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REFERENCES

1. Prati F, Regar E, Mintz GS, et al. Expert review document on methodology, terminology, and clinical applications of optical coherence tomography: physical principles, methodology of image acquisition, and clinical application for assessment of coronary arteries and atherosclerosis. Eur Heart J 2010;31:401–15.

2. Gutiérrez-Chico JL, Alegría-Barrero E, Teijeiro-Mestre R, et al. Optical coherence tomography: from research to practice. Eur Heart J Cardiovasc Imaging 2012;13:370–84.

3. Foin N, Mari JM, Nijjer S, et al. Intracoronary imaging using attenuation-compensated optical coherence tomography allows better visualisation of coronary artery diseases. Cardiovasc Revasc Med 2013;14:139–43.

4. Jang I-K, Bouma BE, Kang D-H, et al. Visualization of coronary atherosclerotic plaques in patients using optical coherence tomography: comparison with intravascular ultrasound. J Am Coll Cardiol 2002;39:604–9.

5. Girard MJA, Strouthidis NG, Ethier CR, Mari JM. Shadow removal and contrast enhancement in optical coherence tomography images of the human optic nerve head. Invest Ophthalmol Vis Sci 2011;52:7738–48.

Diagnostic Performance of Myocardial CT Perfusion Imaging With or Without Coronary CT Angiography

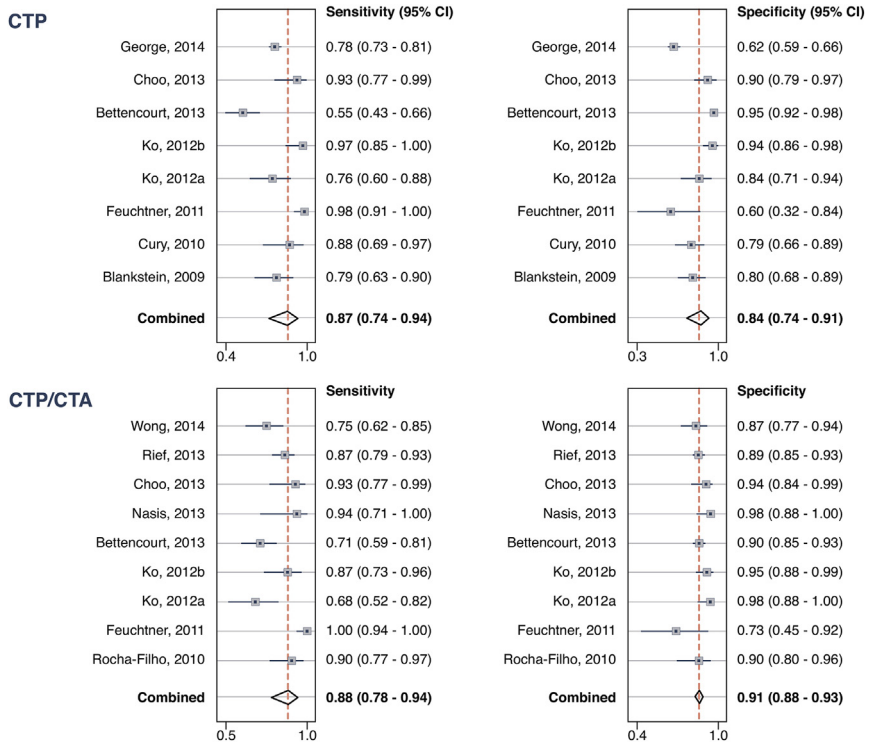
Myocardial computed tomography perfusion (CTP) imaging is used as an alternative to established myocardial perfusion imaging modalities (1). Although coronary computed tomography angiography (CTA) has value in ruling out coronary artery disease (CAD), it is also characterized by high false positive rates and the inability to distinguish functionally significant from insignificant lesions (2). The addition of CTP to CTA may improve its diagnostic performance by providing functional information of coronary stenoses. Results of studies attempting to define the diagnostic characteristics of CTP with or without CTA have been variable. In this meta-analysis, we synthesized available evidence on the diagnostic performance of CTP with or without coronary CTA in reference to invasive coronary assessment.

