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The Impact of Multidisciplinary Nursing and Radiology Teams on Prevention of Contrast-Induced Nephropathy

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Abstract

Background: Contrast-induced nephropathy (CIN) is an important cause of acute kidney injury acquired in the hospital, accountable for increased morbidity, mortality, and healthcare costs, particularly in those who undergo contrast-enhanced imaging. Multidisciplinary nursing and radiology teams offer an unexplored strategy for CIN prevention through the delivery of coordinated care. **Aim:** This review contrasts the impact of combined nursing and radiology teams on CIN prevention, emphasizing risk stratification, hydration protocols, and contrast optimization. **Methods:** A systematic review was conducted incorporating evidence

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of CIN pathophysiology, risk factors, and prevention. Team-based intervention information, specialty-specific protocols, and outcomes were compiled. **Results:** Integrated teams successfully reduced the rate of CIN by 10–20% across interventional radiology, diagnostic CT, and cardiology clinics. Nurse-initiated hydration and risk assessment, along with radiologist-initiated contrast dose reduction, improved outcomes in high-risk groups. Barriers include inconsistent protocol adherence and knowledge gaps.

Conclusion: Multidisciplinary radiology and nursing teams enhance CIN prevention with standard protocols and cross-disciplinary skills. Standardization of protocols and emerging technologies will have to be the target of forthcoming research to further reduce CIN rates.

Keywords: Contrast-induced nephropathy, nursing, combined teams, prevention, radiology.

Introduction

Contrast-induced nephropathy (CIN), or contrast-induced acute kidney injury (CI-AKI), is a severe iatrogenic disease caused by an acute reduction of renal function following intravascular administration of iodinated contrast media. It is typically defined as an increase in serum creatinine of ≥0.5 mg/dL or a rise of ≥25% from baseline within 48–72 hours following exposure, after excluding other causes that may be discovered (1). CIN is a significant problem in clinical practice and accounts for approximately 10–12% of AKI acquired in the hospital (2). This condition is associated with severe morbidity, including longer hospital stay, increased healthcare costs, more morbidity, and higher mortality, particularly in patients with initial renal impairment or comorbid diseases such as diabetes mellitus or cardiovascular disease (3).

The growing reliance on contrast media-enhanced imaging modalities such as CT scans, coronary angiography, and other interventional radiologic procedures has increasingly demanded effective CIN prevention strategies. Low-osmolar and iso-osmolar contrast agents have reduced the risk of nephrotoxicity of contrast agents compared to conventional high-osmolar contrast agents, but this risk still exists, especially in populations at risk who might have compromised renal function before CIN or multiple risk factors (4). As a solution to this issue, collaborative radiology and nursing teams have been suggested as a new multidisciplinary approach. These combined teams balance nurses' clinical expertise in patient assessment, education, and hydration protocol implementation with radiologists' technical skills in optimizing contrast media delivery and imaging techniques. This review aims to evaluate the efficacy of combined nursing and radiology staff in the prevention of CIN and patient outcomes.

Pathophysiology of CIN

CIN pathogenesis is caused by a multifactorial interaction of pathophysiologic mechanisms, which are induced by iodinated contrast media (Figure 1). These involve direct cytotoxicity to the renal tubular cells, medullary renal hypoxia induced by vasoconstriction, and oxidative stress produced by the generation of ROS (5). When given, contrast agents induce vasoconstriction of the renal vasculature, i.e., the afferent arterioles, limiting renal perfusion and inducing ischemic injury in the oxygen-sensitive renal medulla (1). The induced ischemia, combined with the direct cytotoxicity of the contrast agents on tubular epithelial cells, can result in acute tubular necrosis in widespread cases. Besides, ROS generation increases cellular damage by oxidative stress, which disrupts cellular homeostasis and triggers inflammatory processes (6).

