

Coronary CT Angiography-derived Fractional Flow Reserve Testing in Patients with Stable Coronary Artery Disease: Recommendations on Interpretation and Reporting

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Conflicts of interest are listed at the end of this article.

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Noninvasive fractional flow reserve derived from coronary CT angiography (FFR_{CT}) is increasingly used in patients with coronary artery disease as a gatekeeper to the catheterization laboratory. While there is emerging evidence of the clinical benefit of FFR_{CT} in patients with moderate coronary disease as determined with coronary CT angiography, there has been less focus on interpretation, reporting, and integration of FFR_{CT} results into routine clinical practice. Because FFR_{CT} analysis provides a plethora of information regarding pressure and flow across the entire coronary tree, standardized criteria on interpretation and reporting of the FFR_{CT} analysis result are of crucial importance both in context of the clinical adoption and in future research. This report represents expert opinion and recommendation on a standardized FFR_{CT} interpretation and reporting approach.

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Since the first study on coronary CT angiography-derived fractional flow reserve (CT FFR) diagnostic performance by Koo and colleagues in 2011 (1), an abundance of data pertaining to this modality has been published. Several tools have been introduced for the calculation of CT FFR (1–3); however, the majority of existing evidence and clinical experience is based on the HeartFlow FFR_{CT} method (HeartFlow, Redwood City, Calif), which is the only CT FFR cleared by the United States Food and Drug Administration (4) and endorsed by the National Institute for Health and Care Excellence in the United Kingdom (5). Comprehensive reviews of the principle of FFR_{CT} have been described previously (6–8). FFR_{CT} assessment is increasingly used in mainstream clinical practice (9–14) and is likely to further expand with the increased utilization of coronary CT angiography as a first-line test in patients suspected of having coronary artery disease (CAD). While there has been much focus on the diagnostic performance and potential clinical utility of FFR_{CT} in patients with moderate CAD (9–18), there has been less focus on interpretation, reporting, and integration of FFR_{CT} results into routine clinical practice (19). A broadly adopted standardized FFR_{CT} interpretation and reporting approach providing rich and consistent information may facilitate more appropriate clinical implementation and stimulate further high-quality research. Thus, this report, which was written by an independent group of

physicians with years of clinical experience with FFR_{CT} , proposes standardized criteria for FFR_{CT} interpretation and reporting for application in clinical practice and for clinical research.

FFR versus FFR_{CT}

FFR_{CT} provides simultaneous calculation of pressure and flow across the entire coronary tree (Fig 1). In contrast, information pertaining to invasively measured FFR is only available in vessels that have been interrogated with the pressure wire, which is typically decided during invasive coronary angiography at the discretion of the interventionists (20). While anatomic percentage of stenosis is evaluated at the location of the lesion, invasive FFR is typically measured by positioning the pressure sensor in the distal part of the vessel and then manually pulling the pressure sensor back to the ostium to assess the distribution of abnormal epicardial resistance along the course of the vessel (20). In both invasive FFR and FFR_{CT} , the distal values in any given vessel reflect the cumulative pressure loss and impact of all disease proximal to the measurement location. Values obtained by both techniques may vary depending on the measurement location within a vessel. Accordingly, in vessels that have been assessed using both techniques, if the measurement locations of invasive FFR and FFR_{CT} are not matched, their values can be different and may not closely correlate.

Abbreviations

CAD = coronary artery disease, FFR = fractional flow reserve, FFR_{CT} = CT angiography–derived FFR, LAD = left anterior descending artery, SCCT = Society of Cardiovascular Computed Tomography

Summary

Expert opinion and recommendation was given by an independent group of physicians on a standardized interpretation and reporting approach for CT-derived fractional flow reserve testing supported by years of clinical experience.

