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Failure to Reassess Ejection Fraction after Acute Myocardial Infarction in Potential Implantable Cardioverter Defibrillator Candidates: Insights from the Translational Research Investigating Underlying Disparities in Acute Myocardial Infarction Patients' Health Status (TRIUMPH) Registry

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Abstract

Background—Current practice guidelines advocate delaying assessment of primary prevention implantable cardioverter defibrillator (ICD) candidacy at least 40 days after an acute myocardial infarction (AMI), as early ICD implantation post-AMI has not demonstrated survival benefit. The

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rate at which interval reassessment of left ventricular ejection fraction (LVEF) occurs in potential primary prevention ICD candidates is unknown.

Methods—We examined AMI patients in the TRIUMPH registry with in-hospital LVEF <40% discharged alive after their index presentation, excluding patients with a prior ICD and those who declined ICD during the index admission or were discharged to hospice. We conducted multivariable Poisson modeling to identify independent factors associated with LVEF reassessment by 6 months post-AMI.

Results—Of the 533 patients meeting inclusion criteria, only 187 (35.1%) reported LVEF reassessment in the first 6 months post-AMI and only 13 patients (2.4%) underwent ICD implantation by 1 year. In multivariable analysis, early cardiology follow-up post-AMI was associated with a higher likelihood of LVEF reassessment (odds ratio (OR) 1.16, 95% confidence interval (CI) 1.06,1.28); whereas uninsured status and cardiologist driving inpatient medical decision-making were associated with lower likelihood of LVEF reassessment (OR 0.84, 95% CI 0.74,0.96 and 0.78, 95% CI 0.68,0.91 respectively).

Conclusions—In contemporary practice, almost 2 out of 3 potential primary prevention ICD candidates did not report follow-up LVEF evaluation, with a very low rate of ICD implantation at one year. These results suggest an important gap in quality, highlighting the need for better transitions of care.

Introduction

Multiple studies have demonstrated the benefit of implantable cardioverter defibrillators (ICDs) for primary prevention of sudden cardiac death in patients with ischemic cardiomyopathy.¹ Candidacy for primary prevention ICD implantation is determined primarily by left ventricular ejection fraction (LVEF).² While current American College of Cardiology/American Heart Association performance measures for acute myocardial infarction (AMI) include assessment of LVEF,³ a reduced LVEF in the acute setting may not necessitate future primary prevention ICD implantation. LVEF can be dynamic following AMI, with over one third of patients having at least partial LVEF recovery in the first several weeks post-MI.⁴ Furthermore, several trials have failed to demonstrate any mortality benefit in patients receiving an ICD early after infarction and/or revascularization.⁵⁻⁷

These observations form the basis of the ACC/AHA Guidelines-recommended interval of 40 days post-AMI prior to consideration of a primary prevention device,² as well as the current Center for Medicare and Medicaid Services (CMS) national coverage decision requiring an interval of 40 days post-AMI and 90 days post-revascularization prior to primary prevention ICD implantation.⁸ As such, AMI patients with a low LVEF during the index hospitalization need interval reassessment of LVEF post-discharge in order to be considered for primary prevention ICD. This process requires care coordination between inpatient and outpatient care teams and engenders multiple points of vulnerability in the transition of care process that risk failure to reassess LVEF, and by extension, missed opportunities to offer patients a primary prevention ICD. To date, the rate at which AMI patients with a reduced LVEF during the index hospitalization undergo subsequent LVEF reassessment to define candidacy for primary prevention ICD in the United States is unknown. Accordingly, we examined data from the longitudinal, observational Translational Research Investigating Underlying disparities in acute Myocardial infarction Patients Health Status (TRIUMPH) Study to describe the incidence of LVEF reassessment in AMI patients with LVEF <40%, and to characterize sociodemographic and clinical factors associated with failure to reassess LVEF among potential ICD candidates in routine practice.

Methods

Patient Population

TRIUMPH enrolled 4,340 patients from 24 US hospitals between April 11, 2005 and December 31, 2008. Inclusion criteria for enrollment were age ≥ 18 years and presentation to the hospital <24 hours into an AMI, as evidenced by elevated biomarkers (creatinine kinase-MB fraction or troponin) and either prolonged ischemic signs/symptoms or ST-segment changes on electrocardiogram. Patients with elevated biomarkers after elective coronary revascularization were excluded from enrollment. Detailed baseline chart abstraction documenting each patient's medical history and inpatient care, including treatments and laboratory results, were obtained by trained data collectors. In addition, patients underwent standardized interviews at baseline and at 1, 6, and 12 months after AMI. The Institutional Review Board at each participating center approved the study, and informed consent was obtained from all participants in the registry.