Two investigators searched the MEDLINE, EMBASE, and CENTRAL databases using relevant key words for studies published before December 2014. References of eligible studies were perused for additional eligible studies. We included studies evaluating pharmacological stress CTP with or without CTA in reference to quantitative coronary angiography (QCA) or fractional flow reserve (FFR) for the diagnosis of CAD. We only included studies in which qualitative perfusion assessment was performed. We constructed 4 × 4 diagnostic performance tables adhering to QCA and FFR cutoffs adopted by individual studies for CAD definition. When results for different cutoffs were available, for consistency we used QCA stenosis >50% and FFR <0.80 thresholds. We calculated summary sensitivity, specificity, and areas under the receiver-operating characteristic curves (AUC_{ROC}) with 95% CI using bivariate random-effects meta-analysis on a per-vessel basis. Although traditional diagnostic meta-analysis unifies sensitivity and specificity into 1 measure (the summary ROC), bivariate meta-analysis maintains their distinct characteristics and takes into account their potentially negative correlation. Heterogeneity was quantified with the I^2 statistic.

Twelve studies including 920 patients (median n = 39) and 1,563 coronary vessels (median n = 104) were eligible. Stenosis of 50% (n = 5 studies) or 70% (n = 2) per QCA and FFR <0.8 (n = 4) or <0.75 (n = 1) were the reference cutoffs. By QCA or FFR, a median 51.5% of patients (interquartile range: 35% to 71%) had significant CAD. The diagnostic performance of CTP alone and CTP/CTA was assessed in 8 and 9 studies, respectively. Per-vessel summary sensitivity, specificity, and AUC_{ROC} (95% CI) for CTP were 0.87 (0.74 to 0.94), 0.84 (0.74 to 0.91), and 0.92 (0.89 to 0.94), respectively. The respective summary values for CTP/CTA were 0.88 (0.78 to 0.94), 0.91 (0.88 to 0.93), and 0.91 (0.88 to 0.93) (**Figure 1**). No significant differences were observed in separate analyses for QCA and FFR as reference methods or when studies using QCA stenosis >50% as reference were excluded. Heterogeneity was significant (I^2 > 50%) in the main and sensitivity meta-analyses of both CTP and CTP/CTA.

This bivariate meta-analysis indicated favorable diagnostic performance of CTP compared with "gold-standard" invasive methods for CAD assessment. Addition of CTA to CTP resulted in slightly improved specificity without significantly improved sensitivity or overall performance. We note the significant

FIGURE 1 Bivariate Random-Effects Summary Sensitivity and Specificity of Myocardial CTP With and Without Coronary CTA for the Detection of Coronary Artery Disease



CTA = computed tomography angiography; CTP = computed tomography perfusion.

heterogeneity as a potential limitation of this analysis. Such degree of heterogeneity can be attributed to varying pre-test CAD probabilities among the included patient populations, variations in CTP imaging techniques, and slightly different diagnostic reference cutoffs. Despite its suggested diagnostic superiority compared with single-photon emission computed tomography (3), CTP has not yet gained widespread popularity in clinical practice. Although alternative well-established perfusion assessment methods remain available (single-photon emission computed tomography, positron emission tomography, stress echocardiography, and cardiac magnetic resonance), the possible superior diagnostic characteristics of CTP should be weighed against the cost, radiation exposure (4), and risk for contrast-induced nephropathy, even though the latter has been disputed and remains the subject of further investigation (5). In addition, the prognostic value of CTP-detected perfusion defects and the downstream effects on patient management remains to be determined. The ultimate clinical significance of the favorable diagnostic characteristics of CTP imaging will be established on the basis of patient outcome improvements in randomized trial comparisons in which different diagnostic modalities inform clinical decision making.

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REFERENCES

1. Blankstein R, Shturman LD, Rogers IS, et al. Adenosine-induced stress myocardial perfusion imaging using dual-source cardiac computed tomography. J Am Coll Cardiol 2009;54:1072–84.

2. Budoff MJ, Dowe D, Jollis JG, et al. Diagnostic performance of 64-multidetector row coronary computed tomographic angiography for evaluation of coronary artery stenosis in individuals without known coronary artery disease: results from the prospective multicenter ACCURACY trial. J Am Coll Cardiol 2008;52:1724–32.

3. George RT, Mehra VC, Chen MY, et al. Myocardial CT perfusion imaging and SPECT for the diagnosis of coronary artery disease: a head-to-head comparison from the CORE320 multicenter diagnostic performance study. Radiology 2014;272:407–16.

4. Einstein AJ, Berman DS, Min JK, et al. Patient-centered imaging: shared decision making for cardiac imaging procedures with exposure to ionizing radiation. J Am Coll Cardiol 2014;63:1480–9.

