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ORIGINAL RESEARCH

Shortening Door-to-Balloon Time: The Use of Ambulance versus Private Vehicle for Patients with ST-Segment Elevation Acute Myocardial Infarction

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Purpose: Time is critical when dealing with acute myocardial infarction (AMI) patients in the Emergency Department (ED), as 90 min is crucial for overall health. Using non-EMS transportation for critical patients, such as patients with acute myocardial infarction, to a hospital might delay the rapid identification of the underlying medical disease and initiating definitive treatment. We aim to evaluate the association between the mode of transportation and the D2B time in patients presenting at the ED with AMI.

Patients and Methods: We conducted a retrospective cohort study with patients who presented at ED with AMI and underwent percutaneous coronary intervention (PCI). The participants were patients with confirmed AMI at the ED of King Abdullah Medical City (KAMC) from January 2019 to December 2019.

Results: In total, 162 AMI patients were enrolled in the study and divided based on the method of transportation. Less than half (n=65, 40.1%) were transported with an ambulance and 97 (59.9%) patients with a private car. The door-to-balloon (D2B) time for the ambulance group was 93.6±38.31 minutes, and the private car group was 93.8±30.88 minutes.

Conclusion: There was no statistical significance when comparing the D2B time between the private car group and the ambulance group (P = 0.1870). Finally, ambulance transport significantly shortened the time to first ED physician contact. However, it was not associated with shortened D2B time when compared to private vehicle transport.

Keywords: chest pain, acute myocardial infarction, ambulance, door to balloon, emergency department

Introduction

Emergency departments (EDs) receive a significant number of patients complaining of chest pain, constituting 5.3 million visits annually.[1] This significant number of visits increases healthcare concerns regarding the rising incidence of cardiovascular diseases (CVDs). A new incident of coronary heart disease (CHD) occurs in the USA every 42 s.[2] CVDs were not a concern in the early twentieth century; however, they now account for more than half of all mortality in developed countries and 25% in developing countries.[3] Evidence showed that 76% of mortality due to CHD occurred outside of hospital.[2] More than 200,000 CHD-related mortality rates annually occur in or out of the hospital.[2] The significant burden of CHD-related mortality globally has focused the attention on Gulf Council countries, including Saudi Arabia.[4]

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The World Health Organization reported the impact of CVD in Saudi Arabia in 2018. More than a third (37%) of deaths in 2016 were linked to CVD.[5] Acute coronary syndrome (ACS) is a type of CHD that contributes significantly to mortality in people older than 35 years.

Almost half of CVD-related mortality globally was caused by ischemic heart disease, also known as myocardial infarction (MI) (8). According to the patient's electrocardiogram (ECG), acute myocardial infarction (AMI) can be categorized into ST-elevation (STEMI) or non-ST-elevation (NSTEMI). Both types of MI can be fatal to the patient. Studies have reported that MI is the cause of death of 1.8 million people every year in Europe alone.[6] A study revealed that patients with STEMI have a higher in-hospital mortality rate, compared to patients with NSTEMI who have a worse long-term prognosis.[6] This highlights the importance of early recognition, transportation, and treatment of patients with STEMI.

Patients complaining of STEMI myocardial infarction are time critical. Any delay in recognizing and diagnosing STEMI myocardial infarction and/or providing definitive treatment can increase the risk of adverse outcomes including severe complications (eg, cardiogenic shock, heart failure, and pericarditis) and mortality.[6] Restoring blood flow in a timely manner through primary percutaneous coronary intervention (PCI) is the definitive treatment in most cases of STEMI myocardial infarction. Time is critical when dealing with patients having STEMI myocardial infarction, as 90 min is crucial for overall health. Clinical studies have indicated that a shorter door-to-balloon (D2B) time is linked to lower in-hospital mortality for patients with STEMI myocardial infarction.[7] The American College of Cardiology Foundation/American Heart Association (ACCF/AHA) recommends that the optimal "Door-to-needle time" is 90 min or less; starting from the representation at the ED, to the recommended reperfusion therapy, percutaneous coronary intervention (PCI).[8]

Using non-EMS transportation to transport critical patients, such as patients with STEMI myocardial infarction, to hospitals might delay the rapid identification of the underlying medical disease and definitive treatment. Non-EMS transportation could be delayed by the usual traffic congestion, hospital registration, and hospital triaging. These obstacles could be avoided when patients are transported by an EMS ambulance. Several studies have reported that the method of transportation plays a major role.[1,9] Several studies have measured the effect of the method of transportation.[1,10] However, there is a lack of data in Saudi Arabia about the effect of the method of transportation on the outcomes of patients complaining of STEMI myocardial infarction. This study aims to evaluate the association between the mode of transportation (ambulance vs self-transportation) and the D2B time in patients presenting at the ED with STEMI myocardial infarction.

