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Outcomes Among Patients With Non–ST-Segment Elevation Myocardial Infarction Presenting to Interventional Hospitals With and Without On-Site Cardiac Surgery

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Objectives The goals of this analysis were: 1) to evaluate outcomes among non–ST-segment elevation myocardial infarction (NSTEMI) patients presenting to hospitals with on-site cardiac surgery (OHS hospitals) and without on-site cardiac surgery (No-OHS hospitals); and 2) to specifically examine outcomes among the subset of NSTEMI patients undergoing percutaneous coronary intervention (PCI).

Background Whether backup cardiac surgery improves outcomes among NSTEMI patients or is simply a marker of better adherence to guideline recommendations is unknown.

Methods The NRMI (National Registry of Myocardial Infarction) enrolled 100,071 NSTEMI patients from 2004 to 2006. Outcomes were evaluated in the population as a whole and in propensity-matched analyses in the entire population and in the subset of patients undergoing PCI.

Results In-hospital mortality was significantly lower at OHS hospitals (5.0% vs. 8.8%, $p < 0.001$). Patients presenting to OHS hospitals were significantly more likely to receive aspirin, beta-blockers, and statins ($p < 0.05$ for all) and to undergo PCI (38.4% vs. 14.1%, $p < 0.001$). In the propensity-matched model, the difference in mortality remained significant (5.9% vs. 8.5%, $p < 0.001$). After adjusting for differences in medications administered within 24 h of arrival and hospital characteristics, the difference in mortality was nearly attenuated (hazard ratio: 0.89, 95% confidence interval: 0.79 to 1.00, $p = 0.050$). When the propensity-matched model was restricted to patients undergoing PCI, there was no significant difference in mortality (1.3% vs. 1.0%, $p = 0.51$).

Conclusions NSTEMI patients presenting to No-OHS hospitals have significantly higher mortality. This appears to be due to both modifiable (lower use of guideline-recommended medications) and nonmodifiable factors (hospital size, myocardial infarction volume). In a propensity-matched analysis of patients undergoing PCI for NSTEMI, there was no significant difference in mortality. (J Am Coll Cardiol Intv 2009;2:944–52) © 2009 by the American College of Cardiology Foundation

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Among patients with non–ST-segment elevation myocardial infarction (NSTEMI), early angiography and, if warranted, percutaneous coronary intervention (PCI) have been associated with improved outcomes (1,2). An early invasive strategy is therefore recommended among most patients with NSTEMI (3). As a result, cardiac catheterization in NSTEMI patients is becoming more prevalent (4).

See page 953

Emergent cardiac surgery is sometimes required after complications from cardiac catheterization and PCI (5). While there is evidence that PCI performed among NSTEMI patients at hospitals without on-site cardiac surgery (No-OHS hospitals) is safe (6), other studies have reported higher mortality among patients undergoing PCI at No-OHS hospitals (7). Elective PCI is currently not recommended at sites without surgical backup in the American College of Cardiology/American Heart Association guidelines (3,8).

Surgical backup may improve outcomes because of its use after complications of PCI. Alternatively, it may simply be a marker of quality of care and better adherence to guideline recommendations. There were 2 goals of this analysis: 1) to compare outcomes, the use of PCI, and the use of guideline-recommended medications among NSTEMI patients presenting to OHS and No-OHS hospitals; and 2) to compare outcomes and the use of guideline-recommended medications among the subset of NSTEMI patients undergoing PCI at hospitals with and without backup cardiac surgery. In order to evaluate these objectives, we utilized phase 5 of the NRMI (National Registry of Myocardial Infarction), which collected data from over 450 hospitals from 2004 to 2006.

Methods

NRMI is an industry-sponsored observational study whose methods have previously been described (9,10). To be included in the registry, patients must have had an acute myocardial infarction (MI) documented according to local hospital criteria, usually including a history suggestive of acute MI and corroborated by cardiac enzymes, 12-lead electrocardiogram (ECG), coronary angiography, or International Statistical Classification of Diseases-9 diagnostic code of MI. NSTEMI was defined as all patients enrolled who did not have ST-segment elevation or left bundle branch block (old/new/unknown) on first/subsequent 12-lead ECG.

A registry coordinator at each participating hospital recorded data from each patient, including demographic information. In-hospital mortality was available among patients who were not transferred to another facility.

