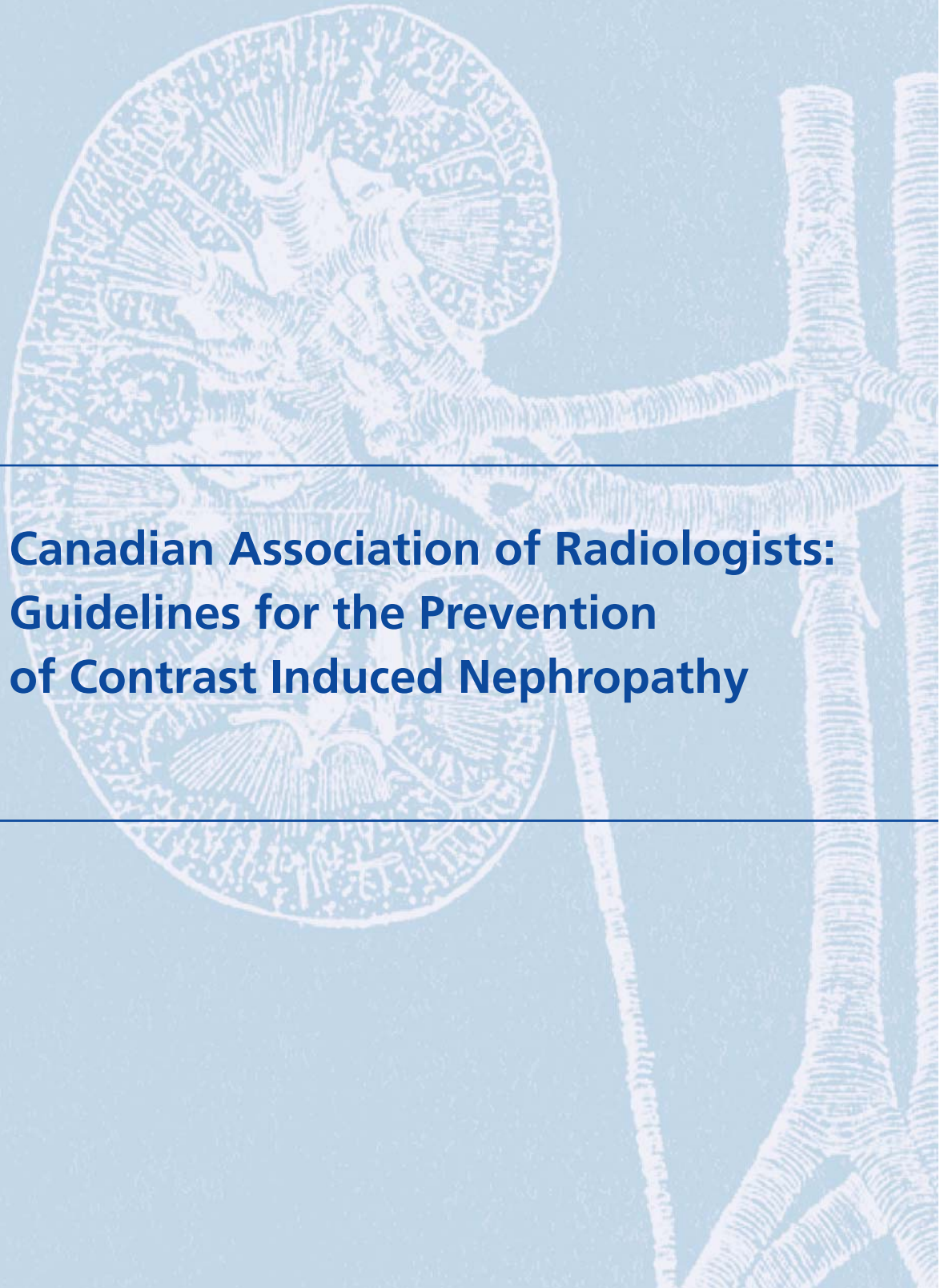




THE CANADIAN  
ASSOCIATION OF  
RADIOLOGISTS

# Canadian Association of Radiologists: Guidelines for the Prevention of Contrast Induced Nephropathy



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## **Authors:**

Benko Andrew, MD  
Fraser-Hill Margaret, MD  
Magner Peter, MD  
Capusten Bernice, MD  
Barrett Brendan, MD  
Myers Andrew, MD  
Owen Richard, MD

