Staged Percutaneous Coronary Intervention with Rotational Atherectomy or Bypass Surgery in Chronic Hemodialysis and Severely Calcified Left Main True Bifurcation Lesion: A Case Report and Literature Review

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ABSTRACT: Previous observational studies and meta-analyses reported that the optimal strategy of coronary revascularization (percutaneous coronary intervention [PCI] and bypass surgery) for anatomically complex coronary artery lesions in the chronic hemodialysis setting is still controversial because the long-term outcomes were superior with coronary artery bypass grafting, especially with regard to repeat revascularization; however, short-term mortality with PCI was significantly lower because it is less invasive. Moreover, no guidelines show a strategy for this setting. We report the case of a patient with chronic dialysis and calcified left main true bifurcation lesion who underwent staged PCI with rotational atherectomy and minimally invasive direct coronary artery bypass for in-stent restenosis who died of non-occlusive mesenteric ischemia.

KEYWORDS: Bifurcation stenting, left main trunk, end-stage renal disease

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Introduction

The optimal strategy of coronary revascularization for anatomically complex lesions in chronic hemodialysis setting remains controversial. A report showed that the total number of death events was similar in percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) at 5-year follow-up after both procedures.[1] A recent meta-analysis showed that long-term outcomes in dialysis patients who underwent CABG were superior to those who underwent PCI, especially with regard to repeat revascularization; however, short-term mortality with PCI was significantly lower than with CABG, specifically for mortality resulting from complications with anesthesia, mechanical ventilation, infection, and bleeding.[2] We report the case of a patient who underwent both PCI and CABG in different phases with a serious complication.

Case description

A 77-year-old man who had acute coronary syndrome with reported chest pain was transported to the emergency department on a weekend night. He had received hemodialysis for more than 10 years and, on admission, had acute heart failure. An electrocardiogram showed ST-segment elevation in the augmented Vector Right (aVR) lead and ST-depression in the V4-6 leads. Left ventricular ejection fraction was 40% with anterior hypokinesis. Mechanical ventilation was performed because of hypoxemia and disturbance of consciousness. Then we performed emergent coronary angiography, which revealed left main true bifurcation lesion (LMTBL) (Medina classification 1-1-1) and severe stenosis in the mid-left anterior descending artery (LAD) with severe calcification (Figure 1A). Thrombolysis In Myocardial Infarction (TIMI) grade 2 flow of left coronary artery system was improved to TIMI grade 3 with support from an intra-aortic balloon pump. The right coronary artery had intermediate stenosis with calcification in the vessel wall (Figure 2). An intravascular ultrasound (IVUS) catheter could not pass the distal left main trunk lesion. Rotational atherectomy (RA) (Rotablator; Boston Scientific, Boston, Massachusetts, USA; burr size 1.5 mm) was performed in both the LAD and the left circumflex artery (LCx), and an additional RA (burr size 2.0 mm) was performed in the left main trunk and proximal LAD with high and low speeds. The procedure was successfully finished with TIMI grade 3 flow using verapamil, nicorandil, and nitroprusside (Figure 1B). Endovascular intervention for arterial access was also performed because of severe stenosis in the left common iliac artery before the initial PCI (Figure 3). Heart failure was controlled by the initial PCI with only RA. SYNTAX score was 47, and SYNTAX-II score was 71.0 for PCI and 59.7 for CABG after initial PCI. We discussed coronary revascularization options (CABG or PCI) in the dialysis setting with the heart team, including the surgeons; however, the patient and his family chose PCI because of the serious expected complications from long-term hemodialysis. We performed the second RA (burr size 1.75 mm) to the mid LAD and proximal LCx with high and low speeds and culotte stenting (LAD: Resolute Integrity 3.0 × 15 mm (Medtronic, Santa Rosa, California, USA); LCx: Resolute Integrity 3.0 × 18 mm, kissing balloon inflation, post-dilatation and proximal optimized dilatation with 4.0-mm non-compliant balloon catheter) with IVUS guidance (Figure 1C). IVUS study showed that the minimum

