ORIGINAL RESEARCH

Multivessel Versus Culprit Vessel–Only Percutaneous Coronary Intervention Among Patients With Acute Myocardial Infarction: Insights From the TRANSLATE-ACS Observational Study

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Background—Among patients with acute myocardial infarction (MI) who have multivessel disease, it is unclear if multivessel percutaneous coronary intervention (PCI) improves clinical and quality-of-life outcomes compared with culprit-only intervention. We sought to compare clinical and quality-of-life outcomes between multivessel and culprit-only PCI.

Methods and Results—Among 6061 patients with acute MI who have multivessel disease in the TRANSLATE-ACS (Treatment With Adenosine Diphosphate Receptor Inhibitors: Longitudinal Assessment of Treatment Patterns and Events After Acute Coronary Syndrome) study, we used inverse probability-weighted propensity adjustment to study the associations between multivessel and culprit-only intervention during the index PCI and major adverse cardiovascular events, unplanned all-cause readmission, and angina frequency at 6 weeks and 1 year. Multivessel PCI was performed in 1208 (20%) of patients with MI who had multivessel disease. Relative to the culprit-only intervention, patients receiving multivessel PCI were similarly aged and more likely to be seen with non–ST-segment elevation MI or cardiogenic shock. At 6 weeks, the initial multivessel PCI strategy was associated with lower major adverse cardiovascular events and unplanned readmission risks, whereas angina frequency was not significantly different between multivessel and culprit-only PCI. At 1 year, major adverse cardiovascular event risk was persistently lower in the multivessel PCI group (adjusted hazard ratio, 0.84; 95% confidence interval, 0.72–0.99), whereas long-term readmission risk (adjusted hazard ratio, 0.94; 95% confidence interval, 0.84–1.04) and angina frequency were similar between groups (adjusted odds ratio, 1.01; 95% confidence interval, 0.82–1.24). Similar associations were seen when patients with ST-segment elevation MI and non–ST-segment elevation MI were examined separately.

Conclusions—Among patients with acute MI who have multivessel disease, multivessel PCI was associated with lower risk of all-cause readmission at 6 weeks and lower risk of major adverse cardiovascular events at 6 weeks and 1 year. However, similar short- and long-term angina frequencies were noted. **(*J Am Heart Assoc*. 2017;6:e006343. DOI: 10.1161/JAHA.117.006343.)**

Key Words: culprit artery • multivessel coronary artery disease • multivessel percutaneous coronary intervention • quality of life

Multivessel coronary artery disease is present among 40% of patients who are seen with ST-segment elevation myocardial infarction (STEMI)[1,2] and up to 70% of those who are seen with non–ST-segment elevation myocardial infarction (NSTEMI).[3–6] Patients with multivessel disease tend to have worse outcomes than those with single-vessel disease,[7] but it remains controversial whether revascularization of only the infarct-related culprit lesion or more complete revascularization during the index procedure leads to better clinical outcomes. Among patients seen with STEMI, current

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Accompanying Table S1 and Figure S1 are available at http://jaha.ahajournals.org/content/6/10/e006343/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- Prior observational studies and small randomized studies demonstrated reduced major adverse cardiovascular events, including cardiac death, myocardial infarction, and recurrent angina, as well as repeated revascularization, with multivessel percutaneous coronary intervention among patients seen with ST-segment elevation myocardial infarction and multivessel disease.
- However, these studies did not evaluate patients' quality of life after discharge, nor did they evaluate patients seen with non–ST-segment elevation myocardial infarction.

What Are the Clinical Implications?

- We have shown that among patients seen with acute myocardial infarction and multivessel disease, performing multivessel percutaneous coronary intervention is associated with lower risk of unplanned readmissions in the short-term after discharge, but similar angina and quality-of-life scores.

guidelines recommend culprit-only percutaneous coronary intervention (PCI)[8,9] based on earlier studies that suggested that multivessel PCI may cause harm in this setting.[10–12] Nevertheless, recent randomized trials have demonstrated that for patients with STEMI, there is clinical benefit to performing multivessel PCI during the index procedure.[13–15] Among patients seen with NSTEMI and multivessel coronary artery disease, there appears to be no clear clinical benefit of multivessel PCI compared with culprit-only PCI.[16] The lack of definitive treatment guidelines for patients with multivessel disease has led to wide variability in practice with regard to performing multivessel versus culprit-only PCI in the setting of an acute myocardial infarction (MI).[17] Although previous studies have compared major adverse clinical outcomes between revascularization strategies, there have been no studies comparing the risk of readmission and quality-of-life outcomes between these strategies.

The TRANSLATE-ACS (Treatment With Adenosine Diphosphate Receptor Inhibitors: Longitudinal Assessment of Treatment Patterns and Events After Acute Coronary Syndrome) study is a large observational study of patients with STEMI and NSTEMI treated with PCI across >200 hospitals in the United States.[18,19] TRANSLATE-ACS is unique in that the data source captures adjudicated downstream clinical events and patient-reported outcomes. As a result, TRANSLATE-ACS data allowed us to evaluate the contemporary use of multivessel PCI in routine clinical practice and to compare clinical and quality-of-life outcomes between multivessel and culprit-only PCI strategies among patients seen with acute MI and multivessel coronary artery disease.

Methods

Study Population

Details about the TRANSLATE-ACS study have been described previously.[18,19] Briefly, TRANSLATE-ACS enrolled 12 365 patients who were seen with either STEMI or NSTEMI and were treated with PCI at 233 US hospitals between April 2010 and October 2012. No treatment intervention was directed by protocol in this observational study; therefore, all treatment decisions were made by the treating physician. Institutional review board approval was obtained at all of the participating sites, and all patients provided informed consent for baseline and follow-up assessments. For this analysis, we excluded patients who had single-vessel disease on coronary angiography (n=6290) and those with missing data for multivessel versus culprit-only PCI status (n=14).

