



Consensus Guidelines for the Prevention of Contrast Induced Nephropathy

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Abstract

The development of contrast induced nephropathy (CIN), also referred to as contrast induced acute kidney injury (CI-AKI) is a significant complication of intravascular contrast medium (CM) use which is linked with excess morbidity and mortality. The increasing use of CM, an aging population and an increase in chronic kidney disease (CKD) will result in an increased incidence of contrast induced nephropathy (CIN) unless effective preventative measures are used. These guidelines are intended 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 (eGFR). Serum creatinine (Scr) as an absolute measure is an unreliable measure of renal function.

Identification of patients at risk

The risk of CIN increases with declining renal function. Serum Creatinine (and eGFR) should be obtained within 6 months in the stable out-patient with one or more risk factors but without significant renal impairment, and within 1 week for in-patients and patients with unstable or acute renal disease. **The main risk factors of renal dysfunction include:** diabetes mellitus, renal disease or solitary kidney, sepsis or acute hypotension, dehydration or volume contraction, age >70 yrs, previous chemotherapy, organ transplant, vascular disease.

Patients with an eGFR of ≥ 60 mL/min have an extremely low risk of CIN and generally do not require preventative measures or follow up. Furthermore, the risk of CIN and in particular poor patient outcomes following IA CM administration appears to be at least twice that following IV administration. Hence, in cases where eGFR is < 60 mL/min and IA CM is proposed preventative measures are recommended. In patients receiving IV CM the risk remains low until eGFR has declined to < 45 mL/min and in these patients preventative measures should also be instituted. Patients are most at risk for CIN when eGFR < 30 mL/min.

For remaining risk factors see [Table 1](#).

Preventative measures in patients at risk

1. Avoid dehydration.
2. Alternative imaging not requiring CM should be considered if the alternate imaging can adequately address the diagnostic questions.
3. CM volume and frequency of administration should be minimized while still maintaining satisfactory image quality. Avoid repeat CM injection within 72 hours.
4. High osmolar CM should be avoided, as iso-osmolar and low-osmolar CM have been proven safer. Local practice and preferences could dictate choice between low-osmolar and iso-osmolar CM.
5. Nephrotoxic medications should be discontinued 48 hours prior to contrast administration (see [Table 1](#)).
 - ◆ Fluid volume loading remains the single most important measure. Hydration regimens using sodium bicarbonate or normal saline may be employed. Though an initial study suggested the superiority of sodium bicarbonate, subsequent larger studies have refuted this and there is probably no difference between the two fluid regimes. Oral hydration is not an evidence-based substitute for IV hydration, although some centres might recommend it in some outpatients receiving intravenous CM, due to the impracticality of administering IV hydration in those patients.
 - ◆ We recommend intravenous hydration be considered for all patients with GFR < 60 mL/min receiving intra-arterial contrast. Where IV contrast is used preventative measures are recommended when GFR < 45 mL/min.

6. N-Acetylcysteine (NAC) was previously advocated to reduce the incidence of CIN, however there is increasing evidence suggesting it is not efficacious in preventing CIN. Its use is not therefore considered necessary, but based on its ease of use and lack of side effects centres may opt to add it to a renal protection protocol.
7. Metformin should be discontinued on the day of the proposed CM administration, withheld for the subsequent 48 hours and recommenced after renal function has been re-evaluated and found to have returned to baseline.

* See text for details and evidence base

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Key words

Contrast Induced Nephropathy, Contrast Induced Acute Kidney Injury, Chronic kidney Disease, Acute renal failure, N-Acetylcysteine, Metformin

Conflicts of Interest

RO, SH, AM, MF-H, and BB certify that there is no actual or potential conflict of interest in relation to this article.

Introduction

CIN is the development of acute kidney injury (AKI) following the administration of radiographic contrast media in the absence of other identifiable causes and is widely accepted as a leading cause of hospital-acquired acute kidney injury. Radiologists play a pivotal role in the responsible use of contrast medium and in the implementation of preventative measures to reduce the risk of CIN. These guidelines are meant to represent a practical and implementable approach to the identification and management of patients at risk of CIN.

