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Original Article

The impact of telecardiology on the outcome of patients with myocardial infarction transported by Tehran's emergency medical services to selected hospitals of Tehran city

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ABSTRACT

Background & Aim: Clinical outcomes and mortality rate of patients with ST-segment elevation myocardial infarction (STEMI) strongly depend on the time of percutaneous coronary intervention (PCI). One way to reduce the delay in this treatment is to use telecardiology in the prehospital setting. The purpose of this study was for comparison of telecardiology on the first medical contact to balloon time and outcome (size of infarct area, left ventricular ejection fraction, and major adverse cardiac events) of patients with myocardial infarction (MI) transported by Tehran Emergency Medical Services to selected hospitals in Tehran, Iran.
Methods & Materials: The present retrospective, comparative study was conducted in 2018 in Tehran city on the medical records of 300 patients with STEMI transported with and without telecardiology (150 records per group). Data for this study included demographic characteristics; how to transport the patients to medical centers, first medical contact to balloon time (FMCTB), and clinical outcomes. Data were analyzed using independent t-test, Fisher's exact test, Chi-square, Mann-Whitney and Kruskal-Wallis test by SPSS software, Version 20.
Results: First medical contact to balloon (FMCTB) time, infarction size based on creatine kinase, the patient mortality rate in one month, and repeated PCI in the group transported with telecardiology was significantly lower than that of the group transported without telecardiology ($P<0.05$). Left ventricular ejection fraction (LVEF) in the first 24 hours, infarction size based on troponin I level, the rate of readmission due to acute coronary syndrome (ACS) and the rate of coronary artery bypass grafting (CABG) were not statistically significant between the two groups ($P<0.05$).
Conclusion: The results of this study showed that the use of telecardiology could reduce the delay in performing PCI and improve some of the clinical outcomes of patients with STEMI. These results can be used to improve the quality of care for patients with STEMI by pre-hospital emergency personnel, physicians and nurses involved in the care of these patients.

Introduction

Coronary artery disease (CAD) is the most common cardiovascular disease (1), which is the leading cause of death in the United States (2). In Iran, 120 to 140 thousand people die each year due to CAD (3) ST-segment elevation myocardial infarction (STEMI) is a type of acute coronary syndrome which develops due to total coronary occlusion (4).

Accepted treatments for acute STEMI include thrombolytic therapy and percutaneous coronary intervention (PCI), but existing guidelines all agree that PCI is a preferred therapeutic approach and is more effective in reducing mortality rates and improving patient outcomes (5). The PCI refers to all interventions of coronary artery repairment that are performed through catheterization and under fluoroscopic

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guidance and increases the diameter of coronary arteries and circulation (6).

It is important to note that the effectiveness of PCI in treating patients with STEMI strongly depends on the time of the intervention (7), and the delay in reperfusion is about infarct size, chronic heart failure, and mortality rate of patients (8). Also, the PCI is more efficient than thrombolytic therapy only when the PCI is performed on time (9).

Measures such as door-to-balloon (DTB) time and first medical contact to balloon (FMCTB) time have been defined to evaluate "timely reperfusion"(10). The time of DTB is defined as "time interval between hospital arrival and the time of the first balloon inflation and reperfusion"(11). The FMCTB is defined as the "time interval between the first examination of the patient by the emergency medical services and the time of the first balloon inflation." The FMCTB is a more appropriate benchmark for assessing the role of emergency medical services (EMS) in the STEMI patient care chain (12), and examining this time can provide measures to minimize pre-hospital delays (13).