Outcomes

The clinical outcomes that were collected included major adverse cardiovascular events (MACEs; including all-cause death, MI, stroke, or unplanned revascularization) and all-cause unplanned rehospitalization at 6 weeks and 1 year. Study physicians independently reviewed medical records to adjudicate all MACEs per study protocol definitions. Rehospitalizations were validated by the collection of medical bills or medical records if bills could not be obtained. Unplanned rehospitalizations excluded any subsequent rehospitalizations that involved a planned or staged coronary revascularization procedure. For quality-of-life outcomes, all patients were contacted by telephone by a trained interviewer at the Duke Clinical Research Institute (Durham, NC) at 6 weeks and 1 year after discharge. In the follow-up interviews, patients were asked the angina frequency questions from the Seattle Angina Questionnaire.[20] The responses were scored from 0 to 100, with higher values indicating less frequent angina; scores from 0 to 60 denote daily/weekly angina, scores from 70 to 90 denote monthly angina, and a score of 100 denotes no angina. The European Quality of Life-5 Dimensions (EQ-5D) instrument was also administered as a generic health status instrument to estimate health utilities based on US weights.[21] Finally, the EQ-5D visual analogue scale score was also recorded for each patient.

Statistical Analysis

We stratified patients with acute MI and multivessel disease into those treated with multivessel PCI versus those treated with culprit-only PCI during the index procedure. To limit the influence of survival bias, patients who underwent staged PCI during the index hospitalization were included with the culprit-only PCI group. Staged PCI was defined as PCI performed

without new symptoms indicating ischemia after the index hospitalization. We compared baseline clinical characteristics between the 2 categories. Categorical variables are given as frequencies (percentages), and differences between treatment groups were assessed using the χ^2 test. Continuous variables are given as medians and first and third quartiles (Q1 and Q3, respectively) and were compared using the Wilcoxon rank-sum test.

For outcomes comparisons, we used the inverse probability-weighting (IPW) approach for multivariable adjustment. To estimate propensity scores for multivessel versus culprit-only PCI, we fitted a logistic regression model for multivessel versus culprit-only PCI. The following variables were selected on the basis of biological plausibility and included in the propensity model: age, sex, race, insurance status, prior MI, prior PCI, prior coronary artery bypass graft surgery, prior stroke/transient ischemic attack, history of peripheral arterial disease, diabetes mellitus, STEMI versus NSTEMI presentation, transfer-in status, cardiogenic shock on presentation, heart failure within 2 weeks, body mass index, admission systolic blood pressure, preprocedure hemoglobin, creatinine, dialysis, ejection fraction, culprit lesion location, 2- versus 3-vessel disease, culprit lesion at bifurcation, culprit lesion preprocedure thrombolysis in MI flow of 0, culprit lesion in-stent restenosis, culprit lesion in-stent thrombosis, and culprit lesion in graft. We also included all possible interactions with STEMI in the propensity model to estimate propensity separately by STEMI. The pre- and post-IPW balance of the covariates between multivessel and culprit-only PCI groups was assessed using standardized differences. After IPW adjustment, all of the variables had an absolute value of the standardized differences of <0.10, which indicates good balance. Figure SI shows the distribution of propensity scores for multivessel versus culprit-only PCI groups.

For comparisons of clinical outcomes, we plotted unadjusted Kaplan-Meier cumulative incidence curves for MACEs and all-cause unplanned readmission. By 1 year after discharge, 371 (3.1%) of patients in TRANSLATE-ACS were unavailable for follow-up. We used Cox proportional hazards modeling with robust SEs to assess risk of MACEs within 6 weeks and 1 year of index PCI procedure and unplanned readmission within 6 weeks and 1 year of the index hospitalization discharge using IPW risk adjustment. In addition, we evaluated differences in the association of multivessel versus culprit-only PCI with outcomes when stratified by STEMI versus NSTEMI. We tested for interaction of multivessel PCI by STEMI in a Cox proportional hazards model. We developed propensity scores for multivessel PCI separately among patients with STEMI and NSTEMI and assessed the association of multivessel PCI with MACEs and readmission risk separately in each of these populations. A secondary composite end point was analyzed that included death, recurrent MI, and stroke only, and excluded the end point of unplanned revascularization. For the outcome of angina frequency, we treated the outcome as ordinal and tested the proportional odds assumption. We failed to reject the proportional odds assumption (P=0.7245) and concluded that it is reasonable to fit a proportional odds model for the angina frequency score. For EQ-5D–derived utilities, we also included baseline EQ-5D score with US weights in the IPW-adjusted model. For the quality-of-life analyses, we excluded 743 (12.3%) and 1225 (20.2%) of patients who either died or had missing follow-up data at 6 weeks and 1 year, respectively. We used SAS version 9.4 for all statistical analysis.

