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Factors Associated With Poorer Prognosis for Patients Undergoing Primary Percutaneous Coronary Intervention During Off-Hours

Biology or Systems Failure?

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Objectives We sought to determine whether poorer outcomes in patients undergoing primary percutaneous coronary intervention (PCI) for ST-segment elevation myocardial infarction (MI) during off-hours are related to delays in treatment, circadian changes in biology, or differences in operator-related quality of care.

Background Previous investigation has suggested that patients undergoing primary PCI during off-hours are more likely to have adverse cardiac events than routine-hours patients, but the reasons for this remain poorly defined.

Methods Clinical, angiographic, and procedural characteristics were compared in consecutive patients (n = 685) undergoing primary PCI in the National Heart, Lung, and Blood Institute Dynamic Registry between 1997 and 2006 that were classified as occurring during routine-hours (07:00 to 18:59) or off-hours (19:00 to 06:59). The primary end points were in-hospital death, MI, and target vessel revascularization.

Results Median time from symptom onset to PCI was similar (off-hours 3.4 h vs. routine-hours 3.3 h). Patients presenting in off-hours were more likely to present with cardiogenic shock and multivessel coronary artery disease but were equally likely to present with complete occlusion of the infarct-related artery. Procedural complications including dissection were more frequent in off-hours patients. In-hospital death, MI, and target vessel revascularization were significantly higher in off-hours patients (adjusted odds ratio [OR]: 2.66, p = 0.001), and differences in outcomes were worse even if the procedure was immediately successful (adjusted OR: 2.58, p = 0.005, adjusting for angiographic success). Patients undergoing PCI on weekends had better outcomes during the daytime than nighttime.

Conclusions Patients undergoing primary PCI for acute MI during off-hours are at significantly higher risk for in-hospital death, MI, and target vessel revascularization. These findings appear related to both diurnal differences in presentation and lesion characteristics, as well as differences in procedural complication and success rates that extend beyond differences in symptom-to-balloon time. (J Am Coll Cardiol Intv 2008;1:681–8) © 2008 by the American College of Cardiology Foundation

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Primary percutaneous coronary intervention (PCI) is now considered the preferred reperfusion modality for patients presenting with ST-segment elevation myocardial infarction (STEMI) regardless of the hour of presentation as long as reperfusion can occur in a timely manner (1–5). In fact, it has been demonstrated that less use of primary PCI during weekends is associated with poorer outcomes during those days. In those who receive primary PCI, recent evidence suggesting that longer door-to-balloon (DTB) time during off-hours accounts for a reduced benefit has led to a nationwide effort to reduce PCI delays during these hours (6–13).

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It is possible that differences in efficacy of PCI during off-hours versus routine hours are also related either to biologic differences linked to circadian variation or other factors associated with nighttime care that extend beyond DTB times (14–21). However, the combination of differences in clinical, angiographic, procedural, and time-related characteristics has not been accounted for simultaneously when examining and comparing the impact of primary PCI during off-hours and routine-hours, in the myocardial infarction (MI) patient.

Abbreviations and Acronyms

DTB = door-to-balloon
GWTG-CAD = Get with the Guidelines–Coronary Artery Disease
MI = myocardial infarction
PCI = percutaneous coronary intervention
STEMI = ST-segment elevation myocardial infarction
TVR = target vessel revascularization

We hypothesized that differences in the rates of in-hospital death, recurrent MI, and repeat target vessel revascularization (TVR) in patients undergoing off-hours versus routine-hours primary PCI could be further explained by a combination of differences in care and biology. To evaluate circadian-related biologic differences, we sought to assess differences in clinical presentation, underlying clinical characteristics, and angiographic features of off-hours versus routine-hours patients undergoing primary PCI including the rates of Thrombolysis In Myocardial Infarction (TIMI) flow grade 0 before PCI, presence of thrombus, location of infarct-related artery, and lesion complexity. To attempt to understand the contribution of care received, we sought to evaluate differences in procedural characteristics and procedural complications, as well as periprocedural medication use.

