



Critically Appraised Topic / Évaluation critique

Adverse Reactions to Contrast Material: A Canadian Update

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Imaging techniques frequently employ contrast agents to improve image resolution and enhance pathology detection. These gadolinium- and iodine-based media, although generally considered safe, are associated with a number of adverse effects ranging from mild to severe. Reactions are classified as either anaphylactoid (“anaphylaxis-like”) or nonanaphylactoid, depending on a number of elements that will be reviewed. Herein, we have summarized predisposing risk factors for adverse events resulting from the use of contrast, their associated pathophysiological mechanisms as well as known prophylaxis for the antitreatment of high-risk patients. In the unlikely event that a serious adverse reaction does occur, we have provided a comprehensive summary of treatment protocols. Our goal was to thoroughly evaluate the current literature regarding adverse reactions to radiocontrast agents and provide an up to date review for the health care provider.

Résumé

Les techniques d'imagerie utilisent souvent des produits de contraste pour accroître la résolution de l'image et faciliter la détection des affections. Ces produits à base de gadolinium et d'iode, que l'on considère généralement comme étant sécuritaires, sont associés à un certain nombre d'effets indésirables bénignes à graves. Ces effets sont classés en tant que réactions anaphylactoides (qui rappellent l'anaphylaxie) ou réactions non anaphylactoides, en fonction de plusieurs facteurs. Dans le cadre de la présente étude, nous avons résumé les facteurs de risque qui prédisposent à des événements indésirables liés aux produits de contraste, les mécanismes pathophysiologiques qui leur sont associés et les mesures connues de prophylaxie destinées aux patients à risque élevé. Dans l'hypothèse peu probable qu'un effet indésirable grave se produirait, nous présentons par ailleurs une synthèse globale des protocoles de traitement. Notre objectif consistait à analyser la documentation sur les effets indésirables liés à des produits de contraste radiologique et de fournir un compte rendu à jour au professionnel de la santé.

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It has been estimated that in the United States alone, 15 million procedures a year employ iodine [1]. Iodine-based contrast agents are classified on the basis of their osmolality. High-osmolar agents dissociate significantly in aqueous solution, whereas low-osmolar agents generally possess an osmolality slightly higher than blood. Historically, high-osmolar iodinated contrast media (CM) have made way for low-osmolar agents, as they are less frequently associated with adverse reactions. The osmolality of an agent

contributes significantly to its risk profile due to the ability to influence the osmolar gradient of the extracellular fluid environment. Despite the relative safety of both ionic and nonionic radiocontrast, adverse reactions do occur. In general, the frequency and severity of adverse reactions to gadolinium-based CM is significantly lower than for iodinated forms. In a study accessing 456,930 contrast doses, a total of 522 cases of adverse events were reported [2]. Of those cases, 458 were attributed to low-osmolar iodinated CM and only 64 to gadolinium injections. However, the percentage of serious adverse reactions to gadolinium-based contrast were almost double that of low-osmolar iodinated forms. Overall rates of adverse reactions resulting from high-osmolar contrast range from 5%-12% compared to 1%-3%

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for lower-osmolar alternatives [3]. The mortality rate due to the use of radiocontrast media does not differ on the basis of ionicity [4]. Overall, the reported incidence of adverse events with low-osmolar iodinated contrast is 1.5 events per 1000 doses (2.62% of which are serious) and 0.4 events per 1000 doses (6.25% of which are serious) with gadolinium-containing agents [2].

Reactions to CM are either anaphylactoid or non-anaphylactoid (chemotoxic) in origin. Although the majority of anaphylactoid reactions to CM occur immediately, delayed reactions have been reported [5]. Anaphylactoid, or idiosyncratic reactions to CM, are poorly understood. Despite possessing characteristics of anaphylaxis, there appears to be no distinct release of immunoglobulin (IgG or IgE) antibodies specific to the radioactive agent [6]. It is believed that intravenous administration of CM causes allergic-like symptoms via a compensatory release of various vasoactive compounds, initiation of the contact and complement systems, the conversion of L-arginine to nitric oxide [7,8] and the release of pseudoantigens, precipitating the discharge of hypotensive mediators [9]. However, the release of histamine from basophils and eosinophils is regarded to be the most important mechanism in the pathophysiology of anaphylactoid reactions, and likely contributes to adverse reactions resulting from the use of high osmolar agents [7]. Cochran [1] reported that more than 90% of adverse reactions to nonionic CM are considered anaphylactoid. There has been debate regarding the usefulness of skin tests for predicting such reactions in high-risk patients. A recent study by Kim et al [10], however, concluded that CM skin testing was of no clinical benefit in predicting hypersensitivity to radiologic CM.