To ensure quality control of registry data, registry coordinators were trained in data entry utilizing a standardized manual of instructions and definitions. Case report forms were required to pass systematic range and internal consistency checking. Hospitals obtained approval of the registry data collection process as dictated by local investigational review boards.

Only hospitals with PCI capabilities were included in the analysis. In-hospital mortality, as well as the incidence of other adverse clinical outcomes, was assessed only among patients who were not transferred as the outcome of patients transferred to other acute care hospitals was not known.

All statistical analyses were performed using a commercially available statistical package (SAS 9.1.3 Service Pack 2, SAS Institute, Cary, North Carolina). Continuous variable values are reported as the mean plus or minus the standard deviation or the median and interquartile range. Model-based approaches were used to analyze unmatched and matched data. To account for clustering of patients within hospitals, model-based group comparisons of binary, continuous, and ordinal data were implemented using a generalized estimating equations approach or generalized linear mixed models. To estimate group differences in survival, Cox proportional hazard regression models for left-truncated and right-censored unmatched data were constructed, with and without adjustment for propensity score (as a continuous variable) and covariates. Treating the transfer-in patient as the truncating event and transfer-out, death, or discharge events as the censoring event, Cox regression analysis was applied to adjust for differences in the administration of guideline-recommended medications (aspirin, clopidogrel, statins, beta-blockers, and glycoprotein [GP] IIb/IIIa inhibitors) within 24 h, and hospital characteristics (region in U.S., hospital type, hospital size, and MI volume).

Abbreviations and Acronyms

CHF = congestive heart failure
GP = glycoprotein
MI = myocardial infarction
No-OHS = hospitals without on-site open heart surgery
NSTEMI = non–ST-segment elevation myocardial infarction
OHS = hospitals with on-site open heart surgery
PCI = percutaneous coronary intervention

In the propensity-matched analysis, cases (patients presenting to No-OHS hospitals) were matched to control subjects (patients presenting to OHS hospitals) using the propensity score generated from a nonparsimonious logistic regression model. No interactions between the predictor variables were used in this model. In both total and PCI patient populations, the C-statistic, or area under the receiver-operator characteristic curve, was 0.68, indicating fair discriminatory ability in predicting no-OHS. The events per variable statistic exceeded 10. A greedy matching algorithm was used to match patients based on 8→1 digit matching. Cases were matched to control subjects using the following set of independent variables: transferred-in status; sex; age; hypertension; diabetes mellitus; hyperlipidemia; stroke; peripheral vascular disease; previous MI; congestive heart failure (CHF); smoking status; and aspirin, clopi-

dogrel, beta-blocker, and statin received within 24 h before arrival. Patients grouped into control subjects were randomly selected without replacement, and 97.5% of pairs had exactly matching covariates. All p values used 2-tailed tests, and p values <0.05 were considered significant.

Results

There were 186,267 patients enrolled at 456 hospitals in the NRMI 5 registry from April 2004 to December 2006. Of these, 158,892 patients presented to 266 hospitals with PCI capabilities. There were 100,071 NSTEMI patients: 9,189 (9.2%) who presented to 52 No-OHS hospitals and 90,872 (90.8%) who presented to 214 OHS hospitals. Baseline characteristics among the entire group are shown in Table 1 (left). Patients presenting to OHS hospitals were slightly younger, more likely to be male, to have hyperlipidemia, to present with Killip class II, and to be receiving aspirin and less likely to have diabetes mellitus, hypertension, and a history of heart failure. The most substantial difference between the groups was that patients presenting to OHS hospitals were far more likely to have been transferred from another hospital (34.8% vs. 5.8%, $p < 0.001$).

Patients presenting to OHS hospitals were significantly more likely to receive aspirin (87.8% vs. 84.0%, $p < 0.001$), beta-blockers (78.6% vs. 74.7%, $p = 0.014$), and statins (44.3% vs. 38.0%, $p = 0.002$) within 24 h after arrival (Table 2, left).

Patients presenting to OHS hospitals were more likely to undergo angiography (68.3% vs. 40.2%, $p < 0.001$) and PCI (38.4% vs. 14.1%, $p < 0.001$) (Table 3, left).

