SCIENCE LETTERS 2014 | Volume 2 | Issue 2 | Pages 65-70

Percutaneous coronary intervention for chronic total occlusion through retrograde epicardial collateral by different techniques

Sondagur Abdool Russeed Ziyad, Lei Xu, Chunjian Li*

Department of Cardiology, First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Road, Nanjing, Jiangsu Province, 210029, China

Abstract
To utilize different retrograde techniques for the percutaneous coronary intervention (PCI) in chronic total occlusion (CTO). Retrograde PCI was performed after failure of the antegrade PCI, and techniques including retrograde wire crossing, kissing wire, retrograde balloon dilation, reverse controlled-antegrade-and-retrograde-subintimal-tracking (CART) were selectively applied in the PCI of two CTOs located in left anterior descending artery (LAD) and right coronary artery (RCA) respectively in two patients. Both CTOs were successfully re-opened and stented under the help of retrograde guidewires via the epicardial collaterals, and two significantly different techniques were finally adopted according to the characteristics of the collaterals and the lesions.
Key words: Chronic total occlusion (CTO), Percutaneous coronary intervention (PCI), Retrograde approach.

Received May 06, 2014; **Revised** June 29, 2014; **Accepted** June 30, 2014
***Corresponding author:** Chunjian Li, E-mail: lijay@njmu.edu.cn. Tel: +86-25-68136018 Fax: +86-25-83674380
Sondagur Abdool Russeed Ziyad and Lei Xu have equal contribution in this manuscript.

To cite this manuscript: Ziyad SAR, Xu L, Li C. Percutaneous coronary intervention for chronic total occlusion through retrograde epicardial collateral by different techniques. Sci Lett 2014:2(2):65-70.

Introduction

Chronic total occlusion (CTO) is characterized by considerable atherosclerotic plaque burden within the artery, leading to incomplete occlusion of the vessel and should be present for more than 3 months to be regarded as a true CTO [1]. Japanese first started retrograde percutaneous coronary intervention (PCI) techniques which expanded new possibilities through usage of small collaterals [2, 3]. The CTO is distinguished by a combination of luminal plaque, thrombin, fibrin, inflammatory cells and neovascular channels. The occlusive thrombus contained mainly collagen-rich extracellular matrix, lipids, smooth muscle cells and a mixture of cholesterol, dense collagen and calcium deposits [4]. One of the main reasons for the retrograde approach to be successful is that the density of the distal fibrous cap is lower than that of the proximal cap [5]. It was reported that retrograde PCI can be effective in recanalizing CTO with a success rate of 65-70% [6, 7]. The PCI for CTO has shown to improve the exercise tolerance [8], left ventricular function and survival [9, 10]. Based on these evidences, we utilized different retrograde techniques for PCI in two patients with CTOs.

Materials and methods

The first case was a 47-year-old male who was admitted in the hospital for exertional chest pain for 3 years which worsened in the past 2 months. The patient had hypertension for 10 years and diabetes mellitus for 8 years. The PCI was performed on the patient in another hospital 2 months ago. Report of PCI showed a 30% stenosis in right coronary artery (RCA), and a CTO in left anterior descending artery (LAD) ostium, where the attempt for PCI was failed. Two stents were implanted, respectively, in proximal and middle segments of the intermediate coronary artery (ICA), and one in the proximal left circumflex artery (LCX). The residual SYNTAX score was 28.5.

PCI procedure

Coronary artery angiography (CAG) was carried out by the transradial approach after admission and the above results were confirmed (Fig. 1A). We advised the patient for reopening of LAD CTO. First, we attempted the antegrade approach for one hour using a 6F BL-3.5 guiding catheter (Terumo Corp) and a PT^2-LS guidewire (Boston Scientific Corp), which successfully passed the proximal CTO lesion, but it always went into the subintima at mid-LAD (Fig. 1B). The antegrade approach finally failed after trying the parallel wire technique. Then we decided to perform a retrograde approach through the ICA→LAD epicardial collateral, which was relatively straight and flexible. A PT^2-LS guidewire was introduced retrogradely via the ICA collateral while another PT^2-LS guidewire was introduced antegradely into the LAD. It took only several minutes to pass the retrograde guidewire through the collaterals into the mid-LAD (Fig. 1C). Then, we tried the kissing wire technique, but failed. Afterwards, we manipulated the retrograde guidewire to proximal LAD and used a Maverick 1.5 × 8 mm and a Maverick 2.0 × 8 mm balloon (Boston Scientific Corp) to dilate mid-LAD (Fig. 1D). After dilation, the PT^2-LS guidewire finally passed the

lumen created retrogradely and successfully crossed mid-LAD. We then used a Sprinter 2.5 × 20 mm balloon (Medtronic, Inc) to dilate the lesion antegradely, after which multiple stenting to LAD was performed (Fig. 1E, F, G, H) and TIMI 3 blood flow was achieved (Fig.1I).