Unlike idiosyncratic reactions, nonanaphylactoid reactions are dose dependent and directly influenced by the physiochemical properties of the CM used. Ionic characteristics of CM have the ability to disrupt neural and cardiac signaling [3], whereas osmolarity significantly influences fluid distribution [7]. Overall, chemotoxic reactions are thought to result from a disturbance in homeostasis [11]. Other factors that may influence the incidence of such reactions include the dose and route of administration. Larger (>100 mL iodinated contrast), intra-arterial doses are

associated with increased risk [12]. For gadolinium agents, standard doses generally range between 0.1–0.3 mmol/kg.

Acute adverse reactions to contrast are classified as mild, moderate or severe. Mild adverse reactions to contrast are noted to be self-limited and absent of progression. Moderate reactions are more diffuse and generally require medical management. Serious adverse reactions are considered life threatening and requiring immediate medical attention [7]. A complete summary of potential mild, moderate and severe adverse reactions is provided in Table 1.

The purpose of this update is to evaluate the etiology, prevention, and treatment of adverse reactions resulting from the use of both ionic and nonionic CM. A summary of current clinical research for the safe and effective uses of these reagents will be provided. It is our hope to provide a concise protocol for Canadian health care providers to follow.

Risk Factors

All patients should be evaluated before receiving contrast, and any missing physical or laboratory information obtained. This includes a thorough medical and contrast-related history, and pertinent laboratory values namely, complete blood count, electrolyte profile, and renal function parameters. The greatest predisposing risk factor for an adverse reaction to CM is a previous reaction [7]. Risk of repeat reaction is as high as 60% if patients are re-exposed to the same contrast agent [13]. CM-related risk factors include larger dose, increased rate of administration, the use of higher osmolar nonionic CM, and intra-arterial (vs intravenous) administration.

Patients with atopic tendencies, including those suffering from asthma are at an increased risk. In an early study, it was found that up to 11% of asthmatics reacted to ionic CM [14], a 5.8-fold increase in incidence relative to health individuals [4]. Although there has been much debate, those suffering from sensitivity to seafood are not at a heightened risk for allergic-type reactions to CM [14]. In cancer patients, it has been proposed that the increase in circulating histamine may point to a potential cause of anaphylactoid reactions in this group [15]. Further yet, those suffering from multiple myeloma are at a heightened risk due to the interaction

Table 1
A summary of mild, moderate, and serious anaphylactoid and nonanaphylactoid reactions [7]

Severity	Type	Reaction
Mild	Anaphylactoid	Limited urticaria/pruritus, limited cutaneous oedema, limited itchy/scatchy throat, nasal congestion, sneezing, conjunctivitis, rhinorrhea
	Nonanaphylactoid	Limited nausea/vomiting, flushing/warmth/chills, headache, dizziness, anxiety, altered taste, mild hypertension, self-limited vasovagal reactions
Moderate	Anaphylactoid	Diffuse urticaria/pruritus, diffuse erythema with stable vitals, facial oedema without dyspnea, throat tightness or hoarseness without dyspnea, wheezing/bronchospasm, mild or no hypoxia
	Nonanaphylactoid	Continuous nausea/vomiting, hypertensive urgency, isolated chest pain, vasovagal reaction reaction that requires and responds to treatment
Severe	Anaphylactoid	Diffuse oedema, facial oedema with dyspnea, diffuse erythema with hypotension, laryngeal oedema with stridor and/or hypoxia, wheezing/bronchospasm, significant hypoxia, anaphylactic shock (hypotension with tachycardia)
	Nonanaphylactoid	Vasovagal reacting resistant to treatment, arrhythmia, convulsions, seizures, hypertensive emergency

Table 2
A summary of common risk factors for adverse reactions to CM

Risk factors	Characteristics
CM related	Previous reaction, increased rate of admin, higher dose (>100 mL), higher-osmolar contrast, ionic vs nonionic, route of admin (intra-arterial > intravenous)
Medical conditions	Diabetes, heart disease, renal disease/dysfunction, asthma, anxiety, dehydration, thyroid disorders, oncological indications, atopic tendencies, mastocytosis
Age	Infants and seniors
Sex	Women at a heightened risk
Concurrent Rx	β -blockers, interleukin-2, nephrotoxic agents (nonsteroidal anti-inflammatories, methotrexate, aminoglycosides, biguanides, hydralazine)
Hematological conditions	Sickle cell disease, polycythemia, paraproteinemias

