JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY VOL. ■, NO. ■, 2015

ISSN 0735-1097/$36.00
PUBLISHED BY ELSEVIER INC. http://dx.doi.org/10.1016/j.jacc.2015.09.051

Quality of Life and Economic Outcomes of Assessing Fractional Flow Reserve With Computed Tomography Angiography

The PLATFORM Study

Mark A. Hlatky, MD,* Bernard De Bruyne, MD, PhD,† Gianluca Pontone, MD, PhD,‡ Manesh R. Patel, MD,§ Bjarne L. Norgaard, MD,‖ Robert A. Byrne, MB BCh, PhD,¶ Nick Curzen, BM (Hons), PhD,# Ian Purcell, MD,** Matthias Gutberlet, MD,†† Gilles Rioufol, MD,‡‡ Ulrich Hink, MD,§§ Herwig Walter Schuchlenz, MD,‖‖ Gudrun Feuchtner, MD,¶¶ Martine Gilard, MD,## Daniele Andreini, MD,‡ Jesper M. Jensen, MD,‖‖ Martin Hadamitzky, MD,¶ Alan Wilk, BS,*** Furong Wang, MD,*** Campbell Rogers, MD,*** Pamela S. Douglas, MD,§ for the PLATFORM Investigators

ABSTRACT

BACKGROUND Fractional flow reserve estimated using computed tomography (FFR_{CT}) might improve evaluation of patients with chest pain.

OBJECTIVES The authors sought to determine the effect on cost and quality of life (QOL) of using FFR_{CT} instead of usual care to evaluate stable patients with symptoms suspicious for coronary disease.

METHODS Symptomatic patients without known coronary disease were enrolled into 2 strata based on whether invasive or noninvasive diagnostic testing was planned. In each stratum, consecutive observational cohorts were evaluated with either usual care or FFR_{CT}. The number of diagnostic tests, invasive procedures, hospitalizations, and medications during 90-day follow-up were multiplied by U.S. cost weights and summed to derive total medical costs. Changes in QOL from baseline to 90 days were assessed using the Seattle Angina Questionnaire, the EuroQOL, and a visual analog scale.

RESULTS In the 584 patients, 74% had atypical angina, and the pre-test probability of coronary disease was 49%. In the planned invasive stratum, mean costs were 32% lower among the FFR_{CT} patients than among the usual care patients ($7,343 vs. $10,734 $p < 0.0001$). In the noninvasive stratum, mean costs were not significantly different between the FFR_{CT} patients and the usual care patients ($2,679 vs. $2,137, $p = 0.26$). In a sensitivity analysis, when the cost weight of FFR_{CT} was set to 7 times that of computed tomography angiography, the FFR_{CT} group still had lower costs than the usual care group in the invasive testing stratum ($8,619 vs. $ 10,734, $p < 0.0001$), whereas in the noninvasive testing stratum, when the cost weight of FFR_{CT} was set to half that of computed tomography angiography, the FFR_{CT} group had higher costs than the usual care group ($2,766 vs. $2,137, $p = 0.02$). Each QOL score improved in the overall study population ($p < 0.0001$). In the noninvasive stratum, QOL scores improved more in FFR_{CT} patients than in usual care patients: Seattle Angina Questionnaire 19.5 versus 11.4, $p = 0.003$; EuroQOL 0.08 versus 0.03, $p = 0.002$; and visual analog scale 4.1 versus 2.3, $p = 0.82$. In the invasive cohort, the improvements in QOL were similar in the FFR_{CT} and usual care patients.

CONCLUSIONS An evaluation strategy based on FFR_{CT} was associated with less resource use and lower costs within 90 days than evaluation with invasive coronary angiography. Evaluation with FFR_{CT} was associated with greater improvement in quality of life than evaluation with usual noninvasive testing. (Prospective Longitudinal Trial of FFR_{CT}: Outcomes and Resource Impacts [PLATFORM]; NCT01943903) (J Am Coll Cardiol 2015;■:■–■) © 2015 by the American College of Cardiology Foundation.

From the *Department of Health Research and Policy and Department of Medicine, Stanford University School of Medicine, Stanford, California; †Cardiovascular Center Aalst, Aalst, Belgium; ‡Centro Cardiologico Monzino, Istituto di Ricovero e Cura a Carattere Scientifico, Milan, Italy; §Duke Clinical Research Institute, Duke University School of Medicine, Durham, North Carolina; ‖Department of Cardiology, Aarhus University Hospital, Aarhus Skejby, Denmark; ¶Deutsches Herzzentrum München, Technische

ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease

CTA = computed tomography angiography

EQ-5D = EuroQOL, 5-item version

FFR = fractional flow reserve

FFR_{CT} = fractional flow reserve estimated with computed tomography

PCI = percutaneous coronary intervention

QOL = quality of life

SAQ = Seattle Angina Questionnaire, 7-item version

VAS = visual analog scale

Evaluation of patients with the new onset of symptoms suggestive of coronary artery disease (CAD) is difficult due to the many testing options. Noninvasive stress testing, often combined with myocardial perfusion imaging or echocardiography, is recommended for stable patients who have an intermediate pre-test probability of CAD (1). Invasive coronary angiography is recommended as an initial test for patients with a high pre-test probability of CAD (1), but invasive angiography does not assess the functional significance of visualized lesions, and it is more costly and carries greater risk than noninvasive testing. Noninvasive coronary computed tomography angiography (CTA) is very sensitive in detecting obstructive CAD, but is limited in its positive predictive value. CTA also does not assess the functional significance of visualized lesions, and often leads to further evaluation with either stress testing or invasive angiography, or both (2–4).