The second case was a 77-year-old male who was admitted complaining of retrosternal chest discomfort and dyspnea for 11years, whichh had increased in severity and frequencyinr the past 2 years. His past history included diabetes for 10 years, but no hypertension. The patient's ECG showed sinus rhythm with T wave inversion in leads III and aVF, while normal QRS and T waves in chest leads (Fig. 2). The pre-hospital dual-source CT (DSCT) reported a 65% stenosis in LAD, a 70% stenosis in LCX, and diffuse lesion in RCA. A collateral circulation from LAD to distal RCA was found in the CT image (Fig. 3). The patient was diagnosed as unstable angina and was arranged for an elective PCI.

Coronary artery angiography

The CAG was carried out after admission which showed a 40% stenosis in Left Main; an 80% stenosis in proximal LAD; a 90% stenosis in proximal second diagonal branch; a CTO in mid-LCX; and another CTO in proximal RCA (Fig. 4A). There was a grade III collateral circulation from LAD to distal RCA. The SYNTAX score was 34.5. A coronary artery bypass graft (CABG) was recommended as the first choice and the procedure was terminated. However, the patient and his families refused to receive CABG and required to try PCI. So PCI was scheduled the next week and we planned to re-open the RCA first.

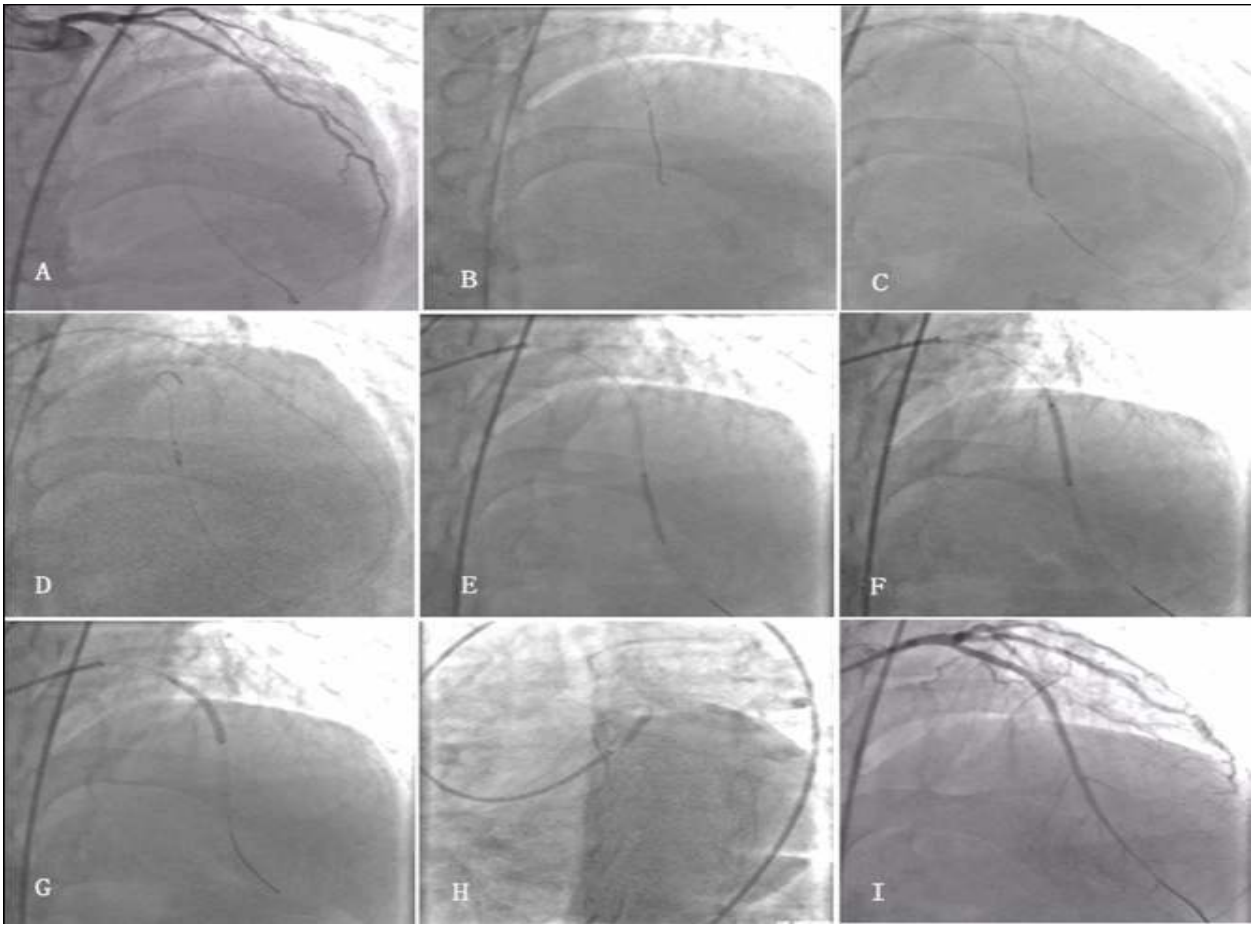

Fig. 1 Coronary artery intervention of Case-1: (**A**) CTO in LAD along with ICA→LAD collateral. (**B**) Terumo Heartrail® II BL 3.5 catheter used to engage the left main and a PT^2-LS guidewire (Boston Scientific) into LAD. (**C**) Another PT^2-LS wire passed retrogradely through ICA→LAD collateral. (**D**) A Maverick 2.0 × 8 mm balloon used to dilate the mid-LAD lesion retrogradely. (**E**). Implantation of a Partner 2.5 × 24 mm stent in distal LAD. (**F**) A Partner 2.75 × 29 stent implanted in mid-LAD. (**G**) Another Partner 2.75 × 29 mm stent implanted in proximal LAD. (**H**) A Partner 3.0 × 15 mm stent implanted in LAD ostium. (**I**) Final angiography of LAD showing TIMI 3 blood flow. CTO: Chronic total occlusion, LAD: Left anterior descending artery, ICA: Intermediate coronary artery.

Fig. 2 Electrocardiogram of the patient at admission: Sinus rhythm with T wave inversion in leads III and aVF, while normal QRS and T waves in chest leads

PCI procedure

