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Administration of N-acetylcysteine for contrast-induced acute kidney injury; an updated mini-review

Sam Mirfendereski[1], Mahboobe Taghipour[2], Farshad Yadollahi[3], Hadi Taghavinejad[4*], Mahdieh Ahmadnia[4]

[1]Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran
[2]Department of Internal Medicine, School of Medicine Hajar Hospital, Shahrekord University of Medical Sciences, Shahrekord, Iran
[3]Departments of Medicine, Medical School, Shahrekord University of Medical Sciences, Shahrekord, Iran
[4]Shahrekord University of Medical Sciences, Shahrekord, Iran

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ABSTRACT

Contrast-induced acute kidney injury (CI-AKI) is a potential complication of medical imaging procedures that use contrast media. It is important to identify and manage risk factors for contrast-induced nephropathy and to monitor patients for signs of renal damage after contrast administration. N-acetylcysteine (NAC) can prevent CI-AKI through multiple mechanisms of action, including reducing oxidative stress, improving renal hemodynamics, reducing inflammation, reducing apoptosis and fibrosis, reducing oxidative stress-induced DNA damage, reducing tubular cell injury, and reducing renal tubular cell apoptosis. However, the exact mechanisms of action may vary based on the specific study or context. Further research is needed to fully elucidate the molecular mechanisms of NAC in preventing CI-AKI.

Keywords: Contrast-induced acute kidney injury, N-acetylcysteine, Nitric oxide, Vasoconstriction, Prostaglandin synthesis, Tubular injury, Inflammation, Contrast-induced nephropathy, Antioxidant

Mini-Review

Implication for health policy/practice/research/medical education:
N-acetylcysteine can improve renal hemodynamics by increasing nitric oxide production, reducing vasoconstriction, increasing prostaglandin synthesis, reducing oxidant stress-mediated renal tubular injury, and reducing inflammation. These effects can help prevent CI-AKI by improving renal blood flow and oxygenation. However, the exact mechanisms of action may vary based on the specific study or context. Further research is needed to fully elucidate the molecular mechanisms of NAC in improving renal hemodynamics.

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Introduction

Contrast-induced acute kidney injury (CI-AKI) is a form of kidney damage that can occur after exposure to medical imaging contrast material. CI-AKI is most commonly defined as an acute renal failure occurring within 48-72 hours of exposure to intravenous contrast administration (1,2). Contrast-induced nephropathy is an iatrogenic disorder resulting from the administration of contrast media. The exact incidence of CI-AKI is unclear and varies depending on the definition used for contrast-induced nephropathy and the characteristics of the contrast agent (3).

The mechanism of contrast-induced renal damage is a direct injury by reactive oxygen species, along with increased oxygen consumption, across other factors risk factors for contrast-induced nephropathy, including the presence of chronic kidney disease, diabetes mellitus, high blood pressure, reduced intravascular volume, and old age (3,4).

N-acetylcysteine (NAC) has been investigated as a potential therapeutic option for preventing or reducing the severity of contrast-induced nephropathy. NAC is a precursor of glutathione, which is an important antioxidant in the body. It has been suggested that NAC's antioxidant properties and its ability to scavenge reactive oxygen species may help protect the kidneys from contrast-induced damage (5,6).

Several studies have examined the administration of NAC in patients at high risk of contrast-induced nephropathy, such as those with pre-existing renal

***Corresponding author**: Hadi Taghavinejad, Email: dr.taghavinejad@gmail.com

impairment or diabetes. The results of these investigations have been conflicting, with some showing a beneficial effect of NAC in reducing the incidence of contrast-induced nephropathy, while others have found no significant benefit. Overall, the evidence for the administration of NAC in preventing contrast-induced nephropathy remains inconclusive (7,8). In this mini-review, we sought to summarize the administration of NAC in preventing or treating contrast-induced nephropathy.