Recent studies have uncovered additional molecular mechanisms of CIN. For instance, studies have illustrated the role played by microRNAs in regulating critical cellular processes such as

apoptosis, pyroptosis, and autophagy during contrast media-stimulated renal cells (7). These molecular results underscore the sophistication of CIN and the necessity of goal-directed preventive therapy. Interdisciplinary radiology and nursing teams apply this information to implement measures against these mechanisms, such as restricting contrast volume to reduce tubular exposure and hydrating to avoid medullary ischemia. By controlling both the hemodynamic and cytotoxic effects of contrast media, these groups play a crucial role in preventing CIN and its complications.

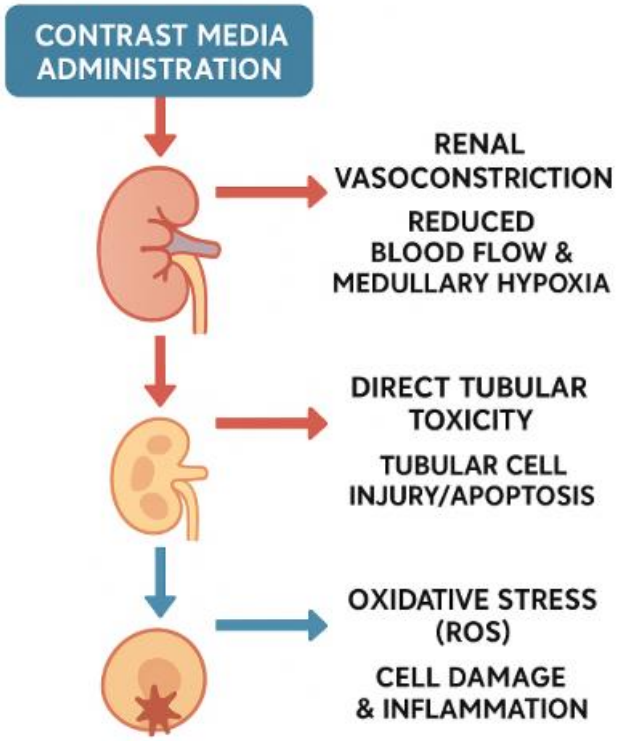

Figure 1. Pathophysiology of Contrast-Induced Nephropathy (CIN)

Risk Factors for CIN

The occurrence of CIN is influenced by numerous patient-related and procedure-related risk factors. The highest risk factor is prior renal impairment, defined as an estimated glomerular filtration rate (eGFR) of <60 mL/min/1.73 m² and carrying a 5–10-fold increased risk for CIN compared with individuals with normal renal function (8). Other confirmed risk factors include diabetes mellitus, which augments renal vulnerability through mechanisms of osmotic diuresis and endothelial dysfunction (9,10); advanced age (>70 years), which is associated with a diminished renal reserve (11); hypertension, which is associated with vascular stiffness and deficient autoregulation of the kidneys (3); and heart failure, which compromises renal perfusion secondary to reduced cardiac output (12). In addition, concomitant nephrotoxic drug exposure, for instance, NSAIDs or aminoglycosides, further increases the risk by further enhancing tubular injury (13).

The procedure-related factors are likewise highly significant. High contrast volumes (>100 mL) transmit a dose-dependent increase in risk for CIN because increased exposure raises the toxic load to the kidneys (14). The cumulative effect of multiple risk factors is of utmost concern because if there are three or more risk factors, the odds for CIN increase exponentially (15). A patient with CKD, diabetes mellitus, and older age undergoing a high contrast volume procedure is at much higher risk than a patient with a single risk factor. Table 1 is a list of risk factors and relative contribution to CIN incidence, emphasizing the need for effective pre-procedure screening by integrated teams.