Results

Baseline Characteristics

Among the 6061 patients with MI who had multivessel disease, 1208 (20%) underwent multivessel PCI and 4853 (80%) received culprit-only PCI. Among patients seen with STEMI, 385 of 2940 (13.1%) underwent multivessel PCI, compared with 823 of 3110 (26.5%) seen with NSTEMI who underwent multivessel PCI. Patients undergoing multivessel PCI were more likely to be women (29% versus 24%), have diabetes mellitus (34% versus 31%), be transferred in from another hospital (44% versus 38%), and have cardiogenic shock (3.3% versus 2.0%), and were less likely to have STEMI (32% versus 53%; $P<0.05$ for all) compared with the culprit-only PCI group (Table 1). There were no significant differences in age, race, insurance status, prior MI, and prior PCI between groups. Those undergoing multivessel PCI were more likely to have a culprit lesion located in the left coronary system compared with the culprit-only PCI group. Among patients undergoing multivessel PCI, the most common nonculprit lesion location was in the circumflex coronary artery territory (41%), followed by the left anterior descending territory (31%) and the right circumflex artery territory (26%). Patients undergoing multivessel PCI were less likely to achieve complete procedural success compared with patients undergoing culprit-only PCI (81.9% versus 93.6%; Table 1). Of the 182 patients (15.1%) with partial procedural success in the multivessel PCI group, 50% were procedures that attempted to dilate 3 or more (up to 6) lesions.

Clinical Outcomes at 6 Weeks and 1 Year

Staged revascularization without new symptoms occurred in 0.3% within 7 days and 6.6% within 60 days after the index PCI procedure. Table 2 displays the cumulative incidence and adjusted hazard ratio (HR) for each clinical outcome. Rates of MACEs at 6 weeks were lower among patients who underwent multivessel versus culprit-only PCI (unadjusted, 6.6%

Table 1. Baseline, Clinical, and Procedural Characteristics of Patients Undergoing Multivessel Versus Culprit Vessel–Only PCI

Characteristics	Multivessel PCI Group (n=1208)	Culprit-Only PCI Group (n=4853)	*P* Value
Demographics			
Age*, y	61.0 (53–70)	61.5 (54–69)	0.79
Female sex	29.06	24.29	0.001
White race	88.66	88.85	0.75
No health insurance	13.99	12.30	0.11
Baseline EQ-5D score with US weights*	0.84 (0.78–1.00)	0.84 (0.80–1.00)	0.02
Medical history			
Prior MI	24.09	24.64	0.69
Prior PCI	26.49	26.15	0.80
Prior CABG	14.82	17.62	0.02
Prior stroke or TIA	6.71	7.11	0.62
Peripheral arterial disease	8.69	8.39	0.74
Prior heart failure	8.61	8.12	0.58
Diabetes mellitus	34.02	30.83	0.03
Hypertension	73.59	72.84	0.62
Dyslipidemia	71.52	70.41	0.46
Current/recent smoker	33.28	36.00	0.07
Chronic lung disease	10.02	10.76	0.45
Clinical presentation			
Transfer from another hospital	44.29	37.91	<0.0001
STEMI	31.87	52.77	<0.0001
Cardiac arrest on presentation	2.32	2.93	0.25
Cardiogenic shock on presentation	3.31	1.96	0.004
Heart failure within prior 2 wks	10.02	7.85	0.01
BMI, kg/m^2*	29.2 (25.9–33.2)	29.3 (25.9–33.3)	0.55
Heart rate, beats/min*	78 (66–90)	76 (65–89)	0.01
Systolic BP, mm Hg*	140 (123–160)	140 (122–160)	0.65
LVEF ≤40	22.43	21.63	0.57
Procedural characteristics			
Radial artery access	9.69	10.80	0.28
Left main >50% stenosis	11.12	4.96	<0.0001
3-Vessel disease	37.42	35.50	0.22
Main coronary artery of culprit lesion			
Left main	7.95	0.00	<0.0001
Left anterior descending artery	33.44	30.08	
Circumflex artery	28.15	26.54	
Right coronary artery	30.46	42.80	
Culprit lesion previously treated	7.12	8.51	0.11
DES used	82.37	69.26	<0.0001

Continued

Table 1. Continued

Characteristics	Multivessel PCI Group (n=1208)	Culprit-Only PCI Group (n=4853)	*P* Value
Procedure success[†]			<0.0001
No	3.06	4.02	
Partially successful	15.07[‡]	2.41	
Successful	81.87	93.57	

BMI indicates body mass index; BP, blood pressure; CABG, coronary artery bypass grafting; DES, drug-eluting stent; EQ-5D, European Quality of Life-5 Dimensions; LVEF, left ventricular ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; TIA, transient ischemic attack.
*Continuous variables given as median (25th–75th percentile). Categorical variables are given as percentages.
[†]Procedure success was defined as the number of lesions attempted to dilate being equal to the number of lesions successfully dilated. (A procedure was successful if the number of lesions attempted to dilate was equal to the number of lesions successfully dilated. A procedure was partially successful if more lesions were attempted to dilate than successfully dilated and at least 1 lesion was successfully dilated. Otherwise, the procedure was considered not successful.)
[‡]Of these procedures, 50% attempted to dilate 3 or more (up to 6) lesions.

versus 8.9% [*P*=0.01]; adjusted HR, 0.67 [95% confidence interval (CI), 0.51–0.88]; Figure 1). Similarly, 1-year MACE risk was lower in the multivessel PCI group (adjusted HR, 0.84; 95% CI, 0.72–0.99; Figure 2). The difference in clinical outcomes was driven by significantly lower risk of unplanned revascularization at both 6 weeks (adjusted HR, 0.48; 95% CI, 0.34–0.68) and 1 year (adjusted HR, 0.73; 95% CI, 0.59–0.89). Unstable angina and NSTEMI accounted for most unplanned revascularization indications for both study groups (Table 3). Except for calcium channel blocker use at 6 weeks, all antianginal medication use was well balanced between the 2 groups at 6 weeks and 1 year (Table 3).

