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Impact of Percutaneous Coronary Intervention of Coronary Chronic Total Occlusion on Left Ventricular Function by Speckle Tracking Echocardiography

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Abstract

Chronic total occlusion (CTO) is a common finding in patients with coronary artery disease and is one of the most challenging targets of lesion recanalization for percutaneous coronary interventions (PCIs). CTO is defined as the complete occlusion of a coronary artery, exhibiting TIMI 0 or TIMI 1 flow, with an occlusion duration of more than three months. The rationale for the revascularization of a coronary CTO is the possible improvement of left ventricular (LV) function via the recovery of hibernating myocardium. Revascularization of CTO lesions by PCI reportedly lead to beneficial effects on symptoms, long-term survival, and incidence of coronary artery bypass grafting (CABG). However, mechanism of the beneficial effects of revascularization of CTO needs more studies and still remains unclear. An angle-independent assessment of myocardial strain is possible using two-dimensional speckle tracking echocardiography (2D-STE), which also gives in-depth knowledge of left ventricular (LV) myocardial contractility. That's why 2D-STE is the gold standard for detecting subtle deteriorations of contractility. These advantages of 2D-STE are useful for the detection of subclinical recovery of dysfunctional but viable myocardium after revascularization of CTO – LAD.

Keywords: Percutaneous coronary intervention, coronary chronic total occlusion, left ventricular function, speckle tracking echocardiography.

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1. Introduction

Speckle tracking echocardiography describes the semi-automated analysis of grey scale (B-mode) echocardiographic studies in which the spatial translocation of derived functional units (speckles) allows quantitative analysis of myocardial function [1]. Speckle tracking constitutes a subset of deformation imaging, which is utilized in the assessment of left ventricular function in the setting of such pathologies as diastolic dysfunction, cardiomyopathies and ischemic heart disease. The latest European Society of Cardiology (ESC) guidelines for the diagnosis and management of non-ST-elevation ACS (NSTE-ACS) and CCS suggest the use of speckle tracking to support diagnosis in patients referred to echocardiography for clinical suspicion of ischemic disease and absence of visual wall motion abnormalities. In fact, high sensitivity and specificity (86% and 73%, respectively) were reported for cutoff values of and of LV global circumferential strain (GCS) > -21.7% (87% and 76%, respectively) to detect significant coronary stenosis in patients with chest pain and inconclusive electrocardiographic (ECG) and blood test results, providing an additive value to the wall motion score index (WMSI) [2]. Accordingly, a meta-analysis including 1385 patients analyzed LVGLS ability to reveal CAD, showing satisfactory results for this noninvasive marker.

The mean values of LVGLS for those with and without CAD were -16.5% [95% confidence interval (CI): -15.8% to -17.3%] and -19.7% [95% CI: -18.8% and -20.7%]. Moreover, abnormal LVGLS detected moderate-to-severe CAD with a pooled 74.4% sensitivity, 72.1% specificity, 2.9 positive likelihood ratio, and 0.35 negative likelihood ratio. The area under the curve (AUC) and diagnostic odds ratio (OR) were 0.81 and 8.5, respectively [3]. What is more, LVGLS bull's eye polar maps offer an easy and quick assessment of regional distribution of myocardial necrosis through regional LS: the division in 17 wall segments from the apex to base and the visualization of a circumscribed blue area in specific segments allow to determine the distribution of blood flow-abnormalities according to the culprit coronary artery. Moreover, regional LS can be useful for differential diagnosis between ACS and Takotsubo syndrome, which has typical LV strain patterns of the polar map with exclusive involvement of apical segment, and between ACS and acute myocarditis, in which polar map is quite different from that of acute myocardial infarction (AMI) since the impaired areas do not follow a typical coronary topographic localization [4].

2. Impact of revascularization of coronary chronic total occlusion on left ventricular function

Chronic total coronary occlusion (CTO) is reported as an independent predictor of ventricular arrhythmias and has an adverse impact on long-term mortality. Recanalization of CTO lesions by percutaneous coronary intervention (PCI) reportedly produces beneficial effects on symptoms, long-term survival, and incidence of coronary artery bypass grafting (CABG). However, mechanism of the beneficial effects of recanalization of CTO still remains unclear. The present study aimed to assess the impacts of PCI for CTO from two different aspects [5]. First, no clinical study has evaluated electrical stability in patients with CTO. Arrhythmogenic substrate would play a role in ventricular arrhythmias. Compared to standard electrocardiogram, signal-averaged electrocardiogram (SAECG) is more sensitive and reproducible modality to evaluate the electrical stability. Late potential assessed by SAECG would serve as a surrogate of the arrhythmogenic substrate.

