Device-Based Therapy in the Prevention of Contrast-Induced Nephropathy

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KEYWORDS

• Device-based therapy • Prevention • Contrast-induced nephropathy • Coronary angiography

KEY POINTS

- Comprehensive strategies are required to reduce the risk of contrast-induced nephropathy in high-risk populations and in scenarios whereby patients are undergoing coronary angiography and intervention.
- Simple medical devices have been developed to reduce radiographic contrast dose and renal exposure and to optimize hydration.
- Ongoing studies are being conducted to investigate the efficacy of these devices and to examine the practicalities of their incorporation in routine clinical practice.

INTRODUCTION

Acute kidney injury after exposure to radiographic contrast media, contrast-induced nephropathy (CIN), is a major cause of acute renal failure associated with significant morbidity and mortality.[1] The incremental presence of predisposing factors, including preexisting chronic kidney disease (CKD), contrast volume, diabetes, and advancing age, contributes significantly to the risk of CIN, which may exceed 30% in the highest-risk patients.[2] Given the frequent coexistence of some of these risk factors in patients with atherosclerosis, individuals undergoing coronary angiography or coronary intervention represent a particularly high-risk group. The development of CIN has major clinical implications, with associated higher periprocedural mortality, longer hospitalization, and risk of permanent renal injury requiring long-term renal replacement therapy. In this context, there has been considerable interest in the development of strategies to reduce the risk of CIN, including a range of pharmacologic[3] and device-based approaches. As reviewed elsewhere, pharmacologic approaches have yielded somewhat variable effects of the incidence of CIN, leading to increasing interest in other techniques that may be more efficacious in the prevention of CIN.

Importantly, the applicability of the various preventive interventions must also be considered in light of the specific clinical scenario. For example, the development of CIN in patients presenting with ST elevation myocardial infarction is associated with a particularly poor outcome. Given the time imperative in this patient group, only effective strategies that can be rapidly implemented and do not require a period of precontrast exposure will be practical in order to avoid any delay in the time

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to coronary intervention. Similarly, the use of other strategies, such as aggressive volume loading, is limited by the presence of left ventricular dysfunction or other causes of significantly elevated left ventricular end-diastolic pressure.

In this article, the authors review the various device-based approaches that have been evaluated as interventions to reduce the risk of CIN. From a conceptual standpoint, a range of device-based strategies has been developed to potentially mitigate the risk of CIN by addressing one or more of several key targets, including the minimization of contrast volume, removal of radiographic contrast to limit renal exposure, and the direct mitigation of contrast-induced renal injury (**Fig. 1**, **Table 1**).

Reducing Radiographic Contrast Volumes

It is well established that the volume of contrast injected during a procedure is a major risk factor for the development of CIN,[4] particularly when repeat delivery of contrast is performed early after the index procedure.[5] Within some high-risk patient populations, the risk of CIN may increase up to 40% with every additional 5 mL of contrast media used.[6] In this context, however, progress in interventional cardiology has seen the use of increasingly complex coronary interventions that require large contrast volumes; this is often coupled with the increasing prevalence of well-established risk factors for CIN in the interventional population, including preexisting CKD, aging, diabetes, heart failure, and ST elevation myocardial infarction (STEMI). Therefore, the limitation of contrast volumes should be a key objective in at-risk individuals; however, this may come at the cost of image quality. One potential source for mitigation of largely wasted contrast volume is that attributable to excess coronary ostial reflux. Although the exact amount of contrast reflux has not been precisely determined, it has been previously shown to be present in more than 60% of contrast injections.[7] Recently, a device designed to attenuate the loss of contrast caused by reflux by altering the contrast injection pressure profile (AVERT, Osprey Medical, Minneapolis, MN) was shown to reduce contrast volumes by approximately 40% without significant loss of image quality.[8] The influence of this approach on the incidence of CIN is currently being evaluated in a randomized clinical trial (AVERT Clinical Trial, NCT01976299).

The use of automated contrast injection systems has also been proposed as a means of limiting the volume of radiographic contrast[9] and possibly the incidence of CIN.[10] Recently, however, Gurm and colleagues,[11] in a large registry study, demonstrated that automated injection systems reduced contrast volumes by less than 3%, and there was no impact on the rate of CIN.

REMOVAL OF CONTRAST MEDIA

Following coronary delivery of iodinated radiographic contrast, the possibility of removing

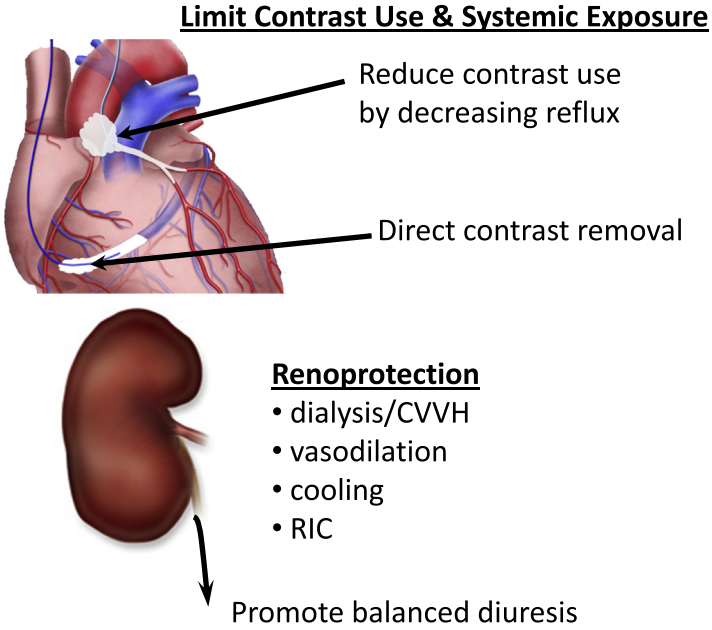

Fig. 1. General schema of potential device-based approaches for the prevention of CIN. CVVH, continuous veno-veno hemofiltration; RIC, remote ischemic conditioning.