After successful insertion of a 6F sheath in the right femoral artery, a 6F XB-RCA guiding catheter (Cordis Corp.) was used to engage the RCA. Initially, we attempted an antegrade approach with two Fielder-XT guidewire (Asahi Intecc Co., Ltd.) using Seesaw technique under the support of a 1.5×15 mm Apex balloon (Boston Scientific Corp.), but the guidewires always went into the subintima of the occlusion and could not cross the lesion (Fig. 4B). We then decided to apply the retrograde approach.

Through the left femoral artery a 6F BL-3.5 guiding catheter was adopted to engage the left coronary artery. Then, a Fielder-FC guidewire (Asahi Intecc Co., Ltd.) and a SION guidewire (Asahi Intecc Co., Ltd.) were used to cross the LAD lesion to LAD→RCA collateral under the support of a Corsair microcatheter (Asahi Intecc Co., Ltd.) (Fig. 4C). After the SION guidewire and Corsair reaching distal RCA, a Miracle 6.0 guidewire (Asahi Intecc Co., Ltd.) was introduced through Corsair to puncture a short occlusion in the distal RCA and then the Miracle 6.0 guidewire was able to reach and easily cross the occlusion retrogradely. However, we failed in trying the retrograde-wire-crossing technique, nor the kissing-wire technique. We also failed in engaging the antegrade guidewire into the Corsair at the proximal part of the CTO. Hence, reverse controlled antegrade retrograde tracking (reverse-CART) technique was adopted. After dilation of the proximal part of the CTO with an Apex 1.5 × 15 mm (Boston Scientific Corp.), a Sprinter 2.5 × 15 mm (Medtronic, Inc.), and a Sapphire NC 3.0 × 12 mm balloon (OrbusNeich Medical, B.V.), a PT-MS guidewire (Boston Scientific Corp.) successfully crossed the CTO retrogradely and engaged the antegrade catheter (Fig. 4D). After failure to engage the antegrade guidewire into the Corsair within the guiding catheter, we tried to push the retrograde guidewire outside the antegrade guiding catheter with the help of an extension guidewire (Asahi Intecc Co., Ltd.). But the two catheters twined together during the process and the procedure almost failed. However, we successfully untangled the catheters after many attempts and set a retrograde orbit in the end by pushing out the retrograde guidewire from the antegrade guiding catheter. Then, a sprinter 2.50 × 15 mm balloon (Medtronic, Inc.) was passed antegradely along the retrograde guidewire to perform the predilation, after which two Partner 2.75 × 29 mm stents (Lepu Medical Technology (Beijing) Co., Ltd.) were implanted from middle to proximal RCA through the retrograde guidewire (Fig. 4E), and a Partner 2.75 × 21 mm stent was implanted across the posterior descending artery to posterior lateral artery through an antegrade guidewire (Fig. 4G). Final