We aimed to assess the prevalence of late potential in CTO patients and effects of CTO-PCI on late potential and its components [6]. Second, improvement of global LV ejection fraction has never been achieved by CTO-PCI so far. Only regional improvement of the hibernating myocardium in the CTO area (collateral flow "recipient" area) was reported in magnetic resonance imaging studies. However, it could be hypothesized that not only collateral flow "recipient" area but also collateral flow "donor" area could be at a risk of ischemia in patients with CTO due to the so-called "steal phenomenon" [7]. Fractional flow reserve (FFR) study demonstrated the improvement of FFR value in "donor artery" after CTO-PCI, suggesting that subtle ischemia is existing in donor area and CTO-PCI could improve the ischemic status in donor coronary region. To detect such subtle ischemic status, strain analysis by two-dimensional speckle tracking echocardiography (2D-STE) would be helpful [8].

3. Impact of CTO-PCI on LV function

Improvements in regional contractile function in the CTO area were previously reported. Kirschbaum et al. evaluated the effects of CTO-PCI using magnetic resonance imaging and reported that segmental wall thickening improved in dysfunctional but viable segments 5 months after CTO recanalization. Further improvement was also seen after 3 years of follow-up [9].

4. Possible mechanism of the improved LV systolic and diastolic function

Ischemia produces a cascade of **events** beginning with metabolic and biochemical alternations that lead to impaired ventricular relaxation and diastolic dysfunction followed by impaired systolic function. In the early stage of ischemia, ventricular relaxation is initially impaired [10]. In CTO patients, as a hypothesis, the distal arterioles of the CTO area would maximally dilate and increase myocardial perfusion from the donor artery. In order to provide enough perfusion for the CTO area, the precapillary arterioles and arteriolar capillary vessels in the donor area must constrict to maintain the perfusion pressure. These compensatory mechanisms might limit the coronary blood flow to the donor area. As a result, myocardium in donor area could be in the early stage of ischemia or more. Improvement of mitral annulus velocity by CTO-PCI could partially be a representation of relief from early stage of ischemia in donor area [11]. In addition, subendocarium is most vulnerable part to ischemia. The longitude component of cardiac deformation predominates in this part of myocardium. Longitudinal strain analysis by 2D-STE is a quite sensitive and suitable method to evaluate this component of cardiac motion. Thus, improvement of strain by CTO-PCI in patients with preserved LV ejection fraction would also reflect the release from the early stage of ischemia [12].

5. Impact of cto-pci on electrical stability

Higher prevalence of late potential than healthy population probably was observed due to prior myocardial infarction. Berkalp et al. reported successful percutaneous transluminal coronary angioplasty for coronary artery disease caused improvement of late potential parameters at 1 month follow-up [13]. Cetin et al. evaluated the effect of CTO-PCI on other electrocardiogram parameters: corrected QT interval dispersion, TpTe interval, and TpTe/QT ratio. They demonstrated the significant improvements of these parameters 24–48 h after the procedure. Although late potential is theoretically a more sensitive and reproducible technology to assess the arrhythmogenic substrates than standard electrocardiogram parameters [13].

6. Echocardiographic evaluation of left ventricular functions after successful percutaneous recanalization of right coronary artery chronic total occlusions

Concomitant severe left main and/or multi vessel coronary artery disease is the primary factor in determining the revascularization mode (coronary artery bypass grafting surgery or percutaneous coronary intervention (PCI)) [14]. The primary therapy goals are symptom alleviation, improved left ventricular (LV) function, and survival. Some studies indicated that opening a CTO is linked too much reduced mortality than leaving one, however other studies disagreed [15]. However, there is no information on whether left ventricular (LV) functions will possibly improve following successful recanalization of RCA CTOs. The assessment of myocardial functions in both the LV and RV improved by new echocardiographic techniques including tissue Doppler imaging (TD I) and two-dimensional speckle-tracking echocardiography (2DSTE), which may also be used to detect subtle alterations brought on by revascularization procedures [16]. Patients with RCA CTOs who underwent successful PCI showed improvement in RV contractility when measured by the TDI-derived IVA, speck-leaf tracking-derived strain, and SR However, improvements in S' myocardial velocity, TAPSE, and FAC values obtained from the TDI failed to approach statistical significance.