CM = contrast media.

between light chains and the contrast agent [16]. Patients suffering from cardiovascular disorders are also at a heightened risk of serious, life-threatening anaphylactoid reactions [17]. Those presenting with systemic mastocytosis are at a heightened risk of developing a mild immediate reaction when exposed to an ionic or nonionic contrast agent [6].

The use of CM can alter renal function by decreasing glomerular filtration rate and causing renal vasoconstriction, which provides a pathophysiological basis for injury. Ensuring adequate hydration is essential as dehydration significantly increases the risk of renal failure due to a reduction in perfusion rates [18]. Nonetheless, many studies evaluating contrast-induced nephrotoxicity following iodinated contrast have failed to include a comparison group not receiving these agents, while other studies have shown that elevations in serum creatinine are common in patients not receiving contrast agents [7]. These authors believe the risk for the contrast-induced nephrotoxicity is exceedingly rare in healthy individuals. In patients with pre-existing renal disease, and in particular an acute recent change in renal function, this risk increases, although there is no clear consensus as to when iodinated contrast is counter indicated.

Gadolinium-enhanced magnetic resonance has been used as an alternative to contrast-enhanced computed tomography

Table 3
Two prophylactic treatment protocols for high-risk patients

Medication	Regimen
Prednisone: 50 mg PO + Diphenhydramine: 50 mg PO/IM/IV	Prednisone: 13 h, 7 h, and 1 h prior Diphenhydramine: 1 h prior
Methylprednisolone: 32 mg PO + Diphenhydramine: 50 PO/IM/IV	Methylprednisolone: 12 h and 2 h prior Diphenhydramine: 1 h prior

IM = intramuscular; IV = intravenous; PO = by mouth.

Table 4
Emergency pretreatment protocol for those to receive contrast

Option	Medication	Regimen
Optimal	Methylprednisolone sodium succinate: 40 mg IV OR Hydrocortisone sodium succinate: 200 mg IV + Diphenhydramine: 50 mg IV	Every 4 h before administration of contrast 1 h prior
If allergic to methylprednisolone, aspirin, nonsteroidal anti-inflammatories	Dexamethasone sodium sulfate: 7.5 mg IV OR Betamethasone: 6 mg IV + Diphenhydramine: 50 mg IV	Every 4 h before administration of contrast 1 h prior
If <4-6 h prior to contrast media admin	Diphenhydramine: 50 mg IV	1 h prior

IV = intravenous.

due to its lack of nephrotoxicity. However, this is misleading, as gadolinium has the potential for nephrogenic systemic fibrosis (NSF) in patients with severe renal impairment, and is thus no longer recommended in conventional angiography in this subset of patients. NSF is a disease leading to fibrosis of the skin and soft tissues, and may involve the heart, lungs, and skeletal muscles, among others. It is generally believed that failure to eliminate gadolinium agents via renal excretion predispose them from dissociating with their parent molecule, leading to deposition in various tissues. Patients at risk of developing NSF include those on dialysis, end-stage chronic kidney disease (estimated glomerular filtration rate <30 mL/min/1.73 m²), an estimated glomerular filtration rate from 30-40 mL/min/1.73 m² who are not currently on dialysis, and acute kidney injury. Agents most frequently associated with NSF include gadodiamide, gadopentetate dimeglumine, and gadoversetamide [7].

It has been suggested that patient anxiety may increase the chance of adverse reaction to CM. Studies assessing whether informed consent should be provided to patients have concluded that it may in fact be prophylactic. Yucel et al [19] demonstrated that by providing a brief description of potential risk factors and adverse reactions, they were able to reduce anxiety levels.

Age is another important factor to consider when identifying at-risk patients. In neonates and infants, the volume of CM agent used must be closely monitored considering low blood volume [7]. Those of advanced age should also be closely monitored [16], particularly due the risk of comorbid maladies.

Patients suffering from thyroid disorders, including those with Graves' disease and multinodular goiter, are at a heightening risk of developing CM induced thyrotoxicosis. This is thought to result from altered iodine uptake due to increases in free systemic levels. Patients should be monitored carefully by attending endocrine specialist [20].