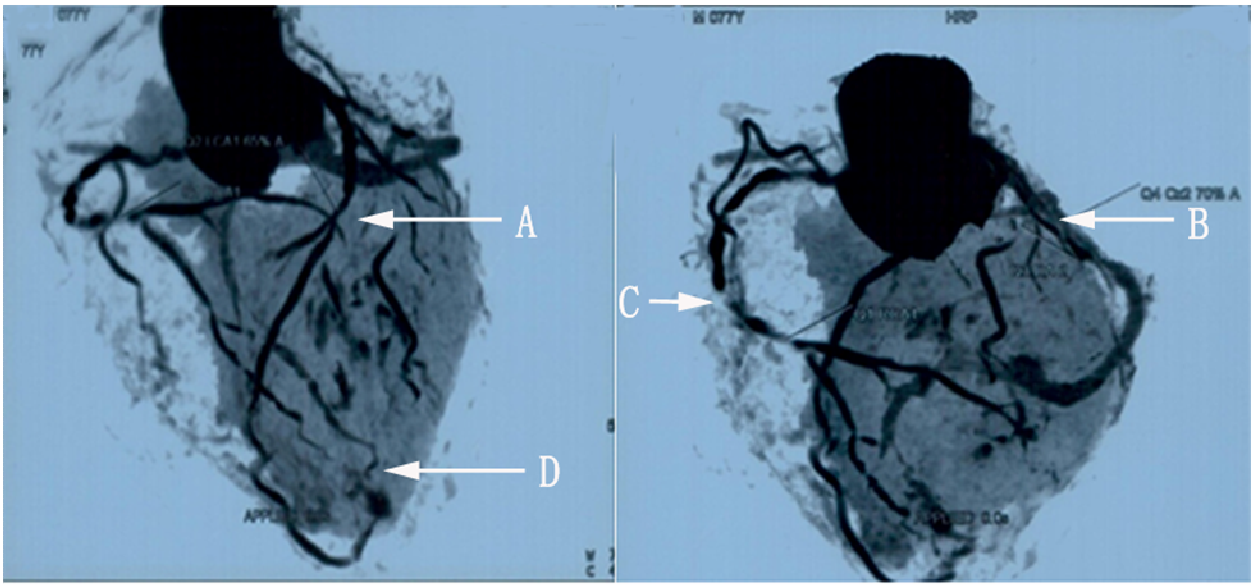

Fig. 3 Pre-hospital Dual-source CT scan of the patient: **(A)** 65% stenosis in LAD; (**B**) 70% stenosis in LCX; (**C**) Diffuse lesion in RCA; (**D**) Collateral circulation from LAD to distal RCA. LAD: Left anterior descending artery; LCX: Left circumflex artery; RCA: Right coronary artery.

angiography showed a TIMI 3 blood flow achieved (Fig. 4H).

Results and discussion

In the first case, the antegrade approach cost more than 1 hour, but failed due to the guidewire was always going into the LAD dissection, whereas the retrograde approach was very simple, which took only several minutes for the retrograde guidewire crossing the collateral as well as the mid-LAD lesion. The whole procedure succeeded within 2 hours and the total contrast used was 280 ml. The patient has not presented any chest pain in the past 33-month follow-up.