In particular in patients with recent occlusions and depressed LV function, the Total Occlusion Study of Canada (TOSCA) reported that the restoration of coronary patency of nonacute occluded coronary arteries is associated with a small but significant improvement in regional and global LV function [17]. In the Occluded Artery Trial (OAT), PCI or best medical care alone was randomly assigned to 2201 stable patients with a persistently occluded infarct-related artery following myocardial infarction. The primary endpoint of death, recurrent MI, or heart failure did not vary overall. Absence of thorough patient identification may contribute to the absence of advantages from CTO recanalization that have

been adequately established. The group that has demonstrated the viability of the myocardial area associated with this artery is more likely to achieve better success when restoring tpatency of the CTO [18]. In a number of cardiopulmonary illnesses, RV function is a significant prognostic factor. Due to complicated anatomy of RV23, however, it is frequently difficult to evaluate it using echocardiography. Traditional echocardiographic parameters (TAPSE and FAC) and S'myocardial velocities by TDI only evaluate longitudinal RV shortening and ignore circumferential RV function [16]. Numerous investigations have shown that speckle tracking technique is sensitive and specific for detecting LV function. This method has recently been employed to evaluate LV function [19]. In summary, after successful percutaneous re-canalization of RCA CTOs, global long-term strain and systolic strain rate readings from 2DST E and TDI revealed improved LV functions, indicating the survivability of the LV in chronic ischemia [20-21].

References

[1] S. Mondillo, M. Galderisi, D. Mele, M. Cameli, V.S. Lomoriello, V. Zacà, P. Ballo, A. D'Andrea, D. Muraru, M. Losi. (2011). Speckle-tracking echocardiography: a new technique for assessing myocardial function. Journal of Ultrasound in Medicine. 30(1): 71-83.

[2] J.-P. Collet, H. Thiele. (2020). The 'Ten Commandments' for the 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J. 41: 3495-3497.

[3] K. Liou, K. Negishi, S. Ho, E.A. Russell, G. Cranney, S.-Y. Ooi. (2016). Detection of obstructive coronary artery disease using peak systolic global longitudinal strain derived by two-dimensional speckle-tracking: a systematic review and meta-analysis. Journal of the American Society of Echocardiography. 29(8): 724-735. e4.

[4] J. Schroeder, S. Hamada, N. Gründlinger, T. Rubeau, E. Altiok, K. Ulbrich, A. Keszei, N. Marx, M. Becker. (2016). Myocardial deformation by strain echocardiography identifies patients with acute coronary syndrome and non-diagnostic ECG presenting in a chest pain unit: a prospective study of diagnostic accuracy. Clinical Research in Cardiology. 105: 248-256.

[5] S. George, J. Cockburn, T.C. Clayton, P. Ludman, J. Cotton, J. Spratt, S. Redwood, M. De Belder, A. De Belder, J. Hill. (2014). Long-term follow-up of elective chronic total coronary occlusion angioplasty: analysis from the UK Central Cardiac Audit Database. Journal of the American College of Cardiology. 64(3): 235-243.

[6] P. Kulakowski, A. Biedrzycka, L. Ceremuzynski. (1996). Late potentials detected by digital Holter ECG: reproducibility, lead systems, and effects of physical activity. Annals of Noninvasive Electrocardiology. 1(1): 70-78.

[7] H. Sasai, K. Sakakura, K. Yuri, H. Wada, K. Arao, H. Funayama, Y. Sugawara, A. Yamaguchi, H. Adachi, S.-i. Momomura. (2013). Fractional flow reserve for a mild stenosis on the donor artery to chronic total occlusion. Cardiovascular intervention and therapeutics. 28: 193-196.

