Comparison of Outcomes Among Patients With Cardiogenic Shock Admitted on Weekends Versus Weekdays

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Cardiogenic shock (CS) is associated with high mortality and often requires involvement of a multidisciplinary provider team to deliver timely care. Care coordination is more difficult on weekends, which may lead to a delay in care. We sought to assess the effect of weekend admissions on outcomes in patients admitted with CS. Patients admitted with CS were identified from 2005 to 2014 in the National Inpatient Sample using ICD9 code 785.51. Baseline demographics, in-hospital procedures, and outcomes were obtained and compared by day of admission. A multivariable model was used to assess the impact of weekend admission on in-hospital mortality. A total of 875,054 CS admissions were identified (age 67.4 ± 15.1 years, 40.2% female, 72.1% Caucasian), with 23% of patients being admitted on weekends. Baseline co-morbidities were similar between groups. Weekend admissions were associated with higher in-hospital mortality (40.6% vs 37.5%) and cardiac arrest (20.3% vs 18.1%, p < 0.001 for both) consistently over the study period. Use of temporary and permanent mechanical support devices and heart transplantation were slightly less common for weekend admissions. In a multivariable model adjusting for relevant confounders, weekend admission was associated with a 10% increased mortality in patients with CS. In conclusion, patients with CS admitted on weekends had higher in-hospital mortality and were slightly less likely to receive mechanical support and advanced therapies compared with those admitted on weekdays. Future studies and health system initiatives should focus on rectifying these disparities with around-the-clock multidisciplinary coordinated care for CS. **(Am J Cardiol 2021;144:20−25)**

Cardiogenic shock (CS) is associated with high inpatient mortality,[1] despite modest improvement in recent years. Acute myocardial infarction with left ventricular dysfunction is the most frequent cause of CS, so advances in percutaneous intervention, hemodynamic monitoring, and support devices have driven this improvement.[2] However, early recognition and management of CS has also been shown to be essential in decreasing mortality.[3,4] Best practices in the care of patients with CS should entail a multispecialty team approach involving critical care physicians, advanced heart failure and interventional cardiologists, cardiothoracic surgeons, palliative care teams, nurses, and other providers to facilitate care and arrange for inter-hospital transfers, if necessary.[5,6] Delays in care delivery for patients with CS, for example due to time spent coordinating such multidisciplinary care, may lead to a cascade of worsening shock, multisystem organ failure, and death.[5] Availability of such consulting teams and support staff is generally greater on weekdays, compared with weekends,[7] and multiple studies have suggested worse outcomes for various medical conditions, when treated on weekends, irrespective of the disease severity.[8,9] We sought to study this "weekend effect" in CS care in a large national database of inpatient hospitalizations.

Methods

The National Inpatient Sample (NIS) is a publicly available database available online at https://www.distributor.hcup-us.ahrq.gov. It is a stratified sample of 20% of discharges from United States hospitals and includes almost 8 million hospital discharges per year. It represents more than 95% of the United States hospitalizations from 44 states participating in the Healthcare Cost and Utilization Project. As the NIS constitutes a random 20% sample of hospital discharges, we used the available weights to produce national estimates. In addition, the NIS went through a sampling change in 2012 from a clustered random sample to a completely random sample; we therefore used the updated trend weights to mimic a consistent weighting scheme across the years.

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Tweet: Patients with #CardiogenicShock admitted on weekends had higher in-hospital mortality and were slightly less likely to receive mechanical support and advanced therapies compared with those admitted on weekdays.

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For this analysis, patients were included between 2005 and 2014. The NIS was queried using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Baseline patient covariates were ascertained using the Elixhauser co-morbidity index to integrate covariates associated with in-hospital status.[10] Code 785.51 was used to capture patients with CS in the primary or secondary diagnosis fields. Additional ICD9 codes for the study (reflecting co-morbidities, procedures performed, and outcomes) are listed in Supplementary Table.

