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Application of the DILEMMA score to improve lesion selection for invasive physiological assessment

Michael Michail, MBBS[1,2], Hakim-Moulay Dehbi, PhD[3], Nitesh Nerlekar, MD, MPH[1], Justin E. Davies, MBBS, PhD[4], Andrew S. P. Sharp, MBChB, MD[5], Suneel Talwar, MBBS, MD[6], James D. Cameron, MBBS, MD, MEngSc[1], Adam J. Brown, MD, PhD[1], Dennis T. Wong, MD, PhD[1], Anthony Mathur, MB, BChir, MA, PhD[7], Alun D. Hughes, MBBS, PhD[2], Om Narayan, MBBS, PhD[1]

[1]Monash Cardiovascular Research Centre and MonashHeart, Melbourne, Australia

[2]Institute of Cardiovascular Science, University College London, London, United Kingdom

[3]Cancer Research UK & UCL Cancer Trials Centre, University College London, London, United Kingdom

[4]Imperial College London, London, United Kingdom

[5]Royal Devon and Exeter NHS Trust, Exeter, United Kingdom

[6]Royal Bournemouth and Christchurch NHS Trust, Bournemouth, United Kingdom

[7]Barts Heart Centre, Barts Health NHS Trust, London, United Kingdom

Abstract

Objectives—We sought to assess the validity of the DILEMMA score against instantaneous wave-free ratio (iFR) and evaluate its utility in rationalizing the number of patients referred for invasive physiological assessment.

Background—The DILEMMA score is a validated angiographic scoring tool incorporating minimal lumen diameter, lesion length and subtended myocardial area that has been shown to predict the functional significance of lesions as assessed by fractional flow reserve (FFR).

Methods—Patients in the DEFINE-FLAIR study who had coronary stenosis of intermediate severity were randomized to either FFR or iFR. DILEMMA score was calculated retrospectively on a subset of this cohort by operators blinded to FFR or iFR values.

Results—Three hundred and forty-six lesions (181 assessed by FFR; 165 by iFR) from 259 patients (mean age 66.0 years, 79% male) were included. A DILEMMA score ≤ 2 had a negative predictive value of 96.3% and 95.7% for identifying lesions with FFR >0.80 and iFR >0.89, respectively. A DILEMMA score ≥ 9 had a positive predictive value of 88.9% and 100% for identifying lesions with FFR ≤0.80 and iFR ≤0.89, respectively. The receiver operating

Correspondence: Om Narayan, Monash Cardiovascular Research Centre, Monash Health, Melbourne, Australia. onarayan2381@gmail.com.

Conflict of interest
J.E.D. holds patents pertaining to the instantaneous wave-free ratio (iFR) technology. He has served as a consultant for and has received significant research funding from Volcano Corporation. No extramural funding was used to support this analysis.

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characteristic area under the curve values for DILEMMA score to predict FFR ≤0.80 and iFR ≤0.89 were 0.83 (95% CI 0.77–0.90) and 0.82 (0.75–0.89) respectively. A DILEMMA score ≤ 2 or ≥9 occurred in 172 of the 346 lesions (49.7%).

Conclusions—Using DILEMMA score in patients with coronary stenosis of intermediate severity may reduce the need for pressure wire use, offering potential cost-savings and minimizing the risks associated with invasive physiological lesion assessment.

1 Introduction

The presence of myocardial ischemia is considered to be a marker for adverse cardiovascular outcomes1 and coronary revascularization aims to reduce both ischemic burden and improve functional status.2 Evidence has demonstrated that physiologically guided percutaneous coronary intervention (PCI) is associated with improved cardiovascular outcomes when compared with angiographically guided PCI.3 This has led to the widespread adoption of invasive physiological indices, including fractional flow reserve (FFR) and instantaneous wave-free ratio (iFR) into routine practice and guidelines.4, 5 These physiological tools are currently recommended for lesions of intermediate angiographic severity. However, this decision is still dependent on subjective visual lesion assessment by the operator, despite the acknowledged shortcomings of this approach. The overall yield of FFR-significant lesions remains low, with up to 75% of interrogated lesions being deferred for treatment in large registries.6 Additionally, there is high variability between cardiologists on assessment of lesion severity.7 Visual assessment is therefore a poor gate-keeper for lesion selection for physiological assessment, consequently leading to many patients undergoing unnecessary invasive tests.

Impairment of blood flow across a lesion is dependent, not only on diameter stenosis at the site of a lesion, but also on the length of the stenosed segment and volumetric blood flow at the vessel inlet.8–10 Lesions subtended by greater myocardial area and mass—and therefore with greater volumetric blood flow across—elicit a greater pressure gradient and so more inducible ischemia than those subtended by smaller myocardial territory.11 The advent of quantitative coronary angiography has permitted more objective and comprehensive evaluation of lesions, accounting for diameter stenosis and lesion length (LL). The evidence, however, has shown that its use does not lead to better prediction of functionally significant lesions over visual assessment,12 potentially as it does not factor the myocardial area subtended by a lesion.

