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REVIEW

Evaluation of the use of contrast agents in medical imaging

Evaluación del uso de agentes de contraste en imagen médica

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ABSTRACT

Advances in medical imaging techniques have significantly improved clinical diagnosis, and contrast agents have become essential tools in procedures such as computed tomography and magnetic resonance imaging. However, their use has been associated with significant risks, particularly contrast-induced nephropathy (CIN), which mainly affects patients with pre-existing renal or cardiovascular disease. The studies reviewed addressed the pathophysiological mechanisms of this complication, as well as the most effective prevention strategies, such as intravenous hydration and the use of agents with lower renal toxicity potential. The safety of iodinated and even gadolinium-based contrast agents was also analysed, highlighting that some compounds offered a safer profile. Despite advances, clinical controversies persisted, and the need for further research to optimise preventive management and ensure patient safety was emphasised.

Keywords: Nephropathy; Contrast; Medical Imaging; Prevention; Safety.

RESUMEN

El avance de las técnicas de imagen médica permitió mejorar significativamente el diagnóstico clínico, y los agentes de contraste se convirtieron en herramientas fundamentales en procedimientos como la tomografía computarizada y la resonancia magnética. Sin embargo, su uso implicó riesgos importantes, especialmente la nefropatía inducida por contraste (NIC), que afectó principalmente a pacientes con enfermedades renales o cardiovasculares preexistentes. Los estudios revisados abordaron los mecanismos fisiopatológicos de esta complicación, así como las estrategias de prevención más eficaces, como la hidratación intravenosa y el uso de agentes con menor potencial tóxico renal. También se analizó la seguridad de los contrastes yodados e incluso los basados en gadolinio, destacándose que algunos compuestos ofrecieron un perfil más seguro. A pesar de los avances, persistieron controversias clínicas y se subrayó la necesidad de seguir investigando para optimizar el manejo preventivo y garantizar la seguridad del paciente.

Palabras clave: Nefropatía; Contraste; Imagen Médica; Prevención; Seguridad.

INTRODUCTION

Advances in medical imaging techniques have revolutionized clinical diagnosis, allowing for more accurate detection of various internal pathologies. In this context, contrast agents have become essential for optimizing the quality of images obtained through studies such as computed tomography (CT) and magnetic resonance imaging (MRI). However, despite their diagnostic benefits, the use of these agents is not without risks, with contrast-induced nephropathy (CIN) being one of the most significant complications, especially in patients with

pre-existing risk factors. This analysis addresses the pathophysiological mechanisms, prevention strategies, and clinical considerations associated with using iodinated and gadolinium-based contrast media to provide a comprehensive overview of their safety and management in medical practice.

DEVELOPMENT

Using contrast agents in medical imaging procedures is a key diagnostic tool, particularly in computed tomography (CT) and magnetic resonance imaging (MRI). Within this category, iodinated and gadolinium-based contrast agents stand out. They mainly aim to improve the visualization of anatomical structures and internal lesions, thus allowing for more accurate diagnoses.[1]

However, one of the main risks associated with their use is contrast-induced nephropathy (CIN), a complication that manifests as acute renal dysfunction following the administration of these agents. The pathophysiological mechanisms behind CIN include renal vasoconstriction, oxidative stress, and direct tubular damage, which are well documented in the biomedical literature.[2]

The European Society of Urogenital Radiology (ESUR) has established clear guidelines to minimize the adverse effects of contrast agents, highlighting the importance of prior assessment of renal function and the use of preventive measures such as intravenous hydration for patients at risk.[3] This practice has been associated with a significant reduction in the incidence of CIN, especially when combined with the use of solutions such as sodium bicarbonate or agents such as N-acetylcysteine.[4,5]

Regarding the choice of agent type, several studies have shown that iso-osmolar contrast media, such as iodixanol, may offer greater renal safety compared to low-osmolar agents, particularly in patients with chronic kidney disease.[6,7] However, other studies have not found statistically significant differences between the two types, suggesting that further research into this relationship is needed.[8]

On the other hand, gadolinium-based contrast agents, mainly used in MRI, have been the subject of concern due to their possible association with nephrogenic systemic fibrosis (NSF) in patients with renal dysfunction. Even so, Group II compounds, such as adulterate meglumine and gadobutrol, have demonstrated a very favorable safety profile, even in patients with advanced kidney disease.[9]

Retrospective and prospective studies have confirmed that, although the overall incidence of CIN is relatively low, it increases significantly in vulnerable populations such as patients with diabetes mellitus, previous renal insufficiency, or congestive heart failure.[10,11] In this regard, risk stratification, selecting the most appropriate agent, and implementing preventive protocols are essential elements in reducing associated morbidity.[12,13]

In terms of acute adverse reactions, non-ionic iodinated contrast media have a low incidence, although cases of hypersensitivity have been reported. The severe prevalence is less than 0.01%, emphasizing the need for premedication protocols in patients with a history of allergic reactions.[14,15]

Finally, the literature suggests that oral and intravenous hydration methods may be equally effective in elective procedures, although the intravenous route is preferred in high-risk patients.[16] Despite the multiple strategies described, a robust clinical consensus on best preventive practices for CIN still needs to be established.[17]