Unplanned all-cause rehospitalization risk at 6 weeks, which excluded readmissions for planned staged revascularizations, was lower among patients who received multivessel PCI (unadjusted HR, 14.09% versus 17.11% [*P*=0.02]; adjusted HR, 0.81 [95% CI, 0.66–0.99]) compared with the culprit-only PCI group (Figure 3A). Nevertheless, at 1 year, the risk for all-cause readmission was similar between the 2 groups (adjusted HR, 0.93; 95% CI, 0.83–1.04; Figure 3B).

When analyses were stratified by STEMI versus NSTEMI presentation, we observed a lower hazard of 6-week MACEs associated with multivessel PCI compared with culprit-only PCI among patients with STEMI; a similar relationship, albeit

Table 2. Unadjusted and Adjusted Clinical Outcomes at 6 Weeks and 1 Year

Clinical Outcomes	Unadjusted Cumulative Incidence, %		Adjusted HR	(95% CI)	*P* Value*
	Multivessel PCI	Culprit-Only PCI			
At 6 wks					
MACE	6.58	8.92	0.67	(0.51–0.88)	0.004
Unplanned revascularization	4.01	7.23	0.48	(0.34–0.68)	0.0001
MI	2.59	2.14	[†]		
Stroke	0.50	0.49	[†]		
All-cause death	1.17	0.76	[†]		
Unplanned readmission	14.09	17.11	0.81	(0.66–0.99)	0.03
At 1 y					
MACE	20.49	22.15	0.84	(0.72–0.99)	0.04
Unplanned revascularization	12.83	17.21	0.73	(0.59–0.89)	0.002
MI	6.78	6.53	[†]		
Stroke	1.46	0.99	[†]		
All-cause death	5.77	3.75	[†]		
Unplanned readmission	40.79	42.04	0.93	(0.83–1.04)	0.22

HR indicates hazard ratio; MACE, major adverse clinical event; MI, myocardial infarction; PCI, percutaneous coronary intervention.
**P* value is for adjusted HR.
[†]Adjusted HR (95% CI) values for the composite end points of MI, stroke, and all-cause death were 1.16 (0.81–1.67) and 1.08 (0.87–1.34) at 6 weeks and 1 year, respectively.

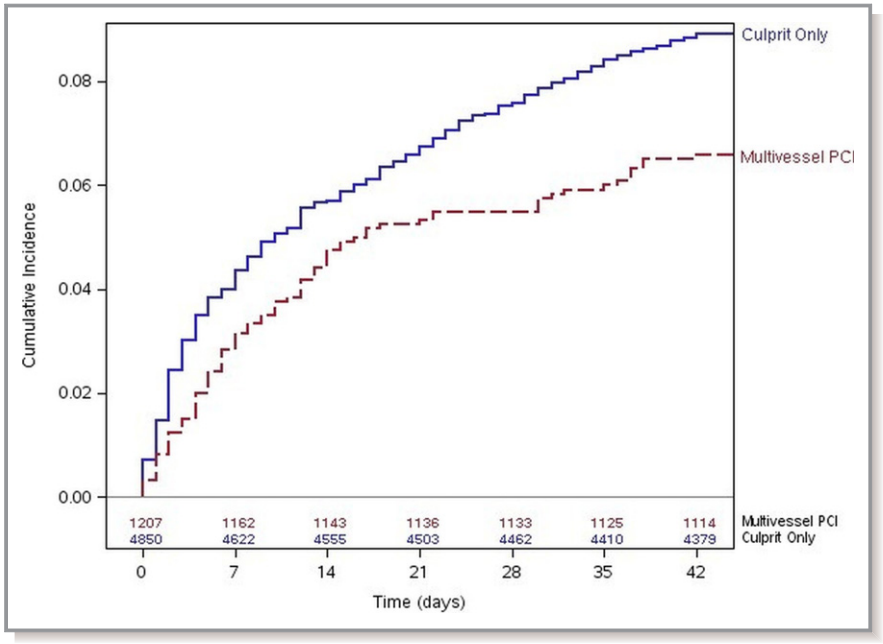

Figure 1. Cumulative incidence of major adverse cardiovascular events (MACEs) within 6 weeks of index percutaneous coronary intervention (PCI). HR indicates hazard ratio.

non-statistically significant, was seen among patients with NSTEMI, and the interaction *P* value was not significant at 0.20 (Table SI). Readmission risk at 1 year was not significantly different between multivessel and culprit-only PCI, regardless of STEMI (adjusted HR, 0.91; 95% CI, 0.75–1.11) versus NSTEMI (adjusted HR, 0.95; 95% CI, 0.83–1.08; interaction *P*=0.73).

Quality-of-Life Outcomes at 6 Weeks and 1 Year

Scores for the Seattle Angina Questionnaire angina frequency scale, as well as the EQ-5D visual analogue scale, values are shown in Table 4. There were no significant differences in the Seattle Angina Questionnaire angina frequency score between the multivessel PCI and culprit-only PCI groups at 6 weeks,