We have previously described the DILEMMA score, a simple angiographic scoring tool that strongly correlates with FFR and incorporates MLD, LL and the Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index (BARI MJI) (reflecting the percentage of myocardium potentially compromised by a lesion) to provide its user a score from 0 to 12. Importantly, a DILEMMA score of ≤2 has demonstrated an excellent negative predictive value for identifying lesions with FFR >0.80 and conversely, a score ≥ 9 had an excellent positive predictive value for lesions with FFR ≤0.80.10, 13 Lesions with a score of 3–8 are considered “gray-zone” and warrant further assessment. The DILEMMA score was derived and validated with a retrospective, single-center cohort and given this, its wider

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applicability remains uncertain.10 Additionally, the validity of the score in predicting lesion functional significance as assessed by iFR has not yet been previously investigated.

Here, we present a retrospective analysis conducted on a subset of DEFINE-FLAIR, a large multi-center trial of patients with coronary artery disease with angiographically intermediate lesions who underwent functional assessment by FFR or iFR. The aim was to assess the validity of the DILEMMA score against iFR before evaluating its utility to rationalize the number of patients referred for invasive physiological assessment with either FFR or iFR.

2 Materials and Methods

The DILEMMA score was applied to a subset of patients who were prospectively enrolled into the DEFINE-FLAIR study from three UK sites: Imperial College Healthcare NHS Trust, Royal Devon & Exeter NHS Foundation Trust and Royal Bournemouth and Christchurch Hospitals NHS Foundation Trust. As this was a post-hoc retrospective analysis, ethics committee approval and specific informed consent were not requested. Patients with coronary artery disease with at least one native artery in which the stenosis was of intermediate severity (typically an artery with 40–70% stenosis of the diameter on visual assessment) were randomized in a 1:1 ratio to undergo either iFR or FFR assessment with a coronary pressure wire (Verrata, Philips Volcano, San Diego, California). An FFR value ≤0.80 and an iFR ≤0.89 were taken to define physiologically significant lesions. Exclusion criteria included bypass graft lesions, significant left main stenosis (diameter stenosis >50% on visual estimation), culprit vessels that collateralize other vessels, tandem lesions, culprit vessels in the setting of myocardial infarction, and cases in which the pressure wire failed to cross the lesion because of tight stenosis or tortuosity. In addition, patients with acute myocardial infarction seen within 48 hr after onset were excluded from the study. The full study protocol of DEFINE-FLAIR study has previously been published (ClinicalTrials.gov identifier NCT02053038).14 The study was approved by the institutional human research ethics committee. No extramural funding was used to support this analysis. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the manuscript, and its final contents.

2.1 DILEMMA score calculation

The DILEMMA score was calculated for each lesion by operators blinded to the FFR and iFR results. The full methods of the calculation of DILEMMA score have previously been published.10 In short, quantitative coronary angiographic analysis using QAngio (Medis Medical Imaging System BV, Leiden, the Netherlands) was performed to derive MLD and LL for each lesion by two Cardiologists (M.M. and O.N.), and BARI MJI was derived from the coronary angiograms. BARI MJI was calculated by assigning an index to all vessels (left anterior descending artery, circumflex, right coronary artery as well as the ramus, diagonal, obtuse marginal, posterior descending, and posterolateral branches) based on their length and caliber. A value of 0 represented an almost insignificant vessel size, and a value of 3 defined a large artery with a length of greater than two-thirds the distance between the cardiac base and apex. Right ventricular marginal and posterior descending artery septal branches were not included in this index. The septal branches had a maximum score of 3.

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The final index was obtained by dividing the sum of vessel scores distal to the culprit lesion by the overall sum of all vessel scores, which permitted estimation of the percentage of left ventricular myocardium subtended by that lesion. The values for the MLD, LL and BARI MJI each receive a score as in Table 1, the total of which is the DILEMMA score. DILEMMA scores were calculated for each lesion undergoing either FFR or iFR in the cohort. The interobserver variability of the DILEMMA score was performed by two study investigators on 30 randomly selected lesions. The intraclass correlation coefficient (ICC) was 0.96 (95% CI 0.84–0.99), which was consistent with previous reports.10, 13 The mean time for DILEMMA score calculation (performed on 30 lesions) was 5 min and 24 sec per lesion.

2.2 Statistical analysis

Continuous variables were described as mean ± standard deviation, and categorical variables as absolute numbers and percentages. Comparisons between assessment methods were made using independent samples t-test for continuous variables and chi-square tests for categorical variables. To calculate correlation coefficients between the DILEMMA score and its components (MLD, BARI MJI, and LL) and FFR and iFR, the DILEMMA score and its components were regarded as continuous variables. The correlations and their significance were calculated using Pearson's test. FFR and iFR were considered reference standards for the study and treated as a binary variable with thresholds at FFR ≤0.80 and IFR ≤0.89 to represent physiologically significant lesions. Receiver operating characteristic (ROC) curve analysis was used to compare diagnostic performance (sensitivity and specificity) of the DILEMMA score. The negative predicted value (NPV) of a DILEMMA score ≤ 2 to identify lesions that have an FFR >0.80 or iFR >0.89 was calculated. Conversely, the positive predicted value (PPV) of a DILEMMA score ≥ 9 to identify significant lesions was calculated. A P-value less than 0.05 was considered statistically significant.