Patients who presented to No-OHS hospitals were much more likely to be transferred to another short-term general hospital (35.3% vs. 2.2%, $p < 0.001$). Baseline characteristics among patients who were transferred out from No-OHS and those transferred in to OHS hospitals were similar, except that patients transferred out from No-OHS hospitals had a slightly higher median body mass index (28.8 vs. 28.3, $p = 0.023$), were less likely Caucasian (81.8% vs. 87.9%, $p = 0.017$), and have angina pectoris (8.9% vs. 15.0%, $p = 0.006$), had a higher median pulse (84 vs. 80, $p < 0.001$), systolic blood pressure (148 vs. 142, $p < 0.001$), and diastolic blood pressure (83 vs. 80, $p < 0.001$).

Among patients who were not transferred ($n = 94,817$), in-hospital mortality was significantly lower among patients presenting to OHS hospitals (5.0% vs. 8.8%, $p < 0.001$) (Table 4, left). The incidence of recurrent MI was similar at the 2 hospital types (1.0% vs. 0.9%, $p = 0.64$), but the incidence of the composite of death and MI (5.8% vs. 9.5%, $p < 0.001$) and the composite of death, recurrent MI, CHF, and cardiogenic shock (21.9% vs. 26.8%, $p = 0.043$) was significantly lower among patients presenting to OHS hospitals.

Among patients who lived and were not transferred, there were significant differences favoring OHS hospitals in the use of guideline-recommended discharge medications, including aspirin (89.6% vs. 81.2%, $p < 0.001$), clopidogrel (55.9% vs. 46.9%, $p = 0.005$), beta-blockers (86.3% vs. 80.5%, $p < 0.001$), and statins (76.9% vs. 61.6%, $p < 0.001$) (Table 5, left).

Propensity-matched analysis. Patients presenting to No-OHS hospitals were matched 1:1 in a propensity-matched model with patients presenting to OHS hospitals based on the following baseline characteristics: transfer-in status; sex; age; hypertension; diabetes mellitus; hyperlipidemia; stroke; peripheral vascular disease; previous MI; CHF; smoking status; and aspirin, clopidogrel, beta-blocker, and statin received within 24 h before arrival.

There were 9,049 patients in each group. Baseline characteristics were similar between the groups and cross-strata comparisons of covariates used in the propensity score models were nonsignificant (Table 1, center).

The differences in the administration of guideline-recommended medications favoring OHS hospitals was mildly attenuated in the propensity-matched analysis (Table 2, center), although patients presenting to OHS hospitals remained significantly more likely to receive aspirin (87.5% vs. 84.2%, $p < 0.001$), beta-blockers (78.5% vs. 75.1%, $p = 0.034$), and statins (42.6% vs. 38.2%, $p = 0.038$) in the first 24 h. The use of GP IIb/IIIa inhibitors and angiotensin-converting enzyme inhibitors or angiotensin receptor blockers was similar. OHS hospitals were less likely to administer a heparin product during stay (70.9% vs. 74.0%, $p = 0.041$).

More patients presenting to OHS hospitals underwent angiography (60.2% vs. 40.5%, $p < 0.001$) and PCI (33.2% vs. 14.2%, $p < 0.001$), and 10.6% of patients presenting to OHS hospitals in the propensity-matched analysis underwent coronary artery bypass grafting (Table 3, center).

There remained a large disparity in that patients presenting to OHS hospitals were far less likely to be transferred to another acute care hospital (2.7% vs. 35.4%, $p < 0.001$). Among patients who were not transferred, patients presenting to OHS hospitals had significantly lower in-hospital mortality (5.9% vs. 8.5%, $p < 0.001$) and had a lower incidence of the composite of death or MI (6.7% vs. 9.1%, $p < 0.001$) (Table 4, center). The rates of recurrent MI, CHF, and cardiogenic shock were not significantly different between the 2 hospital types.

Among patients who lived and were not transferred, patients discharged from OHS hospitals were significantly more likely to be prescribed aspirin (87.6% vs. 81.3%, $p < 0.001$), beta-blockers (85.5% vs. 80.6%, $p < 0.001$), and statins (72.6% vs. 61.8%, $p < 0.001$) (Table 5, center).

