Fractional flow reserve use during elective coronary angiography among elderly patients in the US

Bradley Kay a, Timothy A. Joseph b, Jessica L. Lehrich a, Nick Curzen c, Brahmajee K. Nallamothu a,⁎

a Department of Internal Medicine, University of Michigan Medical School, Ann Arbor, MI, United States of America
b Department of Cardiology, Mayo Clinic, Rochester, MN, United States of America
c Department of Cardiology, University of Southampton, Southampton, United Kingdom

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Fractional flow reserve (FFR) is a physiologic measurement of coronary artery perfusion. Studies have demonstrated its benefit in lowering cost and improving outcomes in patients undergoing elective coronary angiography, though follow-up surveys have demonstrated low usage nationwide. We sought to investigate the actual usage in elderly patients undergoing elective coronary angiography. Overall utilization of FFR for elective coronary angiography was 6.3%. Age, sex, race, prior stress testing and region of the country were all statistically significant predictors for FFR use. There still exist many barriers to widespread adoption of this modality, which require further exploration.

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A B S T R A C T

Recent reports suggest physiologic assessment of coronary artery disease (CAD) prior to revascularization is low despite guidelines supporting its use [1,2]. In prior work, we found ~10% of Medicare beneficiaries undergoing elective percutaneous coronary intervention (PCI) received fractional flow reserve (FFR) or equivalent physiologic measurements [3]. A critique of that analysis (and similar studies from the National Cardiovascular Data Registry [4]) was the focus on patients undergoing PCI. Low use in this setting may be explained by omitting situations in which FFR was used, but PCI was deferred. Studying FFR in all-comers for elective, diagnostic coronary angiography would allow better determination of factors associated with its use.

We used the 20% random sample from the Medicare Carrier, Medicare Provider and Analysis, Outpatient and Denominator files. We restricted patients in our cohort to their index coronary angiogram between January 1, 2012 and December 31, 2014. We included Medicare beneficiaries aged 65 to 99 years old who were fee-for-service eligible for at least three months prior and one month after their procedure to fully capture claims around the procedure. To ensure that the angiograms were elective, we excluded those with a history of acute myocardial infarction or those with emergency department visits at the time of their procedure. We excluded patients who underwent valve studies or procedures within the past year or had a diagnosis of valvular disease. We then determined the use of FFR, stratified on the basis of no revascularization versus revascularization with either coronary artery bypass grafting (CABG) or PCI within 30 days of index coronary angiogram. International Classification of Diseases-9 codes to identify diseases and procedures in this analysis are available in the Supplementary materials. We constructed multivariable logistic regression models to evaluate for factors associated with FFR use. All data were analyzed using SAS version 9.4. We will make statistical code available upon request and plan to place it in a public Github repository following publication.

Our cohort included 136,110 patients who underwent elective coronary angiograms. The average age was 74.0 (±6.1), 45.3% were women, and 7.3% were black. 6.3% of our cohort underwent FFR. 50,896 (37.4%) underwent revascularization within 30 days of their coronary angiogram: 41,763 treated with PCI and 9133 with CABG. FFR was performed in 3848 (7.6%) of those who underwent revascularization and 4719 (5.5%) in whom revascularization was not performed. 2542 (53.9%) of the 4719 non-revascularized patients who had undergone FFR had received stress testing within 30 days of coronary angiography: 41,763 treated with PCI and 9133 with CABG. FFR was performed in 3848 (7.6%) of those who underwent revascularization and 4719 (5.5%) in whom revascularization was not performed. 2542 (53.9%) of the 4719 non-revascularized patients who had undergone FFR had received stress testing (Fig. 1).

Predictors of FFR use included: age, gender, race, region, prior stress testing, and diagnostic study only versus revascularization (Table 1). Older patients, women, black patients, and patients who did not undergo subsequent revascularization had lower odds of...
receiving FFR. Prior stress testing within 30 days of the diagnostic coronary angiography was also a negative predictor for FFR use. FFR use, varied across US regions from 4.1% to 8.6% with a mean of 6.8% ± 1.7%. The South Atlantic and East South Central regions showed lower FFR use while the New England and West North Central regions had greater FFR use (Fig. 2).

Our findings supplement our prior report by documenting low utilization of FFR for ruling out ischemia even when including elective coronary angiograms that do not proceed to PCI. Several large-scale trials have demonstrated the benefits of the FFR-guided approach to coronary interventions including decreased cost and cardiovascular outcomes in patients undergoing elective procedures.

This study has several limitations. We cannot account for visual assessment of the degree of stenosis. Prior work demonstrates considerable across operator-level variation in visual assessment in intermediate stenoses [5], and this variability could have impacted our findings. Our study also did not assess certain factors such as the failure of medical therapy or extent of clinical symptoms, which may have played a role in decisions to perform FFR. More studies are needed to understand potential barriers to its adoption and potential ways to improve its utilization.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcha.2019.01.005.

Conflicts of interest

Brahmajee Nallamothu receives funding from American Heart Association for editorial work for their journals.

Table 1

| Rates and odds ratios of FFR by region, age, sex, race, and prior stress testing, and revascularization. |
|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Number undergoing FFR | Number undergoing elective coronary angiography | Percentage | Odds ratio (CI) | p-Valuea |
| Age
|<65 – 75 | 5058 | 78,376 | 6.45% | N/A | N/A |
|>75 – 85 | 3049 | 49,129 | 6.21% | 0.939 (0.896–0.984) | 0.0081 |
| ≥85 | 460 | 8605 | 5.35% | 0.78 (0.706–0.861) | <0.0001 |
|Sex
|Female | 3577 | 61,682 | 5.80% | 0.94 (0.898–0.984) | 0.0078 |
|Male | 4990 | 74,428 | 6.70% | N/A | N/A |
|Race
|Non-black | 8120 | 125,481 | 6.47% | N/A | N/A |
|Black (or African American) | 393 | 9873 | 3.98% | 0.675 (0.608–0.749) | <0.0001 |
|Revascularization (PCI or CABG) | Yes | 3848 | 50,896 | 7.56% | N/A | N/A |
|No | 4719 | 85,214 | 6.54% | 0.737 (0.704–0.771) | <0.0001 |
|Prior stress test
|Yes | 4764 | 79,289 | 6.01% | 0.869 (0.831–0.908) | <0.0001 |
|No | 3803 | 56,821 | 6.63% | N/A | N/A |
|Region
|New England | 336 | 3935 | 8.54% | N/A | N/A |
|Middle Atlantic | 928 | 14,370 | 6.46% | 0.764 (0.667–0.871) | <0.0001 |
|East North Central | 1389 | 23,315 | 5.96% | 0.698 (0.616–0.791) | <0.0001 |
|West North Central | 949 | 10,993 | 8.63% | 1.015 (0.899–1.137) | 0.8274 |
|South Atlantic | 1884 | 29,848 | 6.11% | 0.751 (0.665–0.849) | <0.0001 |
|East South Central | 624 | 13,498 | 4.62% | 0.531 (0.463–0.61) | <0.0001 |
|West South Central | 871 | 21,194 | 4.11% | 0.474 (0.415–0.54) | <0.0001 |
|Mountain | 646 | 7617 | 8.48% | 0.996 (0.867–1.144) | 0.5532 |
|Pacific | 540 | 11,340 | 8.23% | 0.985 (0.864–1.123) | 0.8235 |

a p-Value of N/A signifies referent category.
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Fig. 2. US census region choropleth map showing odds ratios of Medicare patients receiving FFR during elective coronary angiography. Referent group is the New England region.