Methods

National Heart, Lung, and Blood Institute Dynamic Registry. The National Heart, Lung, and Blood Institute Dynamic Registry has previously been described (22) and involves multicenter recruitment of patients undergoing PCI in 5 recruitment waves from July 1997 through February 1998 (n = 2,524), February through June 1999 (n = 2,105), October 2001 through March 2002 (n = 2,047), February through May 2004 (n = 2,112), and February through August 2006 (n = 2,158). Baseline clinical, demographic, and angiographic characteristics, as well as the incidence of death, MI, and the need for a coronary artery bypass graft or repeat revascularization during the hospitalization, were recorded. Patients were interviewed by telephone at 1 year to collect clinical data, including vital status and the type and date of cardiovascular-related events. Each center received approval from its Institutional Review Board, and data were compiled and analyzed at the University of Pittsburgh.

Definitions. Primary PCI was defined as emergent PCI for the treatment of STEMI within 12 h of symptom onset. Patients undergoing PCI for new left bundle branch block as presentation of acute MI were included. Patients who were previously treated with fibrinolysis ("rescue" or "late" PCI patients) were excluded from the analysis. Patients were stratified by PCI start time, with the routine-hours PCI cohort defined as PCI from 07:00 to 18:59 and the off-hours PCI cohort defined as PCI from 19:00 to 06:59, regardless of the day of the week. A secondary analysis defined the off-hours period to include both: 1) 19:00 to 06:59 for weekdays; and 2) weekends regardless of time of day. This secondary analysis was performed to assess further the association between differences in care during times when personnel were not on-site and biologic differences in circadian rhythm. Angiographic success was defined as at least a 20% reduction in lesion severity and final stenosis of <50%. Myocardial infarction was defined as the presence of either electrocardiographic or biochemical evidence of myocardial necrosis. Myocardial infarction after PCI was defined as a new rise in cardiac enzyme and clinical change to indicate new MI.

Statistical methods. Baseline clinical, angiographic, and procedural characteristics and in-hospital outcomes were compared between the 2 cohorts by chi-square or Fisher exact test for discrete data and by the Wilcoxon rank sum test for continuous variables. Cumulative event rates at 1-year were calculated by the Kaplan-Meier method and comparisons were made using the log-rank test statistic. The associations between off-hours status and individual or composite in-hospital and 1-year outcomes were evaluated in univariate and multivariable analyses using logistic or Cox proportional hazards approaches. With both logistic and Cox regression methodologies, models were adjusted for prespecified risk factors. One set of models included only clinical and demographic factors, a second set included angiographic characteristics, and the final models included a combination of all variables included in the first and second sets. Both TIMI flow grade and time as a dichotomous

variable (i.e., >6 h) were included in the initial model and neither was independently associated with outcome, and as such were not included in the final model presented. Other important variables, such as diabetes mellitus, were also forced into the model but were not significant. They are included in the table for the reader's information, despite lack of statistical significance. Goodness of fit for logistic regression models was assessed using the Hosmer-Lemeshow method ($p > 0.20$ for all models, indicating good fit), and proportional hazards assumptions were evaluated and met. Other analyses including an analysis by wave to assess the impact of time, as well as adjustment for site, were performed, but did not significantly impact on the findings of the main analyses. Although results improved over time, differences between the 2 groups persisted.

Additional sensitivity analyses were performed to assess for potential misclassification of STEMI in Wave 1 of the registry. In this wave, the variable was coded as "acute MI" and "emergent." To assess whether non-STEMI patients could have been misclassified in this wave, analyses were repeated without Wave 1 data and, when compared with the primary analysis, there were no significant differences in characteristics and results.

Results

Of 10,948 patients enrolled in Waves 1 to 5 of the National Heart, Lung, and Blood Institute Dynamic Registry, 685 (6.3%) underwent primary PCI. The majority of interventions (n = 457, 66.7%) were performed during routine-hours, with the remainder performed during off-hours (n = 228). The peak prevalence of procedures was late morning (11:00) and mid-afternoon (15:00 to 16:00). The mean and median times from symptom onset to PCI were somewhat longer in the off-hours versus routine-hours patients (mean time of 4.6 ± 3.0 h vs. 4.3 ± 3.1 h; $p = 0.09$ [median: 3.4 h vs. 3.3 h]).