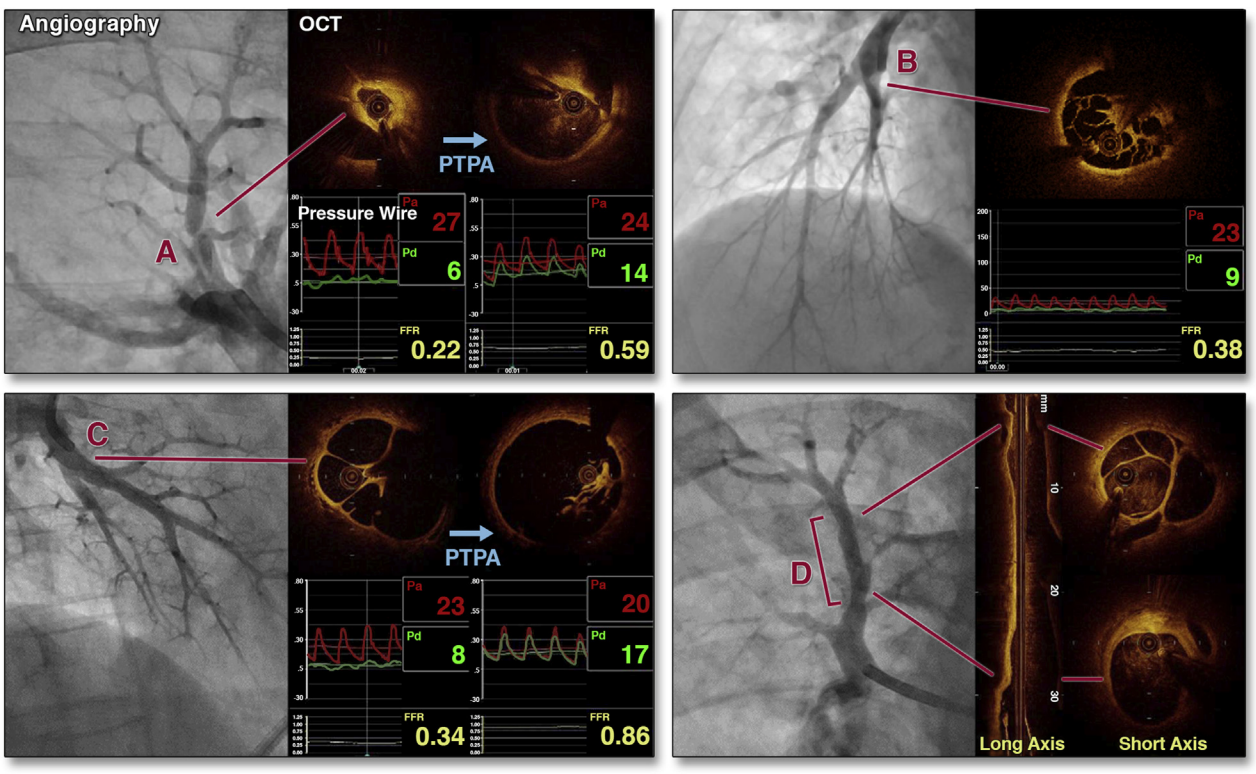
5. McDonald RJ, McDonald JS, Carter RE, et al. Intravenous contrast material exposure is not an independent risk factor for dialysis or mortality. Radiology 2014;273:714–25.

Diversity of Lesion Morphology in CTEPH Analyzed by OCT, Pressure Wire, and Angiography

Percutaneous transluminal pulmonary angioplasty (PTPA), or balloon pulmonary angioplasty, has been the focus of much attention and has rapidly been established as a promising new therapy for chronic thromboembolic pulmonary hypertension (CTEPH) in recent years (1,2). The procedures have been modified by the use of several modalities such as intravascular ultrasound and pressure wire (3). Here, we further present the potential utility of optical coherence tomography (OCT) in the PTPA procedure. In addition, we demonstrate the diversity of lesion morphology in CTEPH analyzed by these modalities.

Lesion type A in **Figure 1** is a representative pulmonary arterial lesion that is easily identified by angiography. Before PTPA, OCT revealed a tight stenosis due to a lipid-rich plaque with possible organized thrombus in this lesion. The lesion was dilated by PTPA, and OCT after PTPA demonstrated eccentrically located organized thrombus accompanied by incomplete improvement of pressure ratio (<0.8), the ratio of distal pressure to proximal pressure across the lesion (shown as fractional flow reserve [FFR] in **Figure 1**) detected by pressure wire, demonstrating that this lesion cannot be easily

FIGURE 1 Angiography, OCT, and Pressure Ratio in Chronic Thromboembolic Pulmonary Hypertension



Fractional flow reserve (FFR) represents the ratio of the distal pressure to proximal pressure across the lesion. **Blue arrows** mean the performance of percutaneous transluminal pulmonary angioplasty (PTPA). OCT = optical coherence tomography; Pa = mean pressure in the proximal area of the target lesion detected by pressure wire; Pd = mean pressure in the distal area of the target lesion detected by pressure wire.