[8] R. Sachdeva, M. Agrawal, S.E. Flynn, G.S. Werner, B.F. Uretsky. (2013). Reversal of ischemia of donor artery myocardium after recanalization of a chronic total occlusion. Catheterization and Cardiovascular Interventions. 82(4): E453-E458.

[9] D. Joyal, J. Afilalo, S. Rinfret. (2010). Effectiveness of recanalization of chronic total occlusions: a systematic review and meta-analysis. American heart journal. 160(1): 179-187.

[10] H. Dokainish. (2015). Left ventricular diastolic function and dysfunction: Central role of echocardiography. Global Cardiology Science and Practice. 2015(1): 3.

[11] P. Reant, L. Labrousse, S. Lafitte, P. Bordachar, X. Pillois, L. Tariosse, S. Bonoron-Adele, P. Padois, C. Deville, R. Roudaut. (2008). Experimental validation of circumferential, longitudinal, and radial 2-dimensional strain during dobutamine stress echocardiography in ischemic conditions. Journal of the American College of Cardiology. 51(2): 149-157.

[12] Y. Sotomi, A. Okamura, K. Iwakura, M. Date, H. Nagai, T. Yamasaki, Y. Koyama, K. Inoue, Y. Sakata, K. Fujii. (2017). Impact of revascularization of coronary chronic total occlusion on left ventricular function and electrical stability: analysis by speckle tracking echocardiography and signal-averaged electrocardiogram. The International Journal of Cardiovascular Imaging. 33: 815-823.

[13] M. Cetin, C. Zencir, M. Cakici, E. Yildiz, H. Tasolar, M. Balli, S. Abus, E. Akturk, S. Ozgul. (2014). Effect of a successful percutaneous coronary intervention for chronic total occlusion on parameters of ventricular repolarization. Coronary artery disease. 25(8): 705-712.

[14] B. Ozkan, M. Urumdas, G. Alici, G. Acar, E. Alizade, M. Kalkan, M. Tabakci, S. Demir, M. Sahin, M. Bulut. (2013). Echocardiographic evaluation of right ventricular functions after successful percutaneous recanalization of right coronary artery chronic total occlusions. European Review for Medical & Pharmacological Sciences. 17(7): 917-22.

[15] H.N. Sabbah. (2016). Targeting mitochondrial dysfunction in the treatment of heart failure. Expert review of cardiovascular therapy. 14(12): 1305-1313.

[16] L. Longobardo, V. Suma, R. Jain, S. Carerj, C. Zito, D.L. Zwicke, B.K. Khandheria. (2017). Role of two-dimensional speckle-tracking echocardiography strain in the assessment of right ventricular systolic function and comparison with conventional parameters. Journal of the American Society of Echocardiography. 30(10): 937-946. e6.

[17] M.E. Ari, F. Ekici, İ.İ. Çetin, E.B. Tavil, N. Yaralı, P. Işık, T. Hazırolan, B. Tunç. (2017). Assessment of left ventricular functions and myocardial iron load with tissue Doppler and speckle tracking echocardiography and T2* MRI in patients with β-thalassemia major. Echocardiography. 34(3): 383-389.

[18] G. Bleeker, P. Steendijk, E. Holman, C. Yu, O. Breithardt, T. Kaandorp, M. Schalij, E. Van der Wall, P. Nihoyannopoulos, J. Bax. (2006). Assessing right ventricular function: the role of echocardiography and complementary technologies. Heart. 92(suppl 1): i19-i26.

[19] V.C.-C. Wu, M. Takeuchi. (2018). Echocardiographic assessment of right ventricular systolic function. Cardiovascular diagnosis and therapy. 8(1): 70-79.

[20] K. Murbraech, E. Holte, K. Broch, K.B. Smeland, H. Holte, A. Rösner, M.B. Lund, H. Dalen, C. Kiserud, S. Aakhus. (2016). Impaired right ventricular function in long-term lymphoma survivors. Journal of the American Society of Echocardiography. 29(6): 528-536.

[21] R. Blessing, I. Drosos, M. Molitor, T. Münzel, P. Wenzel, T. Gori, Z. Dimitriadis. (2023). Evaluation of right-ventricular function by two-dimensional echocardiography and two-dimensional speckle-tracking echocardiography in patients with successful RCA CTO recanalization. Clinical Research in Cardiology. 112(10): 1454-1462.