3 Results

A total of 346 lesions from 259 patients in three different UK cardiac centers were assessed with either FFR or iFR according to random allocation within the DEFINE-FLAIR study. One hundred and four patients were excluded from this analysis as their data was incomplete. The baseline clinical characteristics of the study population are summarized in Table 2. The mean ages were 65.7 ± 11 years and 66.3 ± 10 years, of which 83.2% and 74.6% were male in the FFR and iFR groups, respectively. Of the 346 lesions interrogated with pressure wire, 208 (60.1%) were in the left anterior descending artery, 66 (19.1%) were in the left circumflex artery, 67 (19.4%) were in the right coronary artery, and 5 (1.4%) were in the ramus intermediate artery. There were no statistical differences in lesion location between the FFR and iFR group (P = 0.89). A summary of the lesion characteristics can be found in Table 3.

3.1 Relationship between pressure wire indices and DILEMMA

DILEMMA score demonstrated a strong negative correlation with both FFR (r = −0.66, P < 0.01; Figure 1) and iFR (r = −0.59, P < 0.01; Figure 2). MLD demonstrated a moderate positive correlation with both FFR (r = 0.46, P < 0.01) and iFR (r = 0.40, P < 0.01). LL demonstrated a moderate negative correlation with both FFR (r = −0.48, P < 0.01) and iFR (r = −0.43, P < 0.01). BARI MJI demonstrated a weaker negative correlation with both FFR (r = −0.29, P < 0.01) and iFR (r = −0.29, P < 0.01).

Further analysis demonstrates that these correlations are consistent in different subgroups. In the LAD, the correlation was maintained for the DILEMMA score with FFR (r = −0.63, P < 0.01) and iFR (r = −0.57, P < 0.01). In diabetics, once again, this correlation once again is maintained with FFR (r = −0.63, P < 0.01) and iFR (r = −0.64, P < 0.01).

3.2 Diagnostic performance of DILEMMA

The ROC curves for DILEMMA score, MLD, LL, and BARI MJI to predict FFR ≤0.80 and iFR ≤0.89 are presented in Figure 3. The ROC area under the curve (AUC) values for DILEMMA score, MLD, LL, and BARI MJI to predict FFR ≤0.80 were 0.83 (95% CI 0.77–0.90), 0.77 (0.70–0.85), 0.80 (0.73–0.88) and 0.62 (0.54–0.72), respectively. The ROC AUC values for DILEMMA score, MLD, LL, and BARI MJI to predict iFR ≤0.89 were 0.82 (0.75–0.89), 0.74 (0.67–0.82), 0.75 (0.67–0.83), 0.73 (0.65–0.80), respectively. Further analysis using the DeLong method demonstrates that the difference between the ROC AUC values for DILEMMA score against its individual components are statistically significant, highlighting the incremental value of the diagnostic performance of the DILEMMA score compared to its individual components. Additionally, our analysis demonstrates that the diagnostic performance of the DILEMMA score was maintained in different subgroups. The ROC AUC values for DILEMMA score to predict FFR ≤0.80 and iFR ≤0.89 in LAD-specific lesions were 0.79 (0.70–0.88) and 0.80 (0.71–0.90), respectively and in diabetics, the ROC AUC values were 0.89 (0.81–0.98) and 0.82 (0.69–0.95), respectively.

A DILEMMA score of ≤2 was associated with a NPV of 96.3% and 95.7% for identifying FFR negative (>0.80) and iFR negative (>0.89) lesions, respectively. A DILEMMA score of ≥9 was associated with a PPV of 88.9% and 100% for identifying FFR positive (≤0.80) and iFR positive (≤0.89) lesions, respectively. When this threshold was lowered to ≥7, the PPV decreased to 88.5% with two lesions out of 26 found to have an FFR >0.80. In the iFR cohort, a DILEMMA score of ≥9 had a PPV of 100% in identifying lesions with an iFR ≤0.89. When this threshold was lowered to ≥8, the PPV remained at 100%. These findings suggest that lesions with DILEMMA score ≥ 9 are likely to be functionally significant thereby obviating the need for pressure wire assessment.

3.3 Using DILEMMA score to defer lesions for pressure wire assessment

Overall, 90 out of the 181 lesions (49.7%) assessed by FFR and 82 out of the 165 lesions (49.7%) assessed by iFR had a DILEMMA score ≤ 2 or ≥9 (Figure 4). Of the 346 lesions referred for pressure wire assessment, 172 of those (49.7%) had a DILEMMA score ≤ 2 or ≥9 and could potentially have had their invasive pressure wire assessment deferred.

4 Discussion

This study confirms the validation of DILEMMA score in angiographically intermediate lesions using a diverse patient cohort from a large multi-center, randomized controlled trial. It consolidates the strong diagnostic performance of this scoring tool against FFR and now its validity and performance against a guideline recommended resting physiological index. Consistent with previous data, a DILEMMA score ≤ 2 demonstrated a high NPV in identifying lesions with FFR >0.80 and iFR >0.89 and conversely, a score of ≥9 had a high PPV for the identification of lesions associated with an FFR of ≤0.80 and iFR ≤0.89. The application of DILEMMA score on this cohort using these thresholds would allow the identification of almost half of lesions that could potentially have been deferred without the need for pressure wire assessment.

