Revascularization in A Patient with Left Main Coronary Artery Chronic Total Occlusion and Left Ventricular Dysfunction

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Abstract

Complex and high-risk percutaneous coronary intervention (CHIP) carries prohibitive risk of complications. Mechanical hemodynamic support is often warranted during the procedure to achieve optimal revascularization. Here, we present an elderly patient suffering from refractory heart failure due to ischemic cardiomyopathy and left main (LM) chronic total occlusion (CTO). Revascularization of the LM CTO was performed successfully under elective intra-aortic balloon pump (IABP) support. The patient's clinical condition and the LV systolic function improved dramatically during follow-up.

Keywords: complex and high-risk percutaneous coronary intervention, chronic total occlusion, intra-aortic balloon pump

Introduction

The concept of CHIP refers to procedures done in highly complicated coronary anatomy (such as severe calcification, large thrombotic burden, extreme tortuosity, long lesion length, LM or multivessel disease, or CTO) in patients with clinical characteristics conducive to complications (hemodynamic compromise, severely depressed LV function, comorbidities such as old age, diabetes mellitus, heart failure, peripheral vascular disease, chronic kidney disease, acute coronary syndrome, or previous cardiac surgery).[1] The ability of interventional cardiologists to correctly assess patients undergoing CHIP is essential because these procedures carry prohibitive risk of complications.[2,3] Strategies to achieve successful revascularization include the use of hemodynamic support devices during intervention in selected patients. We present a case of CHIP in an elderly patient suffering from refractory heart failure due to ischemic cardiomyopathy and LM CTO.

Case report

A 78-year-old man, ex-smoker, presented to

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our emergency department with out-of-hospital cardiac arrest. Prior medical history included hypertension, diabetes mellitus, dyslipidemia and chronic kidney disease, stage 3b. Thirteen years before, he had been found to have triple-vessel CAD and had received percutaneous coronary intervention (PCI) to the left anterior descending artery (LAD). Coronary artery bypass surgery was carried out one year later for LAD in-stent restenosis (ISR), complicated with non-ST elevation myocardial infarction, whereupon he was followed up regularly at an outpatient clinic. Three days prior to the present admission, he started to suffer from new onset of chest tightness episodes. On the day of admission, severe dyspnea ensued and he was found unconscious upon arrival of the emergency medical team. Cardiac arrest was noted and resuscitation started immediately, continuing throughout the whole transport. Return of spontaneous circulation was achieved at our emergency department and he fully recovered consciousness. The 12-lead ECG showed sinus rhythm with ST-elevation at lead III and aVF, and ST-depression at lead I, aVL and V4 to V6 (Figure 1A). The right-side ECG showed ST-elevation at V3R to V6R (Figure 1B). The diagnosis of inferior ST-elevation myocardial infarction was made and the cath lab was activated. Coronary angiography showed LM CTO (Figure 1C), diffusely diseased right coronary artery (RCA) with a critical stenosis at the distal RCA (Figure 1D), patent left internal mammary artery (LIMA)

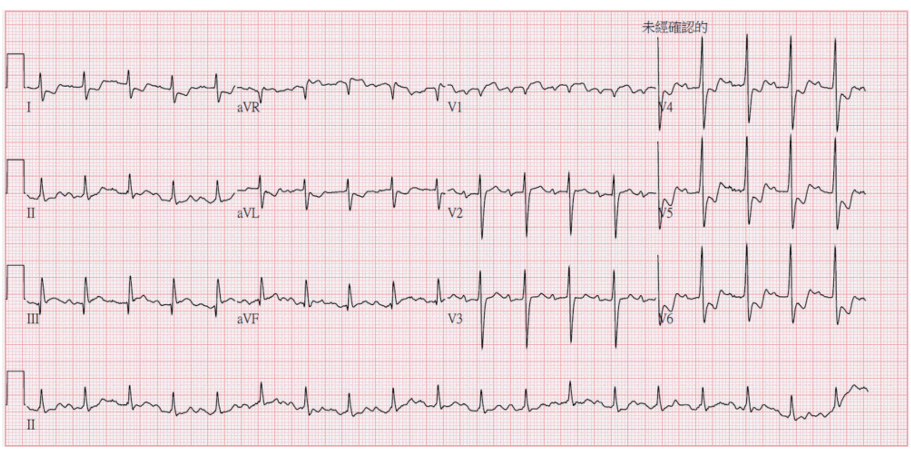

Figure 1A. 12-leads ECG at the emergency department.