Patient and procedural characteristics. Patients undergoing off-hours PCI were younger, more often men, and more often smokers compared with routine-hours patients undergoing PCI (Table 1). Off-hours patients had higher rates of cardiogenic shock compared with the rates of cardiogenic shock in routine-hours patients.

Off-hours and routine-hours patients had similar lesion characteristics, including location of the infarct-related vessel, and off-hours patients were equally likely to present with complete infarct-related vessel occlusion (Table 2). However, the prevalence of 1-, 2-, and 3-vessel disease differed between the 2 groups, with lower rates of 1-vessel disease during off-hours. In addition, TIMI flow grade was generally poorer upon arrival to cardiac catheterization during off-hours ($p = 0.003$ pre-PCI). Rates of stent use, intravascular ultrasound guidance, and mechanical thrombectomy were significantly lower during off-hours cases.

Table 1. Clinical Characteristics

Factor (%)	Off-Hours: Yes (n = 228)	Off-Hours: No (n = 457)	p Value
Age > 65 yrs	32.5	40.3	0.05
Women	27.6	36.1	0.03
Race			0.03
White	74.6	80.3	
Black	18.4	10.5	
Asian	2.6	2.9	
Hispanic	4.4	6.4	
History of coronary artery disease			
Myocardial infarction	18.5	18.5	0.99
Percutaneous intervention	15.8	14.4	0.64
Coronary artery bypass surgery	6.1	5.9	0.90
History of severe renal disease	2.7	2.6	0.99
History of peripheral vascular disease	4.9	4.8	0.98
Hypertension	55.0	57.5	0.53
Hypercholesterolemia	50.5	55.9	0.21
Current or former smoker	73.2	69.6	0.34
Diabetes mellitus	21.7	25.1	0.33
History of congestive heart failure	4.9	5.2	0.90
Cardiogenic shock	17.5	10.5	0.009
Ejection fraction (median)	45	50	0.07

Procedural outcomes varied significantly by group. Flow in treated vessels after PCI was worse in off-hours patients, with 87.5% achieving TIMI flow grade 3 versus 92.9% in routine-hours and 3.8% with persistent TIMI flow grade 0 versus 1.0% in routine-hours ($p = 0.008$). In addition, lesions treated off-hours had a higher incidence of major dissection (10.3% vs. 5.8%, $p = 0.02$), resulting in lower angiographic success rates in those patients treated off-hours. Despite similar American College of Cardiology lesion classification, operators more often felt that the lesion was treated successfully but did not respond appropriately (12.1% vs. 4.1%, $p = 0.006$) in unsuccessful PCI during off-hours versus routine-hours.

Medication use. Procedural glycoprotein IIb/IIIa receptor inhibitor use (64.5% vs. 64.6%, $p = 0.98$) and heparin use (95.2% vs. 94.2%, $p = 0.7$) did not differ between off-hours and routine-hours patients, and aspirin use before the procedure was similar (82.9% vs. 87.7%, $p = 0.08$). Periprocedural thienopyridine use was lower in patients treated off-hours (48.2% vs. 58.2%, $p = 0.01$). At discharge, however, there was no difference ($p > 0.10$ for all) in the use of secondary prevention agents including angiotensin-converting enzyme inhibitors (63.5% vs. 59.5%), beta-blockers (86.3% vs. 87.0%), calcium channel blockers (10.0% vs. 8.0%), statins (71.1% vs. 68.2%), or aspirin (97.2% vs. 96.1%).

Clinical outcomes. Off-hours patients had significantly higher rates of combined in-hospital death and recurrent

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Table 2. Angiographic and Procedural Characteristics