Categorical data are shown as frequencies and percentages, and were compared with the Cochran Armitage trend test across years of study. Continuous data are presented as mean ± standard deviation and tested with linear trend tests. To compare outcomes among CS patients admitted on weekends (Saturday and Sunday) versus weekdays, Multivariable logistic regression analysis was performed, adjusting for multiple baseline covariates found in Table 1. Elixhauser variables are commonly used to adjust for baseline characteristics in studies using the NIS,[11] and other variables were selected based upon clinical importance. Statistical analyses were performed using SAS 9.4 (Cary, North Carolina) with a "p value" of 0.05 marking statistical significance. The study was reviewed by the Institutional Review Board and approval was not required.

Results

Over the 10-year time period from 2005 through 2014, there were 875,054 total hospitalizations with a diagnosis of CS; 666,931 patients were admitted on weekdays and 208,118 were admitted on weekends. Table 1 summarizes baseline demographics and co-morbidities by weekday versus weekend admission. Mean age was 67.4 ± 15.1 years, 40.2% were women, and 72.1% were Caucasian. Patients were predominantly admitted to large (70.0%) and urban teaching (60.0%) hospitals. There were significantly more patients with a diagnosis of ST elevation myocardial infarction (STEMI) complicating their CS admitted on the weekend as compared with weekday (30.5% versus 26.0%, respectively). Overall myocardial infarction was also more common on the weekends (56.7% vs 50.2%, respectively). There were other small, non-clinically significant differences in baseline characteristics noted in Table 1.

The annual rate of hospital admissions with a diagnosis of CS more than doubled from 58,124 in 2005 to 125,620 in 2014, with a rise in admissions to urban teaching hospitals over time ($p < 0.001$, Supplementary Table 2). Patients admitted with CS also had increasing rates of most collected co-morbidities, implying greater rates of multimorbidity and/or higher case mix index over time. Finally, there was a rise in the use of ECMO and percutaneous mechanical support devices with a fall in IABP utilization over time ($p < 0.001$ for both) for both weekday and weekend admissions.

Overall, 38.3% died during hospitalization with a significant decreasing trend over time, from 45.7% in 2005 to 37.2% in 2014. Length of stay was 10.6 ± 13.7 days, without significant change over time. In Trends in hospital admissions and mortality over time are shown in Figure 1.

CS patients admitted on weekends were significantly less likely to undergo right heart catheterization, coronary artery bypass grafting , percutaneous mechanical circulatory support devices, left ventricular assist devices , extra corporeal membrane oxygenation (ECMO), or heart transplantation ($p<0.001$ for all) during admission (Table 2). However, patients admitted on weekends were more likely to undergo left heart catheterization and percutaneous transluminal coronary angioplasty as compared with those admitted on weekdays ($p <0.001$ for all), likely due to the higher rate of CS patients with STEMI who were admitted on weekends. Right heart catheterization utilization increased over time in weekday patients (10.7% to 12.6%) but not in weekend patients (10.2% to 10.4%, Supplementary Table 2). Severe non-cardiac complications were also increased on the weekend including septic shock, acute kidney injury, acute liver injury, and the need for mechanical ventilation (Table 2).

Weekend admissions were associated with a significantly higher in-hospital mortality (40.6% vs. 37.5%, $p<0.001$) and cardiac arrest (20.3% vs 18.1%, $p<0.001$) as compared with weekdays. This difference was consistent over the study period, even as overall mortality decreased over time (Figure 1). A multivariable model adjusting for all variables in Table 1, weekend admission was associated with a significantly higher risk of inpatient mortality for CS (hazard ratio 1.10, 95% confidence interval 1.07 to 1.13, $p <0.001$). A summary of the findings is found in the Figure 2.

Interactions between weekend admission and hospital region and bed size were not significant ($p = 0.642$ and 0.147, respectively). There was a borderline interaction between hospital teaching status and weekend admission ($p = 0.028$), where weekend admissions in urban teaching and non-teaching hospitals were associated with increased mortality ($p < 0.001$ for both) while weekend admissions in rural hospitals were not ($p = 0.368$).

Discussion

This study of patients in a national multi-center inpatient registry examines trends in cardiogenic shock admissions over time and associations between weekend admission and subsequent in-hospital outcomes. Using this nationwide analysis from 2005 to 2014, we identified more than 875,000 admissions with primary or secondary diagnosis of CS; mortality was 38%, but decreased over the ten-year study period. More than 40% of patients admitted on weekends died prior to hospital discharge, as compared with only 37.5% of those admitted on weekdays, and trends remained consistent throughout the study period. After adjustment for clinically relevant variables, weekend admission was associated with a 10% increase in mortality.