## **Correspondence to**

Dr. Andrew Benko / Dr. Richard Owen  
Canadian Association of Radiologists  
1740 Côte-Vertu Blvd.  
Saint-Laurent, Quebec H4L 2A4  
Ph 514-738-3111  
Fax 514-738-5199  
info@car.ca

**Abstract:**

The development of acute renal failure is a significant complication of intravascular contrast medium (CM) use and is linked with excess morbidity and mortality. The increasing use of CM, an ageing population and an increase in chronic kidney disease (CKD) will result in an increased incidence of contrast induced nephropathy (CIN) unless preventative measures are used. The Canadian Association of Radiologists has developed these guidelines as a practical approach to risk stratification and prevention of CIN. The major risk factor predicting CIN is pre-existing CKD, which can be predicted from glomerular filtration rate (GFR). Serum creatinine (SCr) as an absolute measure is an unreliable measure of renal function. Patients with GFR >60 mL/min are at a very low risk of CIN and preventive measures are generally unnecessary. When GFR is <60 mL/min preventive measures should be instituted. The risk of CIN is greatest in patients with GFR <30 mL/min.

**Preventive measures:**

1. Alternative imaging not requiring CM should be considered.
2. Fluid volume loading is the single most important protective measure.
3. Nephrotoxic medications should be discontinued 48 hours prior to the study.
4. CM volume and frequency of administration should be minimized while still maintaining satisfactory image quality.
5. Use iso-osmolar or low-osmolar CM in patients with GFR below 60 mL/min. High osmolar contrast should be avoided in patients with renal impairment.
6. Acetylcysteine (AC) has been advocated to reduce the incidence of CIN, however not all studies have shown a benefit and it is difficult to formulate evidence-based recommendations at this time. Its use may be considered in high risk patients but is not considered mandatory.

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**Key words** – *Contrast induced nephropathy, Renal failure, Radiographic contrast media, Acetylcysteine, Metformin*

## Introduction

The Canadian Association of Radiologists recognizes the pivotal role radiologists have in the prevention of contrast induced nephropathy (CIN) in at risk groups. These guidelines represent a practical approach to identification and management of patients at risk for CIN.

Prospective studies of patients admitted with acute renal failure (ARF) demonstrate that intravascular contrast medium (CM) was responsible in 11-14.5% of cases<sup>1-3</sup>. This supports the widespread view that CIN is one of the leading causes of ARF. The development of ARF is thus a significant complication of radiographic CM and has been associated with both excess morbidity and mortality<sup>4,5</sup>. The most common procedures associated with CIN in those studies are coronary angiography and contrast enhanced computed tomography (CT). The use of contrast enhanced CT is increasing rapidly and the total amount of CM used in radiology departments is also increasing<sup>6</sup>. These factors coupled with an increased incidence of chronic kidney disease and an aging population will result in an increased incidence of CIN unless effective preventive measures are taken.

Before contrast is administered patients should be fully assessed and precautions must be taken in patients with renal impairment. Implementation of prevention strategies is considered to be the best approach to reducing the development of CIN<sup>7</sup>.

## Methodology

Guidelines from individual Radiology departments in Edmonton, Ottawa, Sherbrooke, Vancouver and Oshawa were reviewed. Following an in-depth literature search with critical review a consensus document was drawn up by AB and RO and distributed to members of the committee. This draft document was critically reviewed and discussed via conference call by the committee members prior to release of the final document. Members of the committee represent interventional and diagnostic radiologists and nephrologists across Canada.

## Definition of contrast induced nephropathy

Contrast-induced nephropathy (CIN) is an acute decline in renal function that occurs 24 to 48 hours after intravascular injection of contrast medium (CM)<sup>7</sup>. The commonest definition in use is an increase in serum creatinine (SCr) of >25% of baseline value occurring following the intravascular administration of CM without an alternative explanation<sup>8</sup>. Serum Creatinine usually peaks 2-3 days following CM use and returns to the baseline within 14 days, however some patients progress to acute renal failure (ARF) requiring dialysis<sup>7,9</sup>.