Table 1. Risk Factors for Contrast-Induced Nephropathy

Risk Factor	Relative Risk Increase	Source
Pre-existing renal impairment (eGFR <60 mL/min/1.73 m²)	5–10x	(8)
Diabetes mellitus	2–3x	(9)
Advanced age (>70 years)	1.5–2x	(11)
Hypertension	1.5x	(3)
Heart failure	2x	(12)
Nephrotoxic medications	1.5–2x	(13)
High contrast volume (>100 mL)	2–3x	(14)

Preventive Strategies for CIN

Prevention of contrast-induced nephropathy (CIN) is multifactorial and comprises an integration of risk stratification, hydration techniques, optimization of contrast media, and, in some cases, pharmacologic treatments. The aim of these interventions is to reverse the nephrotoxic effect of iodinated contrast media by addressing the underlying pathophysiologic mechanisms of renal vasoconstriction, oxidative stress, and direct tubular toxicity. Each preventive technique is elaborated in detail below, based on findings from recent studies.

Risk Stratification

Effective prevention of CIN begins with risk stratification of at-risk patients through rigorous pre-procedure screening. Risk stratification involves assessment of patient-related variables like eGFR, comorbidities (diabetes mellitus, hypertension, heart failure), and medication history, as well as procedure-related variables such as contrast volume (8). Tools like the Mehran risk score, where weighted points are assigned to risk factors like hypotension, intra-aortic balloon pump, and age, are validated in predicting CIN risk in PCI patients (8). Using this standardized approach, clinicians can

give priority to preventive measures in high-risk patients for individualized measures to prevent CIN occurrence.

Hydration Protocols

Intravenous (IV) hydration is the cornerstone of prevention of CIN because it corrects renal vasoconstriction, enhances renal perfusion, and attenuates contrast media concentration in renal tubules (16). The most widely recommended regimen is normal saline (0.9% sodium chloride) at 1–1.5 mL/kg/h administered over 6–12 hours before and after contrast exposure (16). This reduces the incidence of CIN by 50–70% in high-risk patients (16). Sodium bicarbonate hydration has been proposed as an alternative, as it alkalizes urine and is considered to reduce oxidative stress by neutralizing ROS. However, no effect of the benefit of sodium bicarbonate over standard saline was shown in a meta-analysis, with equal occurrence rates of CIN (17). Protocols of hydration function optimally when initiated early and applied uniformly, stressing the importance of coordinated care by integrated teams.

Contrast Media Optimization

The amount and osmolality of the contrast media play a pivotal role in determining the risk of CIN. Low-osmolar agents (e.g., iohexol, iopamidol) and iso-osmolar agents (e.g., iodixanol) are less nephrotoxic compared to high-osmolar agents, lowering the risk of CIN by 20–30% in patients with baseline renal impairment (6). Iso-osmolar agents are particularly beneficial for CKD patients because they minimize osmotic stress on renal tubules (18,19). Also, decreasing contrast volume is crucial as doses above 100 mL increase risk for CIN by 2–3 fold (14). Techniques such as dilution of contrast (contrast: saline ratio 1:3 to 1:5) and automated contrast injection systems allow radiologists to maintain diagnostic image quality with a reduced overall contrast load (13).

Pharmacological Interventions

Pharmacologic measures have been investigated to prevent CIN, with the most studied agent being N-acetylcysteine (NAC). Antioxidant NAC is believed to antagonize oxidative stress by scavenging ROS. Randomized controlled trial meta-analysis demonstrated a minimal decrease in the incidence of CIN with NAC (risk difference = -0.07, 95% CI -0.13 to -0.01), particularly when used together with hydration, but no significant effect on dialysis or death was observed (20). The dose of NAC is 600–1200 mg by mouth twice daily for 48 hours before and after contrast exposure. Other medications, such as theophylline (adenosine antagonist) and statins, have been studied, but with inconsistent evidence to support the use of routine administration. For example, meta-analysis of theophylline did not prove to have a remarkable protective effect against CIN (21), and statins yielded inconsistent results depending on patient population and dosing interval (22). Table 2 summarizes the primary prevention strategies for CIN, their mechanism of action, efficacy, and supporting evidence.