Prospective studies of patients admitted with AKI demonstrate that intravascular contrast medium (CM) was responsible or contributory in 11-14.5% of cases^{1, 2, 3}. This supports the widespread view that CIN is one of the leading causes of AKI. The development of AKI is thus considered a significant complication of radiographic CM use and has been linked with both excess morbidity and mortality^{4, 5}. 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 increasing⁶. These factors coupled with an increased incidence of chronic kidney disease and an ageing population will result in an increased incidence of CIN unless effective preventative 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 CIN⁷.

Methodology

Members of the committee represent interventional and diagnostic radiologists and nephrologists across Canada. The previous guidelines⁸ were reviewed, changes in guidelines from individual Radiology departments in Edmonton, Ottawa, and Oshawa were also reviewed. An in depth up to date literature review was carried out to encompass new publications. A consensus document was drawn up by RO and reviewed by all members of the committee prior to release of the final document. The document was then made available to stakeholders and Canadian Association of Radiologist (CAR) members for review prior to CAR board review.

Definition of contrast induced nephropathy

Contrast-induced nephropathy (CIN) is an acute decline in renal function that occurs 48-72 hours after intravascular injection of contrast medium (CM)⁷. The commonest definitions in use are an increase in serum creatinine (SCr) of >25% of baseline value or an absolute increase in serum creatinine by at least 44 $\mu\text{mol/L}$, occurring following the intravascular administration of CM without an alternative explanation⁹. SCr usually peaks 48-72 hrs following CM use and returns to the baseline within 14 days, however some patients may progress to acute kidney injury requiring dialysis¹⁰.

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)¹¹. 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 and can be estimated from the serum creatinine (see below)¹².

Clinical outcomes

CIN remains one of the most serious adverse effects associated with the use of CM¹³. Patients with CIN experience more systemic and cardiac in-hospital complications than patients without CIN⁵. 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^{2, 13}. Among patients who require dialysis, the median 2-year survival rate is 19%². Even patients who do not require dialysis have dramatically increased mortality rates at 1 year¹⁴.

At risk patients

The single most important predictor of CIN risk is CKD which increases the risk by more than 20 times¹⁴. Risk can be further stratified according to the K/DOQI classification based on eGFR¹². It is widely accepted that the risk of developing CIN in patients with eGFR ≥ 60 mL/min is extremely low. Several studies have also suggested that a threshold for CIN exists when the eGFR is 40 – 45 mL/min and that efforts to reduce the risk of CIN should be concentrated in patients with eGFR <45 mL/min with special emphasis on those patients with severe CKD (eGFR < 30 mL/min)¹⁵. Comorbidities are also important and patients with both renal impairment and diabetes are at highest risk with up to 50% developing CIN¹⁶. Patients should be assessed for the presence of factors predictive of possible pre-existing chronic renal failure 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
◆ Acute hypotension
◆ Dehydration or volume contraction
◆ Age >70 yrs
◆ Previous chemotherapy
◆ Organ transplant
◆ Vascular disease (hypertension, congestive heart disease, cardiac or peripheral vascular disease) Nephrotoxic drugs - loop diuretics, amphotericin B, aminoglycosides, vancomycin, NSAIDs, angiotensin converting enzyme inhibitors.
◆ Human immunodeficiency syndrome or acquired immunodeficiency syndrome
◆ Collagen Vascular Disease
◆ First Nation's peoples

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^{17, 18}. 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^{19, 20, 21}. In a study of CIN 32% of patients were diabetic, 40% had pre-existing renal disease and 16% had both diabetes and renal disease¹⁴. Therefore, it is important to identify patients who may be most vulnerable^{7,22}. 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. 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 CKD would be identified¹⁸. This view is supported by others^{22, 23, 24}.