Key Points

- Standardized criteria on interpretation and reporting of CT-derived fractional flow reserve (FFR_{CT}) analysis results are of importance both in context of their clinical adoption and in future research.
- Use of the FFR_{CT} value 10–20 mm distal to the lower border of the stenosis for decision making is recommended.
- We recommend for clinical decision making a dichotomous interpretation strategy to be considered only in lesions with FFR_{CT} greater than 0.80 or lower than or equal to 0.75, whereas, in patients with FFR_{CT} ranging between 0.76 and 0.80, additional risk stratification information is needed.
- The results of FFR_{CT} must be evaluated in their clinical context, taking into account patient symptoms, the coronary anatomy, and suitability of revascularization.

FFR_{CT} Interpretation

As for CT angiography, FFR_{CT} interpretation should be performed by the local imaging experts determined by level of clinical knowledge and practical experience with the technique. This may include cardiologists and/or radiologists. It is recommended that downstream management decision making beyond FFR_{CT} takes into account both the clinical scenario (symptoms, risk profile, and/or comorbid conditions) and the coronary anatomy.

Evaluation of CT Angiography and Lesion Location

The first step in the interpretation of FFR_{CT} is to re-examine the original coronary CT angiography study with particular focus on the location and severity of detailed anatomic lesions (Table). Because FFR_{CT} declines along the length of the vessel with serial focal lesions or areas of diffuse disease, it is important to correlate the pressure loss to specific lesions, which can only be established by direct comparison between the CT angiography lesion location and the FFR_{CT} three-dimensional coronary tree model in relation to identifiable vessel landmarks, such as origin, branches, and segments. It is recommended that this first step be performed by using the Society of Cardiovascular Computed Tomography (SCCT) coronary segmentation model (21).

FFR_{CT} Threshold

There is high per-patient and per-vessel agreement between FFR_{CT} and invasive FFR using the threshold of 0.80 for both techniques (1,15–18). An FFR_{CT} value greater than 0.80 indicates that the lesion is unlikely to be hemodynamically

significant and that the patient can be safely treated with optimal medical treatment without further downstream testing (1,12–18,22,23). A poststenotic FFR_{CT} value less than or equal to 0.80 indicates the possibility of hemodynamic significance (1,15–18). The use of this dichotomous FFR_{CT} threshold to guide treatment decisions, namely to avoid further downstream testing or consider invasive angiography and revascularization, remains controversial, as it is well known from the invasive literature that the greatest benefit of revascularization is obtained in patients with the most severe pressure loss (24,25). We recommend a dichotomous interpretation strategy to be considered in lesions with FFR_{CT} greater than 0.80 or less than or equal to 0.75 (ie, values >0.80 are “normal” and values ≤ 0.75 are associated with high likelihood of hemodynamic significance) (Table, Figure 2). Several factors support this strategy. First, FFR_{CT} values are lower than measured FFR (with a bias ranging between 0.03 and 0.05) (16,18). Second, among patients with FFR_{CT} values less than or equal to 0.80, there is a graded correlation between FFR_{CT} and invasive FFR, with the highest FFR_{CT} uncertainty in the range between 0.76 and 0.80 and the highest agreement when FFR_{CT} is less than or equal to 0.75 (12,18). Third, FFR_{CT} , similar to FFR, exhibits a continuous relationship between its numerical value and clinical outcomes, with the worst outcome at lower FFR_{CT} values (14,22,23). Finally, symptomatic patients with moderate CAD determined at CT angiography and FFR_{CT} values greater than 0.80 and in whom invasive angiography is deferred have a favorable prognosis (12,14,22,23).

Clinical decision making in patients with FFR_{CT} ranging between 0.76 and 0.80 is nuanced and may benefit from consideration of additional risk stratification information (Fig 2). Identifying patients at incrementally higher cardiovascular risk, who may benefit from an early coronary angiography approach, can be done by assessing several factors: high-risk plaque features (low attenuation, positive remodeling, napkin-ring sign) (26–28), plaque burden (27,28), stenosis location (proximal vs distal; main vessel vs side branch) (25,29,30), vessel territory (left anterior descending artery [LAD] vs non-LAD) (29), ratio of coronary vessel volume to myocardial mass (31), and/or the translesional FFR_{CT} gradient (ΔFFR_{CT}) (32). It is the opinion of the present author group that in certain instances with FFR_{CT} values less than or equal to 0.75 (eg, small vessels, distal lesions, side branches), patients may be treated with optimal medical therapy without referral to invasive angiography as a first-line strategy (14,33).

