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EDITORIAL COMMENT

Outcomes of Intracoronary Imaging-Guided PCI in Patients With Dialysis

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Chronic kidney disease is a global public health problem associated with markedly high mortality and health care costs.[1] Around 4 million individuals with kidney failure are treated with kidney replacement therapy globally,[2] and hemodialysis (HD) is the most common type of dialysis accounting for approximately 70% of all kidney replacement therapy.[3] Despite notable advances in dialysis technology over the last 6 decades since the inception of HD, the 1-year mortality rate remains high among patients undergoing dialysis, ranging from 6.6% in Japan to 21.7% in the United States.[4] Cardiovascular disease affects more than two-thirds of patients receiving HD, and accounts for almost 50% of mortality.[5] In addition to the high prevalence of conventional cardiovascular risk factors including diabetes and hypertension, several dialysis-specific factors such as uremic toxin accumulation, increased inflammation, greater oxidative stress, and abnormal calcium-phosphorus metabolism may contribute to this increased cardiovascular risk.[6] Coronary arteries in dialysis-dependent patients have been shown to exhibit more atherosclerotic changes and extensively distributed coronary calcium,[7] which may adversely impact the effective dilation of a coronary stenosis and thus procedural results.

There is a growing body of evidence that percutaneous coronary intervention (PCI) guided by intracoronary (IC) imaging such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT) improves not only acute procedural results but also subsequent clinical outcomes. A recent meta-analysis synthesizing data from 25 randomized controlled trials comparing IC imaging- vs angiography-guided PCI (n = 17,128) has demonstrated that IC imaging guidance was associated with a reduced risk of cardiac death, target lesion revascularization, and stent thrombosis.[8] Previous studies have consistently shown that lesions with greater complexity (ie, long lesion, unprotected left main, chronic total occlusion) derive more benefits by IC imaging guidance. Thus, international guidelines on myocardial revascularization recommend the use of IC imaging (ie, IVUS and OCT) for procedural guidance, particularly in complex lesions (American College of Cardiology/American Heart Association: Class IIa[9] and European Society of Cardiology: Class I[10]).

In this issue of *JACC: Asia*, Lin et al[11] compare clinical outcomes among patients with maintenance dialysis undergoing IVUS-guided (n = 4,316) or OCT-guided PCI (n = 443) between 2015 and 2021 using the Taiwan National Health Insurance Research Database of the National Health Insurance program, which covers >99% of the Taiwanese population. There was a notable increase in the use of IC-imaging guidance from 3.1% in 2012 to 27.5% in 2017, with more utilization of IVUS (24.8%) than OCT (5.5%). The average dialysis duration of the current cohort was 5.6 years, and the major dialysis modality was hemodialysis (92.2%). Cardiovascular risk factors were frequent (hypertension 94%, diabetes 76%, and dyslipidemia 52%), and 31% of patients presented with acute coronary syndrome. Complex PCI, defined as ≥2 vessels intervened or ≥3 stents implanted during the index admission in the current study, was performed in 53% of patients. In the whole cohort, an incidence of major adverse cardiovascular endpoints (MACE), defined as a composite of cardiovascular death, acute myocardial infarction, and revascularization, was extremely high (≈60%) during a mean follow-up period of 2 years. After propensity score matching, there was no significant difference between the IVUS- and OCT-guided PCI groups in MACE (42.1 vs 47.6 events per 100 person-years; HR: 0.88; 95% CI: 0.74-1.06). Similarly, no significant differences in the primary endpoint were observed across

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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TABLE 1 Summary of Exclusion Criteria Regarding Renal Function in Previous Intracoronary Imaging Trials

Study Name or First Author	Year	N	Imaging Modality	Exclusion Criteria Regarding Renal Function	% of Included Patients With Dialysis	% of Included Patients With Renal Failure	Definition of Renal Failure
HOME DES IVUS	2010	210	Angiography vs IVUS	NA	NA	NA	NA
Habara et al	2012	70	OCT vs IVUS	Cr >2.0 mg/dL	NA	NA	NA
AVIO	2013	284	Angiography vs IVUS	Cr >2.0 mg/dL	NA	NA	NA
RESET	2013	543	Angiography vs IVUS	Cr >2.0 mg/dL	NA	NA	NA
MOZART	2014	83	Angiography vs IVUS	Unstable or unknown renal function	NA	44.6%	CCr <60 mL/min
Wang et al	2015	80	Angiography vs IVUS	Renal dysfunction	NA	NA	NA
AIR-CTO	2015	230	Angiography vs IVUS	Cr >2.5 mg/dL	NA	5.7%	Chronic renal insufficiency
Kim et al	2015	117	Angiography vs OCT	Cr ≥2.0 mg/dL	NA	NA	NA
Tan et al	2015	123	Angiography vs IVUS	NA	NA	NA	NA
CTO-IVUS	2015	402	Angiography vs IVUS	Cr ≥2.0 mg/dL or ESRD	NA	NA	NA
OCTACS	2015	100	Angiography vs OCT	Cr >170 μmol/l	NA	NA	NA
DOCTORS	2016	240	Angiography vs OCT	eGFR ≤30 mL/min	NA	NA	NA
OPINION	2017	817	OFDI vs IVUS	eGFR ≤30 mL/min/1.73 m^2 or Cr ≥1.5 mg/dL	NA	NA	NA
ROBUST	2018	201	Angiography vs OCT	Cr >2.0 mg/dL	NA	NA	NA
Liu et al	2019	327	Angiography vs IVUS	Renal failure	NA	NA	NA
Lee et al	2020	176	Angiography vs OCT	Cr ≥2.0 mg/dL or ESRD	NA	NA	NA
IVUS-XPL	2020	1,400	Angiography vs IVUS	Cr >2.0 mg/dL	NA	NA	NA
OPTIMUM	2020	105	Angiography vs OFDI	GFR <45 mL/min	NA	NA	NA
OPTICO BVS	2020	38	Angiography vs OCT	CCr <45 mL/min or dialysis	NA	NA	NA
ILUMIEN 3	2021	450	Angiography vs OCT vs IVUS	No dialysis and eCCr <30 mL/min	NA	NA	NA
ULTIMATE	2021	1,448	Angiography vs IVUS	NA	NA	NA	NA
iSIGHT	2021	51	Angiography vs OCT vs IVUS	eGFR <50 mL/min/1.73m^2	NA	NA	NA
EROSION 3	2022	226	Angiography vs OCT	Cr >2.0 mg/dL or ESRD	NA	NA	NA
HONEST	2022	75	Angiography vs OCT	Cr >150 μg/L	NA	NA	NA
RENOVATE-COMPLEX-PCI	2023	1,639	Angiography vs Imaging	NA	NA	18.1%	Chronic renal insufficiency
OCTOBER	2023	1,201	Angiography vs OCT	eGFR <50 mL/min/1.73 m^2	NA	2.2%	Renal failure
OCTIVUS	2023	2,008	OCT vs IVUS	No dialysis and eGFR <30 mL/min/1.73 m^2	2.3%	NA	NA
ILUMIEN 4	2023	2,487	Angiography vs OCT	No dialysis and eGFR <30 mL/min/1.73 m^2	2.1%	17.9%	CCr <60 mL/min
IVUS-ACS	2024	3,505	Angiography vs IVUS	eGFR <20 mL/min/1.73 m^2	NA	7.4%	eGFR <60 mL/min/1.73 m^2