Of the 4,340 patients in the TRIUMPH database, in-hospital LVEF was $<40\%$ (as demonstrated by echocardiography, nuclear scintigraphy, or ventriculogram) in 810 (18.6%) patients. When multiple LVEF assessments were performed during the index hospitalization, the measurement obtained closest to discharge was captured in the database. Patients were excluded if they had a prior ICD ($n=41$), received an ICD during the index admission ($n=36$), refused an ICD during the index admission ($n=4$), expired prior to discharge ($n=11$), were discharged to hospice ($n=1$), or were lost to follow-up or had incomplete post-discharge survey results precluding determination of LVEF reassessment status ($n=184$), resulting in a final study population of 533 patients.

At standardized 1- and 6-month post-discharge follow-up interviews, patients were asked to report any subsequent cardiac imaging. Patients were asked "Since your hospitalization for your heart problem, have you had any of these outpatient diagnostic tests done?" Queries include echocardiogram (described to the patient as probe like a microphone placed on chest with gel) and stress nuclear imaging (described as dye injected in a vein and patient is put through a machine before and after the heart rate is increased). No clinical record corroboration of imaging was collected. Post-discharge LVEF reassessment was determined by patient report of an echocardiogram or stress test with imaging within the 6 months post-discharge.

Statistical analysis

Baseline characteristics, in-hospital treatments, and laboratory results were compared between patients with and without post-discharge LVEF reassessment. Univariable analyses employed chi-square testing or Fisher's exact test, as appropriate, for ordinal/nominal variables, and Student's t-test for continuous variables. The relatively small sample size constrained the number of variables that could be included in multivariable modeling. As such, a subset of variables was entered into a multivariable analysis which used a modified Poisson model. Typical analyses utilize logistic regression to estimate adjusted odds ratios, which are then generally interpreted as relative risks. However, in this study, the event being modeled (LVEF reassessment at 6 months) was not rare, in which case odds ratios are poor estimates of relative risks. To address this issue, we estimated adjusted relative risks directly using a Poisson regression model with a robust error variance.⁹ Variables were selected for inclusion based on a number of factors, including the published literature (e.g., variables such as gender^{10, 11} and race^{10, 12} have been shown to influence ICD utilization) and statistically-significant results in univariable comparisons. These results are expressed as hazard ratios with 95% confidence intervals.

In addition, we examined LVEF reassessment rates as a function of the site from which the patient was discharged. The extent of site variation was quantified by the median rate ratio, which describes the likelihood that two hypothetically identical patients would have different probabilities for reassessment of their LVEF based on their discharge from two different sites. All tests for significance were two-tailed, using an α of 0.05. All analyses were conducted in SAS version 9.2 (SAS Institute), and imputation was performed using IVEWARE.¹³

Results

In the TRIUMPH study population, 810 patients (18.6%) had an LVEF <40% during their index admission. Among the 533 patients with LVEF <40% during the index AMI hospitalization who met criteria for primary ICD candidacy, LVEF reassessment was reported within the first 6 months post-discharge in 187 patients (35.1%). This was not a consequence of early mortality, which occurred at a rate of 3% by 6 months in this population. Only 7 patients (1.3%) and 13 patients (2.4%) reported that they had received an ICD within 6 months and 1 year after discharge, respectively.