Factor	Off-Hours: Yes (n = 228)	Off-Hours: No (n = 457)	p Value
Severity of disease			
1-vessel	34.4	42.1	0.04
2-vessel	33.5	34.2	
3-vessel	32.2	23.7	
Lesion characteristics (number of attempted lesions)	(n = 263)	(n = 522)	0.65
Culprit lesion location			
LAD	45.4	44.3	
LCx	13.7	16.5	
RCA	36.3	35.3	
Length, mean, mm	16.6	16.3	0.14
Reference vessel size, mean, mm	3.1	3.1	0.13
Initial TIMI flow grade			0.21
0	57.4	58.3	
1	12.9	6.0	
2	14.8	14.3	
3	14.8	21.3	
Thrombus	74.8	71.3	0.31
Calcification	24.6	24.1	0.88
Bifurcation	12.1	12.4	0.91
ACC/AHA classification type			0.78
A	1.6	3.4	
B (B1 and B2)	61.9	59.4	
C	36.5	37.1	
Device use			
Stent	76.0	82.4	0.04
Balloon angioplasty only	16.3	12.8	0.10
Intravascular ultrasound	0.8	4.6	0.005
Mechanical thrombectomy	1.9	6.3	0.007
TIMI flow grade after intervention			0.002
0	3.8	1.0	
1	1.5	0.8	
2	7.2	5.4	
3	87.5	92.9	
Procedural complications			
Major dissection	10.3	5.8	0.02
Perforation	0.4	0.4	0.99
Branch occlusion	3.1	3.3	0.88
Embolization	4.6	4.8	0.88
Abrupt closure	1.1	0.8	0.60
Total angiographic success	93.8	96.2	0.12

ACC/AHA = American College of Cardiology/American Heart Association; LAD = left anterior descending artery; LCx = left circumflex artery; RCA = right coronary artery; TIMI = Thrombolysis In Myocardial Infarction.

MI, as well as combined death, MI, and repeat TVR rates (Table 3, Fig. 1). When examining individual outcomes by time quartile (Fig. 1), the main difference remained in a "diurnal" pattern, with similar event rates during both halves of the day and during both halves of the night. After adjusting for important differences in clinical and angiographic characteristics (as noted in Table 4), the risk of in-hospital death, recurrent MI, and TVR remained higher (adjusted odds ratio [OR]: 2.66) (Tables 3 and 4) in patients presenting during off-hours. Although initial differences in stent use and TIMI flow grade were present, these were not independently associated with outcome in multivariable analysis. Ejection fraction and lesion characteristics including thrombus presence were also examined but were not independently associated with outcome. The end point of TVR was examined in greater detail, and TVR via PCI occurred in 0.9% of routine-hours patients and 3.5% of off-hours patients, while TVR via coronary artery bypass grafting occurred in 2.0% of routine-hours patients and 4.9% of off-hours patients.

To evaluate the effect of procedural outcomes on subsequent death and MI, angiographic success was included in the adjusted model. A successful procedure was strongly protective against hospital death and MI, regardless of the time of intervention (adjusted OR: 0.18, $p < 0.001$). Furthermore, failure to treat lesions successfully during routine-hours conferred a higher risk of subsequent event than did successful PCI during off-hours; however, an unsuccessful procedure during off-hours conferred the highest risk of death or MI (Table 5).

In an analysis of 1-year outcomes, initial differences in adverse outcomes were still present (off-hours vs. routine-hours death/MI/TVR: 28.3% vs. 22.7%, hazard ratio: 1.39, $p = 0.04$), but the majority of this difference came from initial differences in in-hospital events.

Classification of off-hours. To examine further the association between mortality and time of day versus immediate availability of medical resources, we examined death and MI, and death, MI, and TVR by both time and weekday and weekend (Fig. 2). In both weekdays and weekends, adverse outcomes were highest at night. In addition, rates of adverse outcomes were only slightly higher on weekends at either time than at night, and this was not statistically significant. Finally, adverse outcomes were only slightly higher during weekend days than weekday days, and this was not statistically significant.