In the second case, the antegrade guidewire placement costed approximately 1 hour before changing to the retrograde approach, whereas the retrograde guidewire placement was very complicated and it took more than 3 hours before we could implant the three stents. The total contrast usage was 430 ml. The patient did not present any chest pain in the past nine-month follow-up, so he is keeping on medical treatment, but refuses to do further intervention for the left coronary artery. Two significantly different techniques were adopted according to the characteristics of the collaterals and the lesions in the mentioned 2 cases. Joyal et al [10] demonstrated that patients subjected to successful PCI for CTO had a considerable reduction in recurrent angina, improvement in mortality and a reduction for the need for CABG during a 6-year follow-up in contrast to those undergoing failed PCI. However, the success rate of the routine antegrade approach was low [11-13], which was principally due to the failure to pass the guidewire into the distal true lumen [14-16]. The retrograde approach like CASE-2 is generally complicated, which has to be performed under the support of the micro-catheter, and doctors have to try different techniques during the procedure. However, our report indicates that the retrograde approach could be performed very easily even without the support of a micro-catheter for cases with ideal collaterals and with lesions that could be easily passed by the retrograde guidewire as case-1.

Regarding the collateral selection, generally septal collaterals are favored [17], but if an epicardial collateral has to be chosen in cases without ideal septal collaterals as in the mentioned two patients, we would prefer the minimal tortuosity to diameter of the collateral [5]. Besides, it should always keep in mind that meticulous care of devices and wires is primordial due to high risk of perforation of collateral.

The DSCT can outline the routes of CTOs and identify plaques [18]. In a recent study, the sensitivity and specificity of CT in detection of CTO were 95% and 94%, respectively [19]. Mollet et al [20] reported that the procedural success for crossing CTOs could be portended based on various features by CT angiography. Besides, CT angiography can also demonstrate coronary collaterals in patients with CTO as in case 2 [21]. However, the quality of DSCT could be influenced by many factors and the result may differ significantly from CAG even in highly