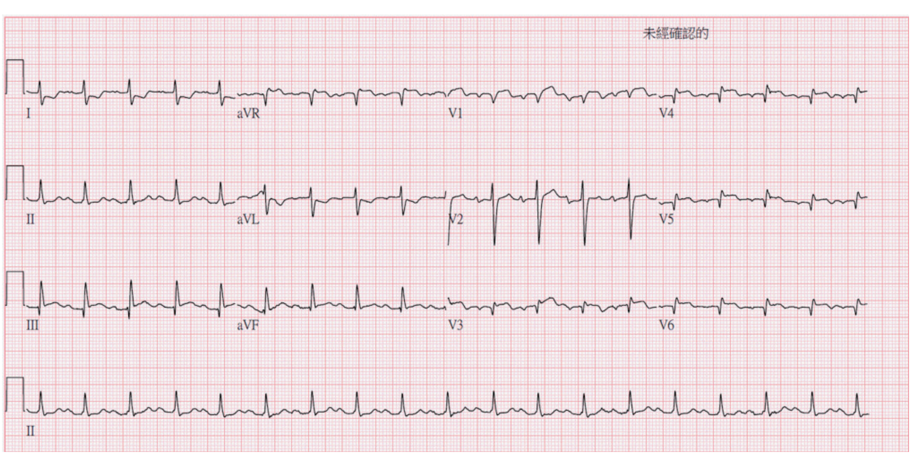

Figure 1B. Right-sided ECG at the emergency department showed ST-elevation at V3R to V4R.

to distal LAD (Figure 1E), patent saphenous vein grafts (SVG) to the posterior descending artery (PDA) (Figure 1F) and obtuse marginal (OM) branch (Figure 1G). There was also mid LAD ISR and diffuse stenosis of the native left circumflex artery (LCX) (Figure 1E and 1G). Primary PCI was performed to the RCA with two drug-eluting stents (DES) deployed at the proximal and distal RCA. However, unstable blood pressure refractory to hydration, inotropic agents and vasopressors developed during the procedure, so veno-arterial extracorporeal membrane oxygenator (VA-ECMO) was deployed. After the procedure, the

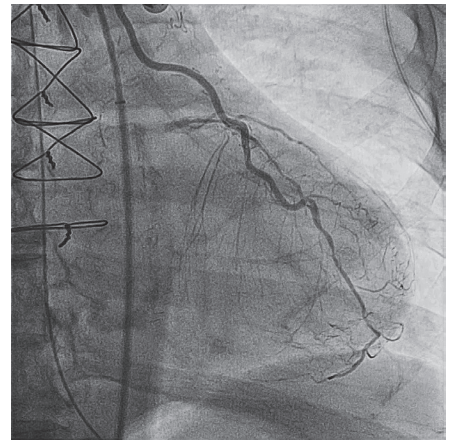

Figure 1E. Patent LIMA to distal LAD with diffuse ISR proximal to the middle LAD stent.

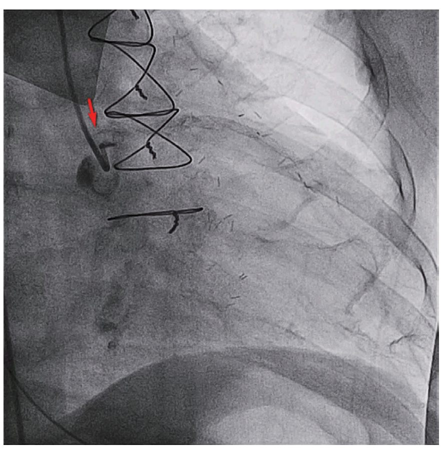

Figure 1C. Coronary angiography showed CTO of the LM artery.

Figure 1F. Patent SVG to posterior descending artery.