When this propensity-matched population was further adjusted for differences in the administration of aspirin, clopidogrel, beta-blockers, statins, and GP IIb/IIIa inhibitors within the first 24 h, and hospital region, type, size, and MI volume, the difference in mortality was largely

Table 1. Baseline Characteristics

Characteristic	Unmatched Patients			Matched by Propensity Score			Matched by Propensity Score, PCI Only		
	No-OHS (n = 9,199)	OHS (n = 90,872)	p Value	No-OHS (n = 9,049)	OHS (n = 9,049)	p Value	No-OHS (n = 1,282)	OHS (n = 1,282)	p Value
Age, yrs, mean ± SD*	69.5 ± 13.9	68.5 ± 13.3	0.039	69.5 ± 13.9	69.4 ± 13.8	0.70	63.5 ± 12.9	63.5 ± 12.7	0.93
Age, yrs, median (IQR)*	71 (58–81)	69 (58–80)	0.029	71 (58–81)	71 (58–81)	0.94	62 (53–74)	62 (53–73)	0.71
Male sex, %*	56.2	60.4	<0.001	56.3	56.3	0.92	64.5	65.8	0.45
Caucasian, %	81.9	84.8	0.26	82.0	82.3	0.76	84.5	84.9	0.90
Weight, kg, mean ± SD	82.1 ± 22.5	82.9 ± 21.7	0.15	82.1 ± 22.5	81.4 ± 21.8	0.15	87.2 ± 20.7	86.5 ± 20.2	0.47
Weight, kg, median (IQR)	80 (66–95)	81 (68–95.5)	0.14	80 (66–95)	79.5 (66–94)	0.46	85 (73–100)	85 (72–100)	0.65
Body mass index, mean ± SD	28.6 ± 7.0	28.7 ± 6.7	0.66	28.6 ± 7.0	28.5 ± 6.7	0.26	29.7 ± 6.5	29.5 ± 6.2	0.49
Body mass index, median (IQR)	27.6 (24.0–32.3)	27.8 (24.3–32.0)	0.65	27.6 (24.0–32.3)	27.5 (24.0–31.9)	0.50	28.8 (25.4–33.2)	28.6 (25.4–33.3)	0.47
Medical history, %									
Diabetes mellitus*	34.7	33.0	0.05	34.7	34.8	0.49	24.9	24.2	0.73
Hypertension*	70.2	68.5	0.039	70.3	70.1	0.85	65.9	66.1	0.94
Hyperlipidemia*	46.8	52.1	0.003	47.0	46.2	0.68	51.2	52.2	0.71
Current smoker*	27.8	28.4	0.68	27.8	27.3	0.74	38.6	37.4	0.64
Previous MI*	26.0	25.8	0.79	26.1	25.6	0.67	20.7	19.1	0.46
Previous PCI	16.9	18.2	0.14	17.0	16.6	0.70	17.6	18.4	0.64
CABG surgery	16.4	17.4	0.15	16.4	17.0	0.45	12.1	13.1	0.54
Stroke/CVA*	11.2	10.1	0.067	11.2	10.3	0.23	5.3	4.1	0.14
Peripheral vascular disease*	12.5	12.3	0.81	12.6	12.2	0.72	7.8	6.5	0.26
Chronic kidney disease	12.0	10.8	0.15	12.0	11.8	0.84	5.4	6.1	0.51
Atrial fibrillation	11.2	9.5	0.027	11.1	10.4	0.40	4.4	5.4	0.27
Heart failure*	21.8	17.0	<0.001	21.7	21.5	0.83	9.8	8.2	0.33
COPD	18.9	16.6	0.079	18.9	16.8	0.14	12.8	11.2	0.43
Medications 24 h pre-arrival									
Aspirin*	37.4	42.0	0.11	37.3	37.4	0.97	37.4	38.5	0.81
Clopidogrel*	7.6	7.8	0.85	7.5	6.0	0.14	4.2	3.5	0.58
Beta-blocker*	23.5	25.6	0.49	23.5	23.0	0.87	16.1	16.9	0.81
Statin*	18.7	22.0	0.26	18.7	18.1	0.81	14.7	14.8	0.98
ACE inhibitor/ARB	18.3	18.5	0.90	18.3	17.9	0.89	12.5	14.1	0.55
Symptom onset-to-door time, %			0.77			0.77			0.35
<2 h	21.1	20.5		21.1	20.5		27.1	23.8	
2–4 h	10.9	11.0		10.9	11.2		12.2	11.9	
4+ h	15.1	17.4		15.2	17.2		19.6	21.5	
Missing	52.9	51.2		52.7	51.1		41.1	42.8	