Although the American College of Radiology (ACR) manual does not consider gender as a major risk factor for adverse reactions to IV contrast, a recent study assessing

Table 5

Detailed management and treatment of adverse reactions to CM [7,18,26]

Symptom	Notes	Treatment
Urticaria	- Monitor; most improve. If symptomatic consider treatment. - If severe, consider adding 2	1. Diphenhydramine: 1 mg/kg (max = 50 mg) PO/IM/IV (if IV dose, administer slowly over 1-2 minutes) 2. Epinephrine: IM 0.3-0.5 mL of 1:1000 OR EpiPen: IM 0.3 mL of 1:1000 Pediatric dosing of epinephrine: 0.01 mg/kg IM
Facial/laryngeal oedema	- In severe; call emergency medical team - If severely hypotensive, IV epinephrine preferred	1. Oxygen by face mask 6-10 L/min 2. Epinephrine: IM 0.3-0.5 mL of 1:1000; can repeat every 5-10 minutes up to 1 mg total OR EpiPen: IM 0.3 mL of 1:1000; can repeat every 5-10 minutes up to 3×, if required Pediatric dosing of epinephrine: 0.01 mg/kg IM OR (if severely hypotensive) Epinephrine: IV 1-3 mL of 1:10,000 given slowly over 2-3 min; repeat 1 mg dose as needed
Bronchospasm	- Continuously monitor. If progressively worse, consider adding additional treatment 3. - IV epinephrine preferential for severe reactions, or if severely hypotensive - Call emergency medical team	1. Oxygen by face mask 6-10 L/min 2. Beta-agonist (Albuterol?) inhaler: 180 mcg; can repeat 3× 3. Epinephrine: IM 0.3-0.5 mL of 1:1000; can repeat every 5-10 minutes up to 1 mg total OR EpiPen: IM 0.3 mL of 1:1000; can repeat every 5-10 minutes up to 3×, if required Pediatric dosing of epinephrine: 0.01 mg/kg IM OR (if severely hypotensive) Epinephrine: IV 1-3 mL of 1:10,000 given slowly over 2-3 min; repeat 1 mg dose as needed
Hypotension with bradycardia	- Usually spontaneous recovery	1. Oxygen by face mask: 6-10 L/min 2. Elevate legs 3. Saline 0.9%: 10-20 mL/kg 4. Atropine: IV 0.6–1.0 mg, saline flush; can repeat up to 3 mg
Hypotension with tachycardia	- If severely hypotensive, IV epinephrine preferred	1. Oxygen by face mask: 6-10 L/min 2. Elevate legs 3. Saline 0.9%: 10-20 mL/kg 4. Epinephrine: IM 0.3-0.5 mL of 1:1000; can repeat every 5-10 minutes up to 3×, if required OR EpiPen: IM 0.3 mL; can repeat every 5-10 minutes up to 3×, if required Pediatric dosing of epinephrine: 0.01 mg/kg IM OR (if severely hypotensive) Epinephrine: IV 1-3 mL of 1:10,000 given slowly over 2-3 min; Repeat 1 mg dose as needed
Hypertension		1. Oxygen by face mask: 6-10 L/min 2. Labetalol: IV 20 mg over 2 min; can double every 10 min 3. Furosemide: IV 20-40 mg over 2 min
Seizures	- If continuous, call emergency medical team	1. Turn patient onto side to avoid aspiration 2. Suction airway if required 3. Oxygen by face mask: 6-10 L/min 4. Lorazepam: IV 2-4 mg
Pulmonary oedema	- Call emergency medical team	1. Oxygen by face mask: 6-10 L/min 2. Elevate head of bed 3. Furosemide: IV 20-40 mg over 2 min 4. Morphine: IV 1-3 mg; repeat as needed

(continued)

Table 5 (continued)