In a recent retrospective study, a large pressure drop ($\Delta FFR_{CT} \geq 0.06$) was a stronger predictor of culprit lesions for future acute coronary syndromes than FFR_{CT} measured distal to the lesion alone (32). Ongoing studies are assessing the potential diagnostic value of ΔFFR_{CT} in clinical practice. Overall, the results of FFR_{CT} , as for invasive FFR, must always be evaluated in their clinical context, taking into account patient symptoms and comorbid conditions, which inform the goals of coronary intervention, in combination with the coronary anatomy and suitability of revascularization.

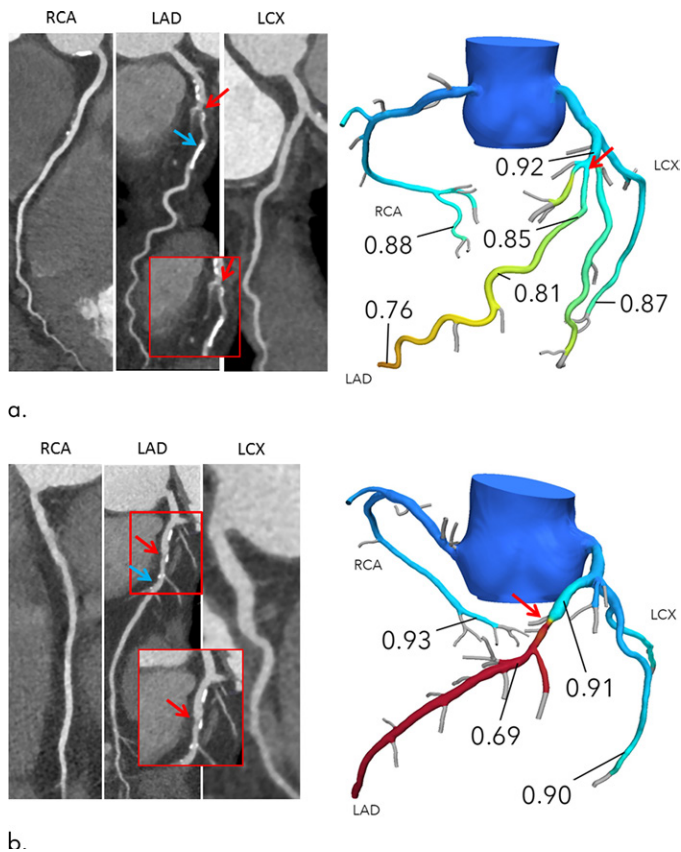


Figure 1: (a) Interpretation of FFR_{CT} results in a 65-year-old woman with typical angina. Agatston score, 333. Left: Coronary CT angiography curved multiplanar reconstructions demonstrate a 50%–69% proximal left anterior descending artery (LAD) stenosis (red arrow) and in the mid-LAD, nonobstructive diffuse disease. The blue arrow indicates where the lesion-specific FFR_{CT} value was assessed. Right: In the FFR_{CT} three-dimensional model, the FFR_{CT} value 16 mm distal to the stenosis was 0.85, indicating that the lesion did not cause significant pressure loss. However, FFR_{CT} was significantly low (0.76) in the terminal vessel segments. (b) Interpretation of FFR_{CT} results in a 63-year-old man with atypical angina. Agatston score, 245. Left: Coronary CT angiographic images demonstrate a 50%–69% proximal LAD stenosis (red arrow). The blue arrow indicates where the lesion-specific FFR_{CT} value was assessed. Right: In the FFR_{CT} three-dimensional model, the FFR_{CT} value 14 mm distal to the stenosis indicated that the lesion was hemodynamically significant with a value of 0.69. Coronary CT angiography and FFR_{CT} reporting are demonstrated in Figure 4. LCX = left circumflex coronary artery, RCA = right coronary artery.