Given the excellent diagnostic performance for DILEMMA scores of ≤2 and ≥9, only patients scoring between 3 and 8 (51.3% of this cohort) would require further invasive testing. Besides the potential significant cost savings, there is a reduction in risk associated with reduced use of invasive coronary sensor-tipped guidewires and overall contrast medium. This is especially pertinent given that 74.9% of lesions in a large registry were deferred on the basis of FFR >0.80 (with FFR 0.75–0.80 at the discretion of the treating physician), suggesting poor yield of physiologically significant lesions when using FFR in routine clinical practice.[6] This scoring tool therefore has potential to significantly improve lesion selection for invasive interrogation and enhance their positive yield. Importantly, DILEMMA scores of 3–8 (the “gray zone”) offer more objective gate-keeping to invasive physiological interrogation by reducing operator variability and bias. Additionally, a large proportion of patients undergo diagnostic angiography in regional hospitals without the onsite capability of invasive functional assessment or PCI. Applying the DILEMMA score to patients at such centers may reduce the number of referrals for invasive functional assessment to tertiary units, thus shortening the patient's diagnostic journey. A key advantage of the DILEMMA score is that it is easily calculated (within 5–6 min) using widely available, non-proprietary techniques. The ease and rapidity with which the score is calculated facilitates retrospective assessment, for example, as a decision-making tool when considering staged revascularization in the outpatient clinic. Future development and automation of this scoring tool may enable instantaneous calculation of DILEMMA score while patients are on the catheter laboratory table to decide whether to proceed onto invasive physiological testing.

Patients recruited into the DEFINE-FLAIR study were selected primarily on the basis of having coronary disease with vessel stenosis of questionable physiological severity (typically, an artery with 40–70% stenosis).[14] Other studies including DEFER, FAME I and II also used percentage diameter stenosis as the principal lesion selection criterion to identify intermediate lesion severity for pressure wire assessment, despite the critical influence of LL and extent of myocardium subtended distal to the lesion upon the degree of ischemia.[15–17] The use of visually estimated maximal percentage diameter stenosis may therefore result in ischemic lesions with a milder degree of diameter stenosis being inappropriately deferred, and therefore denying these patients appropriate revascularization; this phenomenon was observed in the RIPCORD study, where 13% of lesions that were deemed to have <30% coronary stenosis on visual assessment in fact had an FFR ≤0.80.[18] Conversely, vessels may be inappropriately revascularized if deemed to have significant diameter stenosis on visual assessment, as seen once again in the RIPCORD study, where as many as 47% of the lesions that were graded to have >70% stenosis were found to have FFR >0.80.[18] Given that the DILEMMA score factors in the other important determinants of volumetric flow besides diameter stenosis at the site of the lesion, it may also be a useful tool in stratifying lesions causing mild or severe vessel stenosis which are currently not routinely functionally assessed. This may help identify ischemic lesions with mild diameter stenosis and prevent the considerable proportion of patients with severe stenosis and FFR >0.80 undergoing inappropriate revascularization. This scoring tool would need further validation for use in all patients with any degree of coronary stenosis, rather than those with intermediate severity coronary stenosis as in this study.

4.1 Limitations

Our study has some limitations that should be considered when interpreting results. First, while patients in the DEFINE-FLAIR cohort were prospectively recruited for invasive physiological assessment, DILEMMA scoring was retrospectively applied. Second, the DEFINE-FLAIR was a randomized clinical trial which included selected lesions and patients, and so the current findings may not be generalized to the wider population. Third, the calculation of the DILEMMA score has inherent limitations; the measurement of both LL and MLD is to some degree subjective and dependent on the identification of normal proximal and distal reference segments. This, however, is largely mitigated as each of the constituents of the scoring tool is a whole integer representing a range of measurements. This minimizes interobserver variability, which was notably excellent in this study (ICC of 0.96), consistent with the two previous studies.10, 13 Of note, one of these studies performed extensive analysis to address interobserver and intraobserver variability using 185 lesions demonstrating ICC of 0.97 and 0.98, respectively. Fourth, 104 patients from the DEFINE-FLAIR cohort from the three centers were excluded from this analysis due to incomplete data; in the majority of excluded cases, the complete diagnostic coronary angiogram (which is required for the BARI MJI calculation) was not available, and in the remaining, the angiographic views acquired were inadequate to assess the vessels included in the calculation. We do not believe this would limit the use of the scoring tool in everyday practice as the incomplete data predominantly relates to challenges with retrospective data analysis. Fifth, the precise delineation for quantitative coronary angiography may be hampered by poor contrast opacification, lesion “haziness” or by patient factors (particularly obesity). Finally, it is evident that despite similar LL, MLD, and BARI MJI, differences in lesion morphology and geometry may result in markedly different pressure gradients, due to non-linear effects relating to turbulence and divergence in flow.19

5 Conclusions

We have demonstrated using a large, multi-center study that the use of DILEMMA score in patients with coronary disease of intermediate severity could significantly reduce the number of patients requiring invasive physiological assessment and may therefore provide an objective and unbiased gatekeeper for lesion selection compared to visual assessment. Besides the potential cost-savings and shortened diagnostic journey for many patients, this could offer a net safety benefit with the reduction of invasive pressure wire and contrast use. A large prospective, randomized outcome trial is required to confirm the safety and application of this tool.