Table 2. Prevention Strategies for CIN

Strategy	Mechanism	Efficacy	Source
IV hydration (normal saline)	Dilutes contrast, reduces vasoconstriction	Reduces CIN incidence by 50–70%	(16)
Low/iso-osmolar contrast media	Lower nephrotoxicity	20–30% risk reduction	(6)
N-acetylcysteine (NAC)	Antioxidant	Modest reduction (7%)	(20)
Sodium bicarbonate	Alkalinizes urine, reduces ROS	No significant benefit over saline	(17)
Contrast dose minimization	Reduces toxic load	Dose-dependent risk reduction	(14)

Integrated Nursing and Radiology Teams' Role

Both clinical expertise of nurses and technical expertise of radiologists combined, integrated nursing and radiology teams represent a synergistic approach to CIN prevention. The multidisciplinary team provides high adherence to evidence-based guidelines, maximizes patient outcomes, and ensures the complexities of CIN prevention at the pre-procedural, procedural, and post-procedural phases are addressed (23, 24).

Pre-Procedural Phase

Nurses have an important part to play in the pre-procedure process by completing detailed risk assessments to target vulnerable patients for CIN. This involves examining eGFR, recording comorbidities (such as heart failure and diabetes), and screening medication histories for nephrotoxic medicines such as NSAIDs or aminoglycosides using standardized checklists (25). Nurses also educate patients on the importance of fluid intake and the possible risks of contrast medium, improving compliance with preventive measures. Radiologists also select appropriate contrast media, prioritizing low- or iso-osmolar media in high-risk patients, and calculate the highest safe doses of contrast based on patient weight and renal function (e.g., volume-to-creatinine clearance ratio) (26). An outpatient CT quality improvement project demonstrated that a nurse-implemented protocol of oral hydration (1 L of water pre-procedure) and IV normal saline reduced CIN incidence by 15% compared with usual care (23).

Procedural Phase

Radiologists apply sophisticated techniques during the procedure to minimize contrast exposure without increasing diagnostic quality. These include contrast dilution (contrast: saline ratio 1:3 to 1:5) and low-dose imaging methods, such as iterative reconstruction algorithms, which reduce the amount of contrast medium necessary to achieve appropriate visualization (13). Nurses play a critical role in monitoring hydration status within patients, ensuring IV fluid maintenance is maintained to protocol, particularly for at-risk patients receiving

complex procedures like PCI. For example, aggressive hydration regimens (e.g., 3 mL/kg/h for 1 hour before PCI and 1.5 mL/kg/h for 4 hours after PCI) have been shown to significantly reduce CIN risk in patients with CKD (12).

Post-Procedural Phase

After the procedure, the renal function is assessed by serial monitoring of serum creatinine and eGFR at 48–72 hours to detect CIN early so that the intervention can be performed immediately if renal dysfunction is detected (2). They also provide continuous hydration and provide patient education for follow-up, including the avoidance of nephrotoxic drugs. The radiology staff contributes their part by interpreting imaging information and providing recommendations on the avoidance of repeat contrast exposure when not necessary, particularly in patients with borderline renal function. A single-center trial demonstrated that a multidisciplinary approach involving nurse-monitoring and radiologist-follow-up reduced post-procedure AKI by 10% in patients who were undergoing high-risk procedures (27).

Evidence from Recent Studies

Recent studies demonstrate the success of combined radiology and nursing staff in averting CIN. A 2019 patient-level study among patients undergoing coronary angiography found that a pre-procedure risk stratification, hydration, and low-osmolar contrast regime among a nurse-radiologist lowered CIN rates from 12% to 8% (28). Alike, in a 2022 study of patients with CKD concluded that team training and standardized checklists lowered the rate of CIN by 20%, showing how necessary it is to follow protocols and education (29). Nevertheless, there are still challenges, such as variable awareness of definitions and risk factors of CIN among health professionals. A 2007 survey revealed only 45% of radiologists accurately diagnosed CIN using serum creatinine criteria, with a clear requirement for continuous education and standardized protocols (24). Table 3 is a summary of key studies that evaluate the impact of combined team interventions in preventing CIN. Figure 2 summarizes the role of integrated nursing & radiology teams in CIN prevention.