Fractional flow reserve (FFR) assesses the functional significance of individual coronary lesions, and has been used to guide use of percutaneous coronary intervention (PCI). FFR measured during invasive coronary angiography identified patients for whom performing PCI was cost-effective compared with medical therapy in a randomized trial of patients who had an FFR <0.80 (5). FFR can now be estimated noninvasively from standardly acquired computed tomography data (FFR_{CT}), based on computational fluid dynamics (6). FFR_{CT} was recently cleared for clinical use by the U.S. Food and Drug Administration, and in 2011 received a CE mark in Europe. The clinical effectiveness of a strategy of using FFR_{CT} to guide management, compared with conventional testing, has been recently demonstrated in PLATFORM (Prospective Longitudinal Trial of FFR_{CT}: Outcomes and Resource Impacts) (7). The purpose of this study was to assess the quality of life and economic outcomes of evaluation strategies that use FFR_{CT}, based on data collected prospectively from the PLATFORM study.

METHODS

The design (8) and main results (7) of the PLATFORM study have been previously described. Briefly, between September 10, 2013, and November 26, 2014, PLATFORM enrolled 2 consecutive cohorts of patients with suspected CAD in 11 European centers. Patients were eligible for enrollment if they were symptomatic, had an intermediate likelihood of CAD (between 20% and 80%), did not have an established diagnosis of CAD, and were referred for clinically indicated testing to evaluate CAD. Patients referred for noninvasive testing were enrolled in a separate stratum than patients referred for invasive testing. The choice to refer the patient for invasive testing rather than noninvasive testing was

Universität München, Munich, Germany; #University Hospital Southampton NHS Trust, Southampton, United Kingdom; **Freeman Hospital, Newcastle upon Tyne, United Kingdom; ††University of Leipzig Heart Centre, Leipzig, Germany; ‡‡Hospices Civils de Lyon and Laboratoire de Recherche en Cardiovasculaire, Métabolisme, Diabétologie et Nutrition, Institut National de la Santé et de la Recherche Médicale, Lyon, France; §§Cardiology Department, Johannes Gutenberg University Hospital, Mainz, Germany; ||||Department of Cardiology, Aarhus University Hospital, Aarhus Skejby, Denmark; ¶¶Department of Radiology, Innsbruck Medical University, Innsbruck, Austria; ##Department of Cardiology, Cavale Blanche Hospital, Brest, France; and ***HeartFlow, Inc., Redwood City, California. Supported by HeartFlow, Inc., Redwood City, California. Dr. Hlatky has received research grants from HeartFlow. Dr. De Bruyne has received grants from HeartFlow, Abbott, St. Jude Medical, and Medtronic; and has received consultant's fees (to his institution) from St. Jude Medical, Boston Scientific, and Opsens; and holds equities in Omega Pharma, Siemens, Edwards Lifesciences, GE, Sanofi, HeartFlow, and Bayer. Dr. Pontone has received institutional grants and fees from GE Healthcare, Medtronic, and Bracco. Dr. Patel has received grants from HeartFlow, Jansen, Johnson & Johnson, AstraZeneca, NHLBI, and AHRQ; and has received personal advisory board fees from AstraZeneca, Genzyme, Jansen, Bayer, and Merck. Dr. Norgaard has received grants from Edwards Lifesciences. Dr. Byrne has received grants from HeartFlow; and has received speaker fees from B. Braun, Biotronik, and Boston Scientific. Dr. Curzen has received grants from HeartFlow, Boston Scientific, Medtronic, Haemonectics, and St. Jude Medical; has received honoraria or consulting fees from Haemonectics, HeartFlow, and Lilly/Daiichi Sankyo; has received speaker's fees from HeartFlow and St. Jude Medical; and has received travel sponsorship from St. Jude Medical, Abbott Vascular, and Biosensors. Dr. Rioufol has received grants from HeartFlow; and has received personal fees from St. Jude Medical and Boston Scientific. Dr. Feuchtner has received research support from Medtronic. Dr. Gilard has received travel sponsorship from Abbott, AstraZeneca, Biotronik, Boston Scientific, Daiichi Sankyo, Edwards, Eli Lilly and Company, Medtronic, and Terumo. Dr. Andreini has received grants and personal fees from GE Healthcare. Dr. Hadamitzky has received grants from Siemens Healthcare. Mr. Wilk, Dr. Wang, and Dr. Rogers are employees of HeartFlow. Dr. Douglas has received grants from HeartFlow; and has received other support from GE Medical Systems. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received September 16, 2015; revised manuscript received September 25, 2015, accepted September 25, 2015.

made by the local clinicians before enrollment in the study, and reflected prevailing practice patterns. The first cohort of patients, enrolled at the start of the study, was evaluated by standard clinical testing in the enrolling center. The second cohort of patients, enrolled after completion of the enrollment of the first cohort, was evaluated by CTA, with determination of FFR_{CT} when a lesion of ≥30% stenosis was detected, or the patient was referred to invasive angiography.