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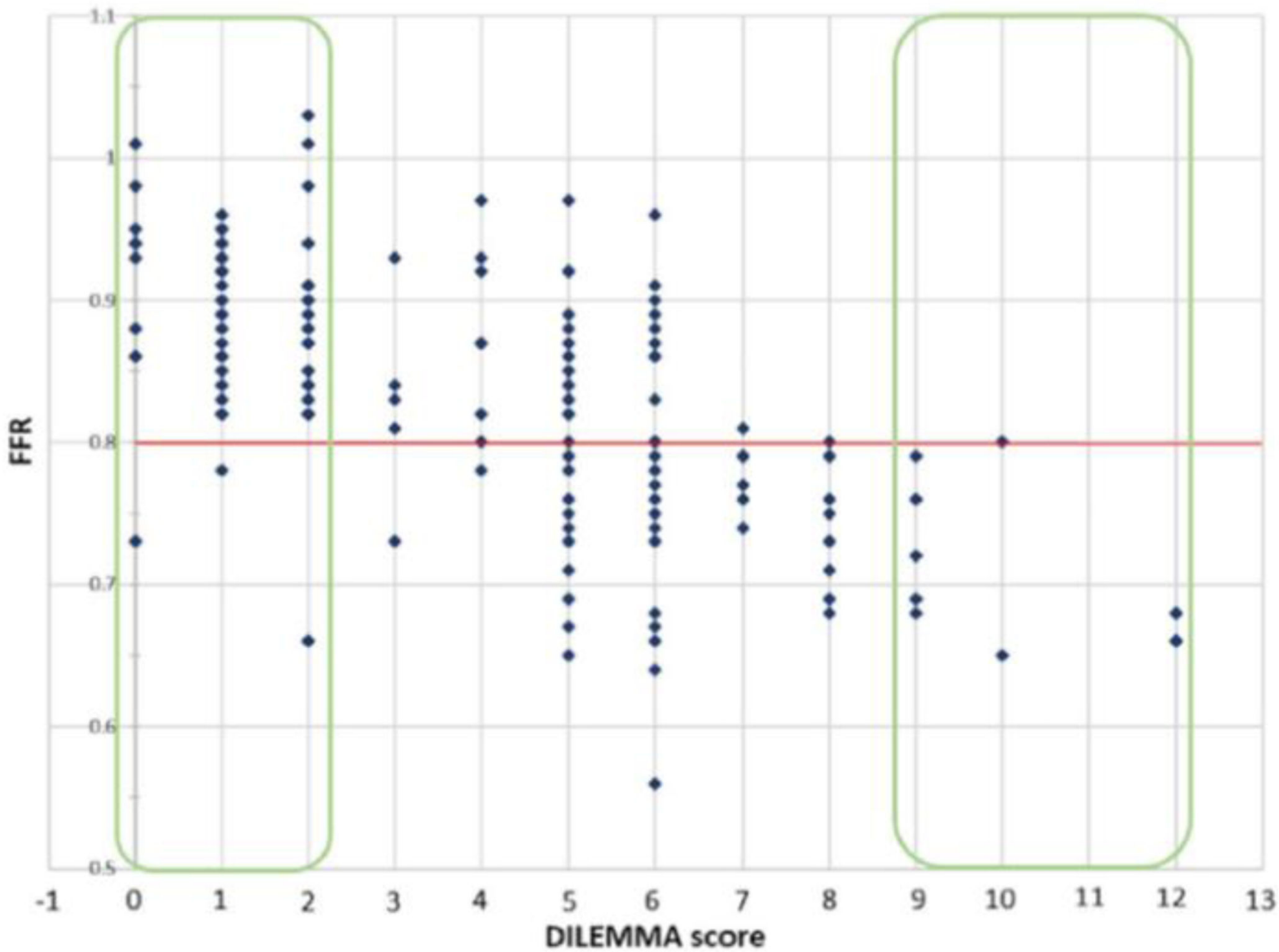

Figure 1.

Scatter plot of 181 lesions that underwent FFR assessment and corresponding DILEMMA scores. Of the total, 90 lesions (49.7%) had a DILEMMA score ≤ 2 or ≥9 (green boxes)