As a minimum requirement it is therefore recommended that SCr (and eGFR) be obtained within 6 months of the contrast procedure in the stable out-patient with one or more of the listed risk factors but without significant renal impairment, and within 1 week for in-patients and patients with unstable or acute renal disease. 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 in imaging whilst awaiting SCr results may adversely affect patient care. Fortunately, evaluation of patients' known risk factors will identify almost all patients with renal impairment²⁵. In situations where the contrast procedure cannot be delayed, if the patients' medical history reveals one or more risk factors for renal impairment, preventive measures (particularly pre-procedural fluid administration) should be implemented empirically, rather than risk deterioration of the patient's clinical status. It is often possible to administer a bolus of 300 to 500 mL of intravenous fluid during the time required to transfer the patient to the imaging department.

Risk stratification based on eGFR

Radionuclide techniques give the most accurate measurement of GFR but are labor intensive and expensive²⁶. Clinical assessment of GFR is usually based on plasma or serum creatinine (SCr). 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 serum creatinine levels and factors predictive of muscle mass; any such calculation will, however, be subject to issues affecting the creatinine measurement, including age, female sex, African, Asian or Hispanic ethnicity, extremes of muscle mass, and nutritional status. The MDRD (modification of diet in renal disease) and Cockcroft-Gault equations are valid in adults; the Schwartz and Counahan-Barratt equations in children¹². The MDRD formula uses SCr, age and gender to estimate GFR and is reported in mL/min/1.73m². It can readily be calculated by clinical laboratories, and is already reported routinely in many parts of Canada. The Cockcroft-Gault equation utilizes SCr, age, gender and weight, and gives a result in mL/min. Both equations are, in general, more accurate estimates of GFR than 24-hour urine creatinine clearance. Both equations assume a relatively normal body composition; eGFR calculations may be less reliable in individuals with markedly abnormal body composition, including extreme obesity, cachexia, amputations and paralysis. In these cases 24-hour urine collection for creatinine clearance may be necessary¹².

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

It is recommended that risk assessment and prophylactic strategies be based on eGFR rather than the absolute level of SCr.

- ◆ eGFR \geq 60 mL/min: **very low risk** for CIN. These patients require no specific prophylaxis or follow up.
- ◆ eGFR 45- 59 mL/min*: **low risk** for CIN. In the absence of additional risk factors patients receiving IV CM require no specific prophylaxis or follow up. For patients receiving AI CM preventative measures are recommended.
- ◆ eGFR < 45 mL/min*: **moderate risk** of CIN, preventative measures are recommended. IV hydration recommended for patients receiving intra-arterial contrast. For intravenous administration, either oral or IV hydration could be used; IV hydration being preferred if eGFR < 30 mL/min.
- ◆ Patients with unstable renal function, an acute illness and/or acute renal failure: GFR calculation in these patients is unreliable. They are thought to be at particular risk, full preventative measures, including intravenous hydration and follow up are recommended.

*The absolute risk of developing CIN in patients with eGFR 30-59 mL/min (i.e. K/DOQI grade 3) is still open to debate but the risk of developing CIN when the eGFR \geq 45 mL/min appears low and further studies are required to refine the figures. Recommended strategies are based on current literature and consensus opinion and may require future revision.

Route of CM administration

The majority of publications regarding CIN have been in patients undergoing intra-arterial (IA) contrast administration, in particular in the cardiac setting. It has been widely assumed that the risks were similar following IV CM administration, particularly in the CT setting. Several recent publications question this assumption^{15; 27; 28; 29}. In two clinical trials in patients receiving intravenous contrast involving 1075 patients only 1 case of CIN was observed in patients with an eGFR > 40 mL/min and in the 55 patients that did develop CIN none progressed to dialysis or had a fatal outcome^{30; 31}. It appears therefore that the risk of CIN and in particular the risk of a serious outcome following IV contrast use is significantly lower than that after IA contrast administration. Hence, we recommend full preventative measures for all patients with eGFR < 60 mL/min receiving intra-arterial contrast. On the other hand, for patients receiving intravenous contrast, intravenous hydration regimens are recommended when the eGFR < 45 mL/min.