Standardized Interpretation of Hemodynamically Significant Lesions

In patients with CAD, as for measured FFR, FFR_{CT} values decline from the ostium to the distal vessel irrespective of the vessel territory, stenosis severity, and location (14,19,34–36). In FFR practice, it is advised that the FFR value within the throat of the lesion (which may correspond to the minimum FFR_{CT} value) is not used clinically and that the pressure is assessed at least 2–3 cm distal to the stenosis of interest (20). Likewise, for clinical decision making, we recommend using the FFR_{CT} value distal to the lesion. With the interactive three-dimensional coronary model tool (HeartFlow), it is possible to obtain multiple values across the vessel. Hence, after localizing the stenosis, the vessel should be serially interrogated downstream from the lesion. Notably, the FFR_{CT} value may transiently rise immediately after the stenosis because of poststenotic vessel

dilatation, resulting in reduced flow velocity and pressure recovery (Fig 3). In a recent study, it was suggested that a reliable location at which to assess FFR_{CT} was 1 cm distal to the end of a stenosis (36). For clinical decision making, we recommend using the FFR_{CT} value 1–2 cm distal to the lower border of the stenosis, avoiding the pressure recovery phenomenon.

Distal Vessel FFR_{CT} Values

FFR_{CT} provides simultaneous computation of pressure and flow in the entire coronary tree, thus exposing both lesion-specific pressure as well as nadir FFR_{CT} values across the coronary system, which in various settings may drop less than or equal to 0.80 (14,19,34–36) (Fig 1). Low terminal vessel FFR_{CT} values (rather than a value distal to stenosis) may include effects unrelated to the stenosis (19,35–37). These low values remote from a focal lesion may be due to diffuse CAD or reflect the sum of serial flow-limiting lesions (35–37). In recent studies, 35%–44% of patients with stable CAD and terminal vessel FFR_{CT} values less than or equal to 0.80 were reclassified as negative when the FFR_{CT} point of reading was 1–2 cm distal to stenosis (14,35). In one observational single-center study, the intermediate follow-up clinical outcome was favorable in patients with terminal FFR_{CT} values less than or equal to 0.80 who were treated with optimal medical treatment (14). In vessels without a significant pressure loss within 2 cm distal to the lesion of interest, but with FFR_{CT} values less than or equal to 0.80 in nearby (eg, mid coronary) segments, we recommend assessment for extent of upstream disease including both CT angiography and FFR_{CT} . FFR_{CT} values less than or equal to 0.80 in such circumstances may be clinically relevant (especially when present distal to a lesion in a proximal segment supplying a large myocardial territory). The group recognizes that more research is needed, particularly in large vessels that have discordance between lesion-specific FFR_{CT} and values taken 2 cm beyond an upstream lesion.

Serial Lesions

The individual contribution of a given lesion in the event of serial stenosis cannot be assessed with FFR_{CT} , similar to measured FFR, in any straightforward way because of the complex physiologic interplay between stenoses (Fig 3). At present, there is no accepted way to identify the lesion that contributes most to this cumulative pressure loss. Intuitively, the intrinsic impact of a given lesion should relate to ΔFFR_{CT} of that individual lesion, and previous data have in fact demonstrated excellent correlation between ΔFFR_{CT} and invasive ΔFFR (38). However, in a recent study, it was demonstrated that ΔFFR_{CT} (as well as ΔFFR) may underestimate the physiologic contribution of stenosis in vessels with serial lesions (39). An interactive revascularization FFR_{CT} -based planner tool (HeartFlow) may more accurately predict the invasive FFR contribution of each stenosis in serial CAD (39). The

ongoing Precise Percutaneous Coronary Intervention plan (P³) study (ClinicalTrials.gov: NCT03782688) investigates the diagnostic value of the FFR_{CT} revascularization planner tool.

FFR_{CT} Reporting

Coronary CT angiography and FFR_{CT} uniquely provide simultaneous anatomic and functional information in a noninvasive fashion. To provide useful, actionable guidance for medical or invasive management, the FFR_{CT} report must relate the observed anatomic coronary CT angiography findings with lesion-specific FFR_{CT} values. The principal purpose of the report is to communicate these findings and their clinical implications (Fig 4).