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Table 1. Continued

Characteristic	Unmatched Patients			Matched by Propensity Score			Matched by Propensity Score, PCI Only		
	No-OHS (n = 9,199)	OHS (n = 90,872)	p Value	No-OHS (n = 9,049)	OHS (n = 9,049)	p Value	No-OHS (n = 1,282)	OHS (n = 1,282)	p Value
Arrival time, %	n = 9,097	n = 83,172	0.47	n = 8,949	n = 8,925	0.63	n = 1,249	n = 1,231	0.10
Day (8 AM to 4 PM)	43.4	43.9		43.3	44.0		42.4	46.0	
Evening (4 PM to 12 AM)	34.6	34.2		34.6	33.9		36.1	33.3	
Night (12 AM to 8 AM)	22.0	21.9		22.0	22.1		21.5	20.7	
Transferred-in, %*	5.8	34.8	<0.001	5.9	5.9	1.00	15.2	15.2	1.00
Bed size, %			<0.001			<0.001			<0.001
<151	34.0	5.3		33.8	5.0		49.7	6.2	
151–250	45.2	15.4		45.3	16.4		37.7	15.6	
>250	20.7	79.3		20.9	78.6		12.6	78.2	
AMI volume, mean ± SD	187.8 ± 78.8	483.7 ± 240.3	<0.001	188.2 ± 78.5	464.0 ± 236.4	<0.001	157.8 ± 55.5	486.4 ± 246.0	<0.001
AMI volume, median (IQR)	184.9 (128.4–218.5)	466.5 (286.9–628.4)	<0.001	180.7 (118.7–218.5)	417.7 (280.7–603.3)	<0.001	170.2 (120.7–194.0)	473.8 (281.5–639.6)	<0.001
Pulse, mean ± SD	90.2 ± 24.9	87.1 ± 23.6	<0.001	90.2 ± 24.9	88.9 ± 24.2	0.029	84.6 ± 22.1	82.8 ± 20.6	0.094
Pulse, median (IQR)	87 (73–104)	84 (70–100)	<0.001	87 (73–103)	86 (72–101)	0.045	81 (70–96)	79.5 (68–93)	0.072
Systolic blood pressure, mm Hg, mean ± SD	145.0 ± 33.9	145.1 ± 31.7	0.86	145.2 ± 33.8	144.9 ± 32.0	0.70	151.8 ± 29.7	149.1 ± 29.0	0.058
Systolic blood pressure, mm Hg, median (IQR)	144 (122–167)	144 (123–165)	0.44	144 (122–167)	144 (123–165)	0.93	150 (132–172)	147 (130–166)	0.035
Diastolic blood pressure, mm Hg, mean ± SD	79.6 ± 19.5	80.2 ± 18.5	0.29	79.7 ± 19.5	79.5 ± 18.8	0.76	85.1 ± 17.5	83.6 ± 17.1	0.11
Diastolic blood pressure, mm Hg, median (IQR)	80 (67–93)	80 (68–92)	0.16	80.0 (67.0, 93.0)	80.0 (67.0, 92.0)	0.86	85.0 (74.0, 96.0)	84.0 (72.0, 95.0)	0.065
Creatinine, mg/dl, mean ± SD	1.4 ± 1.1	1.4 ± 1.1	0.092	1.4 ± 1.1	1.4 ± 1.2	0.99	1.1 ± 0.6	1.2 ± 1.0	0.035
Creatinine, mg/dl, median (IQR)	1.1 (0.9–1.5)	1.1 (0.9–1.4)	0.009	1.1 (0.9–1.5)	1.1 (0.9–1.5)	0.40	1.0 (0.9–1.2)	1.0 (0.9–1.2)	0.55
Killip class, %	n = 9,195	n = 90,683	<0.001	n = 9,045	n = 9,047	0.28	n = 1,279	n = 1,280	0.001
No CHF	76.0	80.7		76.2	77.9		87.0	91.3	
Rales, JVD	17.6	12.8		17.5	15.1		10.6	6.2	
Pulmonary edema	5.8	5.8		5.8	6.1		2.1	2.4	
Cardiogenic shock	0.6	0.7		0.6	0.8		0.3	0	

*Predictor variables used in the propensity score model.

