EDITORIAL COMMENT

Diagnostic Optimization of Coronary CT Angiography*

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Combined evaluation of coronary anatomy and myocardial ischemia has become the holy grail of noninvasive diagnostic imaging. Several approaches, such as hybrid imaging combining coronary computed tomography angiography (CTA) for anatomy and stress-rest nuclear imaging for perfusion, are adding to the complexity, cost, and radiation burden of both techniques. In theory, a single imaging device that could provide both anatomic

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and functional assessment would be preferable. Choi et al. (1) describe a post hoc analysis of coronary CTA that optimizes and expands its diagnostic power such that this single modality can fulfill these requirements.

Essential Findings

Choi et al. (1) evaluated the transluminal attenuation gradient (TAG) by 64-slice coronary CTA in 370 major coronary arteries and correlated TAG with coronary stenosis as assessed by coronary CTA and conventional quantitative coronary angiography (QCA). Findings by TAG were also related to coronary flow velocity evaluated by Thrombolysis In Myocardial Infarction (TIMI) frame count.

The authors found that the linear regression coefficient between TAG and the length from the coronary ostium decreased consistently and signif-

icantly with maximum stenosis severity on a per-vessel basis ($p < 0.0001$) and was related to TIMI frame count ($p < 0.0001$).

In addition, applying the TAG technique significantly improved the diagnostic accuracy of coronary CTA in vessels with calcified lesions and refined the classification of stenosis severity by coronary CTA when using QCA as a reference standard.

Why This New Approach Is Potentially Important and Clinically Relevant

As a promising noninvasive imaging tool, coronary CTA is increasingly used in clinical practice to evaluate coronary artery disease (CAD) and to rule out obstructive CAD in symptomatic patients with low to intermediate pre-test probability of disease (2). Although studies have shown good agreement between coronary CTA and conventional QCA in the assessment of coronary stenosis severity (3), visual estimates of stenosis severity are routinely used in clinical practice.

Although the information content of coronary CTA is much superior to the one provided by the standard 2-dimensional invasive coronary angiogram, simultaneous 3-dimensional imaging of plaque burden and plaque composition often compromises our ability to adequately size the degree of luminal stenosis. Yet current revascularization paradigms are based on the recognition of "significant" luminal diameter reduction. Typically, the presence of ≥50% diameter stenosis will trigger further therapeutic intervention and evaluation of the appropriateness of mechanical revascularization to complement optimal medical therapy.

As it is now widely recognized, reliable assessment of coronary stenosis severity can be extremely challenging in patients with complex or calcified coronary lesions.

One important finding in the present study (1) was that the diagnostic accuracy of visual interpretation of coronary CTA can be significantly improved when combined with TAG analysis, especially in patients with calcified lesions.

The second important contribution of the TAG approach is that it allows the extraction of functional data, not just anatomic information, from the coronary CTA. Recent practice guidelines (4) increasingly insist on the need for combined anatomic and functional evaluation of CAD for the optimal use of treatment modalities, such as coronary stenting and bypass surgery. Yet visual interpretation of coronary CTA correlates poorly with functional testing. When compared with imaging of stress-induced ischemia or the invasive pressure-derived fractional flow reserve, only about half of the "significant" stenoses by coronary CTA were of hemodynamic importance (5). As a consequence, decisions based purely on anatomy may lead to a large proportion of inappropriate revascularization procedures. In the present study, TAG analysis correlated with coronary flow velocity evaluated by the TIMI frame count, showing at least the potential of coronary CTA to provide an integrated assessment of the hemodynamic impact of coronary stenosis as well as its anatomic severity.

Thus, applying both features of TAG analysis to coronary CTA interpretation may represent a useful approach to correct one of the major limitations of coronary CTA (i.e., its significant overestimation of both anatomic and functional coronary severity).

Unanswered Questions

The current approach deserves to be further refined from at least 4 aspects.

1. From a methodological viewpoint, it remains to be determined to what extent beam hardening and partial volume effect may affect TAG analysis. Perhaps even more importantly, the 64-slice coronary CTA scanner used in the present study does not image the entire coronary tree at the same time. Therefore, the impact of more recent scanning protocols with 320-detector row machines needs to be evaluated and may actually increase the incremental diagnostic value of the TAG approach.

2. TAG was derived by the linear regression coefficient calculated over the entire vessel from proximal to distal at 5-mm intervals. Although intervals comprising significant stenosis, severe calcification, and stent were excluded to reduce bias caused by the nonlinearity of luminal attenuation, flow can also significantly diverge at coronary bifurcations. This will cause nonlinearity of luminal attenuation across the bifurcations. Therefore, future iterations of the analysis protocol might benefit from including dedicated bifurcation analysis approaches (6).

3. This study showed that the classification of coronary CTA stenosis severity by visual estimation was refined with the combined use of TAG analysis. However, it might be interesting to explore the incremental diagnostic improvement per stenosis severity classes, especially for mild to intermediate stenoses with uncertain significance. A refined diagnosis will be most clinically relevant when it results in stenosis reclassification from mild class (30% to 49% diameter stenosis) to the moderate class (50% to 69% diameter stenosis) or the reverse.

4. A refined TAG technique deserves to be further validated against more sophisticated standards than presently used.

From the anatomic perspective, to fully understand the added value of the technology, reference stenosis severity by coronary CTA should be analyzed quantitatively using dedicated 3-dimensional software instead of 2-dimensional technology. The estimation of the reference diameter, in particular, will be more accurate with the use of 3-dimensional QCA by integrating information from 2 projections (7).

From the functional viewpoint, the lesion-specific fractional flow reserve is the obvious standard of reference with which TAG estimates of hemodynamic stenosis severity should be compared in future prospective studies (5).

Pending further refinement and validation, TAG analysis might help coronary CTA to become one of the serious contenders for the most wanted position of "one-stop shop coronary imaging" tool.

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