Baseline characteristics and in-hospital treatments between patients with and without LVEF reassessment are shown in Table I. Compared with patients who had LVEF reassessment, patients without LVEF reassessment were more likely to be uninsured (28.4% vs. 14.8%; $p<0.001$) or to be of non-white race (35.8% vs. 20.3%; $p<0.001$). They were less likely to present with an ST-elevation myocardial infarction (45.4% vs. 61.0%; $p<0.001$), or to undergo in-hospital diagnostic cardiac catheterization (91.3% vs. 96.3%; $p=0.033$) or percutaneous coronary intervention (PCI) (55.8% vs. 69.5%; $p=0.002$). While there was a statistically significant difference in mean LVEF between groups, this difference was not clinically substantial ($30.7\% \pm 6.0\%$ vs. $29.1\% \pm 7.1\%$; $p=0.013$). A history of prior heart failure or stroke was more common in patients who did not report LVEF reassessment. Patients who did not report LVEF reassessment also had slightly lower physical function scores (mean SF-12 Physical Component Score 39.3 ± 12.8 vs. 41.8 ± 12.6 , $p=0.035$). There was no significant difference in the predicted 6-month Global Registry of Acute Coronary Events (GRACE) mortality risk score between patients with and without LVEF reassessment. In-hospital rates of ventricular tachycardia or ventricular fibrillation requiring cardioversion or antiarrhythmic therapy were also not significantly different between groups. Of note, patients without LVEF reassessment were more likely to have a cardiologist involved in their medical decision-making during the index hospitalization (71.7% vs. 57.8%; $p=0.001$), although the rate of scheduled follow-up with a cardiologist was similar between groups.

When discharge and follow-up metrics were compared between patients with and without LVEF reassessment by 6 months (Table II), no significant differences in prescription rates of beta-blockers and angiotensin-converting enzyme inhibitor (ACE-I)/angiotensin receptor blocker (ARB) at discharge between groups were observed, although there was a trend towards higher use of these agents in patients who did undergo LVEF assessment. In contrast, diuretic therapy at discharge was more commonly prescribed in patients not reporting LVEF reassessment. Patients not reporting LVEF reassessment were less likely to be seen in follow-up by a cardiologist within the first month post-discharge, however by 6 months post-AMI, 90% of patients in both groups had seen a cardiologist in follow-up. At 6 months post-AMI, the rate of all cause re-hospitalization was lower in patients without LVEF reassessment.

Rates of LVEF reassessment varied widely across sites (Figure 1), ranging from 0% at a number of sites to at best 70% at 1 site, which had only 10 patients. Of the 24 sites, only 5

had LVEF assessment rates exceeding 50%. After adjusting for patient characteristics, the median rate ratio across sites was 1.19, suggesting minimal difference between two randomly selected sites in the likelihood to perform LVEF reassessment for a given patient.

In multivariable modeling (Figure 2), lack of insurance was an independent factor associated with lower likelihood of LVEF reassessment. Moreover, involvement of a cardiologist as a driver of medical decision-making during the index AMI hospitalization was associated with significantly lower likelihood of LVEF reassessment. In contrast, patients who saw a cardiologist in the first month post-discharge were associated with a higher likelihood of LVEF reassessment. Trends that were observed but did not meet statistical significance included the observation that women and non-white race may be associated with lower likelihood of LVEF reassessment, while STEMI presentation and discharge beta blocker and ACE-I/ARB prescription may be associated with greater likelihood of LVEF reassessment.

Discussion

Our study showed that only one third of patients with LVEF <40% during the index MI hospitalization reported LVEF reassessment in the first 6 months post-AMI. Not surprisingly, given the low rate of LVEF reassessment, very low rates of ICD implantation were observed by 1 year post-AMI. Although lack of insurance was a significant factor associated with failure to reassess LVEF, early follow-up with a cardiologist after discharge increased the likelihood of LVEF reassessment. These results suggest an important gap in the transition of care for patients who may benefit from primary prevention ICD implantation.

Primary prevention ICD implantation presents a unique challenge to the care transition process for AMI patients as it should not be performed for a set interval after infarction and/or revascularization² despite known arrhythmic risk in the early post-AMI period.¹⁴ Given the absence of mortality benefit with early ICD therapy after AMI^{5, 6} and the possibility of LVEF improvement in the first several weeks post-MI,⁴ current ACC/AHA/HRS guidelines provide a Class I recommendation for ICD therapy in patients who are at least 40 days post-AMI.² Thus, consideration of primary prevention ICD therapy is typically a downstream decision, rendering it susceptible to errors of omission. Understanding the points of vulnerability in the transition of care for patients who may benefit from ICD implantation is critical to ensure appropriate management.