## Renal Function Estimates

Renal impairment can be expressed using a variety of indices of renal function, including the SCr level, GFR, and creatinine clearance (CrCl)<sup>7,9</sup>. GFR and CrCl are to all intents and purposes similar and although there is variance particularly when there is a profound reduction in

renal function (due to a compensatory increase in tubular secretion), for the purposes of this document they are considered interchangeable. Despite widespread use in clinical practice, SCr as an absolute measure is an unreliable indicator of kidney function. GFR is considered to be a more appropriate index of kidney function<sup>10, 11</sup> and can be estimated from the serum creatinine (see below).

### Clinical outcomes

CIN remains one of the most serious adverse effects associated with the use of CM<sup>12</sup>. Patients with CIN experience more systemic and cardiac in-hospital complications than patients without CIN<sup>4</sup>. In-hospital death rates increase significantly among patients with CIN, as do number of days in the intensive care unit, number of days in the hospital, and the need for dialysis<sup>3, 12</sup>. Among patients who require dialysis, the median 2-year survival rate is 19%<sup>3</sup>. Even patients who do not require dialysis have dramatically increased mortality rates at 1 year<sup>13</sup>.

### At risk patients

The single most important predictor of CIN risk is chronic kidney disease (CKD) which increases the risk by more than 20 times<sup>14</sup>. Risk can be further stratified according to the K/DOQI classification based on GFR. Patients with both renal impairment and diabetes are at highest risk with up to 50% developing CIN<sup>15</sup>. Patients should be assessed for the presence of factors predictive of possible pre-existing CKD or risk of acute renal failure, particularly sepsis and hypotension (**Table 1**).

TABLE 1:

#### Risk factors for acute or chronic renal impairment and/or development of CIN.

- Diabetes mellitus
- Renal disease or Solitary kidney
- Sepsis or acute hypotension
- Dehydration or volume contraction
- Age >70 yrs
- Previous chemotherapy
- Organ transplant
- Cardio-Vascular disease (hypertension, congestive heart disease, cardiac or peripheral vascular disease) Nephrotoxic Drugs - loop diuretics, amphotericin B, aminoglycosides, vancomycin, non steroidal anti inflammatory drugs, cancer and immune suppressant chemotherapy.
- Human immunodeficiency syndrome or acquired immunodeficiency syndrome

### Identifying patients at risk:

Routine measurement of SCr in all patients undergoing injection of intravascular contrast media is logistically impractical, may delay investigation, disrupt bookings and has an associated cost<sup>16, 17</sup>. Fortunately the majority of patients developing CIN have identifiable risk factors and results from numerous studies suggest that the occurrence of CIN is directly related to the number of pre-existing risk factors<sup>18-20</sup>. In a study of CIN 32% of patients were diabetic, 40% had preexisting renal disease and 16% had both diabetes and renal disease<sup>14</sup>. Therefore, it is important to identify patients who may be most vulnerable<sup>7, 21</sup>. Methods to identify patients at risk include use of patient questionnaires, review of complete medical history and measurement of SCr prior to CM administration.

The absence of risk factors for renal disease effectively eliminates the likelihood of a patient having renal impairment<sup>14</sup>. In a study of 2034 consecutive outpatients referred for CT, only 2 patients (0.1%) had elevation in SCr in the absence of risk factors. The conclusion from this study was that by identifying risk factors the majority of patients with renal dysfunction would be identified<sup>17</sup>. This view is supported by others<sup>22-24</sup>.

As a minimum requirement it is therefore recommended that SCr (and GFR) be obtained within 3 months of the contrast procedure in the stable out-patient with one or more of the listed risk factors, and within 1 week for all in-patients. In patients with unstable or evolving disease, a more recent SCr (and GFR) should be obtained. In some institutions it may be considered safer and more practical to obtain SCr systematically in all patients referred for iodinated CM injection.

### Emergency room patients

In acutely ill patients, delays whilst awaiting SCr results may adversely affect patient care. Fortunately, evaluation of patients' known risk factors will identify almost all patients with renal impairment<sup>25</sup>. In situations where the contrast procedure cannot be delayed, patients with one or more risk factors for renal impairment should receive preventive measures empirically (including peri-procedural fluid administration, consideration of contrast agent and volume and AC when possible). It is often possible to administer a bolus of 300 to 500 mL of intravenous crystalloid during the time required to transfer the patient to the imaging department.