The clinical guideline of the American Heart Association (AHA) recommends that the FMCTB be less than 90 minutes (14). According to various studies, most patients with STEMI receive no standard care within the recommended period (15). Therefore, there is an emphasis on the importance of employing strategies to reduce the delay in reperfusion and thereby improve the outcomes of patients (16). Since electrocardiogram (ECG) is a practical approach for the diagnosis of patients with STEMI (17), many ambulances are equipped with a 12-lead ECG device and an advanced notification system for rapid diagnosis and triage of STEMI patients (18). The use of telecardiology (taking ECG by the EMS staff and transmitting it to the physician and diagnosis of STEMI) and subsequent, direct patient transport to an angioplasty center minimizes the delay in treatment (19, 20). This reduction in delay is achieved by preparing (activating) the angiography ward and not transporting the patient to a hospital without an angioplasty ward as well as not transporting to the emergency department. The results of a study (2019) showed that Symptom-To-Device Time in the group transported with a telecardiology directly to a medical center equipped by angiography ward (181 min) was significantly lower than that of the group transported without telecardiology to emergency department (281 minutes) (19). Other notable outcomes after myocardial infarction include the size of the infarct area, left ventricular ejection fraction, and major adverse cardiac events (MACE) in hospital and after hospital discharge. Infarct size is defined as the maximum amount of troponin I and the maximum amount of creatine kinase in the first 24 hours after STEMI. Major adverse cardiac events include mortality rate, readmission due to acute coronary syndrome, re-percutaneous coronary intervention and coronary artery bypass surgery (21). It is also important to note that the greatest risk of major adverse cardiac events is in the first 30 days after a myocardial infarction (22).

Tehran EMS was established in 1974 and is managed by the Ministry of Health. Access to EMS services anywhere in the country is possible through calling 115, which provides free services to people since the government finances it. Tehran EMS consists of Emergency Medical Dispatch Center (contact recipient, dispatch, admission, and medical telephone consult units) and Emergency Medical Operation Deputy (The level of an EMS operational staff is paramedic (EMTP), EMT-I, EMT-B, and First responder. An emergency communication nurse answers an emergency telephone call. The nature of the emergency is determined by asking questions based on an integrated algorithm (i.e., chief complaint, level of consciousness, airway and breathing, etc.) The nurse may find it necessary to give urgent advice in life-threatening situations (i.e., CPR Instructions, delivery management, choking). If needed, a physician may give some medical consultations. Finally, if the case is recognized as emergent, the address is completely received and forwarded to the dispatch unit. The operator of the dispatch unit pages the nearest ambulance station to the address of the incident, and immediately then, the ambulance crew begins their mission. The telecardiology and the subsequent, direct transport of the patient to a medical center equipped by angioplasty ward have been conducting in Tehran from December 2016, but no studies have examined its effectiveness.

The telecardiology procedure consists of five steps:

1. Recording of 12-lead ECG signals by an EMS technician.
2. Data transmission using mobile data-network infrastructure to the cardiologist for interpretation
3. Cardiologist's recognition of ST-elevation in the patient's ECG
4. Activation of "code 247" by dispatch nurse in EMS and informing cath lab's supervisor
5. Direct transfer of the patient to cath-lab for primary angioplasty (23).

The present study was conducted for comparison of telecardiology on the outcome of MI patients transported by the Tehran EMS to selected hospitals in Tehran city.

Methods

In the retrospective, comparative study, the samples were collected after obtaining permits and performing necessary coordination, from the selected hospitals in Tehran city and Tehran EMS. In this study, the medical records of patients with STEMI (elevated ST segment in at least two adjacent leads in the first ECG) transported to the hospital by EMS personnel and underwent for the early PCI were selected for analysis and entered into the study. The medical record of patients with a history of MI or CABG and the patients who had a cardiac arrest or complications such as dangerous arrhythmias that delayed PCI before hospital arrival, as well as the patients with unconfirmed STEMI after angiography and so the absence of PCI were excluded. The convenience sampling method was performed from files archived in the IT system of selected hospitals in Tehran (Imam Khomeini, Sina, Shahid Modares, Imam Hossein, and Ayatollah Taleghani Hospitals) as well as Tehran EMS centers.