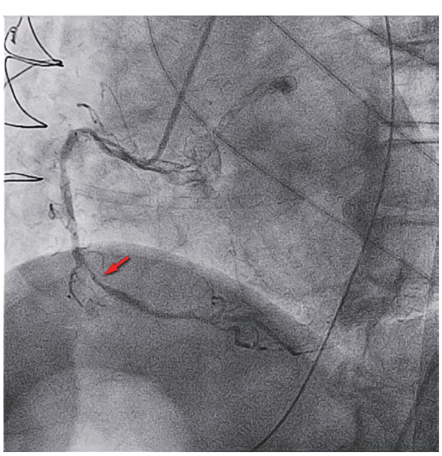

Figure 1D. Diffusely diseased RCA with a critical stenosis at the distal RCA.

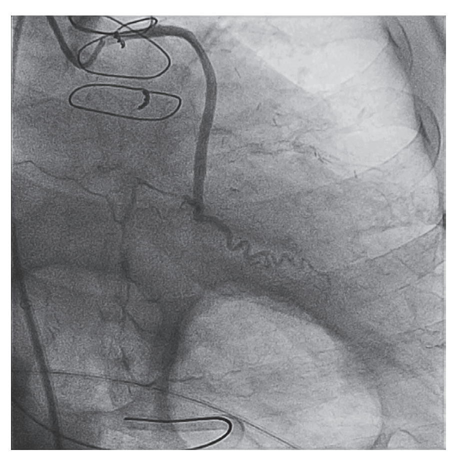

Figure 1G. Patent SVG to obtuse marginal branch with diffusely diseased LCX.

(CTO: chronic total occlusion, LM: left main, RCA: right coronary artery, LIMA: left internal mammary artery, LAD: left anterior descending artery, SVG: saphenous vein graft, LCX: left circumflex artery) patient was transferred to the cardiac intensive care unit. His hemodynamics improved over the following days and VA-ECMO was removed. Weaning from the mechanical ventilator was successful and he was transferred to a general ward within one week.

Nevertheless, pulmonary edema resistant to diuretics and inotropic agents developed in the general ward and he was put on a non-invasive positive pressure ventilator. In addition, he also reported intermittent angina and the 12-leads ECG showed remaining ST-depression and T-wave inversion at lead I, aVL and V4 to V6 (Figure 2A). The echocardiography showed severely reduced LV systolic function with ejection fraction 27.5% and global hypokinesia. Myocardial viability studies were not performed due to the patient's unstable clinical condition but viable myocardium was supported by the remaining R wave at the precordial and lateral leads on the 12-leads ECG (Figure 2A). After discussion among the heart team, revascularization to the LM was planned with the aim of improving the patient's LV function. Due to the complex nature of the procedure and the patient's high clinical risk, elective endotracheal intubation and IABP insertion via the right common femoral artery (CFA) were performed in the cath lab prior to PCI. His left CFA was not accessible due to prior injury after V-A ECMO. A 7 French BL 3.5 guiding catheter (Terumo Inc., Tokyo, Japan) was used to engage the LM via the right brachial artery, and a 6 French IM diagnostic catheter was engaged to the LIMA via the left radial artery for contralateral injection (Figure 2B). The J-CTO score was two due to severe calcification and occlusion length > 20 mm. Antegrade wire escalation strategy was adopted according to the

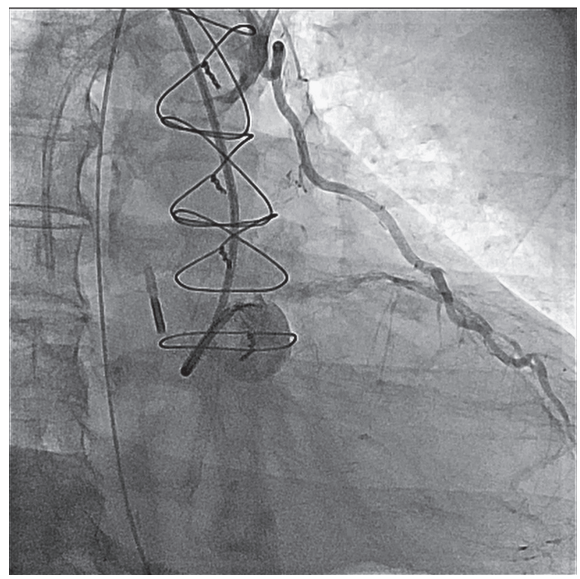

Figure 2B. Dual injection of coronary angiography demonstrated the characteristics of LM CTO. (LM: left main, CTO: chronic total occlusion)