### Risk stratification based on GFR:

Radionuclide techniques give the most accurate measurement of GFR but are labor intensive and expensive<sup>26</sup>. Clinical assessment of GFR is usually based on plasma or serum creatinine. SCr reflects both muscle production of creatinine and renal excretion. It is therefore not reasonable to classify risk or base therapeutic decisions on the absolute value of SCr as a measure of renal function, without factoring for muscle mass.

GFR can be accurately estimated from predictive equations that take into account factors predictive of muscle mass. The MDRD (modification of diet in renal disease) and Cockcroft-Gault equations are valid in adults; the Schwartz and Counahan-Barratt equations in children<sup>11</sup>. The MDRD formula uses SCr, age and gender. It can readily be calculated by clinical laboratories, and is already reported routinely in many parts of Canada. The MDRD *estimated* or eGFR result is reported in mL/min/1.73m<sup>2</sup>: in very small individuals, the absolute GFR may be significantly lower than the reported normalized value. The Cockcroft-Gault equation utilizes SCr, age, gender and weight, and gives a result in mL/min. The Cockcroft-Gault formula may overestimate GFR by up to 20% in renal failure. Both equations are, in general, more accurate estimates of GFR than 24-hour urine creatinine clearance.

Both equations assume a relatively normal body composition; in patients with gross abnormalities of muscle mass (e.g. severe wasting, major paralysis) or gross obesity GFR will be overestimated. In these cases 24-hour urine collection for creatinine clearance may be necessary<sup>11</sup>.

**It is recommended that risk assessment be based on GFR rather than the absolute level of SCr.**

- GFR > 60 mL/min: normal or near normal renal function and **extremely low risk** for CIN. These patients require no specific prophylaxis or follow up.
- GFR below 30 - 60 mL/min: moderate renal dysfunction and **low-moderate risk** for CIN
- GFR < 30 mL/min: severe renal dysfunction and **high risk** for CIN
- GFR < 15mL/min: renal failure. These patients are usually on dialysis.
- Patients recovering from acute renal failure due to acute tubular necrosis (ATN) are at particular risk.

As shown in Figure 1, a 65 year old man weighing 72 kilograms with an GFR of approximately 30 mL/min has about a 30% to 40% risk of developing CIN.

**Prevention strategies based on GF**

General agreement exists that patients with GFR <30 mL/min are at high risk of CIN and that patients with GFR >60 mL/min are at a very low risk. The absolute risk of developing CIN in patients with GFR 30-60 mL/min (i.e. DOQI grade 3) is still open to debate and further studies are required to refine the figures. Recommended strategies are based on literature and opinion at this time and may require future adjustment.

**Risk factor reduction**

In patients with an GFR <60 mL/min, non-essential nephrotoxic medications such as NSAIDs should be discontinued prior to the procedure, ideally 2-3 days beforehand. Diuretics, especially furosemide, should be withheld at least the day of and the day prior to the procedure

(holding diuretics is a recommendation made to the referring physician who must assess if the patient can be taken off this medication in order to decrease the risk of contrast nephropathy). Other Nephrotoxic medications include antibiotics such as Amphotericin B, aminoglycosides and Vancomycin. Chemotherapies for cancer and immunological disorders also may increase the risk of CIN. Whenever possible, nephrotoxic drugs should be held for 48 hours prior to CM.

### Fluid administration

There is universal acceptance that fluid volume loading is the single most important measure that can be taken prior to intravascular CM administration and this approach is advocated in all recently published studies. Patients considered at risk for CIN should undergo volume expansion prior to CM. How this is carried out is open to debate; many studies advocate intravenous isotonic saline whilst a very favourable reduction in CIN followed isotonic sodium bicarbonate administration in one randomized controlled trial<sup>27</sup>. The minimal length of time, as well as the optimal rate and fluid composition of intravenous fluid administration are yet to be determined and further study is needed.

### Intravenous fluid administration:

- **For in-patients, the standard recommendation is:**  
0.9% NaCl at 1 mL/kg/h 12 hours pre-procedure and continue for 12 hours post-procedure<sup>28</sup>
- **When patients need to be fluid loaded for procedures scheduled the same day:**  
0.9% NaCl or NaHCO<sub>3</sub> at 1-2 mL/kg/h, 3 to 6 hours before the procedure and 6 hours after the procedure is a reasonable albeit abbreviated alternative<sup>29-31</sup>. Depending on the patient's weight, at least 300 to 500 mL of IV hydration should be received before contrast is administered.
- **A shorter IV sodium bicarbonate regimen that could be considered is:**  
NaHCO<sub>3</sub> - 3 amps (150 meq) in 850 ml D5W at 3 mL/kg/h for 1 hour before contrast administration and at 1 mL/kg/h for 6 hours after contrast administration<sup>30</sup>.