Given that the telecardiology system has been implementing by Tehran EMS from December 2016, the medical records of patients suffering from a myocardial infarction transported by the Tehran EMS (without the use of the telecardiology system) to the medical centers from March 2016 to September 2016 were taken in the control group, and the medical records of patients transported to medical centers (with the use of the telecardiology system) from March 2017 to September 2017 were placed in the case group, and the data were compared between the two groups. According to similar studies (24) in the field of telecardiology effects, the sample size was estimated at 150 medical records in each group and a total of 300 cases were identified. The data collection tool was a researcher-made questionnaire comprised of two sections: demographic information of patients and their clinical outcomes (left ventricular ejection fraction (LVEF), infarct size, and major adverse cardiac events, which were completed by a researcher and with the aid of their medical records. The study data included demographic characteristics of patients (age, gender, marital status, educational level, occupation), how to transport the patients to medical centers (with or without telecardiology), time of FMCTB, LVEF and infarct size (maximum levels of Troponin I and creatine kinase) in the first 24 hours after admission and major adverse cardiac events (mortality rate, readmission due to ACS, repeated PCI and CABG) during one month. Phone calls were made with patients to collect information on major adverse cardiac events over one month. Content validity was assessed qualitatively and face validity was evaluated by ten faculty members of the school of nursing an midwifery, Shahid Beheshti University of Medical Sciences. They approved the questionnaire after applying the desired changes. To verify the reliability of the questionnaire, 15 questionnaires were investigated by the researcher within a week and the Kappa agreement coefficient was used to determine the correlation between the responses in which the result was equal to one.

This article has been adapted from the Master's thesis in Emergency Nursing, written by the first author of the article, approved by the ethical committee of Shahid Beheshti University of Medical Sciences (Ethics Code: IR.SBMU.PHNM.1396.1009), Tehran, Iran.

Data were described by descriptive statistics (including mean, Interquartile range, standard deviation, frequency, and percentage); the Kolmogorov-Smirnov test assessed the normality of the variables. A significance level was considered to be P<0.05. Data were analyzed using independent t-test, Fisher's exact test, Chi-square, Mann-Whitney and Kruskal-Wallis test by SPSS software, Version 20.

Results

In this study, 300 records of STEMI patients were assessed. There was no significant difference in gender and occupational status between two groups of patients transported with and without telecardiology. There was no statistically significant difference in marital status between the two groups. There was no statistically significant difference in educational status between the two groups. There was no significant statistical difference in age between the two groups. The demographic variable summarized in Table 1.

Table 1. Descriptive statistics demographic variables of patients with STEMI in two groups

Variables		**Use of telecardiology**	**Non–use of telecardiology**
		N (%)	**N (%)**
Gender	**Female**	30 (20)	33 (22)
	Male	120 (80)	117 (78)
Marital status	**Single**	1 (0.70)	5 (3.30)
	Married	136 (90.60)	134 (89.30)
	Deceased spouse	1 (0.70)	0 (0)
	Divorced	12 (8)	11 (7.40)
Educational level	**Primary school**	34 (22.67)	45 (30)
	Secondary school	33 (22)	31 (20.70)
	High school	36 (24)	41 (27.30)
	Academic	28 (18.66)	12 (8)
Occupation	**Self-employed**	65 (43.33)	62 (41.33)
	Employee	28 (18.67)	31 (20.67)
	Retiree	26 (17.33)	25 (16.67)
	Unemployed	10 (6.67)	8 (5.33)
	Housekeeper	21 (14)	24 (16)
Age		**Mean±SD**	**Mean±SD**
		58.83±11.67	59.93±11.08

The Mann-Whitney test result showed that the mean FMCTB in STEMI patients transported by Tehran EMS to the selected hospitals in Tehran in the group using telecardiology was significantly lower than that of the non- telecardiology group 116.80±94.29 minutes with median 91, interquartile range 55 minutes versus 156.008±105.24 minutes with median 130, interquartile range 71.25 minutes, (P<0.001).

Also, the result of this test showed that the infarct size based on creatine kinase (p=0.048) was significantly lower than in the patients transported with telecardiology to the patients transported without using telecardiology. However, there was no significant difference based on troponin I (p=0.79). The mean LVEF was compared in two groups of patients transported with and without telecardiology using the Mann-Whitney test, which showed no significant difference between the two groups (p=0.384) (Table 2). The Chi-square test showed that the mortality rate (p=0.033) and repeated PCI (p=0.022) were significantly lower in the patients transported with telecardiology than in the patients transported without ECG. However, the results of this test showed that the ACS-caused readmission rate (p=0.684) and CABG incidence (p=0.759) were not significantly different in both MI patients transported with and without telecardiology (Table 3).