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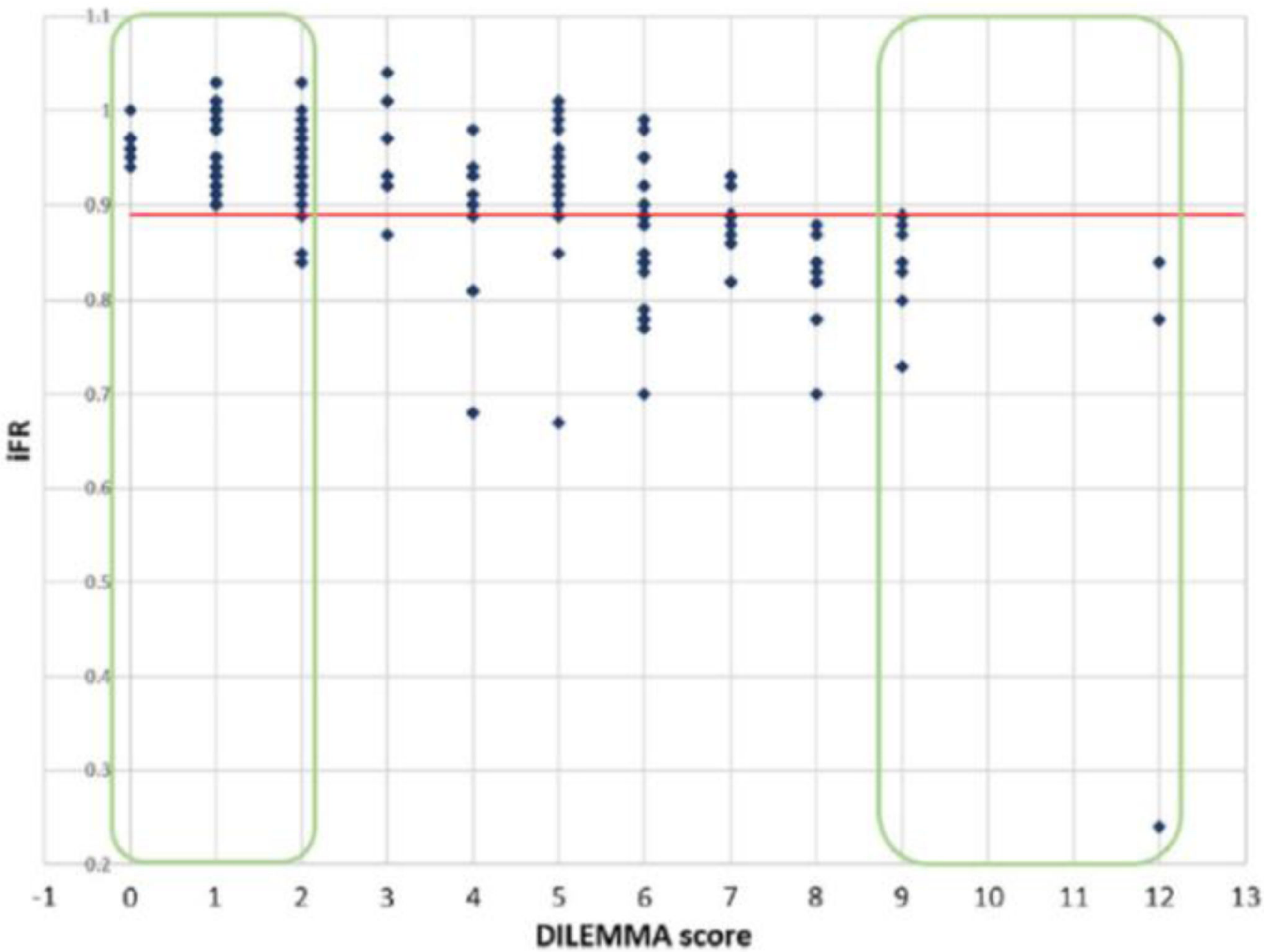

Figure 2.

Scatter plot of 165 lesions that underwent iFR assessment and corresponding DILEMMA scores. Of the total, 82 lesions (49.7%) had a DILEMMA score ≤ 2 or ≥ 9