ACE = angiotensin-converting enzyme; AMI = acute myocardial infarction; ARB = angiotensin receptor blocker; CABG = coronary artery bypass grafting; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; IQR = interquartile range; JVD = jugular venous distension; MI = myocardial infarction; No-OHS = hospitals without on-site open heart surgery; OHS = hospitals with on-site open heart surgery; PCI = percutaneous coronary intervention.

Table 2. Medications Within 24 h After Arrival

Medication, %	Unmatched Patients			Matched by Propensity Score			Matched by Propensity Score, PCI Only		
	No-OHS (n = 9,199)	OHS (n = 90,872)	p Value	No-OHS (n = 9,049)	OHS (n = 9,049)	p Value	No-OHS (n = 1,282)	OHS (n = 1,282)	p Value
Aspirin	84.0	87.8	<0.001	84.2	87.5	<0.001	92.3	93.5	0.30
Clopidogrel	35.7	40.0	0.17	35.8	38.0	0.50	66.4	58.7	0.020
Beta-blocker	74.6	78.6	0.014	75.1	78.5	0.034	84.6	84.3	0.91
GP IIb/IIIa inhibitor	27.5	32.0	0.065	27.6	28.9	0.60	58.9	53.0	0.18
UFH	31.9	37.7	0.13	32.0	36.9	0.21	40.4	48.1	0.20
LMWH	46.5	40.1	0.11	46.6	39.5	0.084	50.5	39.5	0.081
Any heparin during stay	73.7	72.1	0.27	74.0	70.9	0.041	82.4	80.9	0.51
ACE inhibitor/ARB	36.4	36.4	0.99	36.6	36.8	0.94	44.5	37.8	0.012
Statin	38.0	44.3	0.002	38.2	42.6	0.038	49.2	48.4	0.83

GP = glycoprotein; LMWH = low-molecular-weight heparin; UFH = unfractionated heparin; other abbreviations as in Table 1.

attenuated (hazard ratio: 0.89, 95% confidence interval: 0.79 to 1.00, p = 0.050) (Table 6).

Propensity-matched analysis, PCI patients. The propensity matching was then restricted to patients who underwent PCI (n = 1,282 in each group). Baseline characteristics, medication use, and presenting characteristics were well matched between the groups (Table 1, right). Patients undergoing PCI were substantially younger, more likely to be men, less likely to have diabetes mellitus, hypertension, prior coronary artery bypass grafting, stroke, chronic kidney disease, atrial fibrillation, CHF, or chronic obstructive pulmonary disease and were more likely to have hyperlipidemia or be smokers than either the unmatched population or entire propensity-matched population. They were also more likely to have been transferred in and generally had a lower Killip class.

No-OHS hospitals were significantly more likely to administer clopidogrel (58.7% vs. 66.4%, p < 0.001) and angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (37.8% vs. 44.5%, p < 0.001) within the first 24 h (Table 2, right). The administration of aspirin, GP IIb/IIIa inhibitors, beta-blockers, heparin products, and statins within the first 24 h was similar at the 2 hospital types.

In-hospital mortality (1.3% vs. 1.0%, p = 0.49); the composite of death and recurrent MI (2.0% vs. 1.1%, p = 0.088); and the composite of death, recurrent MI, cardiogenic shock, and CHF (9.4% vs. 8.6%, p = 0.52) among patients undergoing PCI at OHS and No-OHS hospitals was similar. Patients presenting to OHS hospitals who underwent PCI had a significantly higher incidence of recurrent MI (0.8% vs. 0.2%, p = 0.041).

Discussion

Patients with NSTEMI presenting to hospitals without on-site cardiac surgery have significantly higher in-hospital mortality than those presenting to hospitals with on-site cardiac surgery. This difference was observed in both unadjusted and propensity-matched models. However, the difference in mortality was of marginal significance after adjusting for both modifiable characteristics, such as the administration of guideline-recommended medications within 24 h, as well as nonmodifiable characteristics, such as hospital size, region, type, and MI volume. Furthermore, in patients who underwent PCI at No-OHS hospitals, who were generally of better health than the population as a whole, there was no increase in mortality when compared with similar patients undergoing PCI at OHS hospitals.