CONCLUSIONS

Although contrast agents are indispensable diagnostic tools, their use must be accompanied by a careful risk-benefit assessment, especially in patients with renal or cardiovascular comorbidities. Implementing preventive protocols, the appropriate choice of contrast type, and proper hydration have proven effective measures to minimize the incidence of CIN and other adverse reactions. However, the variability in the findings of clinical studies highlights the need for further research to establish more precise and personalized guidelines. Ensuring patient safety without compromising diagnostic quality remains the main challenge in the clinical use of contrast media

BIBLIOGRAPHICAL REFERENCES

1. Shams E, Mayrovitz HN. Contrast-Induced Nephropathy: A Review of Mechanisms and Risks [Internet]. Cureus; 2021 May 4 [cited 2024 Oct 4]. Available from: https://www.cureus.com/articles/58401-contrast-induced-nephropathy-a-review-of-mechanisms-and-risks

2. Mamoulakis C, Tsarouhas K, Fragkiadoulaki I, Heretis I, Wilks MF, Spandidos DA, et al. Contrast-induced nephropathy: Basic concepts, pathophysiological implications and prevention strategies. Pharmacol Ther. 2017 Dec;180:99–112.

3. Contrast Media Safety Committee. ESUR Guidelines on Contrast Agents, version 10.0. European Society of Urogenital Radiology; 2018.

4. Weisbord SD, Palevsky PM, Kaufman JS, Wu H, Androsenko M, Ferguson RE, et al. Contrast-associated acute kidney injury and serious adverse outcomes following angiography. J Am Coll Cardiol. 2020 Mar;75(11):1311–20.

5. Sun Z, Fu Q, Cao L, Jin W, Cheng L, Li Z. Intravenous N-acetylcysteine for prevention of contrast-induced nephropathy: A meta-analysis of randomized, controlled trials. PLoS One. 2013 Jan 30;8(1):e55124.

6. Lee T, Kim WK, Kim AJ, Ro H, Chang JH, Lee HH, et al. Low-osmolar vs. iso-osmolar contrast media on the risk of contrast-induced acute kidney injury: A propensity score matched study. Front Med. 2022 Apr 29;9:862023.

7. Gomi T, Nagamoto M, Hasegawa M, Katoh A, Sugiyama M, Murata N, et al. Are there any differences in acute adverse reactions among five low-osmolar non-ionic iodinated contrast media? Eur Radiol. 2010 Jul;20(7):1631–5.

8. Van Der Molen AJ, Dekkers IA, Bedioune I, Darmon-Kern E. A systematic review of the incidence of hypersensitivity reactions and post-contrast acute kidney injury after ioversol in more than 57,000 patients: part 1—intravenous administration. Eur Radiol. 2022 Mar 21;32(8):5532–45.

9. Weinreb JC, Rodby RA, Yee J, Wang CL, Fine D, McDonald RJ, et al. Use of intravenous gadolinium-based contrast media in patients with kidney disease: Consensus statements from the American College of Radiology and the National Kidney Foundation. Radiology. 2021 Jan;298(1):28–35.

10. Qian G, Liu C, Guo J, Dong W, Wang J, Chen Y. Prevention of contrast-induced nephropathy by adequate hydration combined with isosorbide dinitrate for patients with renal insufficiency and congestive heart failure. Clin Cardiol. 2019 Jan;42(1):21–5.

11. Everson M, Sukcharoen K, Milner Q. Contrast-associated acute kidney injury. BJA Educ. 2020 Dec;20(12):417–23.

12. Gorelik Y, Yaseen H, Heyman SN, Khamaisi M. Negligible risk of acute renal failure among hospitalized patients after contrast-enhanced imaging with iodinated versus gadolinium-based agents. Invest Radiol. 2019 May;54(5):312–8.

13. McDonald RJ, McDonald JS, Bida JP, Carter RE, Fleming CJ, Misra S, et al. Intravenous contrast material-induced nephropathy. Contrast Media. 2013;267(1).

14. Honda T, Kuriyama K, Kiso K, Kishimoto K, Tsuboyama T, Inoue A, et al. Incidence rate of severe adverse drug reactions to nonionic contrast media at the National Hospital Organization Osaka National Hospital. Allergo J Int. 2020 Nov;29(7):240–4.

15. Cha MJ, Kang DY, Lee W, Yoon SH, Choi YH, Byun JS, et al. Hypersensitivity reactions to iodinated contrast media: A multicenter study of 196,081 patients. Radiology. 2019 Oct;293(1):117–24.

16. Cheungpasitporn W, Thongprayoon C, Brabec B, Edmonds P, O'Corragain O, Erickson S. Oral hydration for prevention of contrast-induced acute kidney injury in elective radiological procedures: A systematic review and meta-analysis of randomized controlled trials. N Am J Med Sci. 2014;6(12):618.

17. Ehrmann S, Quartin A, Hobbs BP, Robert-Edan V, Cely C, Bell C, et al. Contrast-associated acute kidney injury in the critically ill: systematic review and Bayesian meta-analysis. Intensive Care Med. 2017 Jun;43(6):785–94.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTION

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