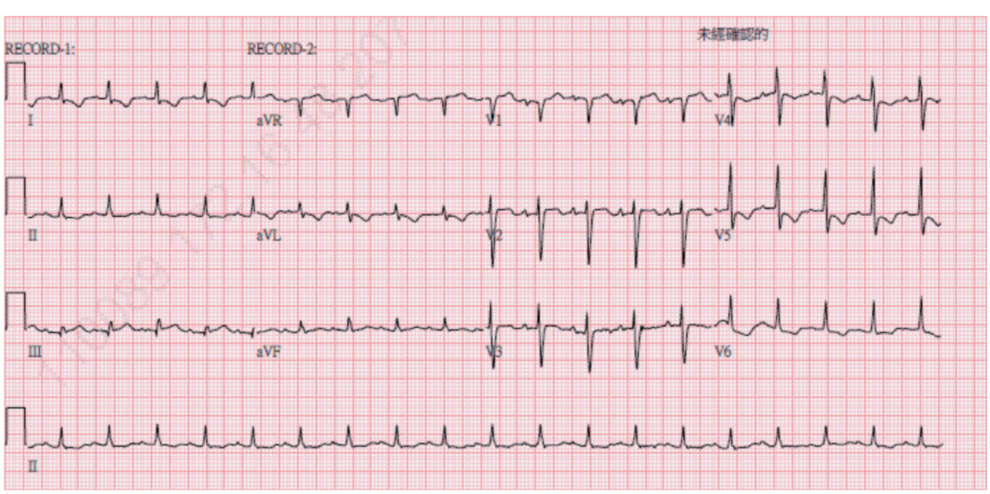

Figure 2A. 12-leads ECG during hospitalization.

Asia Pacific Chronic Total Occlusion (APCTO) algorithm.[4] A Sion black guidewire (Asahi Intecc, Nagoya, Japan) and 135 cm Corsair microcatheter (Asahi Intecc, Nagoya, Japan) were used to probe the LM CTO, but failed to penetrate the proximal cap. Sion black was then changed to GAIA second guide wire (Asahi Intecc, Nagoya, Japan), which crossed the CTO segment entering the distal true lumen. Antegrade flow was established after pre-dilation with a 1.5*10 mm and 2.0*15 mm balloon. Intravascular ultrasound (IVUS, Refinity, Volcano, California, USA) showed under-expansion of the previous LAD stent with diffuse ISR and severely calcified neo-atherosclerosis, and diffusely diseased LCX with the arc of calcification over 270 degrees (Figure 2C). As a result, rotational atherectomy was performed with a 2.0 mm burr (Boston Scientific, Massachusetts, USA) from the LM to the LAD at 197000 rpm and in the LCX at 200000 rpm. After rotational atherectomy, plaque modification with a 2.5*13 mm scoring balloon (NSE Alpha, B.Braun, Aichi, Japan) and a 2.75*20 mm non-compliant (NC) balloon was performed sequentially from the distal to proximal LAD, followed by kissing balloon inflation with a 2.75*20 mm NC balloon from LM to LAD and a 2.5*20 mm NC balloon from LM to LCX. After lesion preparation, balloon angioplasty with a 2.75*40 mm and 3.0*30 mm drug-coated balloon (SeQuent Please, B.Braun, Berlin, Germany) was performed from the distal to proximal LAD. Finally, a 3.5*23 mm drug-eluting stent (COMBO, OrbusNeich, Hoevelaken, Netherlands) was deployed in the LM to the proximal LAD, followed by proximal optimization technique (POT) with a 4.0*8 mm NC balloon. The final angiogram was acceptable with antegrade TIMI 3 flow in both the LAD and LCX (Figures 2D and 2E).

After the intervention, IABP and ventilator were removed after quick and smooth weaning. In the general ward, the patient's respiration remained smooth and he denied any symptoms of chest discomfort. Temporary hemodialysis was initiated due to uremia during hospitalization. Two months after discharge, follow-up echocardiography showed significant improvement of LV systolic function with ejection fraction up to 46%. The patient was in New York Heart Association functional class I, and his renal function recovered without further need for renal replacement therapy.