Risk factor reduction

As a general guideline for all patients with eGFR<60 it is recommended that alternative imaging studies not requiring iodinated contrast be first considered.

In patients with an eGFR < 60 mL/min receiving IA CM, non-essential nephrotoxic medications such as NSAIDs should be discontinued at least 48 hrs prior to the procedure. Diuretics, especially furosemide, should be withheld at least the day prior to and the day of the procedure. (Holding diuretics is a recommendation made to the referring physician who must assess if the patient can safely be taken off this medication in order to decrease the risk of contrast nephropathy).

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. All patients considered at risk for CIN should be fluid loaded. Isotonic saline and bicarbonate solution (containing 3 ampoules/154 mmol of sodium bicarbonate in 0.85 litres 5% dextrose) are the two most commonly used crystalloids. Though initial studies and meta-analyses supported the use of sodium bicarbonate³² this beneficial effect has not been sustained in a number of subsequent trials and metanalyses^{33; 34}. The conclusion from the most recent meta-analysis was that the potential benefit, if any, of the bicarbonate based solution over normal saline was likely to be very small in clinical practice. It would appear there is little advantage in clinical practice of bicarb over normal saline. However, where hydration regimes using sodium bicarbonate have been set up it would reasonable to continue using them.

Intravenous fluid administration:

- ◆ **For inpatients, the standard recommendation is:**
0.9% NaCl at 1 mL/kg/hr for 12 hours pre-procedure and 12 hours post-procedure³⁷
- ◆ **When patients need to be fluid loaded for procedures scheduled the same day:**
Isotonic NaCl or NaHCO₃ at 3 mL/kg/hr, a minimum of 1 hour before the procedure and 6 hours following the procedure is a reasonable abbreviated alternative^{35; 36}.
- ◆ Depending on the patient's weight, **at least 300 to 500 mL of IV hydration** should be administered before contrast is given³².

Oral hydration

There is no substantial evidence that oral hydration has any effect on the incidence of CIN. It is however important to avoid fluid restriction - all patients should be encouraged to drink fluids and salt (e.g. salty soup) for volume expansion prior to the investigation, where practical. For patients requiring a period of fasting this should be kept to a minimum, in most circumstances nil by mouth for 4 hours is sufficient, for example, prior to a procedure requiring sedation.

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 dialysis³⁷. A significantly increased risk of CIN has also been demonstrated among patients who received a second dose of CM within 48 hours^{38; 39; 40}. If possible, reasonable attempts to minimize contrast volume and to avoid repeat injections within 72 hours should be made. Use of lowest concentration of iodinated contrast in mg/mL required to achieve satisfactory image quality is encouraged. It is often possible to dilute iodinated contrast further with normal saline without affecting image quality.

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 AKI. 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*)⁴¹ 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 function⁴². Other authors feel there is no longer any requirement to stop metformin for 48 hours prior to contrast injection. This view is supported by the American College of Radiology⁴³. In our opinion, the only exception would be in a patient with marked renal impairment (eGFR < 30 mL/min) or in ARF where, if a contrast study is deemed necessary, it would be appropriate 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, since the risk of metformin-induced lactic acidosis is high in those with eGFR < 30 mL/min irrespective of CM administration. Conversely, the risk to patients with normal renal function is extremely low^{42; 44} 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. In summary as a minimum requirement we suggest that:

- ◆ In patients with eGFR < 45 mL/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).
- ◆ 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.