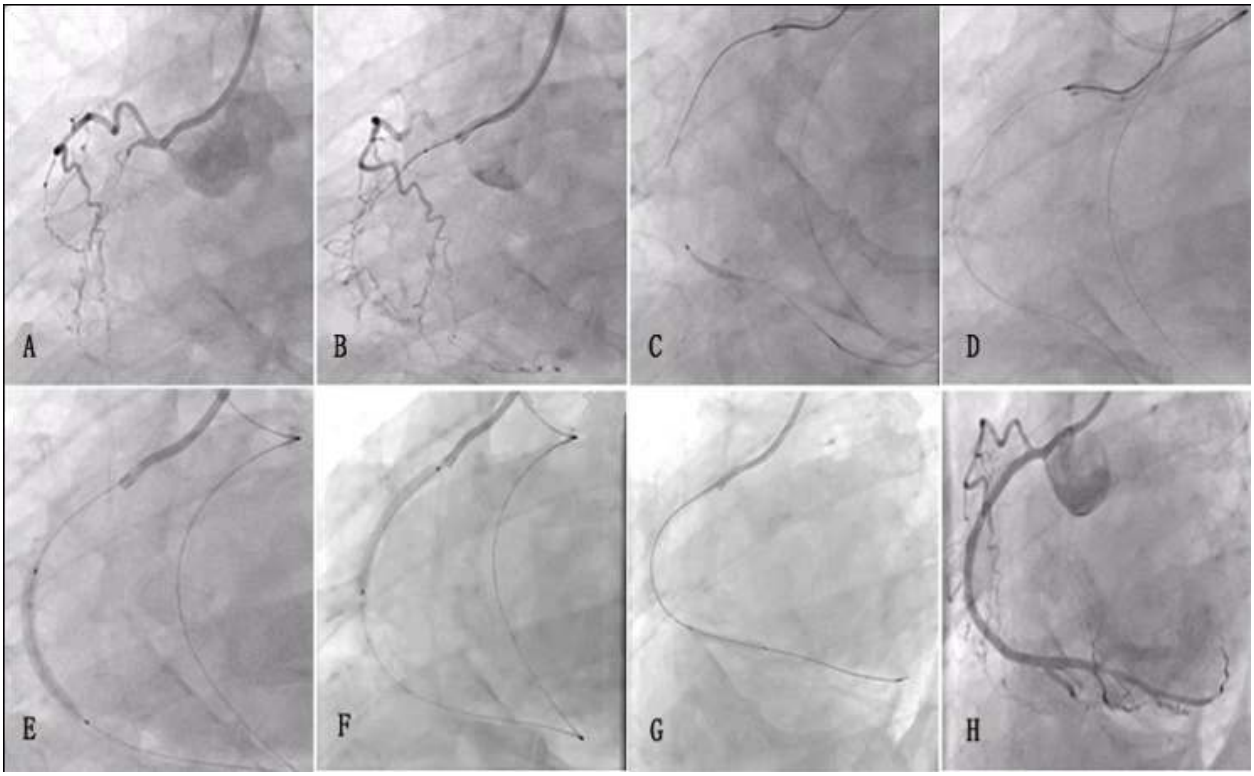

Fig. 4 Coronary artery intervention of Case-2: (**A**) CTO in RCA. (**B**) Introducing an antegrade guidewire in proximal RCA. (**C**) Retrograde guidewire passed from LAD to RCA via collateral branch. (**D**) Retrograde guidewire in the opposite guiding catheter after crossing the lesion. (**E**) Implantation of a Partner 2.75 × 29 mm stent in mid-RCA. (**F**) Implantation of another Partner 2.75 × 29 mm stent in proximal RCA. (**G**) Implantation of a Partner 2.75 ×21 mm in distal RCA through an antegrade guidewire. (**H**) Final angiography of RCA showing TIMI 3 blood flow. CTO: Chronic total occlusion; RCA: Right coronary artery; LAD: Left anterior descending artery.

experienced centers [22, 23]. In addition, due to the non-selective characteristics of DSCT, it may be difficult to identify whether a vessel is totally occluded or highly narrowed as the distal part of the occluded vessel could also emerge when there are good collaterals as in case 2.

The SYNTAX score has been suggested as a reference while choosing PCI or CABG for complicated coronary lesions [24]. However, SYNTAX score is only an anatomically based tool to quantitatively characterize the coronary vasculature regardless of the patients' clinical status [25]. So real-world clinical practice has to sometimes be modified according to the clinical setting and patients' willing. This report suggests that the patients' symptoms can be significantly improved if we can appropriately treat some lesions and reduce the patients' SYNTAX score by PCI for those who reject the recommended CABG [26].

Acknowledgement

This work is supported by a project funded by the Priority Academic Program Development (PAPD) of Jiangsu Higher Education Institutes.

References

[1] Stone GW, Reifart NJ, Moussa I, Hoye A, Cox DA, Colombo A, et al. Percutaneous recanalization of chronically occluded coronary arteries: a consensus document: part II. Circulation 2005;112:2530-7.

[2] Surmely JF, Tsuchikane E, Katoh O, Nishida Y, Nakayama M, Nakamura S, et al. New concept for CTO recanalization using controlled antegrade and retrograde subintimal tracking: the CART technique. J Invasive Cardiol 2006;18:334-8.

[3] Surmely JF, Katoh O, Tsuchikane E, Nasu K, Suzuki T. Coronary septal collaterals as an access for the retrograde approach in the percutaneous treatment of coronary chronic total occlusions. Catheter Cardiovasc Interv 2007;69:826-32.

[4] Jayasinghe R, Paul V, Rajendran S. A universal classification system for chronic total occlusions. J Invasive Cardiol 2008;20:302-4.

[5] Ge JB. Current status of percutaneous coronary intervention of chronic total occlusion. J Zhejiang Univ Sci B 2012;13:589-602.

[6] Rathore S, Katoh O, Matsuo H, Terashima M, Tanaka N, Kinoshita Y, et al. Retrograde percutaneous recanalization of chronic total occlusion of the coronary arteries: procedural outcomes and predictors of success in contemporary practice. Circ Cardiovasc Interv 2009;2:124-32.

[7] Yamane M, Muto M, Matsubara T, Nakamura S, Muramatsu T, Oida A, et al. Contemporary retrograde approach for the recanalisation of coronary chronic total occlusion: on behalf of the Japanese Retrograde Summit Group. EuroIntervention 2013;9:102-9.

[8] Finci L, Meier B, Favre J, Righetti A, Rutishauser W. Long-term results of successful and failed angioplasty for chronic total coronary arterial occlusion. Am J Cardiol 1990;66:660-2.