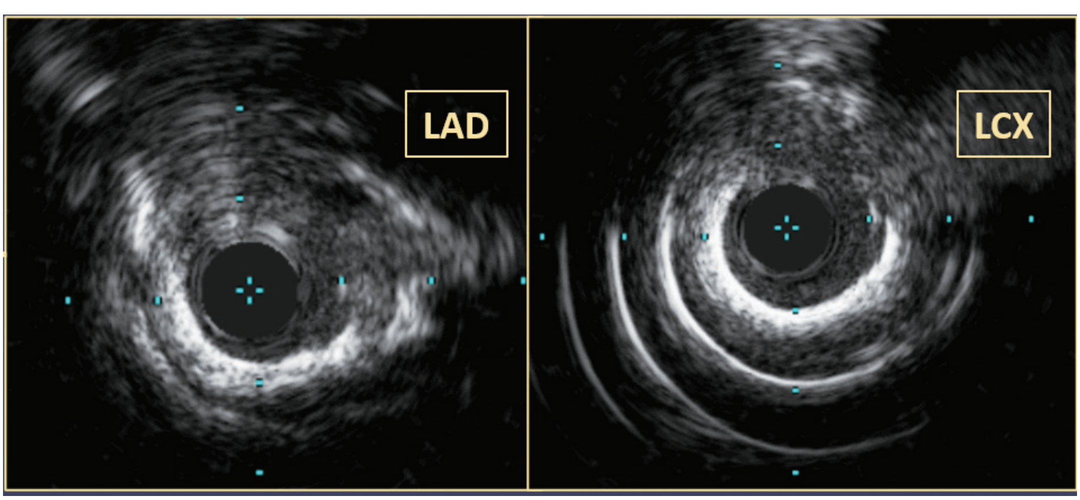

Figure 2C. IVUS pull-back from the LAD showed under-expansion of the previous LAD stent with diffuse ISR and calcified plaque. IVUS pull-back from the LCX showed diffusely diseased vessel with the arc of calcification over 270 degrees. (IVUS: Intravascular ultrasound, LAD: left anterior descending artery, ISR: in-stent restenosis, LCX: left circumflex artery)

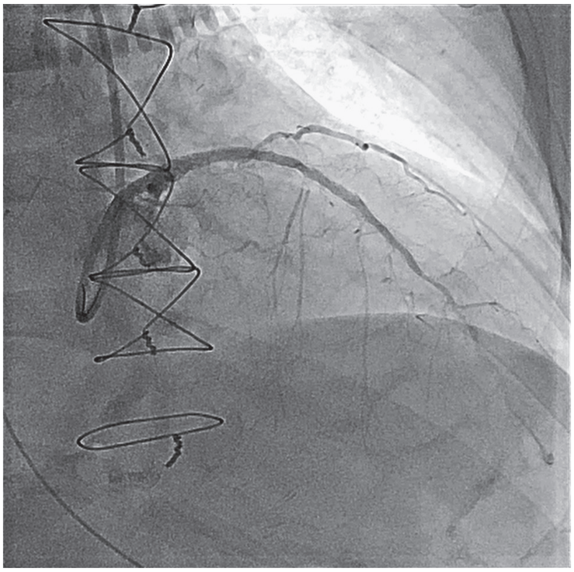

Figure 2D. Final coronary angiography.

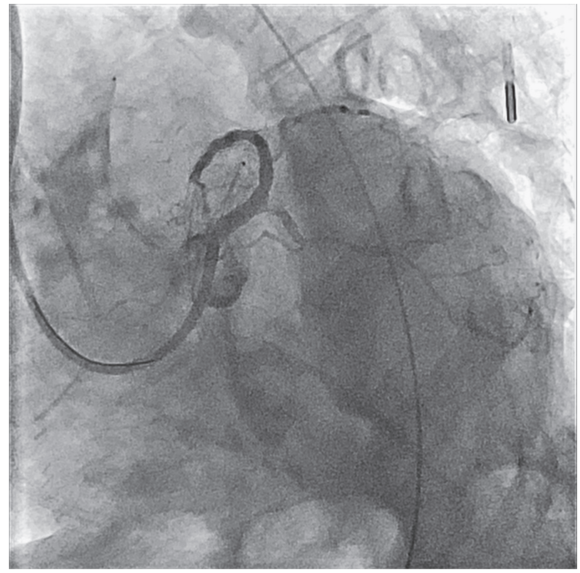

Figure 2E. Final coronary angiography.