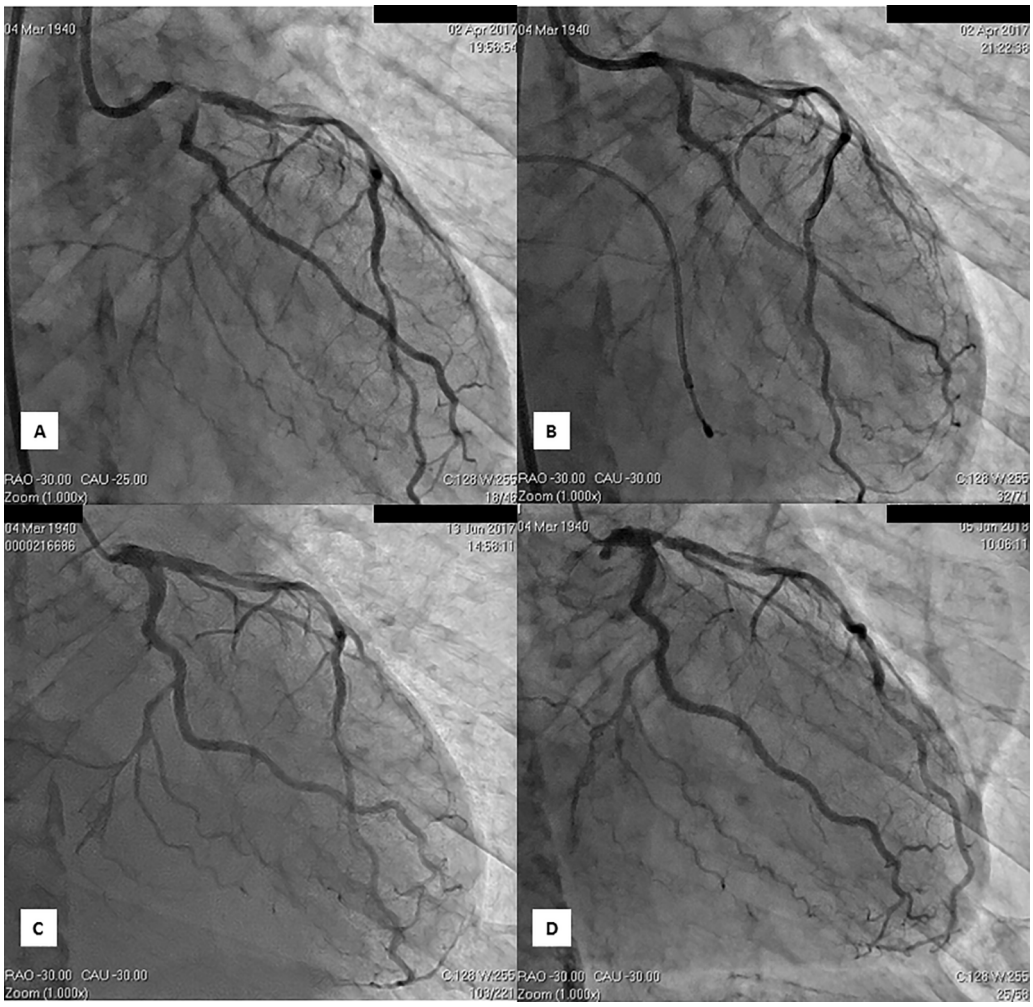

Figure 1. Coronary angiography series in left coronary artery. (A) Significant left main true bifurcation lesion with severe calcification was revealed before percutaneous coronary intervention (PCI). (B) Post-initial PCI with only rotational atherectomy. (C) Post-bifurcation two-stenting with additional rotational atherectomy. (D) Angiographic follow-up at 1 year after bifurcation two-stenting.

Figure 2. Coronary angiography in right coronary artery. Right coronary artery had intermediate stenosis with calcification in the vessel wall.

stent areas were 11.87 mm^2 in the left main trunk, 8.91 mm^2 in the LAD, and 6.62 mm^2 in the LCx (Figure 4A–C), and no malapposition of the drug-eluting stent (DES). There was no elevation in creatine kinase-MB after either PCI. Aspirin and clopidogrel were selected as dual antiplatelet therapy.

One year after undergoing culotte stenting, the patient developed dyspnea on exercise without heart failure. Follow-up angiographic surveillance was performed and showed in-stent restenosis in the proximal LAD, which had functional significance with fractional flow reserve value 0.72 (Figure 1D). We discussed this with the heart team again, and minimally invasive direct coronary artery bypass (left internal mammary artery to LAD) was performed by the cardiac surgeons. The patient, however, died a few days later in an intensive care unit because of non-occlusive mesenteric ischemia (NOMI), which was found by lactate acidosis on arterial blood gas evaluation and contrast-enhanced computed tomography (Figure 5A–C).