Symptom	Notes	Treatment
Cardiac arrhythmia; normotensive	- Generally no treatment required. - Perform 12-lead ECG?	1. Oxygen by face mask: 6-10 L/min
Cardiac arrhythmia; hypotensive	- Call emergency medical team - If severely hypotensive, IV epinephrine preferred	1. Oxygen by face mask: 6-10 L/min 2. Saline 0.9%: 10-20 mL/kg 3. Epinephrine: IM 0.3-0.5 mL of 1:1000; can repeat every 5-10 minutes up to 3×, if required OR EpiPen: IM 0.3 mL of 1:1000; can repeat every 5-10 minutes up to 3×, if required Pediatric dosing of epinephrine: 0.01 mg/kg IM OR (if severely hypotensive) Epinephrine: IV 1-3 mL of 1:10,000 given slowly over 2-3 min; repeat 1 mg dose as needed Available antiemetic
Nausea/vomiting	- Monitor; if unrelenting/severe administer recommended treatment	
Hypoglycemia	- If patient can swallow, consider 2 - If patient cannot swallow, consider 4	1. Oxygen by face mask: 6-10 L/min 2. 4 ounces fruit juice OR 3. Dextrose 50%: IV D50 0.5 ampule over 2 min OR 4. Glucagon: IM 1 mg
Unresponsiveness	- Call emergency medical team - Initiate life support	

IM = intramuscular; IV = intravenous; PO = by mouth.

immediate hypersensitivity reactions to gadolinium-based CM found that women were at a heightened risk [21]. The European Society of Urogenital Radiology (ESUR) guidelines also support this theory.

Concurrent medications can increase the risk of allergic reactions to both ionic and nonionic CM. Although there remains some uncertainty as to whether β -blockers increase the incidence of idiosyncratic reactions [22], there is agreement that treatment does predispose patients to management complications if a reaction does occur [18]. Patients being treated with interleukin-2 prior to receiving radiological contrast are also at a heightened risk for an allergic reaction. These reactions tend to be delayed (>1 hour post procedure) and generally quite serious [23]. Concurrent treatment with hydralazine can promote lupus erythematosus following administration of iodine-based contrast. Coadministration of these two drugs is thus contraindicated [24]. Other nephrotoxic agents, including nonsteroidal anti-inflammatories (NSAIDs), methotrexate, aminoglycosides, and biguanides, also have the ability to work synergistically with the contrast agent to induce renal failure. Careful consideration should be made for patients concurrently being treated with these medications. Biguanides, in particular, have the unique ability to induce lactic acidosis when administered with iodinated contrast in patients with renal dysfunction or who have other comorbidities impairing metabolism of lactate (liver dysfunction or alcohol abuse) or increasing anaerobic metabolism (cardiac failure, myocardial or peripheral muscle ischemia, sepsis, or severe infection). The ACR manual on CM suggests patients taking metformin with

no renal disability or comorbidities do not require any cessation of their medication prior to receiving iodinated contrast. In patients with no known renal disability but who suffer from other comorbidities, metformin should be withheld 48 hours prior to receiving contrast. Reinstatement of metformin should be made following the assessment of renal function. Finally, in patients with renal dysfunction, metformin should be suspended prior to receiving intravenous (IV) contrast. Metformin therapy should be reinstated following cautious follow up and assessment of renal function [7].

CM has been noted to alter blood flow, plasma viscosity and various red blood cell characteristics. It is believed that those suffering from certain hematological disorders, including sickle cell anemia, polycythemia, and paraproteinemias may be at a heightened risk for CM induced hematological complications. The etiology of such reactions is a direct result of the hyperosmolarity and viscosity of the CM being used [25].

In older contrast safety guidelines it has suggested that patients with confirmed or suspected pheochromocytomas receive α - and β -blockade before receiving iodinated contrast. Recent guidelines do not endorse this preparation as there is little evidence to support the increase in serum catecholamine levels in patients receiving nonionic or gadolinium-based agents. In patients receiving direct intra-arterial iodinated contrast, however, antitreatment with α - and β -adrenergic agents is warranted [18].

We have provided a comprehensive summary of the discussed risk factors in Table 2. Patients to be considered high risk include those with previous reaction to contrast, persons

exhibiting significant atopic tendencies, patients with significant morbidities, including renal impairment, those possessing multiple of the indicated risk factors, and finally those exhibiting complications secondary to asthma. Pretreatment should be considered in all high-risk patients.

Pretreatment Protocols for High-Risk Patients

Prophylactic administration (either oral or intravenous) of an H-1 receptor antagonist has been shown to reduce the risk of urticarial, angioedema, and respiratory symptoms [7], although this is considered secondary to steroid treatment. Table 3 provides a summary of two antitreatment protocols as recommended by the ACR and outlined in a recent review published in the *Canadian Association of Radiologists Journal* [26]. The ESUR has proposed similar recommendations [18].