Prophylactic dialysis or hemofiltration

CM can be easily removed with hemodialysis, however there is no evidence that this removal reduces the risk of CIN. Reduction of CIN with dialysis is also not biologically plausible since the CM would reach the kidneys within one or two cardiac cycles and subsequent removal of CM is unlikely to stop the cascade of renal injury, which would have already begun. Though one study⁴⁵ did show a reduction in CIN with hemofiltration, this result has not been reproduced by other studies and meta-analysis^{46; 47}. In patients who are already receiving renal replacement therapy, dialysis after CM administration may be helpful in individual situations only if volume loading has occurred.

Patients on dialysis

Patients undergoing hemodialysis need not be fluid loaded prior to contrast administration. 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 may be considered.

Choice of Contrast medium

Ionic and high-osmolar contrast media are associated with more adverse events overall, (including CIN), compared with low-osmolar and iso-osmolar CM and their use should be avoided in patients with CKD. The iso-osmolar CM iodixanol* (Visipaque®) became more widely used in patients with CKD following a study suggesting its superiority compared to

iohexol (Omnipaque®) in reducing CIN⁴⁸. Larger studies and meta-analyses have failed to show a significant difference between iodixanol and most other low-osmolar CM^{49; 50}. A report of the American College of Cardiology Foundation and the American Heart Association found that despite inferences of differences between different low-osmolar and iso-osmolar agents the strength and consistency of the relationships between specific agents and CIN or renal failure are inadequate to provide a guideline statement on selection among commonly used low-osmolar or iso-osmolar media⁵¹. The current CAR recommendation is to use an iso-osmolar or low-osmolar CM in patients with eGFR < 45 mL/min for intravenous CM use and GFR < 60 mL/min for intra-arterial CM studies. However, a higher risk of iohexol compared to iodixanol cannot be entirely ruled out⁴⁹. Where intra-arterial CM is to be used other considerations such as viscosity may also influence choice of CM. Many radiology departments use iso-osmolar CM in high risk patients, especially those with eGFR < 30 mL/min, and local practice could dictate choice between low-osmolar and iso-osmolar CM use.

*Iodixanol is not currently licenced in Canada for use in children.

Gadolinium

In catheter based angiography, iodinated contrast should not be replaced by intra-arterial or intra venous gadolinium in an attempt to prevent CIN. Intra-arterial injection of gadolinium is associated with nephrotoxicity⁵² and its safety in high risk patients is unproven. In patients with eGFR < 30 mL/min, who are at high risk of CIN, gadolinium also carries a risk of a rare and potentially fatal disease, nephrogenic systemic fibrosis^{53; 54}. Hence, replacement of iodinated CM with gadolinium to reduce CIN is not recommended.

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 CO₂ angiography before considering this alternative. When used properly, there appears to be no significant nephrotoxicity associated with CO₂.

Pharmacological Preventative Strategies

Acetylcysteine (Mucomyst®)

N-Acetylcysteine (NAC) has been in widespread use for the prevention of CIN in at risk populations following an initial publication by Tepel et al where 600 mg of NAC was given orally for 2 days prior to the procedure⁵⁵. Subsequently, NAC has been studied at higher doses (1200 mg bid for 48 hours) and as an intravenous formulation (total dose ranging from 2400 mg to 150 mg/kg)^{56; 57; 58}. There have been widely conflicting results with more than 40 clinical trials and 13 meta-analyses⁵⁹. There have been doubts raised about the artifactual effect of NAC on creatinine levels which may drive the positive results⁶⁰. Indeed, the most meticulous meta-analysis does not support the use of NAC to reduce CIN risk⁶¹. However, NAC use is not associated with major adverse effects (except with high-dose intravenous use which carries a risk of anaphylactoid reactions)⁵⁶ and its use is not generally contraindicated. It should, however, not be considered as a *substitute* for hydration.

Follow up

A follow-up serum creatinine measurement is recommended 48 to 72 hours after CM injection in patients receiving IA CM and should be considered in those receiving IV CM with eGFR below 45 mL/min.

Children

This document is targeted for adult patients 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.