We followed all patients for at least 90 days to document the primary study outcome of invasive angiography without evidence of significant coronary stenosis among patients in the invasive stratum. We enumerated the use of key medical resources from the time of enrollment through the 90-day follow-up visit, and counted the numbers of CTAs, noninvasive stress tests (stress perfusion imaging, stress echocardiography, exercise electrocardiography, stress cardiac magnetic resonance imaging), invasive tests (invasive coronary angiography, invasive fractional flow reserve, optical coherence tomography, intravascular ultrasound), coronary revascularization procedures (coronary artery bypass graft surgery, PCI, number of coronary stents), cardiac medications (aspirin, statins, antiplatelet medications), and clinical events (cardiac hospitalizations, procedural complications). We assessed quality of life (QOL) at baseline and 90 days using the 7-item Seattle Angina Questionnaire (SAQ) (9), the 5-item EuroQOL scale (EQ-5D) (10), and a visual analog scale (VAS) (with 0 = worst and 100 = best).

We measured the cumulative medical costs over 90 days for each patient by multiplying a standardized cost weight for each medical resource times the number of resources used by the individual patient, applying as cost weights the 2015 Medicare reimbursement rates (national average of technical and professional fees) and online pharmacy costs for drugs (Online Table 1). We did not discount costs because of the short duration of follow-up. We applied a range of cost weights for FFR_{CT}, because the Medicare reimbursement rate for this procedure has not yet been determined. In the base case analysis, we set the cost weight for FFR_{CT} to zero to estimate the cost offset attributable to use of FFR_{CT} (i.e., the difference in subsequent costs between patients in the FFR_{CT} strategy and in the conventional strategy). In sensitivity analyses, we recalculated 90-day costs after application of a series of cost weights for FFR_{CT} that were multiples of the cost weight for CTA.

We compared the costs of the FFR_{CT}-guided strategy with the costs of the conventional management strategy separately in the planned noninvasive testing stratum and in the planned invasive testing stratum. We compared unadjusted costs between strategies using the nonparametric Wilcoxon rank sum test. To control for baseline characteristics, we created a propensity score for enrollment into the FFR_{CT}-guided group, and matched patients on propensity score using a greedy matching algorithm, as described in detail in the clinical results paper (7). We tested whether the intended form of testing (noninvasive versus invasive) significantly modified the relative costs of the FFR_{CT}-guided and usual care strategies by performing an interaction test in a log-linear model that included stratum (noninvasive or invasive) and strategy (FFR_{CT} or usual care) as independent variables.

We compared the change in QOL scores from baseline to 90 days of follow-up using the Wilcoxon rank sum test, and compared changes between groups using a nonparametric test. We compared patients in the FFR_{CT}-guided strategy and the usual care strategy within the pre-defined strata: planned noninvasive and planned invasive evaluation.

We performed data analyses using SAS Statistical Software (version 9.3, Cary, North Carolina). The institutional review boards of each enrolling center and of Duke University Medical Center approved the study protocol. All patients provided written, informed consent to participate.

TABLE 1 Baseline Clinical Characteristics by Cohort and Evaluation Strategy

	Invasive Cohort		Noninvasive Cohort	
	Usual Care (n = 187)	FFR_{CT} (n = 193)	Usual Care (n = 100)	FFR_{CT} (n = 104)
Age, yrs	63.4	60.7	57.9	59.5
Male	58%	62%	66%	58%
Diabetes	19%	16%	8%	6%
Current smoker	22%	20%	22%	22%
Hypertension	59%	58%	38%	55%
Hyperlipidemia	41%	40%	22%	27%
Atypical angina	65%	74%	91%	77%
Prior noninvasive testing	49%	52%	0%	5%
Pre-test probability of CAD	51.7%	49.4%	44.5%	45.3%
SAQ	67.0	71.6	74.1	71.8
EQ-5D	0.79	0.81	0.82	0.81
Visual analog scale	69.5	72.9	75.3	73.8
Medications				
Aspirin	61%	47%	29%	43%
Statin	44%	40%	24%	28%
Clopidogrel	10%	4%	2%	5%

Values are mean or %.

CAD = coronary artery disease; EQ-5D = EuroQOL 5-item version; FFR_{CT} = fractional flow reserve estimated using computed tomography; SAQ = Seattle Angina Questionnaire.