Indications

The indications for the FFR_{CT} analysis should include clinical information from the original coronary CT angiography report, as well as specific anatomic details from the impression of the report that motivated the performance of FFR_{CT} analysis. Mention should be made of factors pertinent to the FFR_{CT} indication and suitability for analysis, such as angiographic degree of stenosis, extent of calcifications, and overall image quality (signal-to-noise ratio, motion artifacts, luminal contrast opacification). The indications should specify the anatomic lesions from the original coronary CT angiography report that were of particular concern in ordering the FFR_{CT} analysis. The present author group finds FFR_{CT} testing appropriate in patients with intermediate anatomic stenosis. FFR_{CT} values may be less than or equal to 0.80 in lesions of less than 50% diameter stenosis. Physiologic characterization with FFR_{CT} may be relevant in a small proportion of such lesions when located in proximal coronary segments supplying a large myocardial territory because they may have prognostic implications (40). On the other hand, even high-grade anatomic lesions with stenosis severity greater than 70% or even greater than 90%, which are generally considered flow limiting, may overestimate the physiologic significance (41,42). Therefore, we commonly use FFR_{CT} testing in the setting of more severe anatomic disease and multivessel disease to help guide decision making on downstream catheterization and potential revascularization planning (Fig 2). As with any test, the appropriateness is often determined on a case-by-case basis and commonly related to many factors beyond stenosis severity (Fig 2). Finally, because the impact of coronary occlusion on the diagnostic performance of FFR_{CT} is unknown, we do not recommend FFR_{CT} analysis to be prescribed in such circumstances.

Approach to Interpreting FFR_{CT}

Summary FFR_{CT} Values

> 0.80: Not hemodynamically significant

0.76–0.80: Borderline hemodynamically significant

≤ 0.75: Hemodynamically significant

Relate coronary CT angiography lesions to the FFR_{CT} value

Focal lesion with adjacent FFR_{CT} value ≤ 0.80 (lesion-specific pressure loss)*

Absence of lesion-specific pressure loss, but terminal vessel FFR_{CT} value ≤ 0.80 (diffuse pressure loss)

Sequential lesions with sequential FFR_{CT} values (distal to each lesion)

* We recommend using the minimum FFR_{CT} value 10–20 mm distal to the lower border of the stenosis.

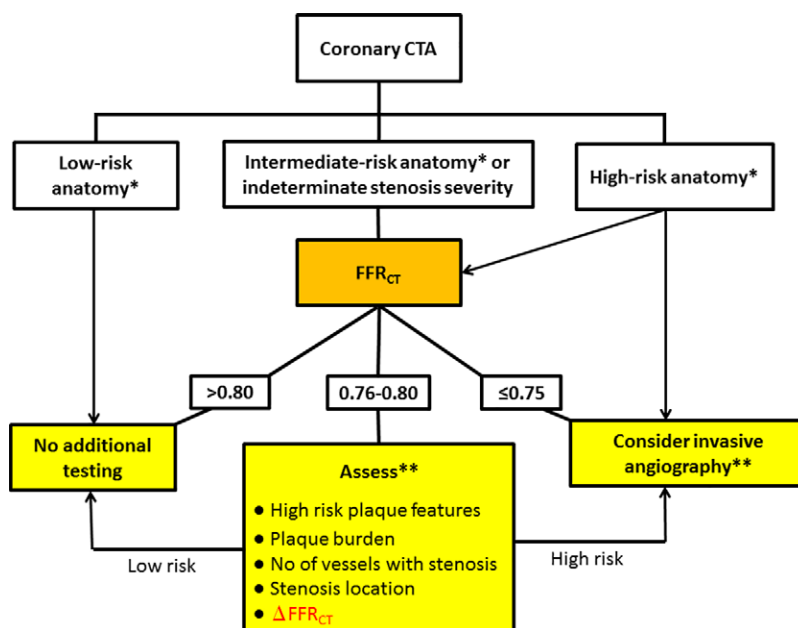


Figure 2: FFR_{CT} appropriateness and interpretation recommendation. * = Low risk: patients either without coronary disease or with maximum stenosis less than 30%. Intermediate risk: patients with one or more intermediate range stenosis (30%–69%). High risk: patients with left main, three-vessel disease or stenosis 70% or greater. Anatomic characteristics beyond stenosis severity, patient symptoms, and suitability of revascularization may influence decisions on management after coronary CT angiography (CTA). ** = Posttest risk stratification: Test results must always be evaluated in their clinical context, taking into account patient symptoms and preferences as well as high-risk anatomic features and likelihood of revascularization.