Materials and Methods

Study Settings and Population

This was a retrospective cohort study with patients who presented at ED with AMI and underwent PCI. It aims to measure the D2B time when using different transportation methods. The inclusion criteria were patients with confirmed AMI at the ED of King Abdullah Medical City (KAMC) from January 2019 to December 2019.

The participants were registered in KAMC medical records, and the data was managed by the Cardiac Sciences Department in King Abdulaziz Cardiac Center at KAMC. All the required data were requested from the Cardiac Sciences Research and Data Governance Committee in a meeting to conduct the study. After approval, the data were retrieved, which included the time reported during the journey of the AMI patient from the ED to the placement of the stent. Other data related to the history and demographic information of the patients were collected independently on a separate sheet from the participants' medical records in the BEST Care System. The mode of transportation in this study was limited to using a private car or an EMS ambulance. Other methods were excluded from the study. The data related to the method of transportation was gathered in different databases. For the ambulance group, the data was retrieved from the ambulance database in the ED. The data of the private car group was retrieved from the medical records in the BESTCare system. A total of 171 patients with AMI were included, 9 patients were excluded due to missing time stamps. The final sample size was 162 eligible patients (Figure 1).

Exposure Definitions

The process of diagnosing AMI patients is initiated in the ED and finalized at the Cardiology Department. After confirmation of an AMI incident at the ED, the cardiologist is called to confirm and activate the cath lab. The time measured in this study

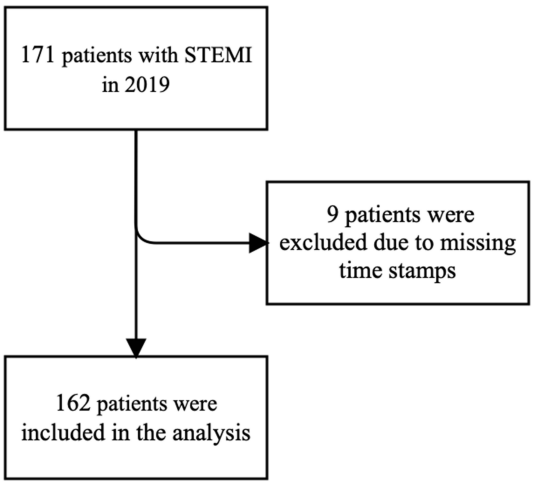

Figure 1 Flow chart of study population.

was the patient's journey from the ED to cath lab. The D2B time is measured as the time difference between the registration of the patient in the ED and the insertion of the catheter through the lesion. Triage-to-ECG is the time difference between the registration of a patient in ED and the first ECG done. The triage-to-ER physician is the time difference between the registration of a patient in ED to first ER physician contact with the patient. The activation of the cath lab was measured as the time difference between the registration of patient in ED and the activation of cath lab. The length of hospital stay was also collected for both modes of transportation.

Gender and age were collected to provide sociodemographic information of the sample. Past medical history included variables relevant to diabetes, hypertension, previous MI, previous angina, dyslipidemia, smoking, and stroke. The duration of symptoms was described as more than or less than 3 hr. The type of MI on the ECG was listed as anterior wall, septal wall, lateral wall, inferior wall, and posterior wall. The first vital signs taken at ED were collected and included blood pressure, heart rate, and oxygen saturation. The discharge date was retrieved from medical records.

Statistical Analysis

After completing the data collection, data were analyzed with the SAS 9.4 software (SAS Institute Inc., Cary, NC, USA). The tests used were an independent *t*-test, Wilcoxon rank sum test, chi-square test, and Fisher's exact test. The continuous variables in the study are expressed as mean ± SD, median, and quartile interval, and the categorical variables as cases (n) and percentage (%).

Ethics Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board King Abdullah International Medical Research Center, Riyadh, KSA (IRBC/2087/21). The data accessed complied with relevant data protection and privacy regulations.

Results

The sample was realized as 162 AMI patients, classified by method of transportation. Less than half (n=65, 40.1%) used an ambulance and 97 (59.9%) a private car. The majority (86.4%) were male, and the mean age was 58.3±12.89 years (Table 1). The chief complaint was chest pain in 148 (91.4%) of the cases. The past medical history of the patients was diabetes (n=75, 46.3%), hypertension (n=69, 42.6%), smoking (n=53, 32.7%), dyslipidemia (n=32, 19.8%), previous MI (n=27, 16.7%), and stroke (n=5, 3.1%). The time from symptom onset was divided in two periods: >3 hours and <3 hours. More than half of the patients (89, 54.9% experienced symptoms for more than 3 hr before seeking medical intervention). The mean of length of stay for the ambulance group was 13.0±45.84, and the car group was 7.4±5.06 (P = 0.5137). The triage to ECG mean in the ambulance group was 5.9±6.22 minutes and in the car group 8.4±17.50 minutes (P = 0.7646). The time of first contact with an