In this light, the observation that cardiologist driving medical decision-making during the index admission was associated with lower rates of LVEF reassessment in our study stands in contrast to prior work,¹⁵ as well as to our *a priori* expectations. Patients with a longstanding low LVEF with low expectation of recovery after revascularization, or patients with known low LVEF who had previously declined a primary prevention ICD may be associated with lower likelihood of and need for LVEF reassessment. However, prior heart failure was a small proportion (<20%) of patients who did not receive LVEF reassessment. This discrepancy may reflect confusion regarding who would initiate the referral, a communication gap between the inpatient and outpatient care teams, or an implicit (erroneous) trust that the inpatient cardiologist had arranged any necessary testing, resulting in lower LVEF reassessment rates.

Importantly, early cardiology follow-up within 1 month of discharge was associated with higher rates of LVEF reassessment, echoing previous studies showing early cardiology follow-up after AMI or heart failure admission to be associated with better outcomes.^{16, 17} Castellanos et al found that 45% of family medicine practitioners and 28% of internists managing patients with low LVEF had never referred a patient for a primary prevention

ICD.¹⁸ These observations suggest a knowledge gap regarding primary prevention ICDs. As such, the low rates of outpatient LVEF reassessment and primary prevention ICD implantation among eligible candidates may be a challenge in care transition resolvable with close cardiologist follow-up.

Hospital variation in primary prevention ICD implantation rates has been described previously.¹⁹ Our study found low rates of LVEF reassessment across all participating sites. While this suggests a near-universal deficit in referral patterns, patient-level factors did appear to influence practice patterns. In particular, the lack of health insurance was a significant factor associated with lower likelihood of LVEF reassessment, echoing previous literature examining predictors of ICD underutilization.¹⁵ The nonsignificant trend in this study towards lower LVEF reassessment in female and non-white patients parallels previously reported disparities in ICD utilization.^{11, 12, 20-22} Patient refusal of ICD therapy, an exclusion criteria in the present analysis, may also be a contributing factor to lack of LVEF reassessment in community practice.²³

Early and routine identification of potential ICD recipients could facilitate timely and appropriate implantation to reduce arrhythmic deaths in this population, yet underutilization of primary prevention ICD therapy among eligible patients remains a significant challenge.^{10, 11, 24} In the Get with the Guidelines-Heart Failure Registry, only 20% of eligible patients underwent primary prevention ICD implantation,²⁴ and a 16% referral rate was demonstrated in a recent Canadian registry report.²⁵ In the PreSCD II Registry, only 14% of post-MI patients with LVEF <40% received ICD therapy after 36 months of follow-up, with an average interval from AMI until implantation of 307 days.⁸ Our findings highlight a critical gap in LVEF reassessment that may explain the low rate of primary prevention ICD implantation after AMI.

In addition to the low rate of LVEF reassessment, suboptimal use of beta blocker and ACE-I/ARBs among eligible patients with reduced LVEF point to the need for targeted quality improvement initiatives to improve the transition of care. Comprehensive decision support tools may help to ensure appropriate medical therapy and ICD consideration in the post-AMI population. Analogous efforts in heart failure patients have significantly improved the utilization of evidence-based therapies.^{23,26} However, the influence of such interventions deployed in the ambulatory setting alone would be dependent upon the patient being scheduled and presenting for the scheduled follow-up. Both pre- and post-discharge decision support is advisable to increase the likelihood of appropriate follow-up and care.

Limitations

While our study suggests several factors associated with LVEF reassessment, a larger population would bolster these observations and provide the statistical power to allow a more inclusive multivariable model. Although the rate of LVEF reassessment in this study is consistent with rates of primary prevention ICD placement post-AMI in previous studies,⁸ our findings should ideally be validated across a wider scope of institutions and practices. The reliance on patient self-report of LVEF reassessment is a second point of concern given the potential for omissions or inaccurate reporting. Another limitation is the failure to capture a precise LVEF in all patients, due to provider preference in reporting LVEF numerically or categorically. Although patients who declined ICDs were excluded, patients with previously low LVEF in whom repeat LVEF assessment would likely not be indicated remained in our study population. Similarly, patients who declined ICDs after discharge could not be excluded, as that information was not captured in the registry. Finally, as our data did not capture LVEF reassessment results, we could not assess the rate of ICD

implantation among patients whose post-discharge LVEF continued to meet primary prevention criteria.

Conclusions

In community practice, almost 2 out of 3 patients with AMI who were potential primary prevention ICD candidates failed to have guideline recommended follow-up LVEF reassessment, and only 2% received an ICD within 1 year. These results highlight a fundamental gap in care quality that may contribute to broad underutilization of primary prevention ICDs in appropriate patients with moderate to severe LV dysfunction. Targeting care transition processes that optimize post-MI cardiology follow-up may be a solution to reduce missed care opportunities and ensure that patients consistently receive appropriate evidence-based care.

