Editorial

Interventional Cardiology

Off-hours effect: does time of day or day of week influence mortality in patients with acute myocardial infarction?

"Eventually, any patients who develop acute myocardial infarction should receive excellent care process and outcomes regardless of time of day or day of week."

Keywords: acute myocardial infarction • door-to-balloon time • mortality • off-hours • ST-elevation myocardial infarction

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Systems of care have been implemented across the world to improve access to and timeliness of reperfusion therapy for patients with ST-elevation myocardial infarction (STEMI) [1]. Recent advances include developing regional networks and using prehospital electrocardiograms to activate the cardiac catheterization lab team [2,3]. For patients with non-STEMI (NSTEMI), standardized protocols for medications and early angiography have been implemented [4]. Within this context, what are the remaining vulnerable patients and systems of care for patients with STEMI and NSTEMI?

Our recent meta-analysis showed that patients with acute myocardial infarction (AMI), including STEMI and NSTEMI, had higher mortality rates when they presented to the hospital during off-hours (weekends and/or nights) compared with regular hours (odds ratio [OR]: 1.06; 95% CI: 1.04–1.09) [5]. While the OR seems modest, this is clinically significant because of high incidence and mortality rate associated with AMI, and two-thirds of patients with AMI presenting during off-hours. In fact, our study estimates, in the USA, 2000–4000 extra deaths per year from AMI are due to patients presenting to the hospital during off-hours.

The higher mortality during off-hours appears to be concentrated in patients with STEMI (OR: 1.12; 95% CI: 1.03–1.22) but not in NSTEMI (OR: 0.96; 95% CI: 0.91–1.02). Further, the degree of mortality increase during off-hours seems to be different by region; studies in Europe (OR: 1.08; 95% CI: 1.02–1.15) and other regions including Asia and South America (OR: 1.25; 95% CI: 1.15–1.36) were associated with a larger increase in mortality during off-hours than were studies in North America (OR: 1.03; 95% CI: 1.01–1.04). In patients with STEMI, door-to-balloon times were also longer during off-hours compared with regular hours by 14.8 min (95% CI: 10.7–19.0 min), and patients who presented during off-hours were less likely to receive percutaneous coronary intervention within 90 min (OR: 0.40; 95% CI: 0.35–0.45). Meta-regression also suggested the mortality gap between off-hours and regular hours has worsened in recent years ($p = 0.03$).

Are these findings due to higher risk patients or systems of care during off-hours? Concha *et al.* tried to answer this question by investigating patterns in excess mortality risk after admission using administrative database in Australia [6]. For acute disease such as pulmonary embolism and major arrhythmia, they found that patterns in excess mortality were partially attributable to difference in quality of care delivered on the weekend compared with weekday. In our study, higher mortality (OR: 1.07; 95% CI: 1.04–1.10) during off-hours was still observed when the analysis was limited to studies that adjusted for patient risk. Furthermore, we found no consistent evidence that patients presenting during off-hours were sicker compared with those presenting during regular hours. These findings concur with the notion that systems of care are partially responsible for the mortality difference between off-hours and regular hours in patients with AMI.

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What are the vulnerable systems of care for patients with AMI during off-hours? For patients with STEMI, primary percutaneous coronary intervention achieves the best outcomes if it is available 24/7 and delivered in a timely manner [1]. Monitoring and understanding delays in door-to-balloon times during off-hours is an opportunity for improvement in systems of care. At nights or on weekends, hospitals are typically not staffed by on-site cardiologist, catheterization lab nurses and technicians. Thus, activating and assembling the catheterization lab team has inherent delays during off-hours, as demonstrated by Magid *et al.* [7]. Other possible factors contributing to worse outcomes during off-hours include differences in processes of care and hospital staffing (depth and breadth of available expertise). Availability of diagnostic tests and human factors such as sleep deprivation and fatigue can also be contributing causes [8–10]. The hospital has full complement of staffing numbers and expertise Monday through Friday from 8 am to 5 pm, but patients with AMI cannot schedule to have their acute presentation during these 'office hours'.

Is the solution to work more and harder during off-hours, or are there ways to work smarter and differently? With the high cost of healthcare, simply adding more hospital staff to work during off-hours is not feasible. Instead, we suggest redesigning systems of care to provide consistent care 24/7. Stroke center designation by the joint commission or other authoritative bodies has been shown to be associated with lower mortality and better functional outcomes for patients with acute ischemic stroke [11,12]. In fact, McKinney *et al.* found no mortality difference for patients admitted to comprehensive stroke centers on weekends compared with those admitted on weekdays, while admission to nonstroke centers on weekends was associated with higher mortality [13]. A meta-analysis of studies reporting stroke mortality confirms these findings [14]. Similarly, trauma center designation was associated with lower mortality for patients with moderate-to-severe injury [15], and Level I or II trauma centers were associated with smaller mortality increase during off-hours [16]. Mayo Clinic developed and implemented a regional STEMI protocol in 2004 to provide timely reperfusion therapy within a regional network of 28 STEMI referral hospitals [3]. The implementation of this system of care successfully led to achieving comparable door-to-balloon times and outcomes during off-hours versus regular hours for patients with STEMI [17]. All of these examples demonstrate that it is possible to achieve comparable outcomes during off-hours, and not by simply adding more hospital staff to work during off-hours.

The evidence suggests that we can develop and implement systems of care to provide consistent care 24/7 for patients with AMI with existing resources and staff. Since patients can develop AMI anytime and anywhere, these efforts need to be spread and adapted by healthcare organizations within their unique practice and geographic contexts. AMI care should be integrated into networks of coordinated care in which consistent protocols and care processes are applied 24/7. This potentially leads to more efficient utilization of existing resources such as catheterization laboratory, cardiac care units and specialty staff in designated centers. Establishing such systems would require multi-stakeholder engagement and formal accreditation system that is similar to stroke or trauma centers.

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Future efforts should explore causal linkages between potential attributes within the current healthcare system and difference in outcomes between off-hours and regular hours. Potential attributes include resource availability such as expertise and number of staff as well as human factors such as fatigue or sleep deprivation. Furthermore, more knowledge should be accumulated about implementation of effective AMI regional care systems and its association with mortality gap between off-hours and regular hours. Eventually, any patients who develop AMI should receive excellent care process and outcomes regardless of time of day or day of week.

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