Results

We recommend FFR_{CT} values to be reported for each major coronary branch by specific coronary segments (diameter greater than 1.8 mm) using the standardized SCCT guidelines for coronary segmentation classification (21), and that the values be related to specific lesions within a given segment.

Any lesion identified in the original coronary CT angiography report as a potential source of pressure loss should be specifically reported in the FFR_{CT} report and its standard SCCT coronary segment identified. A given FFR_{CT} value may have different therapeutic implications if located in a proximal segment as opposed to either a distal location or within a minor side branch (25,29,30). If no FFR_{CT} value

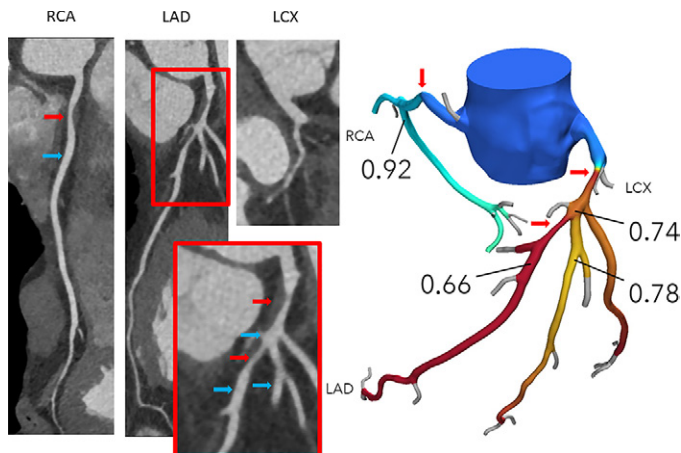


Figure 3: FFR_{CT} assessment in vessels with serial lesions in a 53-year-old man with typical angina. Agatston score, 0. Left: Coronary CT angiography curved multiplanar reconstructions demonstrate a proximal 60% right coronary artery (RCA) stenosis (red arrow) and two serial stenoses in the left anterior descending artery (LAD) (one lesion in the proximal segment with 70% or greater diameter stenosis, and a 50%–69% diameter stenosis lesion distal to the takeoff of the second diagonal [red arrows]). Blue arrows indicate where the FFR_{CT} values were assessed. Right: In the FFR_{CT} three-dimensional model, the FFR_{CT} value 10 mm distal to the proximal LAD stenosis was 0.74 and thus had hemodynamic significance, whereas FFR_{CT} 1.5 mm distal to the second LAD stenosis was 0.66. FFR_{CT} 10 mm distal to the lower border of the proximal RCA stenosis was 0.92, thus this lesion had low likelihood of being hemodynamically significant. Of note, pressure recovery was observed in the proximal part of the second diagonal with a step-up in FFR_{CT} from 0.74 in the LAD to 0.78 when moving downstream the diagonal branch. LCX = left circumflex coronary artery.

of 0.80 or less was reported in a given artery territory, we recommend the lowest value for that territory be reported. It is not necessary to provide FFR_{CT} values greater than 0.80 for minimal (1%–24% stenosis) or mild (25%–49%) lesions unless located in the left main or proximal LAD or when containing high-risk plaque features, in which case FFR_{CT} values should be provided. Any lesion with an abnormal FFR_{CT} value should be reported even if not considered as a likely source of significant pressure loss in the original coronary CT angiography report. We recommend that an FFR_{CT} value be provided for all moderate (50%–69%) and all severe (>70% to 99%) stenoses.