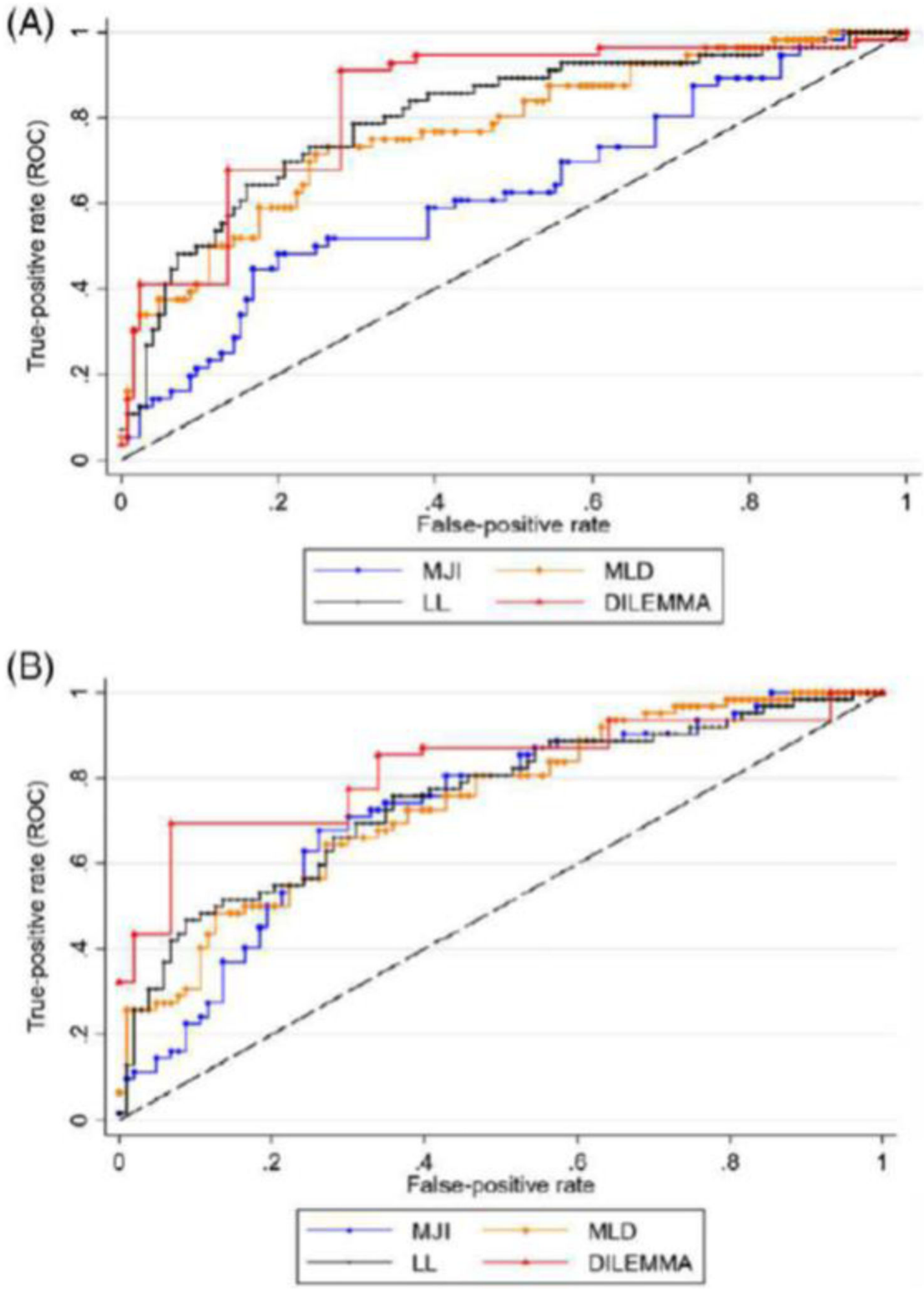

Figure 3.

Receiver operating characteristic curve for DILEMMA score, MLD, LL and BARI MJI to predict (A) FFR ≤0.80 (ROC AUC values 0.83, 0.77, 0.80 and 0.62, respectively) and (B) iFR ≤0.89 (ROC AUC values 0.82, 0.74, 0.75 and 0.73, respectively)

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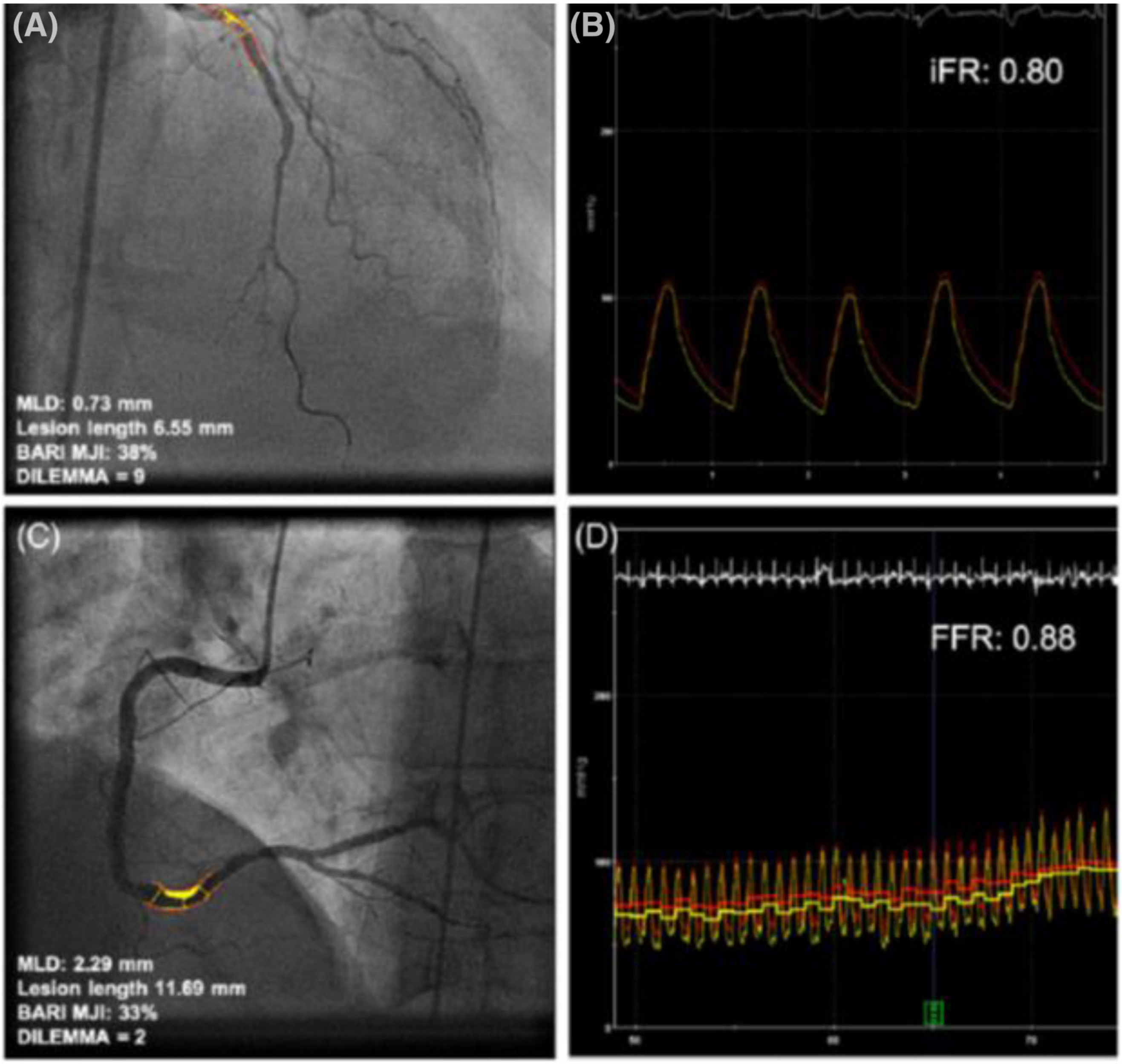

Figure 4.