Table 2. Descriptive statistics of FMCTB, infarct size and LVEF in two groups

Variables		Groups		Mann-Whitney test result
		Use of telecardiology	Non-use of telecardiology	
First medical contact to balloon time (minutes)	Mean±SD	116.80±94.29	156.008±105.24	<0.001
	Median	91	130	
Infarct size at 24 hours after admission based on troponin I content (ng / l)	Mean±SD	76.57±2.26	94.84±7.3	P=0.79
	Median	67	69	
Infarct size at 24 hours after admission based on creatine kinase content (U / l)	Mean±SD	164.89±9.73	200.43±12.19	P=0.048
	Median	165.5	171.5	
Left ventricular ejection fraction (%)	Mean±SD	41.9±9.97	40.66±9.9	P=0.384
	Median	40	40	

Table 3. Descriptive statistics of MACE in two groups

Variables		Groups		Chi-square test result
		Use of telecardiology	Non-use of telecardiology	
		N (%)	N (%)	
Death	Yes	5 (3.33)	14 (9.33)	P=0.033
	No	145 (96.67)	136 (90.67)	
Readmission due to acute coronary syndrome	Yes	2 (1.33)	4 (2.66)	P=0.684
	No	148 (98.67)	146 (97.33)	
Repeated percutaneous coronary intervention	Yes	5 (3.33)	16 (10.7)	P=0.022
	No	145 (96.67)	134 (89.3)	
Coronary artery bypass grafting	Yes	5 (3.33)	6 (4.00)	P=0.759
	No	145 (96.67)	144 (96.00)	

Discussion

The results of this study showed that the use of telecardiology caused a significant decrease in FMCTB in patients with STEMI. This reduction in time can be due to faster diagnosis of MI in patients, direct patient transport to angioplasty ward in hospitals possessing this section, and preparation of angioplasty ward. This study suggests that the use of telecardiology during the transportation and treatment of patients with STEMI, in addition to a significant reduction in the FMCTB, placed this important benchmark, which indicates the quality of provided health services, within the range of standards defined by international communities. AHA clinical guideline recommends that the FMCTB be less than 90 minutes (14). However, an FMCTB of fewer than 90 minutes is difficult to achieve despite best practice pre-hospital 12 lead ECG triage and rapid hospital-based reperfusion. According to a report from the American Heart Association Mission, Lifeline has been on prehospital care, where a significant portion of system delay occurs. This includes the earliest diagnosis (with prehospital ECGs), transporting the patient to the nearest PCI-capable hospital (even if further than a closer non–PCI-capable center), and activation of the catheterization laboratory team as early as possible, each of which has been shown to improve time to reperfusion. The increase in prehospital ECGs from 46% to 71% over

5 years represents a substantial success. This is also reflected in the 9-minute improvement in FMC-to-device time, although the fact that one-quarter of patients still exceeded 102 minutes shows the need for further improvement. Given that the number of hospitals equipped with a 24-hour cath-lab in Tehran city is limited and also, their distribution throughout the city are not balanced that they are concentrated in the city center, results in patients living in the suburbs to be transferred over a longer time. Moreover, traffic in the metropolis of Tehran is a severe problem, which causes many delays.

Similarly, the results of a study by Cheskes et al. in 2011(25) showed that a pre-hospital ECG and diagnosis of STEMI by EMS staff and subsequently the direct transport of patients to the angioplasty ward resulted in a significant reduction of FMCTB in these patients, So using a combination of computer-generated ECG interpretation, EMS staff interpretation, and contact with the treating interventionalist, resulted in a false-positive rate decreased. In this study, contrary to the present study, the EMS personnel diagnosed the myocardial infarction. Ezad et al. in 2018, Brunetti et al. in 2014 (26) and Hutchison et al. in 2013 (27) stated that the FMCTB in the STEMI patients of the group transported with telecardiology was significantly less than in those transported without telecardiology. Referring hospital by field triage reducing time delay related to inter-hospital transfer to PCI. In the present study, the ECG was taken by EMS personnel, and sent to a physician present in the EMS; if confirmed by the physician, the patient was transported directly to a center having angiography ward. However, in Cheskes et al. study, pre-hospital EMS staff performed the entire process of telecardiology, including taking ECG, interpreting it and transporting patients directly to a medical center equipped with angiography ward, and the physician did not make the decision.