FFR_{CT} values 0.80 or lower that are measured more than 2 cm beyond a lesion not causing a significant focal pressure loss (FFR_{CT} > 0.80) should be reported when present in large vessels. The clinical significance of FFR_{CT} values 0.80 or lower in the distal coronary tree remote from any focal lesion is unknown. These may be reported; however, it should be stated that the values are remote from angiographic stenosis and are of uncertain clinical significance.

In the event of serial lesions, we recommend that the value of FFR_{CT} 10–20 mm distal to each lesion should be reported. If this is not possible, FFR_{CT} values between lesions should be reported, including information on the distance between stenosis and the FFR_{CT} value.

Occlusion of small vessels that were overlooked in the primary CT angiography assessment (typically involving distal segments or small side branches) may be revealed by the FFR_{CT} analysis process. While this may or may not be clinically relevant, an occluded branch may have some slight impact on FFR_{CT} in

the parent vessel. The impact will depend on the size of the branch relative to other vessels. Occluded segments should be identified and referenced.

In recognition of the fact that FFR_{CT} is a mathematically derived analysis rather than an actual measurement of flow and pressure, it is recommended that results be described as demonstrating low, borderline, or high likelihood of hemodynamic significance rather than ischemia (Table).

Impression

The report summary should focus on the presence of a low, borderline, or high likelihood of hemodynamic significance of the lesions identified in the impression section of the original coronary CT angiography report. In addition, any other lesion that has a borderline or high likelihood of hemodynamic significance should be reported even if it was not identified in the original coronary CT angiography interpretation. In particular, areas of diffuse coronary disease that produce low FFR_{CT} values distal to the affected segments should be described.

Format

It is recognized that institutional requirements may dictate the specific reporting format required. Ideally, the coronary CT angiography and FFR_{CT} reports can be combined into a single uniform report that will most clearly relate anatomic and functional information. However, it is important to interrogate the anatomy to assess the extent and severity of CAD to determine the need for FFR_{CT} analysis. Given the time gap between the coronary CT angiography and FFR_{CT} results, either a preliminary CT angiography report may be finalized after the FFR_{CT} results are available or an FFR_{CT} report may subsequently be added to the original coronary CT angiography report. Both of these formats closely incorporate the most detailed description of anatomy and functional significance with minimal repetition. If institutions require a separate free-standing report, additional details in the indications should be provided to emphasize the severity, morphology, and location of lesions suspected of causing flow limitation.

FFR_{CT} Images

It is recommended that relevant images from the FFR_{CT} report should be included if technically possible to more accurately convey the location of FFR_{CT} values at a specific anatomic location. This will help other physicians understand the location and extent of the pressure loss and the location for potential confirmatory invasive FFR measurement and will facilitate medical or invasive treatment planning. Providing images combining FFR_{CT} values and their specific location can rapidly and succinctly convey the extent of pressure loss and facilitate therapeutic decision making more easily than if textual description was offered alone.

Management Recommendations

The decision of whether FFR_{CT} interpretation reports should contain management recommendations (ie, consideration for

CTA:

Indications: Typical chest pain, family history of premature CAD.

Protocol: Patient education was provided. 100 mg atenolol followed by intravenous metoprolol (a total of 15 mg), and 0.8 mg of spray sublingual nitroglycerin were administered. Images were obtained using a dual-source 128-slice CT scanner following the rapid IV infusion of 60 ml. of contrast.

Image quality: Good. CTA does not permit accurate assessment of vessels equal to or less than 1.5 mm in diameter. Vessels designated as normal are without visible disease within the limitations of the CTA technique

Coronary anatomy:

Agatston score = 245

Left main: 1-24% non-calcified plaque stenosis.

Left anterior descending artery (LAD): Segment 6 with diffuse CAD including both non-calcified and calcified plaques. 50-69% mixed complex plaque stenosis. In more distal segments and side-branches stenosis severity <24%.

Left circumflex artery (LCX): No CAD detected.

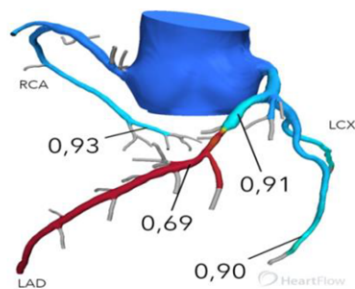
Right coronary artery (RCA): Segment 2 with a non-calcified positively remodeled plaque with 30-49% stenosis. Right dominance.