Fifty milligrams oral prednisone at 13 hours, 7 hours, and 1 hour before administration of CM with the addition of 50 mg diphenhydramine (Benadryl) given either orally or intramuscularly (IM) 1 hour before, was first described by Lasser et al [27] and still remains the most widely used premedication; 32 mg methylprednisolone given orally 12 and 2 hours before may be substituted for prednisolone as described by Greenberger and Patterson [28].

For patients requiring emergency administration of radiological contrast (ie, <12 hours available for premedication with steroids and histamine antagonists), 3 potential anti-medication regimens are summarized (Table 4). The most desirable of these as indicated by the ACR and described in Greenberger et al [29] is the administration of 40 mg methylprednisolone sodium succinate or 200 mg hydrocortisone sodium succinate IV every 4 hours until the administration of CM. In addition, 50 mg of diphenhydramine IV 1 hour prior to contrast administration is recommended. In the event patients have defined allergies to methylprednisolone, acetylsalicylic acid, or NSAIDs, treatment option 2 is suggested. Because the effectiveness of IV corticosteroids is negligible if given <4–6 hours prior to receiving CM, the final option is to provide 50 mg diphenhydramine IV 1 hour prior.

Controversy still remains regarding the effectiveness of antimedication for the prevention of certain type of reactions, particularly those with “allergy-like” characteristics. Breakthrough reactions, although rare, do occur. The ESUR note that mild reactions can be prevented using available treatment protocols but physicians should remain vigilant. The ACR provides guidelines identical to the one we have outlined in Table 3. The European Society of Urogenital Radiology remains impartial on this matter.

Management of Immediate Adverse Reactions

Using the ACR guidelines, the ESUR guidelines and Iyer et al [26], we have compiled an exhaustive list of potentially serious adverse reactions to ionic and nonionic CM. Serious reactions are defined as those with signs and symptoms that are often life threatening, resulting in permanent morbidity or death if not managed appropriately [7]. A treatment

regimen for each of these possible reactions has been recommended and is outlined in Table 5.

For serious anaphylactic-like reactions, the use of epinephrine is required to counteract hypotension and angioedema. Epinephrine has been noted to increase plasma levels of cyclic adenosine monophosphate, a chemical with immunosuppressive properties [30]. As previously suggested [31], we believe it is important to have only one epinephrine concentration immediately available to the radiologist (intended for intramuscular injection). By doing so, the radiology department minimizes the potential for catastrophic dosing errors and delay of treatment. There have been many case reports of such errors, particularly in patients presenting with anaphylaxis to the ED. Overdose is typically associated with tachycardia and hypertension, and although most patients experience spontaneous recovery, prolonged toxicity, and end-organ effects have been documented. Despite best efforts, severely hypotensive patients may require IV administration of epinephrine. In these cases, a dilution of 1:10,000 should be used (ie, 1 mg epinephrine diluted in 10 mL), as IV administration is preferred over IM due to the potential lack of perfusion in the extremities [7]. IV doses of epinephrine should be available to the radiologist, however, not in his or her immediate proximity as to avoid dosing confusion. Subcutaneous injections of epinephrine are not recommended due to the inferior time to reach peak plasma concentrations relative to an IM route [32].

Cardiovascular reactions and seizures are very rare in patients receiving an iodine-based contrast agent. Vasovagal disruptions however, are more frequent and often require attention. The use of high-osmolar CM is associated with frequent, mild physiological reactions [7].

Reactions to gadolinium-based CM are infrequent. Urticaria and bronchospasm are the most common. Less serious, more common issues that may arise are coldness, warmth and/or pain at the injection site, nausea, headache, paresthesias, dizziness, and itching.

Risk Reduction

General precautions should be taken to ensure the likelihood of serious adverse reactions is minimal. Some of these measures include the use of a nonionic contrast agent whenever possible, making sure patients are adequately hydrated, ensuring emergency equipment is available, and monitoring patients' vital signs in the postprocedure period [31]. Additionally, patients should be thoroughly screened for any predisposing risk factors (Table 2) prior to receiving CM. Patients at high risk should then be considered for antitreatment. Patients who previously reacted to CM should be very closely monitored. The contrast agent that caused the initial reaction should not be used again.

Conclusions

This review aimed to compile knowledge regarding the etiology, prevention, and management of adverse reactions to CM. Although serious reactions are rare, imaging

departments should be adequately prepared if such an event were to occur.

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