TABLE 2 Resource Use Over 90 Days, by Cohort and Evaluation Strategy: Number of Times Used (Number of Patients With Any Use)

	Invasive Cohort		Noninvasive Cohort	
	Usual Care (n = 187)	FFR_{CT} (n = 193)	Usual Care (n = 100)	FFR_{CT} (n = 104)
Stress tests				
ECG	2 (2)	8 (8)	7 (7)	4 (4)
Echo	0 (0)	1 (1)	29 (29)	1 (1)
Nuclear	2 (2)	0 (0)	15 (15)	4 (4)
CT angiograms	1 (1)	193 (193)	60 (60)	104 (104)
FFR_{CT}	0 (0)	117 (117)	0 (0)	60 (60)
Invasive tests				
Diagnostic ICA	153 (153)	37 (36)	9 (9)	10 (10)
ICA with PCI	40 (38)	51 (45)	4 (3)	9 (9)
FFR_{INV}	11 (11)	27 (26)	0 (0)	5 (5)
IVUS	7 (7)	4 (4)	3 (3)	2 (2)
Coronary revascularization				
PCI	44 (42)	51 (45)	4 (3)	9 (9)
Stents (mean)	1.82	1.80	1.25	1.22
CABG	17 (17)	10 (10)	2 (2)	1 (1)
Hospital days	445 (109)	259 (54)	28 (8)	46 (16)
Clinic visit	45 (35)	37 (36)	26 (21)	18 (16)
ED visits	8 (8)	2 (2)	1 (1)	1 (1)
Medications at 90 days				
Aspirin	133	117	39	47
Statin	114	107	39	47
Clopidogrel	38	46	3	12
Prasugrel	3	3	0	0
Ticagrelor	1	0	1	0

Values are the total number of resources used (number of patients with any resource used).

CABG = coronary artery bypass graft surgery; CT = computed tomography; ECG = electrocardiogram; ED = emergency department; FFR_{CT} = fractional flow reserve estimated by coronary computed angiography; FFR_{inv} = fractional flow reserve determined by invasive coronary angiography; ICA = invasive coronary angiography; IVUS = intravascular ultrasound; PCI = percutaneous coronary intervention.

RESULTS

The PLATFORM study enrolled 584 symptomatic patients with suspected CAD: 204 in the planned noninvasive testing stratum and 380 in the planned invasive testing stratum (7). Within the planned noninvasive testing stratum, 100 patients were evaluated with the usual care strategy, and 104 patients were evaluated with the FFR_{CT} strategy. In the planned invasive testing stratum, 187 patients were evaluated with the usual care strategy, and 193 patients were evaluated with the FFR_{CT} strategy.

The mean age of the study participants was 61 years, 40% were women, 74% had atypical angina, and the mean pre-test probability of CAD was 49% (Table 1). Clinical characteristics of patients in the FFR_{CT} strategy groups were generally similar to those of patients in the usual care strategy groups (Table 1).

In the planned invasive testing stratum, CTA was, by design, performed in 100% of the FFR_{CT}-guided strategy group, with FFR_{CT} performed in 61% (Table 2). Invasive coronary angiography was performed, by design, in 100% of the patients in the usual care strategy, compared with 39% of patients in the FFR_{CT}-guided strategy. Coronary revascularization was performed in a similar proportion of patients in each strategy (28% vs. 32%), with slightly fewer coronary artery bypass graft procedures in the FFR_{CT}-guided group (5% vs. 9%). The 90-day per-patient cost of medical care was significantly lower in the FFR_{CT}-guided strategy than in the usual care strategy ($7,343 vs. $10,734, $p < 0.0001$, 95% confidence limits on the $3,391 difference, $1,186 to $5,595), driven primarily by the lower costs of invasive procedures (Table 3). The "downstream costs," excluding the costs of the initial tests, were $7,048 for the FFR_{CT} group, compared with $8,422 in the usual care group ($p < 0.0001$). More patients in the FFR_{CT}-guided group had low costs (median = $379) than in the usual care group (median = $6,414) (Figure 1). The pattern of 90-day costs was similar whether patients had prior noninvasive testing ($7,790 vs. $10,615), or did not have prior noninvasive testing ($6,853 vs. $10,849).