Table 1 Patient Characteristics, Time Interval, and Final Diagnosis According to the Way of Transportation

	Total	By Ambulance	By Private Car	p-value
Cases, n (%)	162 (100)	65 (40)	97 (60)	
Age, years, median (IQR)	58.5 (50, 67)	58.0 (51, 64)	59.0 (49, 68)	0.74
Sex				
Male, n (%)	140 (86)	55 (39)	85 (61)	0.58
Female, n (%)	22 (14)	10 (45)	12 (55)	
Chief Complaint, n (%)				
Chest Pain	148 (91.4)	58 (89.2)	90 (92.8)	0.43
Non-Chest Pain	14 (8.6)	7 (10.8)	7 (7.2)	
Past Medical History				
Hypertension	69 (42.6)	29 (44.6)	40 (41.2)	0.67
Stroke	5 (3.1)	1 (1.5)	4 (4.1)	0.64
Smoking	53 (32.7)	21 (32.3)	32 (33.0)	0.92
Diabetes mellitus	75 (46.3)	27 (41.5)	48 (49.5)	0.32
Vitals Sings, mean (SD)				
Heart Rate (bpm)	82.1 (20.9)	82.1 (19.7)	82.1 (21.7)	0.99
Systolic (mmHg)	136.6 (25.6)	137.0 (27.1)	136.3 (24.7)	0.87
Diastolic (mmHg)	82.5 (18.9)	84.3 (19.2)	81.4 (18.7)	0.32
SpO2	97.4 (3.25)	97.5 (2.6)	97.3 (3.7)	0.99
Time, mean (SD)				
Time from Symptom onset	<3 hours	<3 hours	<3 hours	0.82
	73 (45%)	30 (46%)	43 (44%)	
	>3 hours	>3hours	>3hours	
	89 (55%)	35 (54%)	54 (56%)	
Time form Triage to First ECG	7.4 (14)	5.9 (6)	8.4 (17.5)	0.76
Time form Triage to First Contact Physician	9 (16.8)	4.6 (8.7)	12 (20)	<0.0001
Time form Triage to First Contact Cardiology	13.8 (19)	16.2 (23.8)	12.1 (15.2)	0.36
Time from Triage to Cardiology	22.8 (26.2)	20.8 (26.1)	24.1 (26.3)	0.06
Time form Triage to activation of the Cath Lab	33.7 (29.4)	33.1 (31.5)	34.1 (28.1)	0.10
Time to Door to Balloon	93.7 (33.9)	93.6 (38.3)	93.8 (30.9)	0.18

(*Continued*)

Table 1 (Continued).

	Total	By Ambulance	By Private Car	p-value
Type of STEMI, n (%)				
Anterior Wall (V2 to V4)	69 (42.6)	29 (44.6)	40 (41.2)	0.67
Lateral Wall (I, aVL, V5, V6)	29 (17.9)	14 (21.5)	15 (15.5)	0.32
Posterior Wall (V1 to V4)	19 (11.7)	6 (9.2)	13 (13.4)	0.41
Septal Wall (V1 and V2)	3 (1.9)	1 (1.5)	2 (2.1)	1.00
Inferior Wall (II, III, aVF)	85 (52.5)	32 (49.2)	53 (54.6)	0.49

Abbreviations: AMI, Acute myocardial infarction; ED, Emergency Department; KAMC, King Abdullah Medical City; CVSs, cardiovascular diseases; CHD, coronary heart disease; ACS, Acute coronary syndrome; PCI, primary percutaneous coronary intervention; D2B, door-to-balloon.

ER physician was lower in the ambulance group 4.6±8.75) than the car group 12.0±20.13, which was statistically significant (P = <0.0001). The time of activation of the cath lab in the ambulance group was 33.1±31.47 minutes, and the car group 34.1 ±28.13 minutes (P = 0.1001). The D2B time for the ambulance group was 93.6±38.31 minutes, and the private car group was 93.8±30.88 minutes. There was no statistical significance when comparing D2B time between the two groups (P = 0.1870). Finally, primary PCIs for STEMI were performed during on-hours (Sunday-Thursday 08:00 AM-17:00 PM) for 39 patients (24.1%), while 123 patients (75.9%) underwent the procedures during off-hours (Sunday-Thursday 17:01 PM-06:59 AM, Saturday, Friday, and nonworking holidays).