In addition to the difference in in-hospital outcomes between No-OHS and OHS hospitals, patients discharged from No-OHS hospitals were less likely to receive guideline-recommended medications such as aspirin, beta-blockers, and statins. Given the incremental possible benefit derived from each of these medications (11–13), post-

Table 3. Interventional Strategies

	Unmatched Patients			Matched by Propensity Score		
	No-OHS (n = 9,199)	OHS (n = 90,872)	p Value	No-OHS (n = 9,049)	OHS (n = 9,049)	p Value
Coronary angiography, %	40.2	68.3	<0.001	40.6	62.0	<0.001
Elective percutaneous coronary intervention, %	14.1	38.4	<0.001	14.2	33.2	<0.001
CABG, %	0	12.3	<0.001	0	10.6	<0.001

Abbreviations as in Table 1.

Table 4. In-Hospital Clinical Outcomes

Outcome, %	Unmatched Patients			Matched by Propensity Score			Matched by Propensity Score, PCI Only		
	No-OHS (n = 5,949)	OHS (n = 88,868)	p Value	No-OHS (n = 5,842)	OHS (n = 8,809)	p Value	No-OHS (n = 1,237)	OHS (n = 1,276)	p Value
Death	8.8	5.0	<0.001	8.5	5.9	<0.001	1.0	1.3	0.51
Recurrent MI	0.9	1.0	0.64	0.8	1.0	0.50	0.2	0.8	0.047
Death or recurrent MI	9.5	5.8	<0.001	9.1	6.7	<0.001	1.1	2.0	0.11
Death, recurrent MI, CHF, or cardiogenic shock	26.8	21.9	0.043	26.5	25.3	0.63	8.6	9.4	0.62
CHF	19.5	17.5	0.44	19.6	20.4	0.78	6.5	7.8	0.37
Cardiogenic shock	3.0	3.1	0.83	2.9	3.3	0.40	2.2	1.6	0.52
Stroke	1.1	1.1	0.85	1.1	1.2	0.45	0.4	0.2	0.42
Bleeding requiring intervention	7.1	13.3	<0.001	7.0	13.4	<0.001	4.4	6.6	0.020
Related to CABG surgery	0	49.9	<0.001	0	45.8	<0.001	0	7.1	<0.001
Transfusion required	81.3	88.5	0.010	81.7	89.2	0.014	81.8	83.3	0.83
New-onset atrial fibrillation	5.9	7.6	0.025	5.9	7.7	0.023	2.9	3.4	0.59
Thrombocytopenia (<20,000)	0.9	1.8	0.018	0.9	1.8	0.017	0.6	1.4	0.16
Target vessel revascularization	4.5	7.2	0.008	4.5	6.7	0.029	5.7	7.2	0.40
Intra-aortic balloon pump	1.0	3.9	<0.001	1.0	3.5	<0.001	1.8	2.0	0.71
Length of stay									
Mean ± SD	5.0 ± 4.4	5.5 ± 5.8	0.024	5.0 ± 4.5	5.8 ± 5.5	00.001	3.9 ± 2.8	4.0 ± 3.4	0.70
Median (IQR)	3.9 (2.5–6.1)	3.9 (2.4–6.8)	0.006	3.9 (2.5–6.1)	4.1 (2.7–7.0)	<0.001	3.0 (2.2–4.5)	3.0 (2.1–4.4)	0.68
>5 days	35.2	37.5	0.40	35.0	40.7	0.045	20.6	19.0	0.62
Transferred to another acute care hospital	35.3	2.2	<0.001	35.4	2.7	<0.001	3.5	0.5	<0.001
Ejection fraction, %			<0.001			0.002			0.63
≤30	12.1	12.6		12.1	13.1		7.7	7.1	
31–39	8.0	8.4		8.1	8.1		7.7	5.7	
40–50	19.6	25.5		19.7	25.3		27.5	28.2	
>50	33.6	38.9		33.8	37.6		46.4	48.9	
Not available	26.7	14.7		26.3	15.8		10.6	10.1	

Abbreviations as in Table 1.

discharge adverse event rates may very well be increased among patients discharged from No-OHS hospitals.

This is the first study to specifically evaluate outcomes among patients with NSTEMI presenting to OHS and No-OHS hospitals. Current guidelines recommend against elective PCI at hospitals without surgical backup (8). This recommendation is based largely on a review of Medicare data by Wennberg et al. (7), who reported a 38% relative increase in mortality among patients undergoing nonprimary/rescue PCI at No-OHS hospitals after adjusting for differences in baseline characteristics.