### Oral hydration:

It is recognized that intravenous fluid administration is not practical in the majority of out-patients and should be reserved for higher risk patients. For low-moderate risk out-patients, if IV fluid administration is not possible or practical, liberal oral salt and water intake and the avoidance of fluid restriction and of unnecessary diuretics may be an alternative to intravenous fluid administration<sup>32</sup>. One oral volume loading regimen to consider is as follows:

- 250 to 500 mL of saline (e.g. salty chicken soup) the day before and again on the morning of, up to 2 hours before the procedure. Liberal per oral fluids should continue for 24 hours after CM.

The key focus of these guidelines is on patients with GFR below 30 mL/min. These are the patients at high risk of CIN and in whom prevention, including intravenous fluid administration, is crucial. For patients with an GFR between 30 and 60 mL/min, the risk is lower and the population has not been well studied. It is nevertheless important to ensure that these patients are not volume depleted. Intravenous fluids should be administered to all in-patients with GFR below 60 mL/min. For outpatients, an oral fluid and salt regimen should at least be implemented to ensure adequate fluid loading. Since the exact role of oral fluids has not been established in the literature, some may elect to admit these patients to a short stay unit for intravenous fluid administration, especially if the GFR is below 45 mL/min. Evidence based recommendations in patients with GFR 30-60 mL/min are not possible at this time and preventive measures at a given institution should take all factors into account.

### Volume and frequency of administration of contrast media

The prevalence of CIN correlates with CM volume with the lowest rates of CIN occurring in patients receiving less than 100 to 140 mL. CM volumes in excess of 5mL/kg strongly predict nephropathy requiring dialysis<sup>33</sup>. A significantly increased risk of CIN has also been demonstrated among patients who received a second dose of CM within 72 hours. As a general guideline for all patients with GFR<60 it is recommended that alternative imaging studies not requiring iodinated contrast be first considered. If this is not possible, reasonable attempts to minimize contrast volume and to avoid repeat injections within 72 hours should be made.

### Metformin

Metformin is not a risk factor for developing CIN and the injection of CM is not contraindicated in patients taking it. However, serious complications (lactic acidosis) may rarely occur in patients taking metformin who subsequently develop ARF. For this reason, metformin often needs to be discontinued in patients undergoing contrast studies. Whether this should be done at the time of or 48 hours prior to the contrast injection and whether metformin must be held in all patients or only those with underlying renal insufficiency remain somewhat controversial. The monogram for Glucophage® (metformin) in the CPS (Compendium of Pharmaceuticals and Specialities)<sup>34</sup> simply recommends that, in patients in whom any contrast study is planned, metformin should be discontinued *at the time of or prior* to the procedure, and withheld for 48 hours subsequent to the procedure and reinstated only after renal function has been re-evaluated and found to be normal. The European Society of Urogenital Radiology adopts a conservative approach and recommends holding metformin at the time of injection in patients with normal SCr and 48 hours prior to injection for elective studies in patients with abnormal renal function. Other authors consider there is no longer any requirement to stop metformin for 48 hours prior to contrast injection and this view is supported by the American College of Radiology<sup>35</sup>. In our opinion, the only exception would be in a patient with marked renal impairment (GFR<30) or in ARF where, if a contrast study is deemed necessary, it would be indicated to stop metformin 48 hours prior to a non-urgent contrast injection. Furthermore,

in these patients, the indication of using metformin should be reassessed by the clinical team. Conversely, the risk to patients with normal renal function is extremely low<sup>36</sup> and based on available evidence certain authors consider it unnecessary to discontinue metformin or recheck renal function following the use of normal volumes (<100mL) of contrast media in patients with normal baseline renal function<sup>37</sup>. In summary as a minimum requirement we suggest that:

- in patients with GFR <60mL/min: Metformin should be stopped at the time of contrast injection and should not be restarted for at least 48 hours and only then if renal function remains stable (less than 25% increase compared to baseline creatinine). Other preventive measures for CIN should also be used. It is generally unnecessary to stop metformin 48 hours prior to contrast injection but special care should be taken in patients with severe or acute renal dysfunction.
- In patients with 'normal renal function' (GFR >60mL/min) who are receiving larger volumes of contrast (>100 mL), metformin should be withheld for 48 hours after the procedure.