Discussion

Advances in technology and the proficiency of interventional cardiologists mean that CHIP is increasingly considered a feasible alternative for patients with advanced age, multiple co-morbidities, severe LV impairment and LM or multivessel coronary disease. In the present case, we conducted a high-risk PCI in an elderly patient with severely reduced LV function, poor renal reserve and complex coronary anatomy, involving a complicated intervention including rotational atherectomy. Successful revascularization of LM CTO was performed under elective IABP support. The patient's clinical condition improved markedly after the procedure, and the LV function improved dramatically.

Complex coronary interventions, such as rotational atherectomy, can induce prolonged myocardial ischemia, and can be hazardous to patients with minimal tolerance. Various mechanical circulatory support devices may stabilize hemodynamics and maintain tissue perfusion, thus reducing procedural risk. V-A ECMO provides systemic perfusion, but may be deleterious to LV due to the increased afterload and compromised coronary perfusion. IABP reduces LV afterload and augments diastolic myocardial perfusion, but provides little circulatory assistance. The previous randomized controlled trial Balloon pump–assisted Coronary Intervention Study (BCIS-1) showed reduced procedural event rates and potentially long-term mortality by IABP in appropriately selected patients, who are at high risk for adverse events.[3] Impella (Abiomed, Aachen, Germany) both relieves LV and provides complete circulatory support, and may be superior in hemodynamic support over IABP (Table 1). The early results of the PROTECT II study, a randomized clinical trial of hemodynamic support with Impella 2.5 versus IABP in patients undergoing high-risk PCI, failed to show procedural benefit of Impella over IABP. However, there was a significant reduction in major adverse cardiac and cerebrovascular events favoring Impella by 90 days.[2] Several observational studies also demonstrated the safety and efficacy of Impella support in high-risk PCI.[5-7] The latest 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization supports the use of hemodynamic support devices in selected high-risk PCI patients to

Table 1. Comparison of hemodynamic profiles between IABP, V-A ECMO and Impella[12]

	IABP	V-A ECMO	Impella (2.5, CP, 5.0, 5.5)
Flow	0.5 L/min	max 7.0 L/min	2.5 – 5.5 L/min
Pump Speed	NA	Max 5000 rpm	Max 51,000 rpm
Cannula size	7 – 8 F arterial	14 – 19 F arterial 17 – 21 F venous	13 – 21 F arterial
Insertion/Placement	Femoral artery Axillary artery	Femoral artery Femoral vein	Femoral artery Axillary artery
LV unloading	+	-	+ to +++
RV unloading	-	++	-
Afterload	↓	↑ ↑	↓ ↓
Coronary Perfusion	↑	-	↑

prevent hemodynamic compromise, with class 2b recommendation.[8] More randomized studies are needed to confirm the benefit of these support devices during high-risk PCI.

A diffusely diseased coronary artery often leads to incomplete revascularization after coronary artery bypass surgery without endarterectomy.[9] Although the bypass grafts were all patent in our patient, the diffusely diseased native vessel may still have produced proximal myocardial ischemia. Previous study has shown that CTO revascularization significantly improves the health status in patients with stable angina, compared to optimized medical therapy alone.[10] Meta-analysis has also revealed improved LV ejection fraction, reduced adverse remodeling and improvement of survival after successful CTO recanalization.[11] Our patient underwent PCI because of ongoing refractory heart failure and ischemia, although myocardial viability studies were not performed due to his unstable clinical condition. Revascularization to the LM CTO re-established antegrade blood flow to the diffusely diseased LAD and LCX, enabling LV function improvement. This was evidenced by the favorable clinical course. An individualized approach is warranted, despite the lack of high-level evidence from randomized trials.

In the modern era, complex and high-risk PCI will inevitably become more prevalent due to the aging population and a preference for minimally invasive strategies. Advancing and innovative intervention techniques together with improved training of interventional cardiologists have opened a new chapter of precision PCI. We now have the skills and the tools for such treatments, but how to provide them in the most efficient and reasonable way remains to be answered by future studies.

Disclosures

None.

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