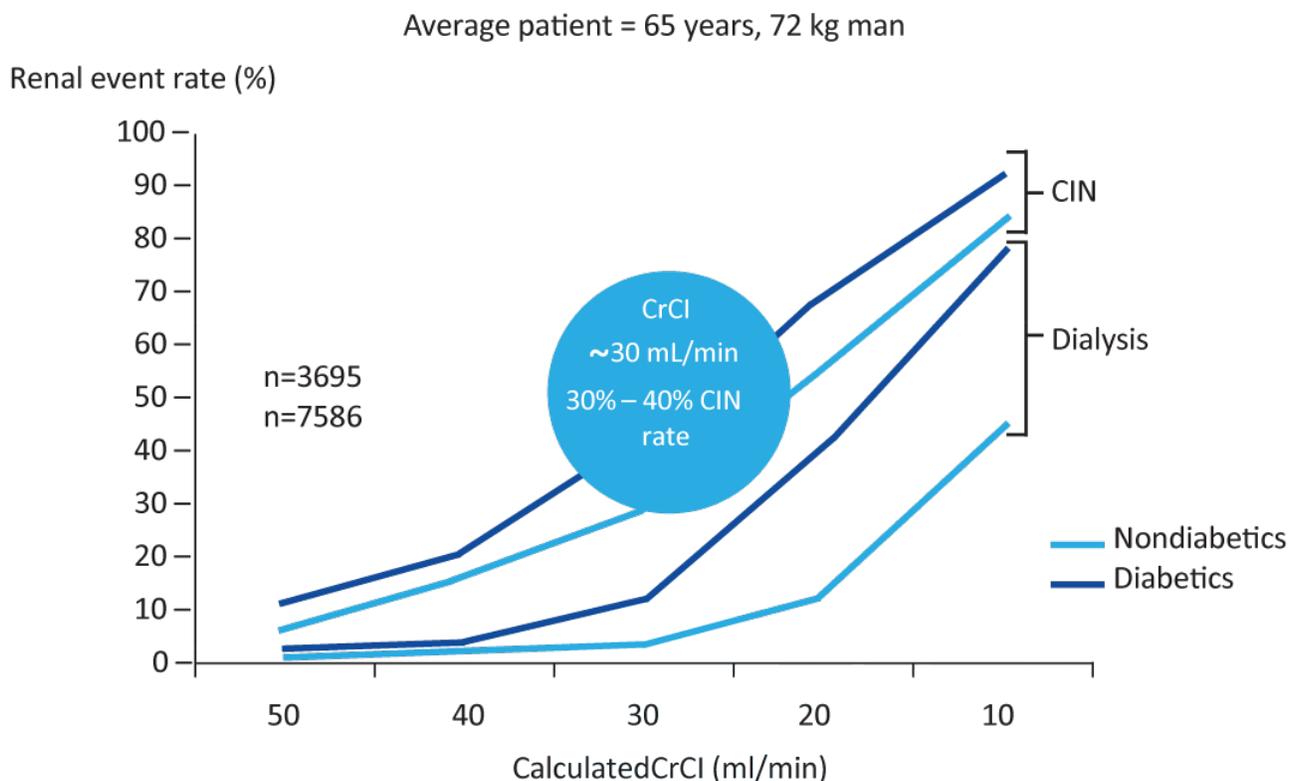
Conclusion

CIN remains one of the most serious complications arising from the use of iodinated CM. The Canadian Association of Radiologists considers risk prediction and preventative 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 the risk factors for renal disease and CIN. The baseline renal function of patients undergoing contrast studies is best assessed with eGFR using the MDRD or Cockcroft-Gault formulae in adults. SCr is not a reliable indicator of renal function. Using eGFR to assign risk levels and implement prevention strategies is considered to be the best approach to reducing the incidence of CIN.

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 al³⁵ with permission.)

