These agents are contraindicated in patients with hemochromatosis or a hypersensitivity to iron.

Ferucarbotran (SHU555A), Resovist® (mean particle size 60 nm)

- Standard dose: 8 mmol/kg
- Dose range: 8–10 mmol/kg
- Resovist may be given by a rapid bolus injection. A T1 enhancement is observed for the first few minutes after injection, but the agent is then taken up by the reticuloendothelial cells, causing significant T2 shortening (similar to the ferumoxides). Because of the T1 enhancement, Resovist produces dynamically enhanced images that are analogous to gadopentate.
- The T2 agents listed above are effective at all magnetic field strengths but produce the greatest effect with stronger magnetic fields.

9 IODINATED CONTRAST FORMULATIONS

Trade name	Iodine content (mg/mL)	Trade name	Iodine content (mg/mL)
<i>Angiovist</i> 282, 292, 370 [®]	282, 292, 370	Optiray® * 160, 240, 320	160, 240, 320
<i>Conray</i> 30, 43, 325, 400 [®]	141, 202, 325, 400	<i>Renografin</i> 60, 76 [®]	292, 370
<i>Conray®</i> (plain), <i>Cysto-</i> , <i>Angio-</i>	282, 81, 480	<i>Reno-M DIP</i> , 60 [®]	141, 282
<i>Diatrizoate meglumine</i> 76%	358	<i>Reno-M-60®</i>	282
<i>GastroView®</i>	367	<i>Renovue DIP</i> , 65 [®]	111, 300
<i>Hexabrix®</i> **	320	<i>Renovist II®</i>	309
<i>Hypaque Meglumine®</i> 30%, 60%	141, 282	<i>Renovist®</i>	370
<i>Hypaque Sodium®</i> 25%, 50%	150, 300	<i>Ultravist 300®</i>*	150, 240, 300, 370
<i>Hypaque-76®</i>	370	<i>Urovist Meglumine®</i> (<i>Cysto-141</i>)	141
<i>Hypaque-M®</i> 75%, 90%	385, 462	<i>Urovist Sodium 300®</i>	300
<i>Isovue®</i> * 128, 200, 300, 370	128, 200, 300, 370	<i>Vascoray®</i>	400
<i>MD</i> 60, 76 [®]	292, 370		
<i>Omnipaque®</i> * 180, 240, 300, 350	180, 240, 300, 350	*Nonionic.	
		**Low osmolality, but ionic.	

10 CONTRAST EXTRAVASATION AND TREATMENT

Contrast extravasation into the soft tissue surrounding the injection site is a relatively common complication of examinations involving iv contrast injection. The severity of this complication can range from trivial to limb-threatening. Examples of treatment for this untoward event are described.

Minimal Extravasation

> 5 mL

No treatment or follow-up needed.

Moderate Extravasation

< 30 mL ionic or < 100 mL nonionic

Elevation of arm above heart

Watch patient for 2–4 h

Call referring physician

Ice packs three times per day for 1–3 days

Document extravasation

Have patient call referring physician if problem arises.

Marked Extravasation

> 30 mL ionic or > 100 mL nonionic

Immediate surgical (i.e., plastic surgery) consultation

Assess for:

–Skin blistering

–Altered tissue perfusion distal to site of extravasation

–Change in sensation distal to site of extravasation

–Increasing pain after 2–4 h.

Document extravasation and notify risk management

Daily phone calls by nurse or radiologist until problems resolve.

11 CONTRAST REACTIONS AND TREATMENT

Check ABCs and vital signs.

Urticaria, Pruritis, or Erythema

Mild to moderate

No therapy needed in most cases.

Benadryl 50 mg or 1 mg/kg po/im/iv

Watch for 30 min

Have someone drive the patient home.

Severe

Epinephrine 1:1000, 0.3 mL sq, or 0.01 mL/kg, if no cardiac contraindication.

Facial or Laryngeal Edema, or Stridor

Oxygen

Epinephrine 1:1,000, 0.3 mL sq (0.01 mL/kg)

–If sq epinephrine fails or if patient experiences vascular collapse, then give *epinephrine* 1:10,000 3 mL iv slow push.

Bronchospasm or Wheezing

Oxygen, pulse oximeter (severe, < 88%)

Bronchodilator nebulized in NS 2.5 mL, such as:

–Isoetharine 1% [Bronkosol®] 0.25–0.5 mL

–Albuterol 0.5% [Ventolin®, Proventil®] 0.5 mL

–Metaproterenol 5% [Alupent®, Metaprel®] 0.3 mL

If no improvement: *epinephrine* 1:1000, 0.3 mL sq (0.01 mL/kg)

If sq fails or if patient experiences vascular collapse then give: *epinephrine* 1:10,000, 3 mL iv slow push.

Hypotension

With Tachycardia, or Shock

Oxygen, Trendelenberg

Lactated Ringer's Solution, iv wide open

If no improvement: *epinephrine* 1:1000, 0.3 mL sq (0.01 mL/kg)

If sq fails or vascular collapse: *epinephrine* 1:10,000, 3 mL iv slow push.

With Bradycardia (Vagal Reaction): no β-Blocker

Oxygen, Trendelenberg

Lactated Ringer's Solution, iv wide open

If no improvement: *atropine* 0.5–1.0 mg iv slow push, repeat up to 2.0 mg total.