Search strategy

For this review, we conducted searches on various databases including PubMed, Web of Science, EBSCO, Scopus, Google Scholar, Directory of Open Access Journals (DOAJ), and Embase. We used a range of keywords such as contrast-induced acute kidney injury, n-acetylcysteine, nitric oxide, vasoconstriction, prostaglandin synthesis, tubular injury, inflammation, antioxidant, apoptosis, contrast-induced nephropathy, and fibrosis.

Effectiveness of NAC in preventing CI-AKI

The effectiveness of NAC in preventing CI-AKI is still a topic of debate. While some studies have found that NAC is associated with preventing CI-AKI, others have found no significant effect. A systematic review and meta-analysis of randomized controlled trials was conducted to determine the effectiveness of NAC in preventing CI-AKI. The review found that NAC was associated with preventing CI-AKI (9). However, a large randomized trial found that acetylcysteine did not diminish the risk of CI-AKI or other renal outcomes in individuals undergoing coronary and peripheral vascular angiography (10).

A previous systematic review by Busch et al of six studies on the administration of NAC in preventing CI-AKI found that only one study showed that the administration of NAC prevented renal injury (11). Moreover, Magner et al in another meta-analysis, found that NAC reduced both the incidence of CI-AKI and the need for kidney replacement therapy (12).

Mechanism of action of NAC

The suggested mechanisms of NAC in preventing CI-AKI are due to the following properties of this agent. 1) Diminishing direct oxidative stress. This drug is a precursor of glutathione, which is an important antioxidant in the body. By increasing glutathione levels, NAC can scavenge free radicals and reduce oxidative stress, which is a major contributor to CI-AKI. 2) Improving renal hemodynamics since NAC can also improve renal blood flow and oxygenation, which can help prevent CI-AKI. This effect may be due to NAC's ability to increase nitric oxide production and reduce vasoconstriction. 3) Some studies suggest that NAC may have broader kidney-protective effects beyond preventing direct contrast-medium-induced nephrotoxicity. For example, NAC may reduce inflammation, apoptosis, and kidney fibrosis, which can help prevent CI-AKI. 4) CI-AKI can also be caused by inflammation in the kidneys. This compound also has anti-inflammatory properties and can reduce kidney inflammation, which can help prevent CI-AKI. 5) Several studies suggest that CI-AKI can also be caused by apoptosis and fibrosis in the kidneys. NAC can reduce apoptosis and kidney fibrosis, which can help prevent CI-AKI. 6) NAC has anti-inflammatory properties and can reduce kidney inflammation, which can help prevent CI-AKI. 7) This medication can also reduce apoptosis and fibrosis in the kidneys, which can help prevent CI-AKI. Further, 7) NAC can reduce oxidative stress-induced DNA damage, which can help prevent CI-AKI. Meanwhile, 8) NAC can reduce tubular cell injury caused by contrast media, which can help prevent CI-AKI. Finally, 9) NAC can reduce renal tubular cell apoptosis caused by contrast media, which can help prevent CI-AKI (13-17).

Conclusion

NAC can prevent CI-AKI through multiple molecular mechanisms, including reducing oxidative stress, improving renal hemodynamics, reducing inflammation, reducing apoptosis and fibrosis, reducing oxidative stress-induced DNA damage, reducing tubular cell injury, and reducing renal tubular cell apoptosis. However, the exact mechanisms of action may vary based on the specific study or context. Further research is needed to fully elucidate the molecular mechanisms of NAC in preventing CI-AKI.

Authors' contribution

Conceptualization: Sam Mirfendereski, Hadi Taghavinejad.
Data curation: Hadi Taghavinejad.
Investigation: Hadi Taghavinejad.
Resources: Mahdieh Ahmadnia, Sam Mirfendereski.
Supervision: Hadi Taghavinejad.
Validation: Hadi Taghavinejad, Sam Mirfendereski.
Visualization: Hadi Taghavinejad.
Writing–original draft: Hadi Taghavinejad, Sam Mirfendereski.
Writing–review and editing: Mahboobe Taghipour, Farshad Yadollahi.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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