Example lesions assessed by DILEMMA score with breakdown of minimal lumen diameter (MLD), lesion length (LL) and Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index (BARI MJI). Panel A demonstrates a lesion causing luminal stenosis in the proximal LAD with MLD of 0.73 mm and LL of 6.55 mm. BARI MJI was calculated by dividing the sum of the vessels subtending the lesion (in this case, 5) by the sum of all the vessels supplying the left ventricle (in this case, 16) giving 38%. The calculated DILEMMA score is therefore 9. Panel B presents the corresponding iFR of 0.80. Panel C demonstrates a lesion causing luminal stenosis in the distal RCA with MLD of 2.29 mm and LL of 11.69 mm. BARI MJI was calculated by dividing 7 (for the sum of the vessels subtending the RCA lesion) by 21 (for the sum of all the vessels supplying the left ventricle), giving 33%. The calculated DILEMMA score is therefore 2. Panel D presents the corresponding FFR of 0.88

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Table 1

The DILEMMA score

Variable	Value	Points
MLD (mm)	<1.1	4
	1.1-1.5	1
	>1.5	0
Lesion length (mm)	>18	3
	9-18	1
	<9	0
BARI MJI (%)	>35	5
	18-35	1
	<18	0
Total		Maximum = 12

Abbreviations: MLD, minimal lumen diameter; BARI MJI, Bypass Angio-plasty Revascularization Investigation Myocardial Jeopardy Index.

Table 2

Patient demographics

	iFR (N = 122)	FFR (N = 137)	*P*-value
Age (years); mean (SD)	66.3 (10.1)	65.7 (11.3)	0.55
Sex			0.09
Male; N (%)	91 (74.6)	114 (83.2)	
Female; N (%)	31 (25.4)	23 (16.8)	
BMI; mean (SD)	28.3 (4.2)	28.4 (4.5)	0.72
Acute coronary syndrome			0.24
ACS; N (%)	15 (12.3)	24 (17.5)	
Non-ACS; N (%)	107 (87.7)	113 (82.5)	
Diabetes			0.47
No diabetes; N (%)	87 (71.3)	92 (67.2)	
Diabetes; N (%)	35 (28.7)	45 (32.8)	
Hypertension; N (%)	91 (74.6)	98 (71.5)	0.24
Hyperlipidemia; N (%)	86 (70.5)	98 (71.5)	0.98
Smoking status			0.64
Never smoker; N (%)	50 (41.0)	57 (41.6)	
Former smoker; N (%)	56 (45.9)	67 (48.9)	
Current smoker; N (%)	16 (13.1)	13 (9.5)	
Previous MI; N (%)	33 (27.0)	40 (29.2)	0.75
Previous PCI; N (%)	46 (37.7)	52 (38.0)	0.64

Abbreviations: iFR, instantaneous wave-free ratio; FFR, fractional flow reserve; ACS, acute coronary syndrome.

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Table 3

Summary of lesion characteristics

	iFR (N = 165)	FFR (N = 181)	*P*-value
Lesion location			0.89
LAD; N (%)	89 (53.9)	99 (54.7)	
RCA; N (%)	30 (18.2)	36 (19.9)	
Cx; N (%)	24 (14.5)	28 (15.5)	
D; N (%)	11 (6.7)	9 (5.0)	
OM; N (%)	8 (4.8)	6 (3.3)	
PLA; N (%)	0 (0.0)	1 (0.6)	
Other; N (%)	3 (1.8)	2 (1.1)	
BARI MJI score			0.39
0; N (%)	35 (21.2)	29 (16.0)	
1; N (%)	75 (45.5)	93 (51.4)	
5; N (%)	55 (33.3)	59 (32.6)	
MLD score			0.04
0; N (%)	78 (47.3)	110 (60.8)	
1; N (%)	52 (31.5)	45 (24.9)	
4; N (%)	35 (21.2)	26 (14.4)	
LL score			0.26
0; N (%)	89 (53.9)	82 (45.3)	
1; N (%)	53 (32.1)	67 (37.0)	
3; N (%)	23 (13.9)	32 (17.7)	
DILEMMA score			0.88
0; N (%)	7 (4.2)	9 (5.0)	
1; N (%)	34 (20.6)	42 (23.2)	
2; N (%)	29 (17.6)	30 (16.6)	
3; N (%)	7 (4.2)	5 (2.8)	
4; N (%)	9 (5.5)	9 (5.0)	
5; N (%)	29 (17.6)	31 (17.1)	
6; N (%)	21 (12.7)	29 (16.0)	
7; N (%)	9 (5.5)	7 (3.9)	
8; N (%)	8 (4.8)	10 (5.5)	
9; N (%)	9 (5.5)	5 (2.8)	
10; N (%)	0 (0.0)	2 (1.1)	
12; N (%)	3 (1.8)	2 (1.1)	

Abbreviations: LAD, left anterior descending artery; RCA, right coronary artery; Cx, circumflex artery; D, diagonal artery; OM, obtuse marginal; PLA, posterolateral artery; BARI MJI, Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index; MLD, minimal lumen diameter; LL, lesion length.