In the planned noninvasive testing stratum, patients in the usual care group had more stress tests and fewer CTAs than patients in the FFR_{CT} group, as expected by the study design (Table 2). FFR_{CT} was performed in 58% of the CTAs in the FFR_{CT} guided strategy and, by design, in none of the CTAs in the usual care strategy. Invasive coronary angiography was performed slightly more often in the FFR_{CT} group than in the usual care group (18% vs. 12%), as was coronary revascularization (10% vs. 5%). The 90-day per-patient cost of care was not significantly different between the FFR_{CT} group and the usual care group ($2,679 vs. $2,137, $p = 0.26$, 95% confidence limits for the $542 difference, −$1,153 to +$2,237). The "downstream costs," excluding the costs of the initial

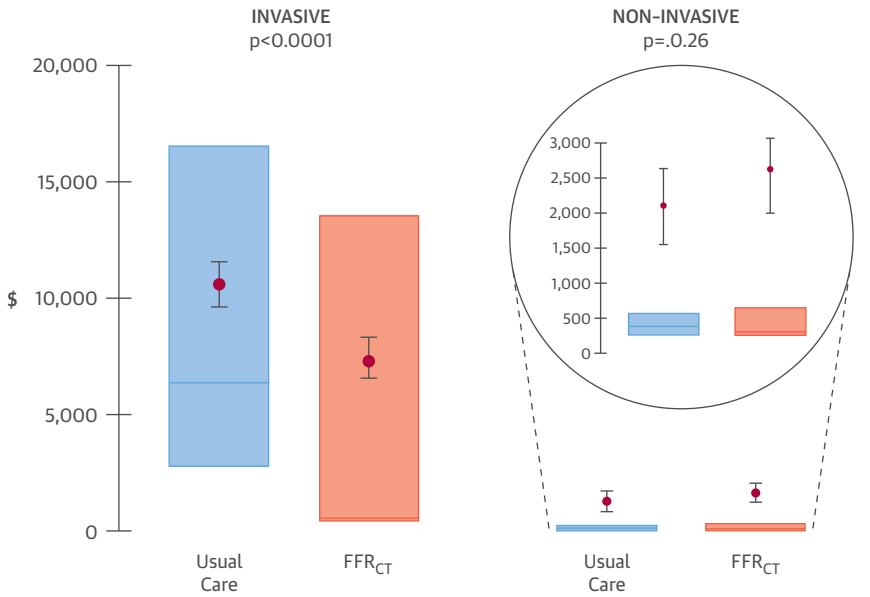
TABLE 3 Mean Medical Costs Over 90 Days, by Cohort and Evaluation Strategy (U.S. Dollars)

	Invasive Cohort		Noninvasive Cohort	
Cost Category	Usual Care (n = 187)	FFR_{CT} (n = 193)	Usual Care (n = 100)	FFR_{CT} (n = 104)
Stress tests	22	14	203	39
Coronary CTA	2	301	180	301
Invasive tests	2,335	570	258	280
Revascularization	5,983	5,276	1,144	1,506
Medications	60	54	23	27
Follow-up hospitalization	2,301	1,107	299	506
Other	31	22	29	20
Total	10,734	7,343	2,137	2,679

Values are mean U.S. dollars ($).

CTA = computed tomography angiography; FFRct = fractional flow reserve estimated by computed tomography coronary angiography.

FIGURE 1 **Ninety-Day Costs by Stratum and Evaluation Strategy**



The **vertical axis** indicates cumulative 90-day medical costs. The **top line of each box** indicates the 75th percentile, the **line in the middle of each box** indicates the 50th percentile (median), and the **bottom line of each box** indicates the 25th percentile. Mean costs are indicated by the point, and the **error bars** indicate ± 1 standard error of the mean. The **insert** shows the expanded vertical scale for the noninvasive stratum. p Values compare the usual care and FFR_{CT} evaluation strategies. FFR_{CT} = fractional flow reserve estimated using computed tomography.

tests, were $2,412 in the FFR_{CT} group, compared with $1,819 in the usual care group ($p = 0.51$). Most patients had relatively low costs in the noninvasive stratum (Figure 1), with median costs of $349 in the FFR_{CT} group and $407 in the usual care group, as the minority of patients who had costly invasive procedures drove the mean costs higher in both groups.

The effect of the FFR_{CT} strategy, compared with usual care, on 90-day costs differed significantly between the noninvasive cohort and invasive cohort (interaction $p < 0.0001$).