Discussion

In the present examination of patients undergoing primary PCI for STEMI, we observed a >2-fold higher risk for subsequent combined in-hospital mortality, MI, and target vessel revascularization among patients treated during off-hours versus routine-hours. In examining whether circadian-related biologic differences were factors, we found that the majority of lesion characteristics in both groups were quite similar, including the rates of TIMI flow grade 0 before PCI, presence of thrombus, location of infarct-related artery, and American College of Cardiology classi-

Table 3. In-Hospital Outcomes

Events	Event Rate (%)		Unadjusted			Adjusted		
	Off-Hours (n = 228)	Routine Hours (n = 457)	OR	95% CI	p Value	OR	95% CI	p Value
Recurrent MI	2.2	1.1	2.04	0.58–7.12	0.26	2.08	0.58–7.49	0.26
Death	7.0	4.4	1.65	0.84–3.25	0.15	1.17	0.50–2.71	0.72
Death/MI	8.8	4.8	1.90	1.01–3.56	0.04	1.59	0.74–3.42	0.23
Death/MI/TVR	16.2	6.8	2.66	1.60–4.42	<0.001	2.51	1.39–4.56	0.002

CI = confidence interval; MI = myocardial infarction; OR = odds ratio; TVR = target vessel revascularization.

fication scores of the lesions. Patients presenting off-hours had similar clinical characteristics as well, with the notable exception of higher rates of cardiogenic shock and multivessel coronary artery disease.

Despite similar lesion characteristics, we found that lesions treated at night were more often accompanied by procedural complications including dissection. Procedural success was a significant factor in subsequent adverse outcomes, but even patients with successful procedures had a higher risk of adverse events during off-hours.

Our findings are consistent with the prior observation that higher angioplasty failure rates occur at night, though hitherto there has not been sufficient angiographic or procedural information to understand potential causes (15,23,24). In this respect, those complications that may be related to operator performance, such as vessel dissection, were more frequent at night, whereas complications potentially related to lesion characteristics, such as distal embolization, were not. The use of time-consuming devices was also less frequent at night than during daytime hours, despite similar lesion characteristics. It is possible that diurnal differences in lesion characteristics, such as lower than TIMI flow grade 3 in the infarct-related artery at the time of intervention during off-hours, and diurnal differences in clinical characteristics, such as higher rates of cardiogenic shock, additionally affected operator performance. Lower rates of preprocedural thienopyridine use during off-hours also may have contributed to higher procedural complications and reduced success.

When procedural success was not achieved, operators were more likely to state that the "lesion did not respond appropriately" during off-hours. We found no significant differences in characteristics indicative of lesion complexity associated with adverse events after PCI (25,26). However, flow characteristics before PCI were less favorable in off-hours patients, and rates of TIMI flow grade 3 were less often achieved after off-hours PCI. It is possible that circadian variations may be associated with differential outcomes after primary PCI. Notably, platelet aggregation is heightened during the morning hours (27,28). A prothrombotic state has been associated with treatment outcome after both fibrinolytic therapy and elective PCI, with resistance to fibrinolytic therapy observed in the early morning hours (29–31). Thus although it is possible that lack of procedural success was purely operator- or procedure-related, it is likely that in some cases biologic factors also contributed to the lower success rates of PCI during off-hours, as poorer flow was present prior to PCI.

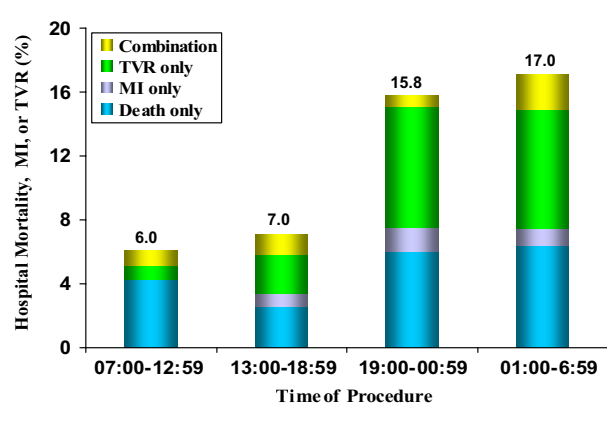

Figure 1. Hospital Mortality, MI, and TVR by PCI Start Time Quartile

Cumulative death, myocardial infarction (MI), and target vessel revascularization (TVR) by time of percutaneous coronary intervention (PCI). Overall and trend: $p < 0.001$.