Table 3. Key Studies for Combined Radiology and Nursing Teams for CIN Prevention

Study	Population	Intervention	Outcome	Source
Lambert et al., 2017	Outpatient CT patients	Nurse-led hydration protocol	15% reduction in CIN incidence	(23)
Valappil et al., 2018	Coronary angiography patients	Nurse-radiologist checklist	CIN incidence reduced from 12% to 8%	(28)
Hirano et al., 2023	CKD patients	Team training and protocol standardization	20% reduction in CIN rates	(29)
Magitta, 2024	High-risk PCI patients	Multidisciplinary protocol	10% reduction in post-procedural AKI	(27)

Figure 2. Role of Integrated Nursing & Radiology Teams in CIN Prevention

Specialty-Specific Protocols

The effectiveness of contrast-induced nephropathy (CIN) preventive interventions varies greatly across clinical specialties, depending on the differences in patient populations, procedural volumes, and contrast media requirements. This variation necessitates specialty-specific guidelines that leverage the collective expertise of the radiology and nursing departments in addressing the unique challenges shared by each specialty. By the creation and implementation of specialty-specific interventions, such as integrated teams, they enhance the precision and efficacy of CIN prevention to guarantee that preventive interventions are specific to the individual needs of patients in different contrast-enhanced procedures.

In interventional radiology, for instance, interventions such as trans arterial chemoembolization or endovascular aortic repair often employ higher contrast volumes, significantly increasing the risk of CIN, particularly in pre-existing renal impairment in patients. To minimize this risk, radiology and nursing teams use risk stratification tools, such as the Mehran risk score, to identify high-risk patients and provide preventive therapy (8). Nurses implement personalized hydration protocols, typically intravenous normal saline 1 mL/kg/h for 12 hours before and after the procedure, in an effort to optimize renal perfusion and dilute contrast media. Concurrently, radiologists use advanced techniques, such as microcatheter-directed contrast injection, to minimize contrast volume with no loss of procedural efficacy. These compounded interventions reduce the nephrotoxic insult to the kidneys, mitigating the augmented CIN risk of demanding interventional radiology procedures.

For diagnostic computed tomography (CT) scanning, contrast volumes are generally smaller than for interventional radiology, but avoidance of CIN remains necessary, especially in comorbid subjects. Nurses provide pre-procedure hydration,

typically requesting that patients receive 500 mL of oral hydration 2 hours prior to the procedure, and monitor compliance to assure an adequate hydration status (30). Radiologists assist by optimizing imaging protocols, employing techniques such as low-dose CT or multiphase imaging to reduce the amount of contrast media utilized without sacrificing image quality. This cooperation guarantees decreased CIN risk without compromising the diagnostic performance of CT scans, particularly in outpatient or elective departments where patient preparation is feasible.

Cardiac interventions, such as PCI, have a greater incidence of CIN with up to 9.9% incidence due to the procedural technical complexity and the comorbidity status in cardiac patients that encompasses diabetes and chronic kidney disease (31,32). Integrated nursing and radiology teams address this elevated risk by implementing rapid hydration protocols, such as administering intravenous normal saline at 3 mL/kg/h for 1 hour before PCI, followed by continued hydration post-procedure. Nurses closely monitor renal function using point-of-care eGFR testing to detect early signs of renal impairment, enabling timely intervention. Radiologists and cardiologists together optimize the use of contrast by choosing iso-osmolar or low-osmolar agents and using dose-sparing strategies. This is a multidisciplinary effort that provides thorough CIN prevention in response to the high-risk situation of cardiology procedures.