It is interesting to note the trend of increasing mechanical circulatory support devices such as ECMO and percutaneous mechanical support devices (ie Impella), while IABP use has decreased. This is consistent with other studies.[12] Compared with weekdays, patients admitted in CS on the weekends were more likely to have a diagnosis of a myocardial infarction and more likely to receive PTCA. Weekday admissions were more likely to undergo coronary artery bypass grafting. The rates of right heart catheterization, left ventricular assist devices, ECMO, or heart transplant were significantly reduced on weekends as compared with weekdays. These findings speak to the fact that

Table 1
Baseline characteristics of patients with cardiogenic shock

Variable	Total (n = 875,054)	Weekend admission (n = 208,118)	Weekday admission (n = 666,931)	p Value
Age (years)	67.36 ± 15.12	67.37 ± 15.33	67.36 ± 15.05	0.883
Women	351556 (40.2%)	84209 (40.5%)	267347 (40.1%)	0.002
				0.646
White	547614 (72.1%)	130205 (72.2%)	417409 (72.1%)	
Black	92911 (12.2%)	21462 (11.9%)	71444 (12.3%)	
Hispanic	62040 (8.2%)	15543 (8.6%)	46497 (8.0%)	
Other	56793 (7.5%)	13090 (7.3%)	43703 (7.5%)	
Myocardial infarction	453131 (51.8%)	118052 (56.7%)	335074 (50.2%)	< 0.001
ST elevation myocardial infarction	237032 (27.1%)	63373 (30.5%)	173660 (26.0%)	< 0.001
Cardiac arrhythmia	462483 (52.9%)	108692 (52.2%)	353786 (53.0%)	< 0.001
Heart block or conduction disease	90586 (10.4%)	23019 (11.1%)	67567 (10.1%)	< 0.001
Pulmonary hypertension	77808 (8.9%)	16355 (7.9%)	61453 (9.2%)	< 0.001
History of pacemaker	18484 (2.1%)	4420 (2.1%)	14064 (2.1%)	0.679
History of debrillator	30731 (3.5%)	6374 (3.1%)	24357 (3.7%)	< 0.001
AHRQ comorbidity measure				
Acquired immune deficiency syndrome	1649 (0.2%)	413 (0.2%)	1235 (0.2%)	0.219
Alcohol abuse	38301 (4.4%)	10111 (4.9%)	28190 (4.2%)	< 0.001
Deficiency anemias	183207 (20.9%)	44143 (21.2%)	139064 (20.9%)	< 0.001
Rheumatoid arthritis/collagen vascular diseases	19211 (2.2%)	4256 (2.0%)	14955 (2.2%)	< 0.001
Chronic blood loss anemia	13382 (1.5%)	3072 (1.5%)	10310 (1.5%)	0.023
Congestive heart failure	182800 (20.9%)	45197 (21.7%)	137602 (20.6%)	< 0.001
Chronic pulmonary disease	209695 (24.0%)	49824 (23.9%)	159866 (24.0%)	0.778
Coagulopathy	170305 (19.5%)	37058 (17.8%)	133247 (20.0%)	< 0.001
Depression	50547 (5.8%)	11752 (5.6%)	38794 (5.8%)	0.003
Diabetes, uncomplicated	217602 (24.9%)	51750 (24.9%)	165847 (24.9%)	0.988
Diabetes with chronic complications	58325 (6.7%)	13483 (6.5%)	44842 (6.7%)	< 0.001
Drug abuse	23653 (2.7%)	6387 (3.1%)	17266 (2.6%)	< 0.001
Hypertension	454083 (51.9%)	107845 (51.8%)	346233 (51.9%)	0.449
Hypothyroidism	85206 (9.7%)	19748 (9.5%)	65458 (9.8%)	< 0.001
Liver disease	29219 (3.3%)	7031 (3.4%)	22188 (3.3%)	0.253
Lymphoma	8259 (0.9%)	1751 (0.8%)	6507 (1.0%)	< 0.001
Fluid and electrolyte disorders	472277 (54.0%)	112785 (54.2%)	359492 (53.9%)	0.020
Metastatic cancer	14520 (1.7%)	3483 (1.7%)	11037 (1.7%)	0.556
Other neurological disorders	69761 (8.0%)	17618 (8.5%)	52144 (7.8%)	< 0.001
Obesity	94295 (10.8%)	21740 (10.4%)	72550 (10.9%)	< 0.001
Paralysis	23623 (2.7%)	5574 (2.7%)	18049 (2.7%)	0.488
Peripheral vascular disorders	107127 (12.2%)	24379 (11.7%)	82748 (12.4%)	< 0.001
Psychoses	23274 (2.7%)	5719 (2.7%)	17556 (2.6%)	0.004
Pulmonary circulation disorders	40871 (4.7%)	9825 (4.7%)	31046 (4.7%)	0.213
Renal failure	234576 (26.8%)	54191 (26.0%)	180380 (27.0%)	< 0.001
Solid tumor without metastasis	16729 (1.9%)	4039 (1.9%)	12690 (1.9%)	0.269
Peptic ulcer disease	291 (0.0%)	62 (0.0%)	229 (0.0%)	0.327
Valvular disease	55356 (6.3%)	13097 (6.3%)	42259 (6.3%)	0.476
Weight loss	92844 (10.6%)	20508 (9.9%)	72336 (10.8%)	< 0.001
Bed size of hospital				< 0.001
Small	73302 (8.4%)	18064 (8.7%)	55238 (8.3%)	
Medium	187981 (21.6%)	44888 (21.7%)	143093 (21.5%)	
Large	610048 (70.0%)	144302 (69.6%)	465741 (70.1%)	
Location/teaching status of hospital				< 0.001
Rural	51971 (6.0%)	12959 (6.3%)	39012 (5.9%)	
Urban nonteaching	296854 (34.1%)	74763 (36.1%)	222091 (33.4%)	
Urban teaching	522506 (60.0%)	119532 (57.7%)	402969 (60.7%)	
Region of hospital				< 0.001
Northeast	160736 (18.4%)	37584 (18.1%)	123152 (18.5%)	
Midwest	194898 (22.3%)	46093 (22.1%)	148805 (22.3%)	
South	328897 (37.6%)	78055 (37.5%)	250837 (37.6%)	
West	190523 (21.8%)	46386 (22.3%)	144137 (21.6%)	