Other studies suggest that PCI in the setting of non–ST-segment elevation acute coronary syndrome at hospitals without surgical backup is safe and effective. In the Swedish Coronary Angiography and Angioplasty registry, 16,245 patients with NSTEMI or unstable angina underwent PCI at hospitals with

Table 5. Medications at Discharge

Medication, %	Unmatched Patients			Matched by Propensity Score			Matched by Propensity Score, PCI Only		
	No-OHS (n = 5,424)	OHS (n = 84,416)	p Value	No-OHS (n = 5,345)	OHS (n = 8,293)	p Value	No-OHS (n = 1,225)	OHS (n = 1,260)	p Value
Aspirin	81.2	89.6	<0.001	81.3	87.6	<0.001	95.5	96.1	0.60
Clopidogrel	46.9	55.9	0.005	47.0	51.9	0.14	84.5	85.6	0.63
Beta-blocker	80.5	86.3	<0.001	80.6	85.5	<0.001	90.8	89.6	0.48
Statin	61.6	76.9	<0.001	61.8	72.6	<0.001	83.5	86.4	0.27
ACE inhibitor/ARB	53.6	55.5	0.28	53.8	54.5	0.69	63.8	61.5	0.43

Abbreviations as in Table 1.

Table 6. Multivariate Model Among Propensity Score-Matched Patients*

Adjustment	Hazard Ratio	95% CI	p Value
None	0.70	0.64–0.77	<0.001
Medications within 24 h†	0.81	0.74–0.89	<0.001
Above + hospital characteristics‡	0.89	0.79–1.00	0.050

*Treating the transfer-in patient as the truncating event and transfer-out, death, or discharge events as the censoring event; †aspirin, clopidogrel, glycoprotein IIb/IIIa inhibitors, lipid-lowering agents, beta-blockers within 24 h after arrival; ‡region, teaching hospital, urban setting, size, volume of myocardial infarctions.
CI = confidence interval.

(n = 12,073) and without (n = 4,172) backup cardiac surgery (14). The 30-day mortality (1.0% vs. 1.2%) was not significantly different between the groups. In a study of patients presenting to a single No-OHS and OHS hospital, there were no deaths or recurrent MIs at either hospital type among the 104 patients who had NSTEMI (6).

The findings presented here suggest that efforts aimed at increasing adherence to guideline recommendations at No-OHS hospitals appear to be warranted and may help close the gap in mortality between the 2 hospital types. Such improvements in adherence are not only within reach, but, when achieved at No-OHS hospitals, are associated with improved outcomes. As noted in the propensity-matched analysis, among low-risk PCI patients, No-OHS hospitals utilized guidelines-based therapies more often, and, in turn, this was associated with a significantly lower incidence of recurrent MI.

Larger hospital size and higher volume have been associated with improved outcomes among patients undergoing PCI (15–17). Many of these studies did not discriminate between truly elective PCI and PCI in the setting of NSTEMI or unstable angina. The findings in the current analysis provide further evidence that hospital characteristics play a significant role in outcomes among patients with NSTEMI, and that outcomes at smaller hospitals with lower MI volumes are significantly worse.

Study limitations. There are several limitations to the current study. While many hospitals participated in the NRMI registry, these hospitals may not be representative of all health care facilities, and they likely reflect larger, more procedure-oriented centers. There was no independent validation of data forms. The outcomes of patients who were transferred to other hospitals are unknown. Long-term outcomes are not known. The American College of Cardiology/American Heart Association guidelines for the management of patients with NSTEMI were updated in 2007. Although all of the medications listed in the current analysis had class I indications in the 2004 guidelines, it is possible that the re-emphasis of an update to the guidelines has increased the use of these medications at hospitals without backup cardiac surgery. Medication treatment may be a function of living long enough to receive medications, rather than the therapies alone. In addition, the added model components may simply reflect the hospital type, such that the significance of hospital type drops as the new variables are added.

Conclusions

Patients with NSTEMI presenting to hospitals without backup cardiac surgery have significantly higher in-hospital mortality, even after adjusting for differences in baseline patient characteristics. The difference in mortality appears to be the result of both modifiable and nonmodifiable factors, suggesting that efforts to increase adherence to guideline recommendations are warranted. Among the relatively healthy cohort of patients who underwent PCI at hospitals without on-site cardiac surgery, there was no increase in mortality compared with similar patients at hospitals with backup cardiac surgery.

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