Table 4. Adjusted Model for In-Hospital Death, MI, and TVR

Variable	OR	95% CI	p Value
Cardiogenic shock	8.10	4.16–15.78	<0.001
Peripheral vascular disease	4.00	1.50–10.69	0.006
Number of lesions treated	2.55	1.67–3.91	<0.001
Off-hours PCI	2.51	1.39–4.56	0.002
Multivessel disease	2.37	1.11–5.06	0.02
Ostial lesion treated	2.32	0.03–0.41	0.001
Totally occluded lesion	2.00	1.04–3.86	0.04
Tortuous lesion	1.86	0.98–3.55	0.06
Age, yrs	1.04	1.01–1.06	0.002
Dyslipidemia	0.50	0.27–0.92	0.03
Diabetes mellitus (insulin requiring)	0.11	0.90–5.97	0.08

PCI = percutaneous coronary intervention; other abbreviations as in Table 3.

Table 5. Association Between PCI Time, Angiographic Success, and In-Hospital Death, MI, and TVR*

Risk Factor		Adjusted OR	
PCI time/angiographic success			
Routine-hours/successful	1.00	reference	n/a
Off-hours/successful	2.40	1.24–4.965	0.009
Routine-hours/unsuccessful	5.98	1.75–20.47	0.004
Off-hours/unsuccessful	11.28	3.30–38.55	<0.001

*Angiographic success added to prior multivariable analysis model.
Abbreviations as in Tables 3 and 4.

Although delays in treatment time have been shown to be a factor in poorer outcomes during off-hours (6–11), in the present study, off-hour angioplasty was not associated with significant delay when using symptom onset to PCI time. Further, we found that the incidence of adverse events was only slightly higher on weekends, a time when delays would be expected to be greater than weekdays, with the majority of difference consistently occurring between nighttime versus daytime PCI, regardless of weekday or weekend. In addition, daytime outcomes were only slightly, and not statistically significantly, better during weekdays than weekends, suggesting that time delay was only 1 factor for subsequent adverse events.

Sicker patients may present during off-hours because of inability to wait for routine-hours. However, the converse has been postulated; namely, that waiting for routine-hours will increase the risk for those who wait, independent of their initial severity. It has also been postulated that off-hours patients are sicker because MI onset while sleeping may lead to longer ischemic times upon arrival. We found higher rates of cardiogenic shock and higher rates of multivessel coronary artery disease in those patients presenting during off-hours. In addition, TIMI flow grade 3 was less likely upon arrival to the catheterization laboratory, although the infarct-related artery was equally likely to be completely occluded in both groups. However, after accounting for these factors, off-hours presentation remained associated with poorer outcomes.

Unlike prior analyses, which mostly have been composed of very large registries, we were able to examine detailed clinical and angiographic features in MI patients (5,6,9,15). In this regard, although difficult to study all potential factors, we found few differences in a wide variety of characteristics, leaving the possibilities of circadian-related differences and operator performance. As mentioned previously, a role for circadian biologic differences may be suggested by less favorable flow upon angiography and after PCI and possibly by higher rates of multivessel coronary artery disease and cardiogenic shock. The possibility of operator fatigue also warrants careful consideration, as this is a potentially modifiable risk factor, and changes in public policy could mitigate its impact. For instance, there has been a recent strong emphasis on the need for public health measures aimed at improving quality of care in MI patients.