Legend: AHRQ = Agency for Healthcare Research and Quality

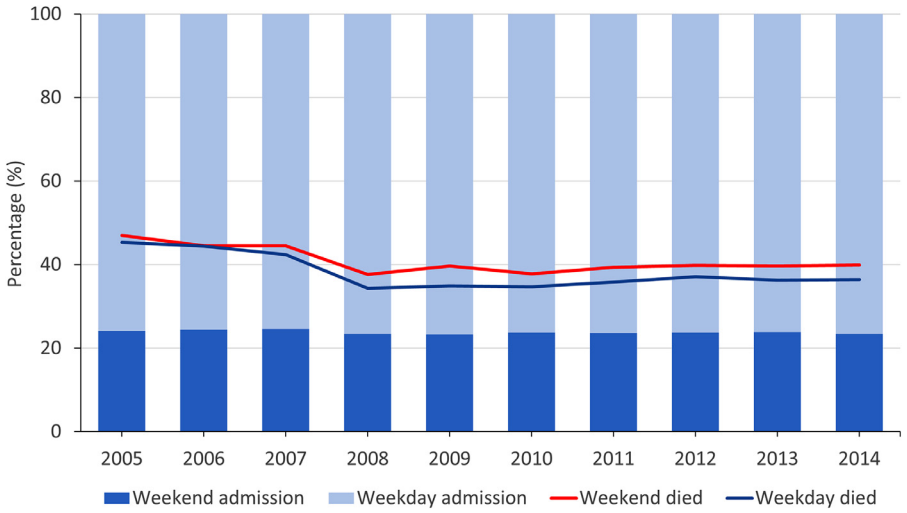

Figure 1. Trends in Weekend Admissions - The bars demonstrate a stable percentage of weekday versus weekend admissions the study period. The lines show a higher in-hospital mortality in patients admitted on the weekends, which is consistent over time.

procedures and surgeries requiring more time and planning were less common for patients admitted on the weekends. Additionally, the interaction noted between weekend admission and urban versus rural hospitals may be associated with a higher case-mix index at urban hospitals.