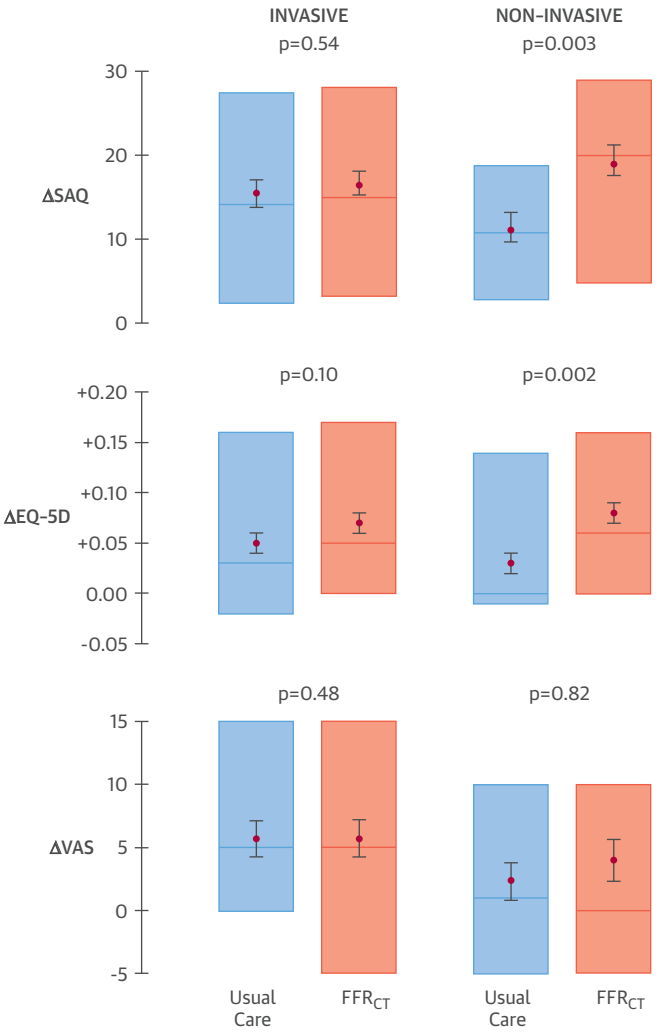
Propensity score matching did not change these study findings materially. In the invasive testing cohort, the cost of the FFR_{CT} strategy was 32% lower in the entire population (Table 3) and was 31% lower in the 148 propensity score-matched pairs of patients ($7,473 vs. $10,833, $p < 0.0001$). In the planned noninvasive testing cohort, the cost of the FFR_{CT} strategy was 25% higher in the entire population (Table 3), and was 41% higher in the 80 propensity-matched pairs of patients ($2,984 vs. $2,119, $p = 0.27$).

In a sensitivity analysis, we assigned a series of cost weights to FFR_{CT} that were multiples of the cost weight for CTA. Even when the cost weight for FFR_{CT} was set to 7 times the cost weight of CTA, the FFR_{CT}-guided strategy still had 20% lower costs than the usual care strategy in the planned invasive testing stratum ($8,619 vs. $ 10,734, $p < 0.0001$); the costs equalized when the cost weight for FFR_{CT} was set to 20 times the cost weight for CTA. In the planned noninvasive testing stratum, however, a cost weight for FFR_{CT} one-half that of CTA led to higher mean per patient costs over 90 days in the FFR_{CT} group compared with the usual care group ($2,766 vs. $2,137, $p = 0.02$).

QUALITY OF LIFE. Functional status and QOL improved from baseline to 90 days of follow-up in the overall study population, with mean improvements of 16 units on the SAQ ($p < 0.0001$), 0.06 units on the EQ-5D ($p < 0.0001$), and 4.2 units on the VAS ($p < 0.0001$). In the planned noninvasive testing stratum, the improvements in QOL scores were greater in the patients in the FFR_{CT} strategy group than in patients in the usual care group: 19.45 versus 11.43 for the SAQ ($p = 0.003$), 0.08 versus 0.03 for the EQ-5D ($p = 0.002$), and 4.05 versus 2.26 for the VAS ($p = 0.82$). The mean improvements in the SAQ subscales were generally consistent with the improvement in the

overall SAQ: 10.06 for the FFR_{CT} group versus 2.60 for the usual care group on the Physical Limitation Subscale; 18.96 versus 11.69 for the Angina Frequency Subscale, and 28.16 versus 18.32 for the Quality of Life Subscale. The FFR_{CT} group had greater improvements on the standard categories for overall SAQ scale (poor to fair = 0 to <50, good = 50 to <75, excellent = 75 to 100): 45% (43 of 96 patients with both baseline and 90-day scores) improved by 1 or 2 categories on the SAQ score versus 33% (29 of 89 patients) in the usual care group. In the planned invasive testing stratum, the improvements in the QOL scores were similar in the FFR_{CT} and usual care strategy groups (Figure 2). These findings were not materially changed in the propensity score-matched population.

FIGURE 2 Change in QOL Scores From Baseline to 90 Days, by Stratum and Evaluation Strategies



Format as in Figure 1. ΔEQ-5D = Change in EuroQol; ΔSAQ = change in Seattle Angina Questionnaire; ΔVAS = Change in visual analog scale; FFR_{CT} = fractional flow reserve estimated using computed tomography; QOL = quality of life.