### Prophylactic dialysis or hemofiltration

There is no evidence that dialysis either before or after contrast administration has any effect on the incidence of CIN<sup>8</sup> and therefore there is no justification for its use in this context. Hemofiltration although of benefit in high-risk patients in some studies<sup>38</sup> is too cumbersome to be of practical benefit in the majority of patients.

### Patients on dialysis

Patients should not be fluid loaded prior contrast studies. Coordination of contrast administration with the timing of hemodialysis is unnecessary. Nephrotoxicity remains a concern in patients who retain residual function and in these patients renal protective measures should be considered.

### Choice of Contrast medium:

High-osmolar CM is associated with more adverse events overall, (including CIN), than low-osmolar and iso-osmolar CM<sup>39</sup>. Therefore, the evidence clearly shows that high-osmolar CM should be avoided in patients with renal impairment. Furthermore, the Nephrotoxic Effects in High-Risk Patients Undergoing Angiography (NEPHRIC) study showed that the use of the iso-osmolar agent iodixanol (Visipaque®) reduces the incidence of CIN in high risk diabetic patients when compared with low-osmolar CM such as iohexol (Omnipaque®)<sup>40</sup>. The evidence from this well controlled randomized study shows a clear difference in nephrotoxicity between the different products. Based on available evidence, many radiology departments currently using iohexol (Omnipaque®) will opt for iodixanol (Visipaque®) in high risk patients, especially those with GFR<30.).

However, all other low-osmolar agents are not identical, and characteristics other than osmolarity may play a role in nephrotoxicity. Pooled data from various non-comparative trials, in patients with varying levels of renal risk suggest no significant differences in nephrotoxicity between iodixanol (Visipaque®) and other low-osmolar agents such as iopamidol (Isovue®) and iopromide (Ultravist®)<sup>41,46</sup>. Further comparative studies are therefore needed to determine if there is a benefit of iso-osmolar agents over other low-osmolar agents in high-risk patients.

### Gadolinium

In catheter based angiography, iodinated contrast should not be replaced by intra-arterial gadolinium in an attempt to prevent CIN. Intra-arterial injection of gadolinium is associated with nephrotoxicity<sup>40</sup> and its safety in high risk patients is unproven.

**Carbon dioxide** can be substituted for iodinated contrast in certain angiographic procedures; however the user must be familiar with the technical aspects, the risks and the interpretation of CO<sub>2</sub> angiography before considering this alternative. When used properly, there appears to be no significant nephrotoxicity associated with CO<sub>2</sub>.

Finally, **dilution** of iodinated contrast with normal saline is commonly used in digital subtraction angiography (DSA) as a technique to decrease contrast dose.

## Pharmacological Preventative Strategies:

### Acetylcysteine (Mucomyst®)

Oral administration of acetylcysteine (AC) has been shown to reduce the incidence of CIN in some studies. Nallamotheu and co-workers<sup>41</sup> recently reviewed randomized trials evaluating the efficacy of AC for lowering the risk of CIN. Overall, they found mixed results. Although, some of the studies demonstrated a significant benefit of AC in reducing the risk of CIN, other studies did not demonstrate any benefit. Therefore, at this time, it is difficult to formulate any evidence-based recommendation on the use of AC for reducing CIN, and more definitive efficacy studies are needed. It must be understood that the use of AC is adjunctive to other more important preventive measures such as hydration. Because AC is safe, inexpensive and may offer benefit, its use should be considered in patients at risk for CIN, especially those with GFR < 30 mL/min. It should be given orally at a dose of 600 mg BID the day before and the day of the procedure. It can alternately be given intravenously (150 mg/kg in 500 mL N/saline over 30 min immediately before contrast followed by 50 mg/kg in 500 mL N/saline over 4 h) as reported in a single study<sup>42</sup>. Its use is not however mandatory and contrast studies should not be cancelled or rescheduled if AC has not been given. No other medication has been reliably shown to decrease the likelihood of CIN.