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References

1. Buxton AE, Lee KL, Fisher JD, Josephson ME, Prystowsky EN, Hafley G. A Randomized Study of the Prevention of Sudden Death in Patients with Coronary Artery Disease. *N Engl J Med.* 1999; 341(25):1882–1890. [PubMed: 10601507]
2. Writing Committee. 2009 Focused Update Incorporated Into the ACC/AHA 2005 Guidelines for the Diagnosis and Management of Heart Failure in Adults: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: Developed in Collaboration With the International Society for Heart and Lung Transplantation. *Circulation.* 2009; 119(14):e391–479. [PubMed: 19324966]
3. Writing Committee. ACC/AHA 2008 Performance Measures for Adults With ST-Elevation and Non-ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures (Writing Committee to Develop Performance Measures for ST-Elevation and Non-ST-Elevation Myocardial Infarction): Developed in Collaboration With the American Academy of Family Physicians and the American College of Emergency Physicians: Endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation, Society for Cardiovascular Angiography and Interventions, and Society of Hospital Medicine. *Circulation.* 2008; 118(24):2596–2648. [PubMed: 19001027]
4. Solomon SD, Glynn RJ, Greaves S, Ajani U, Rouleau JL, Menapace F, et al. Recovery of Ventricular Function after Myocardial Infarction in the Reperfusion Era: The Healing and Early Afterload Reducing Therapy Study. *Annals of Internal Medicine.* 2001; 134(6):451–458. [PubMed: 11255520]
5. Hohnloser SH, Kuck KH, Dorian P, Roberts RS, Hampton JR, Hatala R, et al. Prophylactic Use of an Implantable Cardioverter-Defibrillator after Acute Myocardial Infarction. *N Engl J Med.* 2004; 351(24):2481–2488. [PubMed: 15590950]
6. Steinbeck G, Andresen D, Seidl K, Brachmann J, Hoffmann E, Wojciechowski D, et al. Defibrillator Implantation Early after Myocardial Infarction. *N Engl J Med.* 2009; 361(15):1427–1436. [PubMed: 19812399]
7. Bigger JT. The Coronary Artery Bypass Graft Patch Trial I. Prophylactic Use of Implanted Cardiac Defibrillators in Patients at High Risk for Ventricular Arrhythmias after Coronary-Artery Bypass Graft Surgery. *N Engl J Med.* 1997; 337(22):1569–1575. [PubMed: 9371853]
8. Voller H, Kamke W, Klein HU, Block M, Reibis R, Treusch S, et al. Clinical practice of defibrillator implantation after myocardial infarction: impact of implant time: results from the PreSCD II registry. *Europace.* 2011; 13(4):499–508. [PubMed: 21123220]

9. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol.* 2004; 159(7):702–6. [PubMed: 15033648]
10. Hernandez AF, Fonarow GC, Liang L, Al-Khatib SM, Curtis LH, LaBresh KA, et al. Sex and Racial Differences in the Use of Implantable Cardioverter-Defibrillators Among Patients Hospitalized With Heart Failure. *JAMA.* 2007; 298(13):1525–1532. [PubMed: 17911497]
11. Curtis LH, Al-Khatib SM, Shea AM, Hammill BG, Hernandez AF, Schulman KA. Sex Differences in the Use of Implantable Cardioverter-Defibrillators for Primary and Secondary Prevention of Sudden Cardiac Death. *JAMA.* 2007; 298(13):1517–1524. [PubMed: 17911496]
12. Thomas KL, Al-Khatib SM, Kelsey RC, Bush H, Brosius L, Velazquez EJ, et al. Racial Disparity in the Utilization of Implantable-Cardioverter Defibrillators Among Patients With Prior Myocardial Infarction and an Ejection Fraction of $\geq 35\%$. *The American Journal of Cardiology.* 2007; 100(6):924–929. [PubMed: 17826371]
13. Raghunathan, T.; Solenberger, P.; Van Hoewyk, J. IVEware: Imputation and Variance Estimation Software - User Guide. University of Michigan; 2002.
14. Solomon SD, Zelenkofske S, McMurray JJV, Finn PV, Velazquez E, Ertl G, et al. Sudden Death in Patients with Myocardial Infarction and Left Ventricular Dysfunction, Heart Failure, or Both. *N Engl J Med.* 2005; 352(25):2581–2588. [PubMed: 15972864]
15. Allen LaPointe NM, Al-Khatib SM, Piccini JP, Atwater BD, Honeycutt E, Thomas K, et al. Extent of and Reasons for Nonuse of Implantable Cardioverter Defibrillator Devices in Clinical Practice Among Eligible Patients With Left Ventricular Systolic Dysfunction. *Circulation: Cardiovascular Quality and Outcomes.* 2011; 4(2):146–151. [PubMed: 21304098]
16. Ho PM, Luther SA, Masoudi FA, Gupta I, Lowy E, Maynard C, et al. Inpatient and follow-up cardiology care and mortality for acute coronary syndrome patients in the Veterans Health Administration. *American Heart Journal.* 2007; 154(3):489–494. [PubMed: 17719295]
17. Hernandez, Af; G, MA.; F, GC., et al. Relationship between early physician follow-up and 30-day readmission among medicare beneficiaries hospitalized for heart failure. *JAMA.* 2010; 303(17): 1716–1722. [PubMed: 20442387]
18. Castellanos JM, Smith LM, Varosy PD, Dehlendorf C, Marcus GM. Referring physicians' discordance with the primary prevention implantable cardioverter-defibrillator guidelines: a national survey. *Heart rhythm.* 2012; 9(6):874–81. [PubMed: 22306794]
19. Matlock DD, Peterson PN, Heidenreich PA, Lucas FL, Malenka DJ, Wang Y, et al. Regional Variation in the Use of Implantable Cardioverter-Defibrillators for Primary Prevention. *Circulation: Cardiovascular Quality and Outcomes.* 2011; 4(1):114–121. [PubMed: 21139094]
20. Staniforth AD, Sporton SC, Robinson NM, Cooper J, Earley MJ, Nathan AW, et al. Is there a sex bias in implantable cardioverter-defibrillator referral and prescription? *Heart.* 2004; 90(8):937–938. [PubMed: 15253975]
21. Daugherty SL, Peterson PN, Wang Y, Curtis JP, Heidenreich PA, Lindenfeld J, et al. Use of implantable cardioverter defibrillators for primary prevention in the community: Do women and men equally meet trial enrollment criteria? *American Heart Journal.* 2009; 158(2):224–229. [PubMed: 19619698]
22. Mehta RH, Liang L, Karve AM, Hernandez AF, Rumsfeld JS, Fonarow GC, et al. Association of Patient Case-Mix Adjustment, Hospital Process Performance Rankings, and Eligibility for Financial Incentives. *JAMA.* 2008; 300(16):1897–1903. [PubMed: 18940976]
23. Gravelin LM, Yuhas J, Remetz M, Radford M, Foley J, Lampert R. Use of a Screening Tool Improves Appropriate Referral to an Electrophysiologist for Implantable Cardioverter-Defibrillators for Primary Prevention of Sudden Cardiac Death. *Circulation: Cardiovascular Quality and Outcomes.* 2011; 4(2):152–156. [PubMed: 21304093]
24. Shah B, Hernandez AF, Liang L, Al-Khatib SM, Yancy CW, Fonarow GC, et al. Hospital Variation and Characteristics of Implantable Cardioverter-Defibrillator Use in Patients With Heart Failure: Data From the GWTG-HF (Get With The Guidelines-Heart Failure) Registry. *Journal of the American College of Cardiology.* 2009; 53(5):416–422. [PubMed: 19179199]
25. Parkash R, Sapp JL, Basta M, Doucette S, Thompson K, Gardner M, et al. Use of Primary Prevention Implantable Cardioverter-Defibrillators in a Population-Based Cohort Is Associated

With a Significant Survival Benefit/Clinical Perspective. *Circulation: Arrhythmia and Electrophysiology*. 2012; 5(4):706–713. [PubMed: 22685111]

26. Fonarow GC, Albert NM, Curtis AB, Stough WG, Gheorghiade M, Heywood JT, et al. Improving Evidence-Based Care for Heart Failure in Outpatient Cardiology Practices: Primary Results of the Registry to Improve the Use of Evidence-Based Heart Failure Therapies in the Outpatient Setting (IMPROVE HF). *Circulation*. 2010; 122(6):585–596. [PubMed: 20660805]

Figure 1.
Variation in LVEF assessment rate across participating sites.