Independent Predictors of CIN



IDENTIFICATION and MANAGEMENT of PATIENTS at RISK for CONTRAST-INDUCED NEPHROPATHY (CIN)

Deterioration of renal function (>25% rise in serum Creatinine (SCr)) that occurs 48 to 72 hours following intravascular contrast media (CM) without other definable cause is referred to as CIN. Some patients will progress to acute renal failure with increased morbidity and mortality. The most important risk factor is pre-existing renal impairment. Estimated GFR offers a more accurate measure of renal function than SCr.

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
- ◆ Vascular disease (hypertension, congestive heart disease, cardiac or peripheral vascular disease) Nephrotoxic drugs - loop diuretics, amphotericin B, aminoglycosides, vancomycin, NSAIDs, angiotensin converting enzyme inhibitors.
- ◆ Human immunodeficiency syndrome or acquired immunodeficiency syndrome
- ◆ Collagen Vascular Disease
- ◆ First Nation's peoples

Renal Function Screening Prior to Iodinated CM injection

Serum Creatinine (and eGFR) should be obtained within 6 months in the stable out-patient with one or more risk factors but without significant renal impairment, and within 1 week for in-patients and patients with unstable or acute renal disease.* The MDRD or Cockcroft-Gault formulae offer more reliable estimates of renal function in adults. The MDRD formula (*estimated* GFR or eGFR) corrects for body surface area and can overestimate renal function in persons with very small habitus. The (modified) Cockcroft-Gault formula calculates estimated Creatinine Clearance (CrCl)**. Both formulae are available in a variety of references, including on-line calculators.

Creatinine Clearance Online Calculator Link

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

The Nephron Information Center Online GFR Calculator

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

* In some institutions, it may be more practical to request SCr be provided for all out-patients before injection.

** CrCl and eGFR are considered similar although CrCl overestimates GFR by up to 20% in renal failure.

Which patients require Preventive Measures and Follow-up?

Patients with eGFR \geq 60 mL/min are at very low risk and require no specific prophylaxis or follow up. Dehydration should be avoided.

Patients with eGFR < 60 mL/min are considered at risk and the following additional measures are suggested:

GENERAL GUIDELINE FOR ALL PATIENTS WITH EGFR <60 mL/min:

- ◆ Avoid Dehydration
- ◆ Consider alternate Imaging studies not requiring iodinated contrast medium
- ◆ Minimize contrast medium volume
- ◆ Avoid repeat iodinated contrast studies within especially within 48 hours
- ◆ Use low- or iso-osmolar non-ionic contrast medium

- ◆ eGFR < 45 mL/min AND
- ◆ Intravenous Contrast Administration

MILD-MODERATE RISK OF CIN

- ◆ IV hydration
- ◆ Avoid dehydration (Oral fluids if IV hydration impractical)
- ◆ f/u SCr and eGFR in 48 – 72 hrs.

- ◆ eGFR < 60 mL/min AND
- ◆ Intra-arterial Contrast Administration
- ◆ OR any eGFR w/ acute illness, unstable renal function or inpatients

MODERATE-HIGH RISK OF CIN

- ◆ Hold nephrotoxic drugs (esp. NSAIDs and diuretics),
- ◆ Hydrate with IV NaCl or NaHCO₃
- ◆ Consider NAC
- ◆ f/u SCr and eGFR in 48 – 72 hrs.

PERI-PROCEDURAL FLUID ADMINISTRATION PROTOCOLS

IV FLUID

1. 0.9% NaCl @ 1 mL/Kg/hr for 12 h pre and for 12 hr post contrast administration

for same day examinations:

2. isotonic NaCl or NaHCO₃ @ 3 mL/kg/hr for 1-3 hr pre and for 6 hr post contrast administration

or

3. NaHCO₃ 150 meq in 850 mL D5W @ 3 mL/kg/hr for 1 hr pre and @ 1 mL/kg/hr for 6 h post contrast administration

❖ Depending on the patient's weight, at least 300 to 500 mL of IV fluids should be received before contrast is administered³⁹.

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