[9] Shah PB. Management of coronary chronic total occlusion. Circulation 2011;123:1780-4.
[10] Joyal D, Afilalo J, Rinfret S. Effectiveness of recanalization of chronic total occlusions: a systematic review and meta-analysis. Am Heart J 2010;160:179-87.
[11] Abbott JD, Kip KE, Vlachos HA, Sawhney N, Srinivas VS, Jacobs AK, et al. Recent trends in the percutaneous treatment of chronic total coronary occlusions. Am J Cardiol 2006;97:1691-6.
[12] Prasad A, Rihal CS, Lennon RJ, Wiste HJ, Singh M, Holmes DR, Jr. Trends in outcomes after percutaneous coronary intervention for chronic total occlusions: a 25-year experience from the Mayo Clinic. J Am Coll Cardiol 2007;49:1611-8.
[13] Suero JA, Marso SP, Jones PG, Laster SB, Huber KC, Giorgi LV, et al. Procedural outcomes and long-term survival among patients undergoing percutaneous coronary intervention of a chronic total occlusion in native coronary arteries: A 20-year experience. J Am Coll Cardiol 2001;38:409-14.
[14] Ishizaka N, Issiki T, Saeki F, Ishizaka Y, Ikari Y, Abe J, et al. Angiographic follow-up after successful percutaneous coronary angioplasty for chronic total coronary occlusion: experience in 110 consecutive patients. Am Heart J 1994;127:8-12.
[15] Kinoshita I, Katoh O, Nariyama J, Otsuji S, Tateyama H, Kobayashi T, et al. Coronary angioplasty of chronic total occlusions with bridging collateral vessels: immediate and follow-up outcome from a large single-center experience. J Am Coll Cardiol 1995;26:409-15.
[16] Noguchi T, Miyazaki MS, Morii I, Daikoku S, Goto Y, Nonogi H. Percutaneous transluminal coronary angioplasty of chronic total occlusions. Determinants of primary success and long-term clinical outcome. Catheter Cardiovasc Interv 2000;49:258-64.
[17] Ma JY, Qian JY, Ge L, Fan B, Wang QB, Yan Y, et al. Retrograde approach for the recanalization of coronary chronic total occlusion: collateral selection and collateral related complication. Chin Med J (Engl) 2013;126:1086-91.
[18] Li P, Gai LY, Yang X, Sun ZJ, Jin QH. Computed tomography angiography-guided percutaneous coronary intervention in chronic total occlusion. J Zhejiang Univ Sci B 2010;11:568-74.
[19] Li JY, Li X, Wei MQ, Zhao HL, Zheng MW. Diagnostic accuracy of dual-source computed tomography in the detection of coronary chronic total occlusion: Comparison with invasive angiography. Afr J Biotechnol 2011;10:3854-8.
[20] Mollet NR, Hoye A, Lemos PA, Cademartiri F, Sianos G, McFadden EP, et al. Value of preprocedure multislice computed tomographic coronary angiography to predict the outcome of percutaneous recanalization of chronic total occlusions. Am J Cardiol 2005;95:240-3.
[21] Rieber J, Sheth TN, Mooyaart EA, Shapiro MD, Butler J, Ferencik M, et al. Assessment of the presence and extent of coronary collateralization by coronary computed tomographic angiography in patients with total occlusions. Int J Cardiovasc Imaging 2009;25:331-7.
[22] Tang L, Zhu X, Xu Y, Yu T, Xu H, Tang J, et al. Factors influencing delay time and coronary arterial density during coronary angiography with DSCT. Acta Radiol 2011;52:59-63.
[23] Xu Y, Tang L, Zhu X, Xu H, Tang J, Yang Z, et al. Comparison of dual-source CT coronary angiography and conventional coronary angiography for detecting coronary artery disease. Int J Cardiovasc Imaging 2010;26 Suppl 1:75-81.
[24] Yadav M, Palmerini T, Caixeta A, Madhavan MV, Sanidas E, Kirtane AJ, et al. Prediction of coronary risk by SYNTAX and derived scores: synergy between percutaneous coronary intervention with taxus and cardiac surgery. J Am Coll Cardiol 2013;62:1219-30.
[25] Bach RG. ACP Journal Club. SYNTAX score II predicted mortality after PCI or CABG in complex CAD better than SYNTAX score. Ann Intern Med 2013;159:JC5.
[26] Farooq V, Serruys PW, Bourantas CV, Zhang Y, Muramatsu T, Feldman T, et al. Quantification of incomplete revascularization and its association with five-year mortality in the synergy between percutaneous coronary intervention with taxus and cardiac surgery (SYNTAX) trial validation of the residual SYNTAX score. Circulation 2013;128:141-51.