Discussion

Coronary revascularization in patients with severely calcified LMTBL and chronic hemodialysis is considered to be challenging because no guidelines show a strategy for this setting. Renal dysfunction, especially in the setting of hemodialysis, is related to coronary artery calcification and cardiovascular

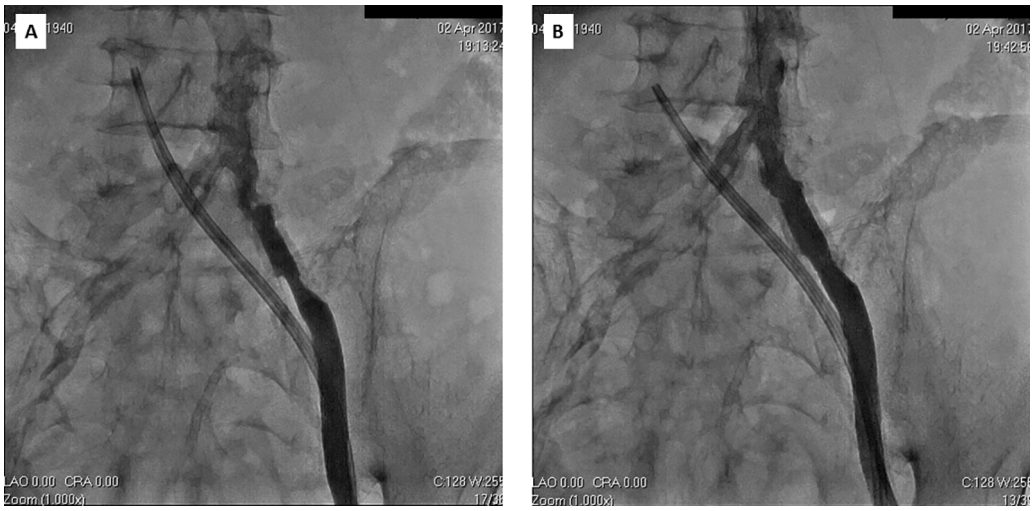

Figure 3. Endovascular intervention for vascular access. (A) Significant stenosis in left common iliac artery. (B) Post-endovascular intervention with SMART stent 9.0 × 60 mm (Cordis, Santa Clara, California, USA).

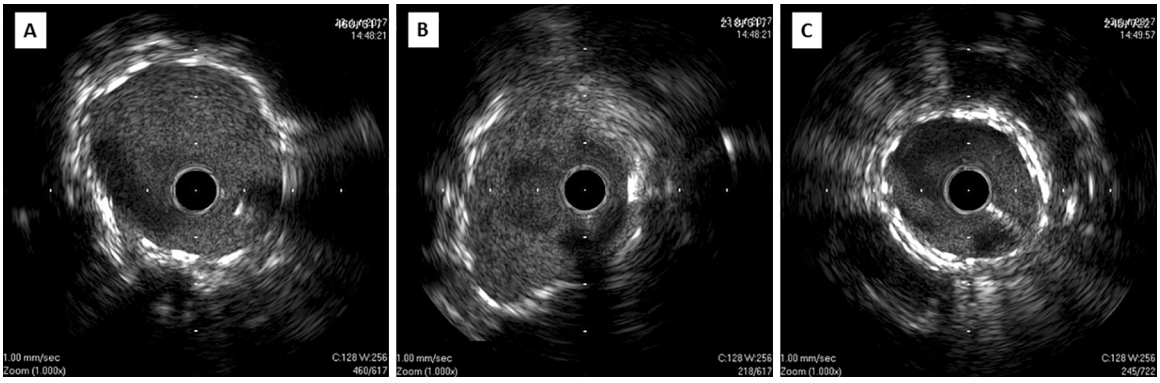

Figure 4. Cross-sectional intravascular ultrasound images in culotte bifurcation two-stenting. (A) Distal left main trunk. (B) Proximal left anterior descending artery. (C) Proximal left circumflex artery.

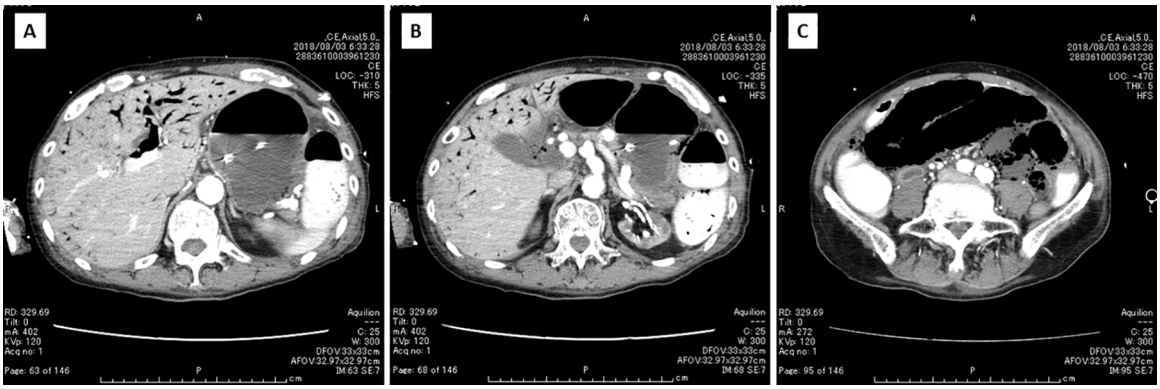

Figure 5. Non-occlusive mesenteric ischemia detected by contrast-enhanced multidetector computed tomography. These images are showed from head side to foot side (Panel A–C). Angiographic phase did not show an occlusion in superior mesenteric artery and showed impaired filling of intramural vessels and mural thinning (paper-thin wall of intestine) (Panel B). Pneumatosis intestinalis in a large segment of small bowel and hepatic portal venous gas were revealed (Panel A and C).

