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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.

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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 media stand out, primarily aiming 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, phenomena that 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.[3,4,5] 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.[6,7]

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.[8,9] However, other studies have not found statistically significant differences between the two types, suggesting that further research into this relationship is needed.[10]

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.[11]

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.[12,13] In this regard, risk stratification, selecting the most appropriate agent, and implementing preventive protocols are essential elements in reducing associated morbidity.

In terms of acute adverse reactions, non-ionic iodinated contrast media have a low incidence. However, cases of hypersensitivity have been reported, with a severe prevalence of 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 NIC 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 adequate hydration have proven effective measures to minimize the incidence of CIN and other adverse reactions. However, 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.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTION

Conceptualization: Aline Aparecida Pacheco; Analía Claudia Sabattini.

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