DISCUSSION

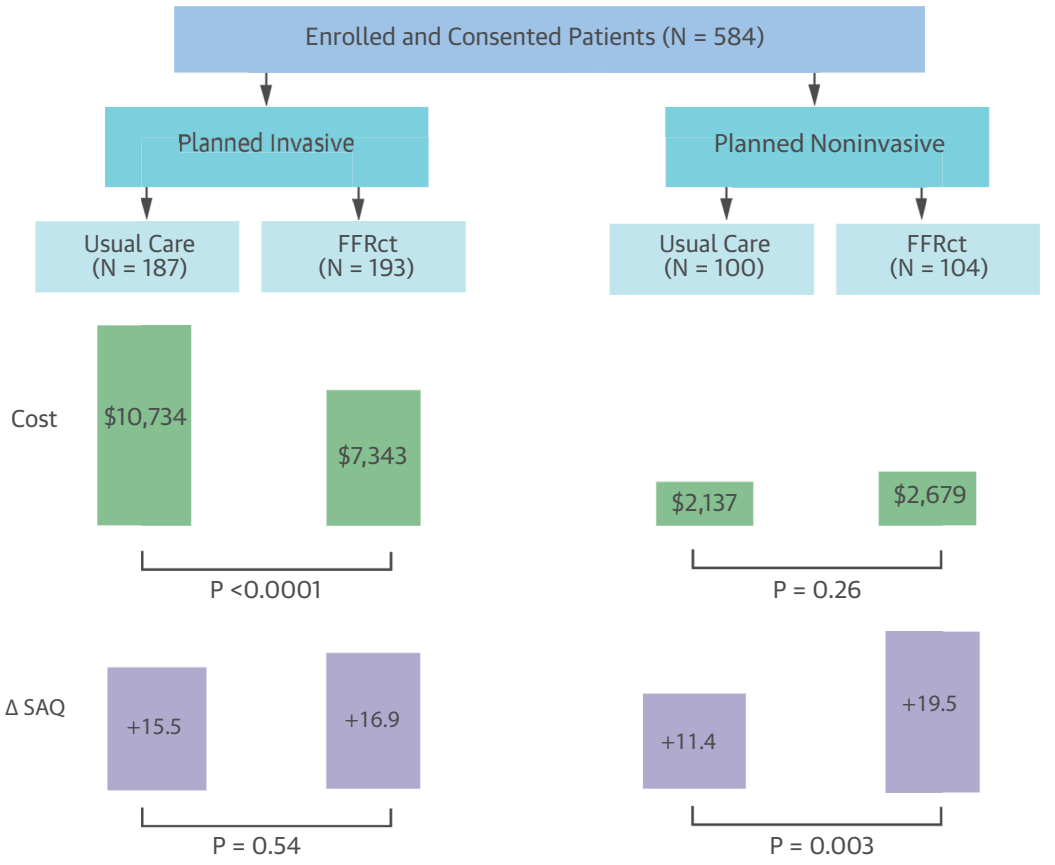
In this multicenter, prospective study of stable, symptomatic patients with suspected CAD, an evaluation strategy based on use of FFR_{CT} was associated with lower use of medical resources and significantly lower costs compared with a strategy of invasive coronary angiography (Central Illustration). The FFR_{CT} guided testing strategy was associated with less than half the rate of invasive coronary angiography, similar rates of overall coronary revascularization, and similar degrees of improvement in QOL than the invasive testing strategy (Central Illustration). These findings suggest that the combination of anatomic and functional data provided by the FFR_{CT}-guided testing strategy may lead to more selective use of invasive procedures than relying solely on the anatomic data provided by invasive coronary angiography.

Among patients who had planned noninvasive testing, the FFR_{CT}-guided strategy was associated with slightly more use of invasive cardiac procedures, and a trend towards higher medical costs, but the FFR_{CT}-guided strategy was also associated with a significantly greater improvement in QOL. In the noninvasive setting, the combination of anatomic and functional data provided by CTA and FFR_{CT} may identify patients who would benefit from coronary revascularization.

The overall effect on costs of an FFR_{CT}-based evaluation strategy depends mostly on the relative cost of performing CTA and FFR_{CT}. The Medicare reimbursement rate for FFR_{CT} has not yet been established, so we tested a range of cost weights for FFR_{CT} in a sensitivity analysis. Even when the cost weight for FFR_{CT} was set to 7 times the cost weight of CTA, the FFR_{CT}-guided strategy still had 20% lower cost than the invasive testing strategy ($p < 0.0001$), and the cost of these strategies was equalized only when the cost weight for FFR_{CT} was set to 20 times the cost weight for CTA. These findings suggest that use of FFR_{CT}-guided evaluation could be cost saving compared with invasive testing under most likely levels of reimbursement for FFR_{CT}.

In light of the importance many cardiologists place upon images of coronary anatomy, the impact of functional data from FFR_{CT} on clinical decision-making appears to be context specific: functional data from FFR_{CT} added to anatomic data might

CENTRAL ILLUSTRATION **Measuring FFR_{CT}: QOL and Cost Outcomes in the PLATFORM Study**



ΔSAQ = Change in Seattle Angina Questionnaire; FFR_{CT} = fractional flow reserve estimated using computed tomography; QOL = quality of life.