Prior studies have examined the "weekend effect" among hospitalized patients with various medical and surgical conditions. Seminal work by Bell and colleagues in 2001 reported a significantly increased mortality on weekends among all hospitalized patients.[8] Additional studies have examined this "weekend effect" in patients with cardiovascular disease. In patients with myocardial infarction, there was increased mortality and decreased performance of invasive procedures for weekend admissions as

Table 2
Outcomes in patients with cardiogenic shock

Outcomes	Total (n = 875,054)	Weekend admission (n = 208,118)	Weekday admission (n = 666,931)	p Value
Disposition of patient				< 0.001
Routine	185087 (21.2%)	43729 (21.0%)	141358 (21.2%)	
Transfer to Short Term Hospital	54891 (6.3%)	13304 (6.4%)	41587 (6.2%)	
Transfer to SNF/ICF	189701 (21.7%)	43088 (20.7%)	146613 (22.0%)	
Home health	106080 (12.1%)	22389 (10.8%)	83686 (12.6%)	
Against medical advice	2811 (0.3%)	731 (0.4%)	2080 (0.3%)	
Died	334522 (38.3%)	84378 (40.6%)	250144 (37.5%)	
Alive, Destination Unknown	1419 (0.2%)	391 (0.2%)	1028 (0.2%)	
Length of stay	11.51 ± 14.98	10.55 ± 13.65	11.81 ± 15.36	< 0.001
Complications				
Acute liver injury	102740 (11.7%)	25631 (12.3%)	77110 (11.6%)	< 0.001
Acute kidney injury	423872 (48.4%)	101969 (49.0%)	321898 (48.3%)	< 0.001
Septic shock	115215 (13.2%)	29115 (14.0%)	86100 (12.9%)	< 0.001
Ventilator	443676 (50.7%)	111086 (53.4%)	332590 (49.9%)	< 0.001
Dialysis	84806 (9.7%)	18924 (9.1%)	65882 (9.9%)	< 0.001
Cardiac arrest	163136 (18.6%)	42231 (20.3%)	120905 (18.1%)	< 0.001
Procedures				
Pacemaker insertion	14717 (1.7%)	3271 (1.6%)	11447 (1.7%)	< 0.001
ICD insertion	15571 (1.8%)	3656 (1.8%)	11915 (1.8%)	0.366
Right heart catheterization	103002 (11.8%)	22210 (10.7%)	80792 (12.1%)	< 0.001
Left heart catheterization	289117 (33.0%)	71635 (34.4%)	217482 (32.6%)	< 0.001
PTCA	180144 (20.6%)	47653 (22.9%)	132491 (19.9%)	< 0.001
Coronary artery bypass grafting	105900 (12.1%)	18851 (9.1%)	87044 (13.1%)	< 0.001
Percutaneous support device	10511 (1.2%)	2329 (1.1%)	8181 (1.2%)	< 0.001
Intra-aortic balloon pump	211914 (24.2%)	50317 (24.2%)	161597 (24.2%)	0.623
ECMO	10647 (1.2%)	2183 (1.0%)	8464 (1.3%)	< 0.001
Left ventricular assist device	15276 (1.7%)	2465 (1.2%)	12811 (1.9%)	< 0.001
Heart transplantation	5602 (0.6%)	963 (0.5%)	4639 (0.7%)	< 0.001

Legend: ECMO = extracorporeal membrane oxygenation; ICD = implantable cardioverter defibrillator; ICF = intermediate care facility; PTCA = percutaneous transluminal coronary angioplasty; SNF = skilled nursing facility.