disorders. The REACH registry showed that atherosclerotic disease refers to atherothrombosis with 2 or more symptoms in the coronary, cerebral, lower limb, peripheral arterial bed, and/or circulatory bed.[3] The patient we describe also had both coronary and iliac artery stenosis and acute congestive heart failure. Physicians need to choose a strategy that considers the patient's physical condition.

Long-term patient outcomes with PCI in LMTBL have improved with DES technology in the last 2 decades.[4] However, two-stenting strategy in LMTBL also remains a problem,

especially in such a severely calcified lesion, because of insufficient stent expansion. In the described patient, staged RA was performed to achieve adequate expansion and avoid the slow-flow/no-reflow phenomenon, which worsens myocardial viability and long-term outcomes,[5] because of the debulked calcified plaque component. We used 2 speeds for the RA, 200 000 rpm and 160 000 rpm. High speed was used first to pass over the lesion; then we changed to low speed to polish the lesion. Rotational speed with low-speed RA was decreased additionally because of the burr's elliptical rotation as compared to the high-speed RA's circulation rotation; therefore, 2 speeds might be effective for intensive RA. From another viewpoint, a new lithotripsy device may simplify the strategy in calcified lesions.[6]

The stenting strategy was selected as culotte two-stenting with a 3.0-mm Resolute Integrity DES because Resolute Integrity's 2-link DES provides for larger expansion, up to 5.0 mm, to cover the bifurcation segment. IVUS images showed an acceptable minimum stent area (over 6.0 mm^2); however, in-stent restenosis occurred in the proximal LAD because renal insufficiency accelerates atherosclerosis and neointimal hyperplasia because of uremia and the chronic inflammation. In addition, the cell that the guide wire re-crossed might be unsuitable for good expansion at the bifurcation part of culotte stenting.

In terms of a 2-stent strategy, double-kissing (DK) crush stenting might be a better alternative,[7] and it is listed in the latest European Society of Cardiology guidelines[8]; however, it would not be easy to control side branch stenting in a severely calcified bifurcation lesion because of the recognition of correct bifurcation carina with the X-ray system. An experimental report showed that culotte stenting had more malapposition in the bifurcation segment compared to DK crush stenting by optical coherence tomography (OCT).[9] An IVUS study did not detect malapposition in this case; however, it may be a limitation of IVUS resolution compared to OCT. In addition, alternative PCI devices (eg, drug-coated balloon, additional DES, directional cutting atherectomy, excimer laser, or brachytherapy) could be considered in the treatment of in-stent restenosis before bypass surgery.

On the other hand, CABG has also improved with the use of new methods such as minimally invasive direct coronary artery bypass and endarterectomy.[10,11] From 1988 to 2003 in the United States, annual rates of CABG among patients with hemodialysis doubled, from 2.5 to 5 per 1000 patient-years; however, in-hospital mortality declined nearly sixfold, from 31% to 5.4%.[12] However, our described patient, unfortunately, died a few days after the surgery because of NOMI. NOMI is defined as mesenteric ischemia without occlusion of the mesenteric arteries.[13] The diagnosis of NOMI is improved by multi-detector computed tomography with contrast media[14]; however, the pathophysiology and treatment are not clear and the prognosis is poor.[15] A prospective observational study described that the preoperative risk factors were renal insufficiency, diuretic therapy, and age >70 years, and the postoperative risk factors were intra-aortic balloon pump support and serum lactate concentrations >5 mmol/L in patients undergoing cardiac surgery.[16] Some of these risk factors would be included in patients with hemodialysis, and therefore, they are potentially considered to be high-risk subsets of NOMI.

The ISCHEMIA chronic kidney disease (CKD) randomized controlled trial (ClinicalTrials.gov. NCT01985360) was performed to compare invasive revascularization strategy (PCI or CABG) and medical therapy in patients with advanced CKD (estimated glomerular filtration rate <30 mL/min/1.73 m^2 or on dialysis).[17] Regrettably, invasive revascularization strategy could not show superiority; however, a subanalysis of the trial may suggest a direction of revascularization strategy (PCI or CABG) in patients with dialysis.

Conclusion

Patients with hemodialysis and LMTBL are still challenging for both interventional and surgical strategies. Further investigation and "tailor made" treatment considering frailty, systemic comorbidity, short- and long-term mortality, and technical limitation of the revascularization strategies by the heart team are warranted in this setting.

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