### Follow up

A follow-up GFR is recommended at 48 to 72 hours in patients with GFR below 30 and should be considered in patients with GFR between 30 and 60.

### Children

This document is targeted for adult patient however general principles hold true in pediatric patients and where drugs and doses are mentioned these can be tailored for use in children provided the doses are adjusted appropriately, no contraindications exist and the product are licensed for use in children.

## CONCLUSION

CIN remains one of the most serious complications of iodinated contrast medium (CM). The Canadian Association of Radiologists considers risk prediction and preventive measures to avoid CIN necessary for optimum radiological practice. The most important risk factor for CIN is pre-existing renal impairment. Radiologists and referring physicians should be familiar with risk factors for renal disease and CIN. The baseline renal function of patients undergoing contrast studies is best assessed with calculations of GFR, such as the MDRD or Cockcroft-Gault formulae in adults. Serum Creatinine is not a reliable indicator of renal function in many patients. Using calculated GFR to assign risk levels and implement prevention strategies is considered to be the best approach to reduce the incidence of CIN.

In summary:

### **General Guidelines for All Patients with GFR < 60:**

- Avoid iodinated contrast medium (CM) whenever possible.
- Avoid Nephrotoxic drugs 48 hours before CM.
- Avoid High Osmolar CM. Use iso-osmolar or low-osmolar CM.
- Minimize contrast volume and avoid repeat contrast injection within 72 hours.
- Consider Acetylcysteine (AC). Do not delay or cancel studies for AC.

### **Specific guidelines for GFR 30 to 60:**

- Patients should not be volume contracted. Consider Oral or IV fluid administration.
- Consider follow up GFR 48 hours post CM.

### **Specific guidelines for GFR <30:**

- IV fluid administration for volume expansion (Normal Saline or Sodium Bicarbonate).
- Follow up GFR 48 hours post CM.

### **Creatinine Clearance Online Calculator Link**

<http://www.globalrph.com/crcl.htm>

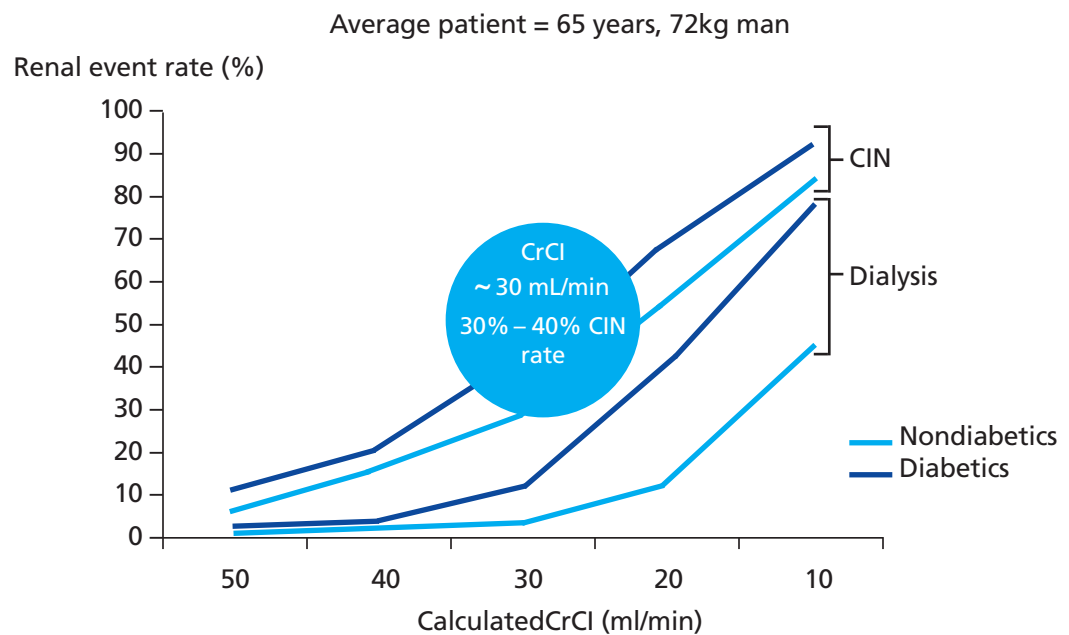
### **The Nephron Information Center Online GFR Calculator**

<http://nephron.com/mdrd/default.html>

**FIGURE 1:**

Validated risk of CIN and dialysis after diagnostic angiography and ad hoc angioplasty by creatinine clearance (CrCl) and diabetes. This assumes a mean contrast dose of 250 mL and a mean age of 65. (Adapted from McCullough PA et al<sup>43</sup> with permission.)