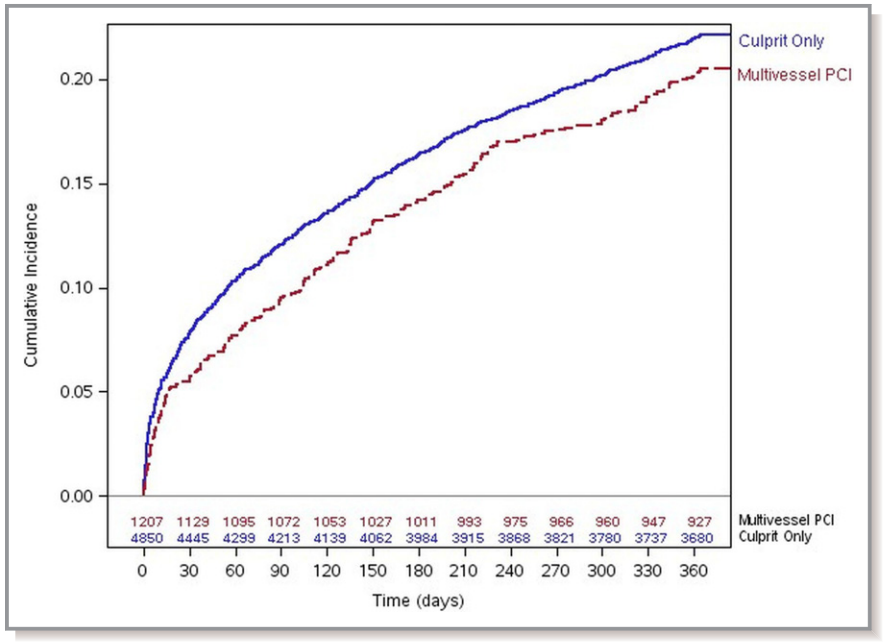

Figure 2. Cumulative incidence of major adverse cardiovascular events (MACEs) within 1 year of index percutaneous coronary intervention (PCI). HR indicates hazard ratio.

Table 3. Reasons for Unplanned Revascularization and Antianginal Medication Use

Variable	Multivessel PCI Group	Culprit-Only PCI Group	*P* Value
Reason for revascularization at follow-up			0.27
STEMI	13 (9)	57 (7)	
NSTEMI	31 (22)	159 (21)	
Unstable angina	68 (49)	327 (43)	
Stable angina	17 (12)	117 (15)	
Other	10 (6)	101 (14)	
Antianginal medications			
At 6 wks			
β Blockers	1012 (83)	4117 (84)	0.36
CCB	161 (13)	522 (11)	0.01
Nitrates	113 (9)	434 (9)	0.66
Ranolazine	11 (0.9)	64 (1)	0.25
At 1 y			
β Blockers	835 (69)	3468 (71)	0.11
CCB	143 (12)	516 (11)	0.20
Nitrates	107 (9)	413 (9)	0.70
Ranolazine	17 (1)	74 (2)	0.76
Any CCB, β blocker, nitrate, or ranolazine through 1 y	1103 (91)	4411 (91)	0.65

Data are given as number (percentage). CCB indicates calcium channel blocker; NSTEMI, non–ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

with an unadjusted proportional odds ratio (OR) of 0.91 (95% CI, 0.78–1.06) and an IPW-adjusted proportional OR of 0.91 (95% CI, 0.76–1.10). At 1 year, angina frequency rates were also similar in the 2 groups, with unadjusted reported angina rates of 78% versus 80% no angina, 18% versus 16% monthly, and 5% versus 5% daily/weekly for multivessel PCI versus culprit-only PCI, respectively (*P*=0.33), yielding an IPW-adjusted proportional OR of 1.01 (95% CI, 0.82–1.24). EQ-5D scores were also similar in both the multivessel and culprit-only PCI groups at 6 weeks, with a median EQ-5D score (with US weights) of 0.84 (Q1–Q3, 0.78–1.00), and at 1 year, with a median EQ-5D score of 0.84 (Q1–Q3, 0.80–1.00). The IPW-adjusted linear regression estimate was 0.0104 (*P*=0.16) at 6 weeks and −0.0041 (*P*=0.58) at 1 year. Furthermore, EQ-5D visual analogue scale scores were similar in both groups at 6 weeks, with a median EQ-5D score of 75 (Q1–Q3, 60–85), and at 1 year, with a median EQ-5D score of 75 (Q1–Q3, 65–88). When patients with STEMI or NSTEMI were analyzed separately, there was no significant difference in angina frequency at 1 year between multivessel and culprit-only PCI strategies (adjusted OR, 1.05 [95% CI, 0.74–1.49] for patients with STEMI; adjusted OR, 0.98 [95% CI, 0.79–1.20] for patients with NSTEMI).

Discussion

Our study examined the association between revascularization strategy (multivessel versus culprit-only PCI) and clinical outcomes, as well as quality of life, in patients with acute MI. Several key findings can be ascertained from the results. In this contemporary study, 26% of patients with NSTEMI and 13% of patients with STEMI underwent multivessel PCI during the index procedure. Consistent with recent randomized trials, multivessel PCI was associated with a lower risk of short- and long-term MACEs, which was largely driven by a lower risk of symptom-driven unplanned coronary revascularization. Our study also showed multivessel PCI to be associated with a lower risk of unplanned rehospitalizations within 6 weeks of hospital discharge compared with culprit-only PCI. Nonetheless, there were no significant differences in short- or long-term angina frequency and quality of life between patients treated with multivessel versus culprit-only PCI.

The rate of multivessel PCI in this all-age patient population is concordant with recently published data from the National Cardiovascular Data Registry,[22] showing that 1 in 10 patients with STEMI and 1 in 4 patients with NSTEMI with multivessel disease received multivessel PCI.[22] The higher rate of multivessel PCI in patients with NSTEMI may be because of the perceived harm of multivessel PCI in patients with STEMI during the study period (2010–2012). Recent randomized trials showed a reduction in unplanned revascularization and adverse cardiovascular events, including death from cardiac causes, nonfatal MI, and refractory angina, with a multivessel PCI strategy during the index event among patients seen with STEMI. In the PRAMI (Preventative Angioplasty in Acute Myocardial Infarction)[14] study, patients who underwent multivessel PCI had lower rates of MACEs (HR, 0.35; 95% CI, 0.21–0.58). Although not included as a primary outcome, the hazard for repeated revascularization was lower in the multivessel PCI group, as well (HR, 0.30; 95% CI, 0.17–0.56).[14] Similarly, the CvLPRIT (Complete Versus Lesion-Only Primary PCI) trial investigators showed that patients with STEMI who underwent multivessel PCI had a significant reduction in MACE rates (composite of all-cause mortality, recurrent MI, heart failure, and ischemic-driven revascularization by PCI/coronary artery bypass graft surgery, 10% versus 21%; *P*=0.009).[13] The DANAMI3-PRIMULTI (Third Danish Study of Optimal Acute Treatment of Patients With ST-Segment Elevation Myocardial Infarction Primary PCI in Multivessel Disease) showed that fractional flow reserve-guided complete revascularization strategy during the index procedure in patients with STEMI resulted in lower risk for unplanned revascularization (HR, 0.31; 95% CI, 0.18–0.53;