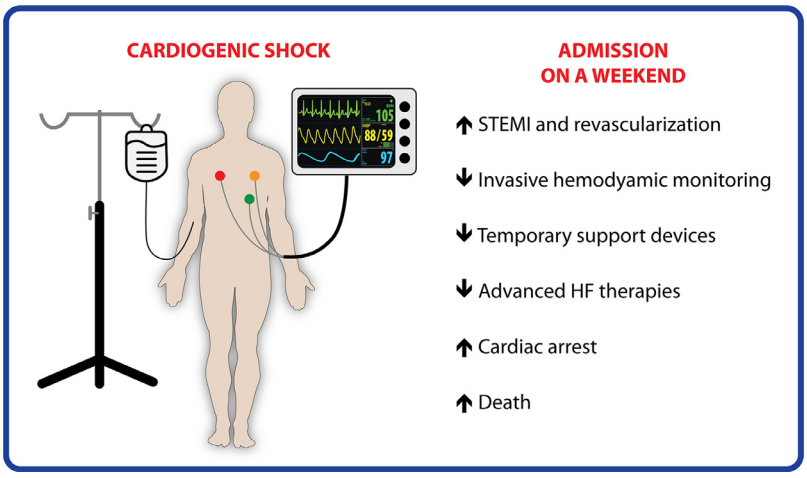

Figure 2. Outcomes associated with weekend admission – Patients admitted on weekends were more likely to have STEMI with revascularization, while less likely to have right heart catheterizations, temporary mechanical support devices, and advanced heart failure therapies like heart transplantation of left ventricular assist device. In-hospital cardiac arrest and death were also significantly higher for patients admitted on weekends.

compared with weekdays.[13] Weekend admissions for atrial fibrillations were associated with increased mortality, less cardioversions, and longer hospital stays.[14] Differential care for heart failure was also evident given the day of week; in 1 study, Friday was associated with the highest discharge and 30-day heart failure readmission rate and weekend heart failure admissions experienced more myocardial infarction, had greater co-morbidities, received less cardiac procedures and predicted higher in-hospital mortality.[15] Another study suggested doubling of in-hospital mortality among patients admitted with heart failure on weekends.[16]

Questioning the safety and quality of medical care on weekends has been a matter of debate with many prior observational studies signaling a worsened outcome after multivariable adjustment. One such study found that both patients and healthcare teams were aware of suboptimal staffing numbers, skill mix, and access to resources on weekends.[17] This may be linked to lower care quality, safety, and patient experience.

This gap in weekend care creates a needed opportunity for multidisciplinary collaboration. Standard team-based care of patients with CS, or "shock teams," have been heralded as effective strategies to improve outcomes in these patients. Several studies have shown that these teams are feasible, and simple algorithms can be used by such teams to risk stratify and guide clinical decision-making.[18] Although public reporting of hospital mortality and readmission rates has led to improvements in coordination of care, these institutional resources are typically much easier to access and mobilize during weekdays. Time is of the essence in patients with shock states, and a multidisciplinary team that can be activated rapidly, regardless of time of the week, is likely to be helpful in further decreasing mortality rates.

This study must be interpreted in the context of the following limitations. First, as with all studies involving the NIS, administrative data are limited due to the accuracy of coding and potentially clinically important details may be missing. The timing and/or sequence of documented diagnoses and performed procedures cannot be assessed in relation to hospital admission using the NIS database. The increased presence of co-morbidities over time could be a reflection of accurate coding rather than a "sicker" population. There is a seemingly low rate of coronary angiography (33%) in this cohort of patients with CS, though only about half of the patients with CS had acute myocardial infarction, and 13% had concomitant septic shock.

In conclusion, in a national multicenter inpatient registry of patients admitted with a diagnosis of CS, over one-third of patients died in the hospital, a trend that has improved slightly over time. Hospital admission for CS on the weekend is associated with a 10% increase in mortality, after adjusting for relevant confounding variables. System-based efforts in around-the-clock multidisciplinary care coordination may allow for continued improvements in mortality for CS and a narrowing of the deleterious effect of weekend admission on mortality.

Credit Author Statement

Ahmed A. Harhash, MD: conceptualization, writing – original draft; Kevin F. Kennedy, MS: software, methodology, formal analysis; Timothy J. Fendler, MD: writing – review & editing; Taiyeb M. Khumri, MD: writing – review & editing; Michael E. Nassif, MD: writing – review & editing; Anthony Magalski: writing – review & editing; Brett W. Sperry, MD: conceptualization, methodology, writing – review & editing, visualization, supervision.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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none

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2020.12.061.

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