JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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PUBLISHED BY ELSEVIER

VOL. 67, NO. 6, 2016
ISSN 0735-1097/$36.00

Letters

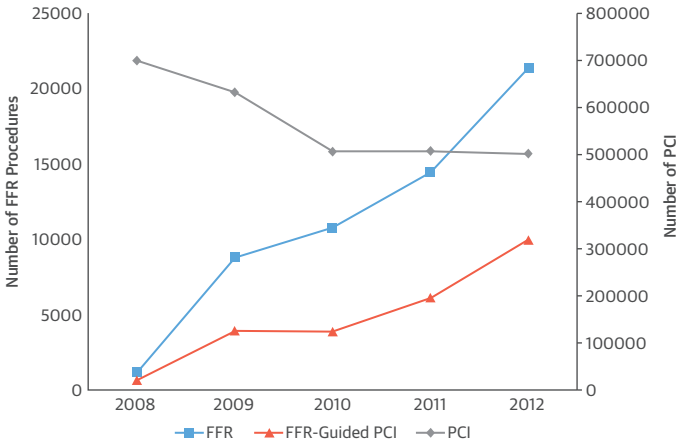
U.S. Trends in Inpatient Utilization of Fractional Flow Reserve and Percutaneous Coronary Intervention

Fractional flow reserve (FFR) of intermediate coronary stenosis is a highly accurate, reproducible, and cost-effective modality with powerful prognostic value. Results of the FAME (Fractional Flow Reserve versus Angiography for Multivessel Evaluation) (1) and FAME-2 trials (2) have shown a significant reduction in major adverse cardiovascular events with FFR-guided coronary intervention in patients with stable coronary disease. More recent studies including the FAMOUS-NSTEMI (Fractional Flow Reserve Versus Angiographically Guided Management to Optimise Outcomes in Unstable Coronary Syndromes) randomized trial, have demonstrated the utility of FFR in patients with acute coronary syndromes (ACS) (3). Despite the strong evidence base, FFR is still underutilized in the United States. A 1-year (2008 to 2009) analysis from the National Cardiovascular Data Registry showed that FFR evaluation was undertaken in only 6% of intermediate lesions (4). We examined U.S. trends of FFR utilization after publication of the pivotal FAME trial (2009).

Data from the Nationwide Inpatient Sample (NIS) dataset for the years 2008 to 2012 was analyzed. The NIS, a nationally representative survey of hospitalizations that is conducted by the Healthcare Cost and Utilization Project, represents a 20% sample of all community hospitals and is the largest all-payer inpatient dataset in the United States. The NIS provides deidentified patient and procedural information based on discharge codes and has been shown to correlate with other hospital discharge databases in previous studies. We identified patients with International Classification of Diseases procedure code 9 (ICD-9) for percutaneous coronary intervention (PCI), either with bare-metal (36.06) or drug-eluting stents (36.07) and FFR (00.59) between 2008 and 2012. Patients with non-ST-segment elevation ACS were identified with appropriate ICD-9 codes for unstable angina and non-ST-segment elevation myocardial infarction.

In-hospital FFR utilization increased from 1,173 procedures in 2008 to 21,365 procedures in 2012, which represents an 18-fold rise. The number of FFR-guided PCIs also increased from 622 in 2008 to 9,945 in 2012, representing a 16-fold increase. There were an estimated 2.85 million patients who underwent PCI in the years 2008 to 2012, with the number of PCIs falling from 698,887 in 2008 to 501,705 in 2012, a 28.2% decrease. In 2012, there were a total of 21,365 FFR procedures and 9,945 FFR-guided PCIs that were performed. This could possibly represent a 53.5% deferral of PCI cases based on FFR results (**Figure 1**). Use of FFR in patients with unstable angina also increased from 444 procedures in 2008 to 10,340 in 2012, a 23-fold rise. Similarly, utility of FFR-guided PCI in non-ST-segment elevation myocardial infarction patients increased 18-fold, from 306 in 2008 to 5,485 in 2012. More than one-half (59.2%) of FFR procedures in 2012 were performed in urban teaching hospitals and 33.6% were performed in urban nonteaching hospitals.

FIGURE 1 U.S. Trends in Utilization of FFR, FFR-Guided PCI, and PCI From 2008 to 2012



Number of fractional flow reserve (FFR) **(blue)** and FFR-guided percutaneous coronary intervention (PCI) **(orange)** are plotted along the primary vertical axis on the left. Numbers of PCI **(gray)** are plotted along the secondary vertical axis on the right.

There has been a significant increase in the utilization of FFR since the publication of FAME trial reflecting the increasing adoption of this procedure by the interventional community (**Figure 1**). In 2012, less than one-half of the discharges with a code for FFR had an associated code for PCI, which may represent a significant impact of FFR utilization on PCI volume over the past decade. Although the value of FFR in patients with ACS has been debated in the past, recent studies have demonstrated clinical utility (3). Our study has significant limitations. Data in NIS is based on diagnostic codes and the accuracy of each entry cannot be validated. However, many previous studies have utilized the same data sample. Secondly, this is an inpatient sample and outpatient FFR procedures are likely to have been missed particularly "deferred cases" not undergoing PCI. We expect that the trends in the use of these procedures on an outpatient basis would parallel our results. Thirdly, in the visits that have codes for both FFR and PCI, we cannot differentiate if both procedures were performed on the same or different coronary arteries. Lastly, all deferred PCIs cannot be attributed to nonischemic FFR results alone, as some patients with positive FFR could have been referred for surgical revascularization. This study demonstrates increased adoption of FFR in clinical practice. Further research is required in understanding if FFR is used as recommended in current guidelines and if not, barriers to more universal adoption.

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http://dx.doi.org/10.1016/j.jacc.2015.11.042

Please note: All authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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Comparison of the American PPCM Registry Data With International Registries

We congratulate McNamara et al. (1) for these exciting new data on a cohort of 100 women diagnosed with peripartum cardiomyopathy (PPCM). This study adds important information with regard to ethnic differences and prognosis as the current management allows it.

However, we noted that several patients had a left ventricular ejection fraction (LVEF) above 45% at the point defined as "baseline" (Figures 2 and 3), although the authors state in the *Methods* section that they used the inclusion criteria of LVEF<45%. Thus, the cohort includes less sick patients with notoriously better outcomes than in other cohorts. The authors should explain this discrepancy.

A second point concerns the definition of full recovery. In the European and African PPCM studies, full recovery is defined as reaching an LVEF above 55% (2,3). Looking at the graphs in Figures 2 and 3, the recovery rate would be considerably lower if these criteria would have been used. For better comparison with the African and European collective, could the authors provide the rate of full recovery in their collective using LVEF >55% as the cutoff?

Finally, the authors state that 15% of PPCM patients in their collective were breastfeeding at the time of diagnosis. Looking at the epidemiological data published by the Centers for Disease Control and Prevention in 2014, 79% of all women in the United States are breastfeeding their newborns and 49% are still breastfeeding 6 months after delivery (4).

Why was the rate of breastfeeding mothers among PPCM patients so low? With regard to outcome, what was the baseline LVEF in breastfeeding PPCM patients and how long did they continue breastfeeding after inclusion?

Importantly, no controlled clinical studies have ever been performed analyzing the effects of heart failure medication transferred to the infant in the