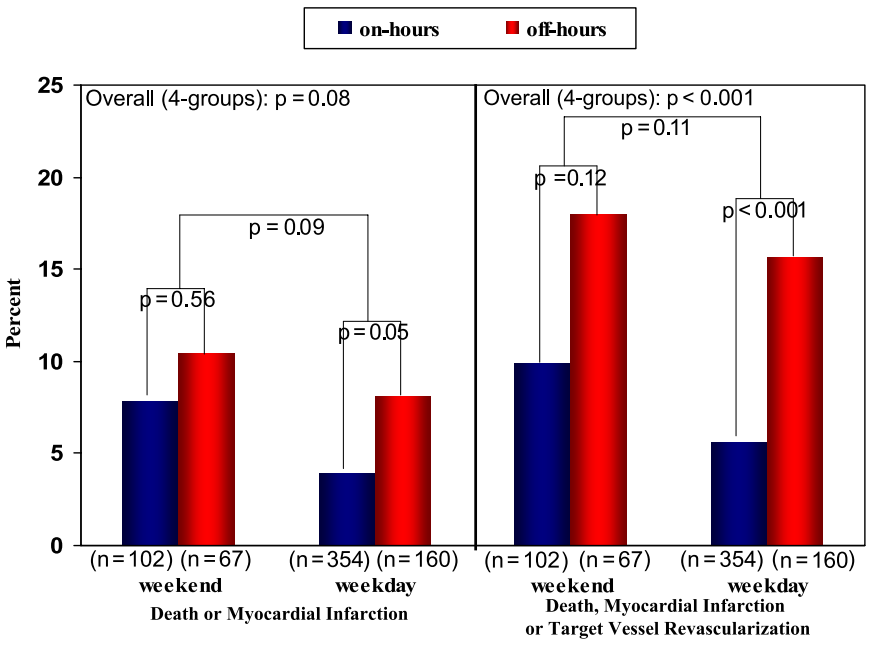

Figure 2. Adverse Hospital Outcomes by Time of PCI and Day of the Week

Adverse outcomes by time of PCI and day of the week. Abbreviation as in Figure 1.

Regionalization of MI care has been advocated by some to allow shorter DTB times and higher volume operators, both of which have been demonstrated to improve outcome (32,33). In a similar fashion, regional or high volume centers may be able to provide resources including more operators or less daytime duties in nighttime operators, which could reduce the impact of possible operator fatigue. If the presently proposed measures are implemented along with those that additionally address operator and staff fatigue, they may further enhance the benefits of primary PCI (33).

Finally, our findings suggesting that the potential hazard of off-hours PCI is not solely related to differences in DTB time are supported by a recent analysis of the Get with the Guidelines–Coronary Artery Disease (GWTG–CAD) database, where over 62,000 patients were examined and found to have similar mortality rates, despite longer DTB times in the off-hours group (34). Importantly, that analysis differed from the present study in that ours is exclusively a primary PCI cohort, whereas the GWTG–CAD database included 12% who received fibrinolysis, 34% who received no reperfusion therapy, and only 42% who had any revascularization. In addition, only 32% of patients in that study had STEMI. Nonetheless, the STEMI cohort in that analysis also had no significant difference in mortality by time of presentation, but even in this cohort, only 60% underwent cardiac catheterization, and only 70% underwent any revascularization, whereas in our study, all patients underwent primary PCI for STEMI. Finally, our study by definition includes centers that have the capacity to provide primary PCI, whereas the GWTG–CAD database looks at many different types of care centers, including some without primary PCI capability. The wide variety of care and severity of illness in the patients examined in that study may have contributed to lack of appreciable differences in overall mortality by time of presentation, even in STEMI patients. Interestingly, despite these differences, Jneid et al. (34), similarly conclude that "although. . .campaigns to reduce time to reperfusion are laudable, improvements in DTB times should be complemented by multifaceted approaches to optimize multiple levels of medical care in parallel."

Study limitations. This analysis uses symptom onset to PCI time. The prognostic significance of symptom onset is not clear, as some prior analyses have suggested a lack of reliability, and others have found symptom onset to be more predictive of adverse events than DTB time (35,36). However, our evaluation of weekend PCI by time allows some understanding of the impact of a "closed" cardiac catheterization laboratory and the effects of its delays in DTB time. Weekend PCI analysis is a means of stratifying outcome, though separate multivariable adjustments were not made for this particular exploratory analysis. The number of control variables required in multivariate models is high given this event rate, leading to overfitted models. Finally, in this cohort study, it is possible that differences exist that are not fully controlled by the statistical methods.

Conclusions

The current study observed over 2.7-fold higher risk for in-hospital mortality, MI, and repeat TVR in patients treated with primary PCI during off-hours. Off-hours primary PCI was associated with lower angiographic success and higher complication rates and may suggest both biologic factors including poorer anterograde flow, as well as nighttime performance issues such as operator fatigue reduced use of adjunctive devices and lower preprocedural thienopyridine use as contributors to poorer outcome. As such, factors that extend beyond differences in DTB time may contribute to poorer outcomes in patients presenting with MI during off hours.

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