Short Communication

Interventional Cardiology

Practice of intravascular imaging in percutaneous coronary interventions with ultra-low or zero contrast

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Abstract

Percutaneous Coronary Intervention (PCI) offered an advance in the management of Coronary Artery Disease (CAD). The use of contrast media agents was essential in this procedure. However, the usage of these agents can pose a serious risk of nephrotoxicity and Contrast-Induced Nephropathy (CIN) in specific high-risk groups of patients. The utilization of Ultra-Low Contrast PCI (ULPCI) procedures offers a tempting solution to this problem. This article provides a brief presentation of these techniques while discussing their need, their clinical usage and the important role of intravascular imaging modalities, especially Intravascular Ultrasound (IVUS), that facilitate their implementation.

Keywords: Percutaneous coronary intervention; Intravascular imaging; Intravascular ultrasound; Contrast-induced nephropathy

Introduction

Since the beginning of interventional treatment for Coronary Artery Disease (CAD), Percutaneous Coronary Intervention (PCI) has been at the forefront of treatment options. The procedure of PCI was accidentally interconnected with the usage of intravenous contrast agents. The coronary lumen can be visualized under fluoroscopy and lesion identification, assessment and intervention can be performed [1]. However, contrary to their well-established advantages of contrast media, it is also well-known that these agents could cause several adverse effects such as severe allergic reactions or nephrotoxicity [2]. A recent review by Dimitriadis, et al., [3], offers a brief review of the need, the benefits and the different Ultra-Low Contrast PCI (ULPCI) techniques, proving their importance in the modern era of interventional cardiology.

Description

ULPCI procedures offer a novel way of reducing contrast exposure in patients at high risk of nephrotoxicity. ULPCI is determined as a coronary intervention, where the ratio of contrast media administered to the estimated Glomerular Function Rate (eGFR) is equal to less than 1 (contrast volume/eGFR<1) [4]. A well-described manifestation of nephrotoxicity caused by intravenous contrast agents, especially in a PCI setting, is Contrast-Induced Nephropathy (CIN). By definition it is a post-intervention renal impairment, presented as a quarter or 0.5 mg/dL increase of plasma creatinine levels, compared with the baseline values, within 2-3 days after the injection of the contrast solution [5]. An alternative definition endorsed by a Kidney Disease Improving Global Outcomes (KDIGO) statement defines CIN as: (a) 50% increase in serum creatinine levels over 7 days after the contrast administration; (b) an increase in plasma creatinine levels by 0.3 mg/dL in the first 2 days post-administration in contrast to baseline; or (c) urinary excretion less than 0.5 mL/kg/h for over a 6 hour-period after the procedure [6]. Despite the fact that the incidence of CIN post-angiography varies

among studies, in a meta-analysis it is estimated at 9.6% [7]. The risk of developing CIN can be predicted according to multiple risk factors. The most common one is Chronic Kidney Disease (CKD) [8,9], and others involve age, volume of contrast administered, atrial fibrillation, diabetes, acute coronary syndrome presentation, heart failure and anemia [10-12]. Considering the high prevalence of CKD in patients with CAD it is well-evident that the incidence and the risk of developing CIN will increase, especially as a lot of these patients need to be treated with PCI.

At the forefront of intravascular imaging in a ULPCI setting, Intravascular Ultrasound (IVUS); an endovascular imaging modality that allows a live 360° cross-sectional image of the vascular system and specifically the coronary arteries, has been widely used, not necessitating the usage of a contrast agent. Further advantages include discrimination and characterization of coronary artery plaques due to the difference in echogenicity of structures at the coronary wall, optimization of stent landing zone and evaluation of post-implantation stent failures, even in complex lesions' interventions that require a large volume of contrast media. However, IVUS lacks in assessing some PCI complications, such as distal embolization. Some trials suggest the use of a low-dose contrast injection to estimate potential complications [13,14], while others adopt an "absolute zero contrast" strategy [15]. The possible side effects of low-dose contrast injection in high-risk patients are yet to be determined. The commentary offered a concise summary of the most important clinical trials that support IVUS effective usage in ULPCI. For example in the MOZART trial, a randomized control study where 83 patients were submitted to either an angiography-guided PCI (n=42) or an IVUS-guided strategy (n=41), it was shown that in the group following an IVUS-guided strategy, the total contrast volume injected was significantly reduced (64.5 mL vs. 20.0 mL, $p<0.001$), as well as the contrast volume°creatinine ratio (1.0 vs. 0.4, $p<0.001$); no statistically significant difference in the creatinine levels or the incidence of CIN post-operatively [13]. However, IVUS does indeed have some limitations in need for further consideration. Specific coronary anatomies such as heavily calcified lesions and tortuous or dilated vessels may not allow probe insertion, effective visualization of the coronary arteries and intervention results. Other ULPCI techniques could involve the usage of Optical Coherence Tomography (OCT) and a novel technology called co-registration.

OCT has better optical discrimination and intravascular visualization capabilities than IVUS [16]. The main disadvantage of the technique is the need for a large amount of contrast for depiction [17]. However, by employing agents such as dextran and colloid infusate, the technique shows promising outcomes in the bibliography [18-20]. A new technology, named co-registration, has been recently described as a combination of IVUS with angiographic images [21]. Dimitriadis, et al., [3], offered a brief description of the technique where the fluoroscopic and IVUS images are automatically merged, allowing for simultaneous estimation of the cross-sectional IVUS images along the coronary artery of interest, which is visualized in the angiogram. In ULPCI settings an intracoronary wire angiographic view contributes to a zero-contrast procedure. Using this method enables the correlation of lesions identified by IVUS with their corresponding positions in the initial angiogram and helps to minimize the amount of contrast injected.

Further research is needed to establish these techniques as an alternative or even an equivalent to IVUS ULPCI intervention.

Conclusion

CAD patients, who are at a high risk of developing CIN, or those with a known history of contrast media allergy, may find it beneficial to reduce or avoid the use of contrast media during PCI procedures. Furthermore, for PCI of complex lesions that typically require a large volume of contrast media, the use of ULPCI presents an opportunity to minimize the amount of contrast media used, regardless of the patient's risk of CIN. In recent years, there has been a growing body of research emphasizing the importance of intravascular imaging, particularly IVUS, in ULPCI procedures. By utilizing IVUS, physicians can obtain a clearer view of the patient's vessels and better assess the severity of the disease, leading to more precise and effective interventions. Studies have shown that these techniques are both effective and safe in high-risk patients. However, it has been suggested that larger randomized trials are necessary to fully incorporate these methods into everyday practice.

Conflicts of Interest

The authors declare no conflict of interest.

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