Discussion

This study aims to assess the association between the modes of transportation, ambulance or private vehicle, with the D2B time for patients presenting with AMI. The findings of this study showed that although ambulance transport significantly shortened the time to first contact with an ED physician, there was no significant association between ambulance transport and D2B time compared to private vehicle transport. There was also no significant association between ambulance or private transport, in terms of in-hospital length of stay, triage to ECG time, and time to cath lab activation. The study indicated that the most frequent presenting complaint for patients with AMI, was chest pain (91.4%). The study highlighted the issue of delayed action from patients seeking medical attention as almost 55% waited for more than 3 hr from the start of their symptoms to access medical care. The findings of this study showed no difference between ambulance and private vehicle transport in reducing D2B time and improving mortality rates. Patients possibly lacked awareness of the signs and symptoms of AMI, as indicated by their delayed response to seek medical attention. This could have impacted the findings of our study, and active actions to improve public awareness about cardiac diseases are required. International literature reported a shortened D2B time and symptom onset to balloon time when patients were transported via ambulance (P<0.001).[11,12] These findings are not consistent with our findings, which showed no significant reduction in D2B time (P=0.1870). Our findings show that EMS transport is significantly associated with a shortened time to first ED physician contact compared to private vehicle transport (P<0.001). This achieved the purpose of using an ambulance to reduce the time to get the patient to the hospital, but it was not reflected in a significantly shortened D2B time. This was possibly due to a prolonged time after the patients arrived at the ED to balloon time despite the significant difference in the time to first contact with an ER physician in the ambulance group. It is interesting to note that there was no significant difference between the activation time of the cath lab and D2B time between the two groups. A possible explanation for these results might be the optimized ECG interpretation and cleared management pathway for ACS.[13]

With regard to the proportions of patients using EMS transport, a study from Saudi Arabia reported that EMS was used by only 5.2% of patients with acute coronary syndrome (ACS).[14] Another Saudi Arabian study also reported that of 5055 patients with ACS, 5% had STEMI and only 5.1% were transported via ambulance.[15] However, our study found a higher rate of AMI patients transported by EMS (40.1%). In this context, existing evidence showed that private vehicle

transport for patients with STEMI will affect the time of perfusion therapy with PCI, even if the D2B time is shortened, possibly due to late identification and transport prior to getting patients to a hospital.[16]

In the current study, both modes of transportation were slightly above the D2B time recommended by the AHA and ACC (within 90 min). Patients transported by an EMS ambulance spent an average of 93.6 min with no significant difference compared to private car transportation (93.8 min). Butt and Bashtawi[5] conducted a study in Riyadh, Saudi Arabia, and reported a D2B of 83 min. This time is shorter than in our study. Moreover, primary PCIs in STEMI were performed twice as often during off-hours as during on-hours which could be a reason of the delay.[17] An investigation of the barriers delaying the D2B time in KAMC and improvement strategies is recommended.

In this study, we encountered several limitations. First, the retrospective nature of this study prevented collecting important variables, including the level of EMS team transporting the patient and level of education and awareness of the patients and their relatives about cardiac emergencies. Another limitation is that the data were collected from a single center. The aim of the study was to determine if using an ambulance could shorten the D2B time compared to private vehicle transport. We were unable to collect data on the possible factors that could impact the D2B time, especially because our findings showed no significant difference in the D2B time based on the mode of transportation.

The current study has significant implications for research and clinical practice. This study is one of few studies comparing the impact of the mode of transportation on D2B time nationally and internationally, which could add a value to existing literature. For clinical practice, it showed a delayed D2B time even when the patients transported via ambulance, which significantly reduced the time of the patient's arrival at the ED. For research, our study highlights several issues related to public awareness about the identification of cardiac diseases, which needs to be addressed. It also highlighted the need for further studies, including large national studies, to investigate the impact of the mode of transportation on D2B time, the factors that could affect D2B time upon patient arrival at the hospital, and the outcomes.

Conclusion

This study assessed the impact of the mode of transportation on the D2B time. Ambulance transport significantly shortened the time to first ED physician contact. However, it was not associated with a shortened D2B time compared to private vehicle transport. The study found that 41.1% of patients with AMI were transported via ambulance, which is higher than comparable Saudi Arabian literature. The findings of this study showed that, although ambulance transport significantly shortened the time to first contact with an ED physician, there was no significant association between ambulance transport and D2B time compared to private vehicle transport. The findings highlight the need for further studies investigating public awareness about the assessment and identification of cardiac emergencies. It also showed that there is a need to conduct further national studies investigating the impact of the mode of transportation on the D2B time, the factors that could affect the D2B time after the patient's arrival to a hospital, and the outcomes.

Ambulance transport shortened the time to first ED physician contact; however, it was not associated with a shortened D2B time compared to private vehicle transport. This study highlights the need for further public awareness about cardiac emergencies and national studies on D2B time and its impact on outcomes.

Disclosure

The authors report no conflicts of interest in this work.

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