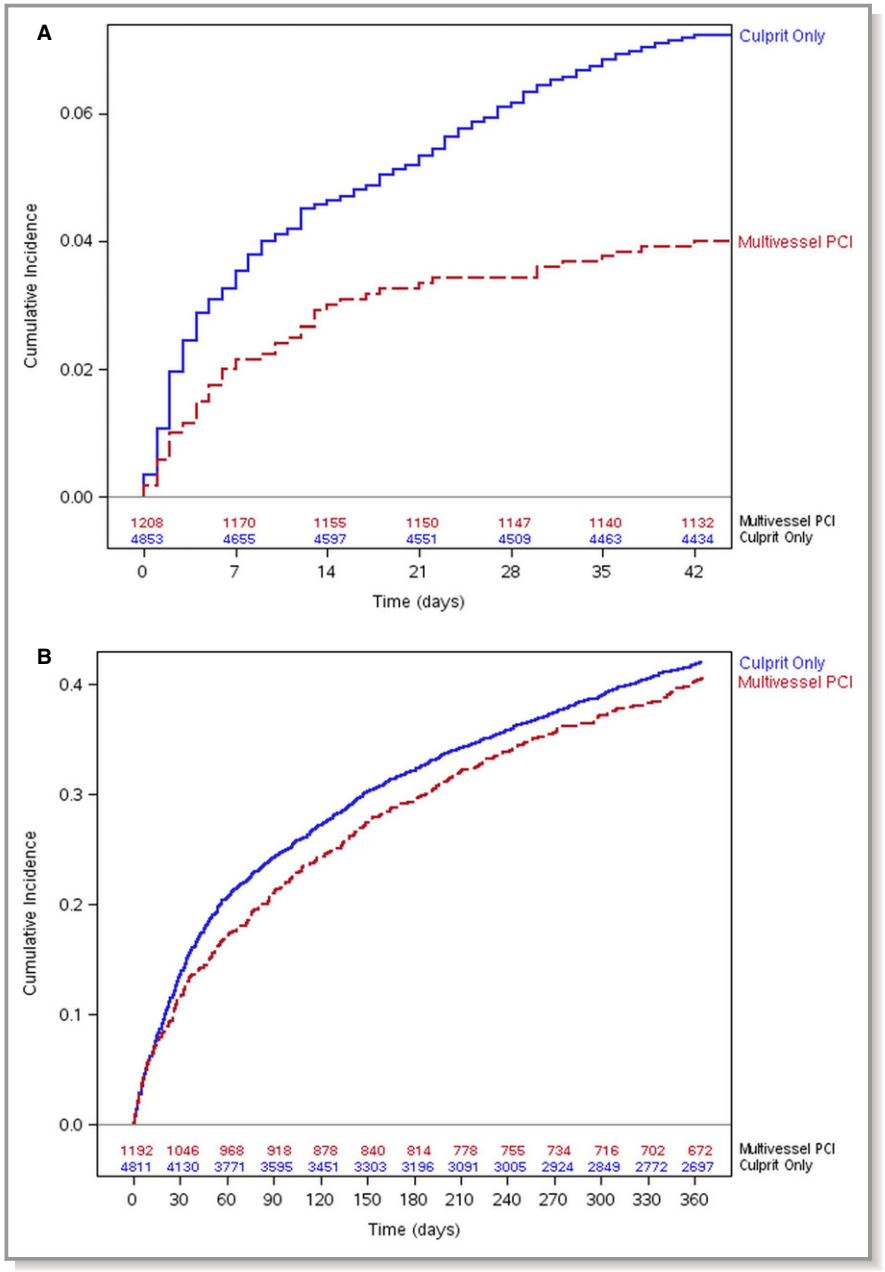

Figure 3. Unplanned readmissions. Cumulative incidence of unplanned readmissions at 6 weeks (A) and 1 year (B) after discharge. HR indicates hazard ratio; PCI, percutaneous coronary intervention.

$P<0.001$). These randomized clinical trials have been criticized for their small sample sizes and event rates.[13–15] Prior observational studies have reported conflicting results, with some showing better/similar[4,11,23] or worse[2,22] outcomes with multivessel PCI. Our study demonstrated lower composite risk of death, MI, stroke, or unplanned revascularization associated with multivessel PCI compared with culprit-only PCI. The improvement in outcomes was driven by unplanned revascularization. Some physicians who perform culprit-only PCI in patients with multivessel disease may plan for patients to return soon after the index hospital discharge for staged revascularizations even when the patients are asymptomatic; other physicians may not intend to further revascularize unless symptoms of ischemia persist or recur. Although we did not detect any difference in hard end points (death, MI, and stroke), most unplanned revascularizations were performed for acute coronary syndrome indications (STEMI, NSTEMI, or unstable angina). Therefore, a multivessel PCI strategy appears to be associated with lower risk of ischemia-driven unplanned revascularization.