Noncoronary cardiac findings:

1. The aorta shows no calcification, dilatation or dissection.
2. The pulmonary artery shows no dilatation or thrombus
3. The pericardium shows no effusion, thickening or calcification.
4. No extra-cardiovascular abnormal findings present.

Impression:

+ CAD. Proximal LAD 50-69% complex mixed plaque stenosis. Mid-RCA stenosis of borderline significance. Further evaluation with FFR_{CT} was prescribed.

FFR_{CT} Report:

LAD: Segment 6: There is a high likelihood of hemodynamic significance with an FFR_{CT} value of 0.69.

LCX: No anatomically disease.

RCA: Low likelihood of hemodynamic significance with the lowest value in the terminal segments of 0.93.

Impression:

Proximal LAD stenosis with high likelihood of hemodynamic significance.

Figure 4: Example of a coronary CT angiography-FFR_{CT} report (patient case, Fig 1b). CAD = coronary artery disease, CTA = coronary CT angiography.

invasive coronary angiography or optimal medical therapy alone) will be determined by local institutional practices. If management recommendations are typically included in reports, note should be made that FFR_{CT} values should not be considered in isolation but are integrated with clinical and other imaging factors such as symptoms, plaque morphology, and lesion location. This is particularly important in cases of borderline FFR_{CT} values between 0.76 and 0.80 (Fig 2).

Limitations

The diagnostic performance and utility of FFR_{CT} has been studied only in patients suspected of having stable CAD. At present, the use of FFR_{CT} in patients with stents or bypass grafts, microvascular dysfunction, prior myocardial infarction, or suspected or known acute coronary syndromes cannot be recommended. FFR_{CT} analysis cannot be performed in all patients. Coronary CT angiography–related artifacts, such as motion, misalignment, low contrast, or blooming from coronary calcification, may impair the diagnostic reliability of CT angiography and FFR_{CT} (43–45). It is our experience that FFR_{CT} has high diagnostic performance in patients with coronary calcification. However, our experience with FFR_{CT} testing in patients with severe calcification (Agatston score > 1000) is limited, and in two previous studies demonstrating high diagnostic performance of FFR_{CT} in vessels and patients with high calcium scores, the number of such patients were low (44,45). In previous multicenter studies of FFR_{CT} diagnostic performance, CT angiographic images were not of sufficient quality for FFR_{CT} analysis in 11%–13% of patients (15,16), whereas in more recent single-center studies that assessed the clinical utility of FFR_{CT} less than 4% of the patients did not meet the image quality requirements (10–12,14).

Conclusion

By virtue of the complexity of the FFR_{CT} analysis providing information on pressure and flow across the entire coronary tree, standardized criteria on interpretation and reporting of the FFR_{CT} analysis results are of crucial importance both in context of clinical adoption of the test and in future research. For assessment of the hemodynamic significance of lesions, we recommend using the FFR_{CT} value 10–20 mm distal to the lower border of the stenosis. For clinical decision making, we recommend a dichotomous interpretation strategy be considered only in lesions with FFR_{CT} greater than 0.80 or less than or equal to 0.75, whereas in patients with FFR_{CT} ranging between 0.76 and 0.80, additional risk stratification information is needed. The results of FFR_{CT} must always be evaluated in their clinical context, taking into account patient symptoms, the coronary anatomy, and suitability of revascularization.

Author contributions: Guarantors of integrity of entire study, B.L.N., M.G.R.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; approval of final version of submitted manuscript, all authors; agrees to ensure any questions related to the work are appropriately resolved, all authors; literature research, B.L.N., T.A.F., R.D.S., M.G.R., B.K., K.N., N.P.S., H.M., J.L.; clinical studies, R.D.S., M.G.R., B.K., N.P.S., H.M., J.L.; statistical analysis, B.L.N., B.K., N.P.S.; and manuscript editing, all authors

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