### Independent Predictors of CIN



Independent risk factors: CrCl >> Diabetes >> Contrast Volume

### Guidelines for screening and prevention of contrast-induced Nephropathy (CIN)

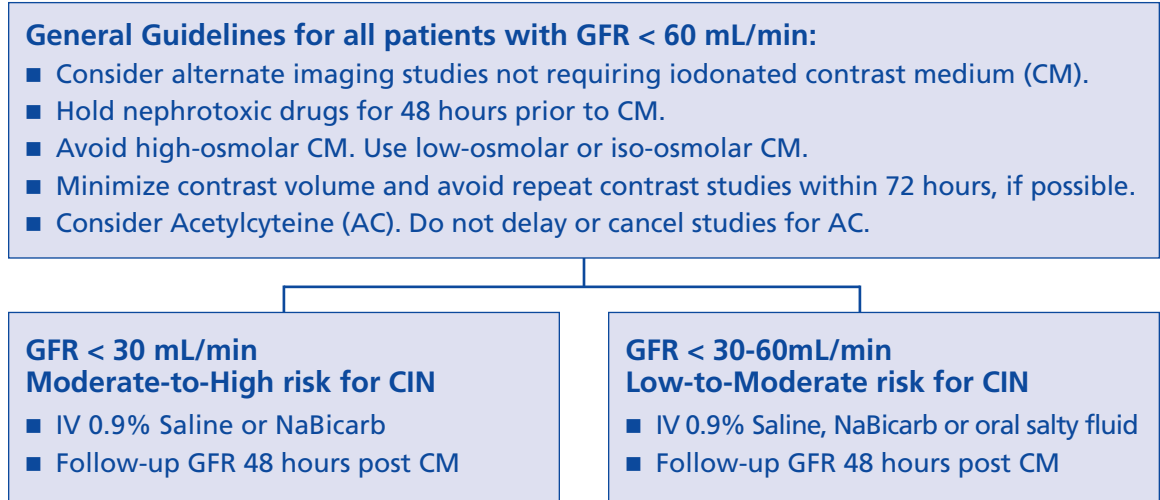
CIN is defined as a deterioration of renal function (> 25% rise in serum Creatine (SCr)) that occurs 24 to 48 hours following intravascular contrast media (CM) without other definable cause. Pre-existing renal failure is the most important risk factor.

#### Risk factors for Acute or Chronic Renal Impairment and/or CIN

- Diabetes Mellitus
- Sepsis or Acute Hypotension
- Dehydration
- Volume Contraction
- Renal Disease or Solitary Kidney
- CardioVascular Disease
- Organ Transplant
- AIDS
- Age >70 years
- Previous Chemotherapy
- Nephrotoxic Drugs

### Screening for Renal Impairment

Patients with one or more risk factor(s) for renal disease should undergo renal function testing prior to contrast, within 3 month for out-patients and within 7 days for in patients. Estimates of GFR including the MDRD and Cockcroft-Gault formulae are more reliable than SCr to estimate GFR in adults. Patients with GFR >60 mL/min are at very low risk and require no specific prophylaxis or follow up. Patients with GFR < 60 mL/min are considered at risk and the following measures are suggested:



**Peri-Procedural Fluid Administration Protocols**

**IV fluids**

1. 0.9% NaCl @ 1 mL/kg/hr for 12 hr pre- and 12 hr post-CM administration

**For same day examinations:**

2. 0.9% NaCl or NaHCO<sub>3</sub> @ 1-2 mL/kg/hr for 3-6 hr pre- and 6 hr post-CM administration

**or (if rapid fluid administration\* necessary)**

3. NaHCO<sub>3</sub> 150 mEq in 840 ml D5W @ 3mL/kg/hr for 1 hr pre and @ 1 mL/kg/hr for 3-6 hr post contrast administration. At least 300 to 500 ml of IV fluids should be given prior to CM.

**Oral fluids**

High salt diet (ie. 300-500 mL salty soup) and liberal fluids the day before, up to 2 hours prior to contrast and continued 24 hours after contrast administration.

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