reduce invasive procedures compared with anatomic data alone, but anatomic data from the CTA added to functional data might increase invasive procedures compared with functional data alone. This interpretation is consistent with prior evidence from randomized and observational studies of the effect on resource use of CTA compared with noninvasive stress testing. In the PROMISE trial (Prospective Multicenter Imaging Study for Evaluation of Chest Pain) (2), patients randomly assigned to initial anatomic testing with CTA were more likely to undergo invasive coronary angiography (12.2% vs. 8.1%) and coronary revascularization (6.2% vs. 3.2%, $p < 0.001$) than patients randomly assigned to noninvasive stress testing. The SCOT-HEART trial (Scottish Computed Tomography of the Heart Trial) also reported an increase in invasive procedures among patients randomly assigned to CTA compared with patients assigned to standard care (11). An observational study of Medicare beneficiaries matched on propensity score found that patients who received CTA were more likely to undergo subsequent invasive coronary angiography than patients who received stress testing (3). Similar findings were reported by the SPARC Registry, which compared CTA with stress myocardial perfusion imaging (4). However, none of these previous studies comparing CTA with other noninvasive tests used FFR_{CT} to evaluate the functional significance of the visualized lesions.

QOL improved in all patient groups in the PLATFORM study (**Figure 2**), potentially reflecting the initiation of treatments based on the test results in these patients with new onset of symptoms suggestive of CAD. Patients who were most symptomatic at baseline (i.e., had lower SAQ scores) generally had more QOL improvement, as did patients who

underwent coronary revascularization. The degree of improvement in QOL differed somewhat depending upon the evaluation strategy used and the initially planned method of evaluation (noninvasive or invasive). In the planned invasive testing stratum, the improvements in QOL were similar in the usual care and FFR_{CT}-guided groups, perhaps because of the similar, and overall high, rates of coronary revascularization. By contrast, in the planned noninvasive testing stratum, QOL improved to a greater degree among patients in the FFR_{CT}-guided strategy. The reasons for this greater degree of improvement are uncertain and difficult to assess due to the nonrandomized and unblinded study design, but may be due to more frequent use of coronary revascularization for functionally significant coronary lesions, which has been previously shown to reduce angina and improve QOL (5).

This study assessed the impact of using an FFR_{CT}-guided strategy on economic and quality of life outcomes, but was too small to evaluate its effect on major cardiac events. As reported previously (7), the rate of the composite outcome (death, myocardial infarction, and unstable symptoms requiring urgent revascularization) was low in both evaluation strategies and did not differ significantly. A substantially larger study would be required to detect clinically meaningful changes in major cardiac events as a result of using an FFR_{CT}-guided evaluation strategy. The 10,003 patient PROMISE randomized trial of CTA and stress testing, with 315 primary outcome events over 25 months of follow-up (1.5% per year), found no significant difference in the rate of major cardiac events, but this finding had relatively wide confidence intervals (hazard ratio 1.04, confidence limits 0.83 to 1.29). Very large outcome studies would be needed to assess the effect of using FFR_{CT} on hard cardiac outcomes in low risk patients such as those enrolled in the PLATFORM study.

The major limitation of this study was that it used a consecutive observational design, and did not randomize patients to evaluation with FFR_{CT}. The balance of patient characteristics and the lack of meaningful change in the study results after propensity score matching suggest that the findings are not due to baseline differences between patient groups. This study was conducted in 11 European centers, and the practice patterns at these centers may not be representative of other centers, and practice patterns may differ between Europe and the United States. This study used Medicare cost weights because they are a widely applicable metric of economic impact. Although alternative sets of price weights might alter these conclusions somewhat, the cost of noninvasive testing is lower than the cost of invasive coronary angiography and coronary revascularization in essentially all health care settings, so the overall conclusions are unlikely to be sensitive to variations in the cost weights. Finally, this study examined a strategy of using FFR_{CT} to guide management among patients eligible to undergo coronary CTA testing, but FFR_{CT} may not be technically feasible in all patients. In the PLATFORM study, 88% of CTAs performed were of sufficient quality to assess FFR_{CT}.

CONCLUSIONS

A strategy of using CT angiography with FFR_{CT} to evaluate patients with suspected CAD was associated with lower costs than a strategy of invasive coronary angiography, and was associated with improved QOL compared with a strategy of evaluation with other noninvasive tests.

REPRINT REQUESTS AND CORRESPONDENCE: Dr. Mark A. Hlatky, Stanford University School of Medicine, HRP Redwood Building, Rm. T150, 259 Campus Drive, Stanford, California 94305-5405. E-mail: hlatky@stanford.edu.

PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: Fractional flow reserve assesses the functional importance of coronary lesions visualized by angiography, and can be estimated noninvasively on the basis of data from coronary CTA.

COMPETENCY IN PATIENT CARE: Clinical guidelines recommend assessment of the functional significance of coronary lesions prior to coronary revascularization.

TRANSLATIONAL OUTLOOK: The PLATFORM study suggests that use of FFR_{CT} may reduce overall costs and improve patient quality of life. Larger, randomized studies are warranted to compare the clinical effectiveness of management strategies based on use of FFR_{CT} with management strategies based on using other methods of anatomic or functional evaluation.

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KEY WORDS coronary angiography, coronary artery disease, cost comparison, myocardial fractional flow reserve, quality of life, stress test

APPENDIX For a supplemental table, please see the online version of this article.