Figure 2. Multivariable analysis of factors associated with LVEF reassessment; hazard ratio and 95% confidence intervals are shown in the right-hand column.

Table I
Comparison of demographic factors, clinical features, and in-hospital characteristics
between patients with and without LVEF reassessment by 6 months

	LVEF Reassessed by 6 months		
	Yes (n=187)	No (n=346)	p-value
Demographics			
Age, years (mean ± standard deviation)	58.6 ± 11.4	58.7 ± 12.9	0.953
Female	26.7%	32.1%	0.200
Non-white race	20.3%	35.8%	< 0.001
Uninsured	14.8%	28.4%	< 0.001
Clinical features			
Prior myocardial infarction	23.0%	28.9%	0.142
Prior PCI	21.9%	23.4%	0.697
Prior coronary artery bypass surgery	12.3%	15.9%	0.262
Prior Heart Failure	10.2%	18.5%	0.011
Cancer	5.9%	5.5%	0.852
Diabetes	29.4%	35.0%	0.193
Atrial Fibrillation	6.4%	3.2%	0.079
Dialysis on Arrival	1.1%	0.9%	1.000
Creatinine clearance, ml/min (mean ± SD)	1.2 ± 1.5	1.2 ± 0.9	0.990
Prior stroke	1.6%	7.2%	0.006
In-hospital characteristics			
STEMI presentation	61.0%	45.4%	< 0.001
Ejection Fraction	30.7 ± 6.0	29.1 ± 7.1	0.013
In-Hospital Cardiac Catheterization	96.3%	91.3%	0.033
In-Hospital PCI	69.5%	55.8%	0.002
In-Hospital coronary artery bypass	10.2%	13.6%	0.252
In-hospital pacemaker	4.3%	7.2%	0.178
In-Hospital Pulmonary Edema	4.8%	5.8%	0.638
In-Hospital Heart Failure	13.9%	12.1%	0.560
In-Hospital ventricular arrhythmia	10.2%	7.5%	0.294
GRACE 6 month mortality risk score	100.6 ± 28.1	105.4 ± 30.2	0.083
PHQ-9 Depression Score	5.0 ± 4.7	5.8 ± 5.8	0.127
SF-12 Physical Component Score	41.8 ± 12.6	39.3 ± 12.8	0.035
Cardiologist driving inpatient decision-making	57.8%	71.7%	0.001

LVEF (left ventricular ejection fraction), STEMI (ST-elevation myocardial infarction), PCI (percutaneous coronary intervention), GRACE (Global Registry of Acute Coronary Events)

Table II
Comparison of discharge medications, post-discharge follow-up, and outcomes rates
between patients with and without LVEF reassessment by 6 months

	LVEF Reassessed by 6 months		
	Yes (n=187)	No (n=346)	p-value
Discharge Medications			
Beta Blocker prescribed	94.7%	90.2%	0.073
ACE-I/ARB prescribed	82.9%	78.9%	0.270
Beta Blocker and ACE-I/ARB prescribed	79.1%	71.4%	0.051
Diuretic at discharge	37.4%	46.8%	0.037
Post-Discharge Follow-up			
Follow-up Scheduled with Cardiologist	85.6%	82.4%	0.344
Seen by cardiologist by 1month	58.6%	44.9%	0.006
Seen by cardiologist by 6 month	92.3%	88.1%	0.148
PHQ-9 Depression Score at 1month	4.3 ± 4.5	4.6 ± 4.9	0.641
SF-12 Physical Component Score at 1month	39.3 ± 11.7	36.8 ± 12.3	0.046
Outcomes			
Overall rehospitalization by 6 months	35.3%	20.5%	< 0.001
Rehospitalized for cardiovascular reason	16.6%	10.7%	0.052
Rehospitalized for heart failure	4.8%	5.8%	0.638
Revascularization by 6 months	8.6%	3.8%	0.02
Mortality			
30 day	0.0%	0.0%	
3 month	0.5%	1.4%	0.670
6 month	1.1%	4.0%	0.055
1 year	3.7%	6.9%	0.133

ACE-I (angiotensin-converting enzyme inhibitor), ARB (angiotensin receptor blocker)