CCr = creatinine clearance; Cr = creatinine; eCCr = estimated creatinine clearance; eGFR = estimated glomerular filtration rate; ESRD = end stage renal disease; GFR = glomerular filtration rate; IVUS = intravascular ultrasound; NA = not available; OCT = optical coherence tomography; OFDI = optical frequency domain imaging.

several subgroups including dialysis duration, dialysis modality, presentation, PCI complexity, and the PCI volume. As noted by the authors, most trials evaluating the benefit of IC imaging-guided PCI have either consistently excluded patients with renal failure or included too few to draw a definitive conclusion of treatment benefits (**Table 1**). Given that only limited observational data are available to date, the current study is an important addition to the body of evidence investigating the role of IC imaging in optimizing PCI among patients with dialysis.

Previous autopsy and in vivo imaging studies have clearly demonstrated a link between renal dysfunction and accelerated calcified plaque formation.[7,12] A uremic environment may in part explain this extensive calcification in HD patients by stressing inhibitory mechanisms of calcification and promoting calcium deposition.[13] Heavily calcified coronary artery lesions hinder the delivery of devices and limit stent expansion, resulting in low procedural success and poor clinical outcomes driven by an increase in restenosis and stent thrombosis. In this regard, IC imaging can provide useful information on precise lesion assessment with a detailed analysis of calcium distribution. In particular, the prestenting assessment is a critical step in calcified lesions to judge the need for lesion preparation with atherectomy devices because treating stent underexpansion because of a heavily calcified lesion is much more challenging and should be avoided. The IVUS- and OCT-derived calcium scores which incorporate morphological characteristics of calcified plaque such as angle, length, thickness, and the presence of calcified nodule are useful to predict stent underexpansion and thus to decide the use of atherectomy devices.[14,15] Unlike IVUS, which is based on ultrasound waves, OCT uses a near-infrared light and can measure calcium thickness. A previous OCT study reported that the optimal threshold of calcium thickness was 0.67 mm to create calcium fracture, an important surrogate marker for better stent expansion.[16] In this regard, OCT may have an advantage over IVUS for the treatment of calcified lesions; however, in line with the previous meta-analysis, clinical outcomes were comparable between IVUS and OCT in the current study.[8] Collectively, although the clear benefit of IC imaging guidance in severely calcified lesions has not been shown in the subgroup analysis of previous imaging randomized controlled trials,[17,18] IC imaging guidance should be more encouraged in this patient subset with greater PCI complexity than general PCI population.

The findings of the present study using the national administrative database should be interpreted in view of several limitations. First, how IC imaging was used (ie, pre- and post-PCI) and whether optimal PCI results were achieved remains unclear. Second, the clinical endpoints assessed in the present study reflect patient- rather than lesion-oriented outcomes, which limits the ability to estimate underlying mechanisms of an increased ischemic risk and benefit of IC imaging on prognosis. Third, because of the inherent limitation of administrative data, there are several unmeasured confounding factors such as stent length, stent diameter, and lesion characteristics. Finally, there was a significant imbalance in the number of patients undergoing IVUS and OCT (4,316 vs 443 patients). Although the propensity score matching was performed, there may be a substantial selection bias. The operators might be more experienced with IVUS and lesions treated with OCT might be simpler because of the need for blood clearance. Indeed, the incidence of clinical events were numerically lower in the OCT group.

Patients undergoing dialysis represent a high-risk population with greater coronary lesion complexity and an increased risk of cardiovascular events. Greater use of IC imaging for complex PCI procedures appears to be the simple and straightforward approach to mitigate the ischemic risk after PCI in patients with dialysis. Major barriers for the broader use of IC imaging, including concerns regarding cost, safety, additional procedural time, and operator expertise, should be overcome. Given the substantial under-representation of this patient group in the previous trials, high-quality data including dialysis patients are required to establish the optimal management strategy of this complex population.

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