Challenges and Future Directions

Despite benefits, integrated teams are prone to issues like resource constraints, lack of standard protocols, and uneven levels of training. CAR guidelines indicate the need for up-to-date training and agreement protocols to fill these gaps (33). New technologies such as renal guard systems and customized dosing for contrast hold promise but require more evidence (34). Future studies should involve randomized controlled trials (RCTs) to evaluate the long-term impact of combined teams on CIN incidence, dialysis rates, and mortality. Inclusion of artificial intelligence for risk stratification and protocol modification can also enhance team performance (35).

Conclusion

Combined nursing and radiology teams are essential in reducing the incidence of CIN through coordinated risk evaluation, hydration, the best contrast dose, and post-procedure monitoring. Evidence indicates that collaborative protocols significantly decrease CIN rates, particularly in high-risk populations such as CKD or in complex procedures such as PCI. Checklists with standardization, specialty-based interventions, and repeated education are required for surpassing variable awareness barriers as well as resource constraints. Future studies will have to advance protocols, introduce new technologies like renal guard systems, and undertake randomized controlled trials in order to more firmly establish long-term advantages of multidisciplinary therapy for the prevention of CIN.

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تأثير فرق التمريض والأشعة متعددة التخصصات على الوقاية من الاعتلال الكلوي الناجم عن المادة المظللة

المستخلص

الخلفية: يُعد الاعتلال الكلوي الناجم عن المادة المظللة (CIN) سببًا مهمًا للإصابة بالضرر الكلوي الحاد في المستشفى، وهو مسؤول عن زيادة معدلات المراضة والوفيات والتكاليف الصحية، خاصة لدى الذين يخضعون للتصوير المعزز بالتباين. تقدم فرق التمريض والأشعة متعددة التخصصات استراتيجية غير مستكشفة للوقاية من الاعتلال الكلوي الناجم عن المادة المظللة من خلال تقديم رعاية منسقة.

الهدف: تهدف هذه المراجعة إلى مقارنة تأثير فرق التمريض والأشعة المشتركة على الوقاية من الاعتلال الكلوي الناجم عن المادة المظللة، مع التركيز على التقسيم الطبقي للمخاطر، وبروتوكولات الترطيب، وتحسين استخدام المادة المظللة.

الطرق: تم إجراء مراجعة منهجية تشمل أدلة على آلية حدوث الاعتلال الكلوي الناجم عن المادة المظللة، وعوامل الخطر، والوقاية. تم تجميع معلومات عن التدخلات القائمة على الفرق، والبروتوكولات الخاصة بالتخصصات، والنتائج.

النتائج: نجحت الفرق المتكاملة في خفض معدل الاعتلال الكلوي الناجم عن المادة المظللة بنسبة 10-20% عبر أقسام الأشعة التداخلية، والتصوير المقطعي التشخيصي، وعيادات أمراض القلب. أدى البدء بالترطيب وتقييم المخاطر بواسطة التمريض، إلى جانب تقليل جرعة المادة المظللة الذي يبدأه أخصائي الأشعة، إلى تحسين النتائج في الفئات عالية الخطورة. تشمل العوائق عدم الالتزام المتسق بالبروتوكولات والفجوات المعرفية .

الخلاصة: تعزز فرق الأشعة والتمريض متعددة التخصصات الوقاية من الاعتلال الكلوي الناجم عن المادة المظللة من خلال البروتوكولات القياسية والمهارات متعددة التخصصات. يجب أن يكون توحيد البروتوكولات والتقنيات الناشئة هدفًا للبحوث المستقبلية لتقليل معدلات الاعتلال الكلوي الناجم عن المادة المظللة بشكل أكبر.

الكلمات المفتاحية: الاعتلال الكلوي الناجم عن المادة المظللة، التمريض، الفرق المشتركة، الوقاية، الأشعة.