Table 4. Patient-Reported Quality-of-Life Outcomes Among Patients Undergoing Multivessel Versus Culprit-Only PCI at 6 Weeks and 1 Year After Discharge

Quality-of-Life Outcomes	Multivessel PCI Group	Culprit-Only PCI Group	*P* Value
At 6 wks			
Seattle Angina Questionnaire			
Angina frequency score, %			0.62
No angina	72	71	
Monthly angina	22	23	
Daily/weekly angina	6	7	
EQ-5D VAS score (1–100)*	75 (60–85)	75 (60–85)	0.35
EQ-5D score with US weights*	0.84 (0.78–1.00)	0.84 (0.78–1.00)	0.60
At 1 y			
Seattle Angina Questionnaire			
Angina frequency score, %			0.33
No angina	78	80	
Monthly angina	18	16	
Daily/weekly angina	5	5	
EQ-5D VAS score (1–100)*	75 (63–85)	77 (65–89)	0.19
EQ-5D score with US weights*	0.84 (0.80–1.00)	0.84 (0.80–1.00)	0.28

EQ-5D indicates European Quality of Life-5 Dimensions; PCI, percutaneous coronary intervention; VAS, visual analogue scale.
*Data are given as median (25th–75th percentile).

When patients with NSTEMI and STEMI were examined separately, the association of multivessel PCI with lower short-term MACE risk was particularly observed in patients with STEMI, although the interaction *P* value did not reach statistical significance. There was no association between multivessel PCI and long-term MACE outcomes in each of these groups separately. Although ongoing randomized trials may shed more light on the best revascularization strategy in patients with STEMI, future randomized studies are needed for patients with NSTEMI.

Patients in the multivessel PCI group also had a lower risk of unplanned rehospitalization at 6 weeks compared with those who underwent culprit-only PCI. Our results expand on a prior small randomized clinical trial[24] in which patients with STEMI and multivessel disease were randomized to 1 of 3 arms during the index procedure: culprit-only PCI, staged PCI, or complete revascularization. Unplanned rehospitalization rates at a mean follow-up of 2.5 years were 35% (culprit-only PCI), 14% (staged PCI), and 12% (complete revascularization) ($P<0.001$). Possibly, the knowledge of coronary anatomy and the residual stenosis lower the threshold for rehospitalization and/or revascularization for patients who are treated with culprit-only PCI.

Interestingly, patients who underwent multivessel PCI did not report lower angina frequency or improved quality of life than those who received culprit-only PCI either at 6 weeks or with prolonged follow-up at 1 year. In the PRAMI trial, a lower hazard of refractory angina (HR, 0.35; 95% CI, 0.18–0.69) was observed in patients undergoing multivessel versus culprit-only PCI.[14] One possible explanation for the divergent results between our study and PRAMI is that angina definitions and reporting differed between the 2 studies. We reported angina scores based on a patient-reported questionnaire that investigated angina status in a cross-sectional manner (ie, during the month that preceded the telephone interview), whereas PRAMI defined refractory angina as any angina episode not controlled by medical therapy in patients with objective evidence of ischemia at any time during the 23-month follow-up period. Patients in the culprit-only PCI group may be more likely to develop angina with longer follow-up.

Our study further assessed the association between multivessel PCI and quality of life after acute MI. Although several studies have shown gains in quality of life with PCI compared with medical management in patients with acute coronary syndrome,[25,26] we observed similar EQ-5D index and EQ-5D visual analogue scale scores between patients who underwent multivessel versus culprit-only PCI. These quality-of-life findings parallel the lack of significant difference in angina frequency associated with multivessel PCI. Furthermore, these findings became manifest in the context of similar antianginal medication use in the 2 study groups.

Clinical Implications

Our study adds important findings to smaller randomized studies and other observational studies that demonstrated reduced MACEs, including cardiac death, MI, and recurrent angina, as well as repeated revascularization, in patients with STEMI.[13,14,24] These studies did not evaluate patients' quality of life after discharge, nor did they evaluate patients seen with NSTEMI. In addition, observational studies that evaluated clinical outcomes in patients with NSTEMI only included older patients (mean age, 75 years) and the primary outcome only consisted of all-cause death.[22] We have shown that among patients seen with acute MI and multivessel disease, performing multivessel PCI is associated with lower risk of unplanned readmissions in the short-term after discharge, but similar angina and quality-of-life scores. Additional randomized clinical trials are warranted.

Limitations

Our results should be viewed in the context of several important limitations. First, the nonrandomized nature of the study limited our ability to account for unmeasured confounding factors. Although statistical adjustments were used, residual selection bias may still exist, along with unmeasured confounding variables. Second, TRANSLATE-ACS did not capture physician rationale for selection of multivessel versus culprit-only PCI, specifically the selection of multivessel intervention in patients with STEMI during an era when multivessel PCI for STEMI was assigned a class III recommendation by the American College of Cardiology/American Heart Association guidelines. Third, angiographic analysis was physician dependent rather than core laboratory adjudicated. Fourth, the multivessel PCI definition only included the index procedure and did not include staged PCI during the index hospitalization. We believe that the timing of PCI in multivessel PCI is best addressed in a randomized manner with intention-to-treat analysis rather than in the setting of observational data, because of the possibility of introducing survival bias in observational studies. Furthermore, the cumulative incidence of staged revascularization without new symptoms was relatively low. Fifth, we did not have information with respect to completeness of revascularization in the multivessel PCI group; however, 15% of multivessel PCI procedures were deemed partially successful revascularizations, suggesting there were residual stenoses that were unable to be treated in this group. Nevertheless, multivessel PCI was still associated with fewer downstream unplanned revascularization procedures. Finally, site participation was voluntary, and longitudinal follow-up required informed consent; therefore, results may not be generalizable to the broader US population.

Conclusions

In patients with acute MI and multivessel disease treated with PCI in a contemporary real-world setting, multivessel PCI is associated with a lower MACE rate in both the short- and long-term, compared with culprit vessel PCI. Moreover, multivessel PCI was associated with lower readmission risk at 6 weeks, but not at 1 year. Interestingly, there were no differences in short- or long-term angina and quality-of-life outcomes between multivessel PCI and culprit vessel PCI strategies. Well-powered, prospective, randomized, clinical trials are needed to confirm these findings, particularly for patients with NSTEMI.

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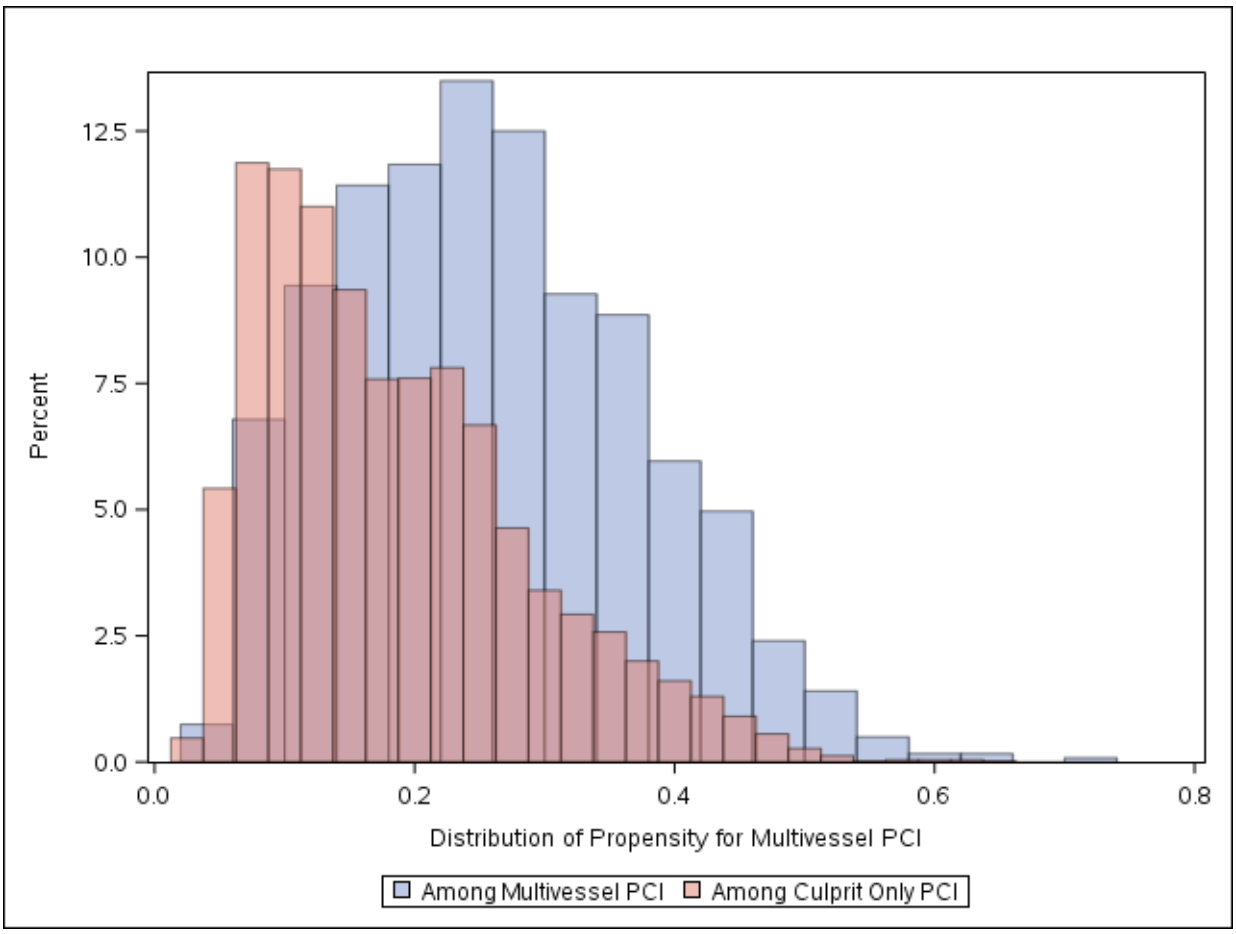
SUPPLEMENTAL MATERIAL

Table S1. Clinical Outcomes Stratified by Patient Presentation STEMI vs. NSTEMI

Outcome	Time	STEMI vs. NSTEMI	Adjusted HR	95% CI	Interaction p-value
MACE	6 weeks	STEMI	0.56	0.35-0.89	
		NSTEMI	0.81	0.59-1.11	0.20
	1 year	STEMI	0.82	0.62-1.08	0.78
		NSTEMI	0.86	0.72-1.03	
All-cause readmission	6 weeks	STEMI	0.77	0.56-1.07	0.62
		NSTEMI	0.85	0.68-1.07	
	1 year	STEMI	0.91	0.75-1.11	0.73
		NSTEMI	0.95	0.83-1.08	

MACE = major adverse cardiovascular events; NSTEMI = non–ST-segment elevation myocardial infarction; STEMI = ST segment elevation myocardial infarction.

Figure S1. Distribution of Propensity Scores



The distribution of the propensity scores for multivessel and culprit-only PCI groups.

PCI = percutaneous coronary intervention