The results of the present study showed that the mean infarct size based on the creatine kinase content in the STEMI patients transported with telecardiology by Tehran's Emergency Medical Services to selected hospitals of Tehran city was significantly lower than in those transported without telecardiology. Similarly, Kobayashi et al. (21) in 2016, showed Emergency personnel transport with STEMI notification was shortened DTB time and smaller infarct size in patients with anterior wall STEMI. However, there are also inconsistent results in this regard. Kawakami et al. (28) in 2016 stated that the use of telecardiology does not affect the infarct size reduction in patients with STEMI. It seems that the results of various studies on the impact of telecardiology on infarct size in patients with STEMI in different geographical areas are different. Some of the possible reasons for these differences can be attributed to differences in the healthcare systems of different countries as well as differences in many socio-demographic and cultural variables. For example, the healthcare systems in some countries are such that the patients diagnosed with chest pain with or without pre-hospital ECG are transported to medical centers with angiography ward, and in some countries in marginal areas, the patients with the use of pre-hospital ECG are transported to the nearest medical center and then to medical centers with angiography ward. It seems that reducing infarct size due to the use of telecardiology can be a proper factor for improving the overall prognosis of these patients and the complications of the disease in the long term, and ultimately can reduce the cost of the healthcare system.

Roswell et al. (14) in 2014, achieved similar results and stated that the telecardiology did not affect the LVEF in the patients with STEMI. However, Kobayashi et al. (21) in 2016 showed that patient transport using telecardiology significantly improved the LVEF. The mean left ventricular ejection fraction was more than in patients transplanted with telecardiology, so the results of this study show that transferring STEMI patients using telecardiology is effective in improving the left ventricular ejection fraction. Other possible causes can be attributed to the difference in measurement method of the LVEF, the involved artery, and the ventricular infarct size.

To telecardiology reduced mortality rate and repeated PCI but did not affect readmission due to ACS and CABG. These results suggest that the use of telecardiology has been effective in the process of transferring and treating patients with STEMI, reducing their mortality, as well as performing percutaneous coronary intervention. Considering the severe and long-term complications of myocardial infarction, a decrease in the number of deaths, and a reduction in the number of re-PCI can be a significant consequence that can have direct and indirect positive impacts on life expectancy, missing the years of life and health care costs.

Ezad et al. (29) in 2018 stated that bypassing in the emergency ward is key to achieving target FMCTB times and improved clinical outcomes, including lower mortality. Similarly, Ong et al. (5) in 2013 concluded that telecardiology by EMS personnel and the diagnosis of STEMI by the physician and the direct patient transport to the angioplasty ward did not affect the mortality rate of these patients. This dissimilarity may be justified by differences in the healthcare systems and healthcare quality. Savage et al. (30) in 2014 also indicated that the use of telecardiology was not effective in the reduction of mortality rate in the patients with STEMI. In this study , the number of people transported with and without telecardiology was 63 and 218 (30), respectively; this may be one of the reasons for the inconsistency of their results with our study.

Clemmensen et al. (31) in 2005 found that the use of telecardiology to reduce the pre-hospital delay in the treatment of patients with STEMI was not effective. In the present study, the pre-hospital delay was measured using the FMCTB, and the results showed the appropriate effect of telecardiology on reducing FMCTB and pre-hospital delay in the treatment process of patients with STEMI. Therefore, the results obtained in the study of Clemmensen et al. are inconsistent with the results in the present study.

Different traffic arrangements in 2016 and 2017 were among the factors that were out of control of the researcher. Other limitations include a history of MI, time of contact, and type of MI, which may affect treatment outcome but in some, recodes were incomplete or unreported, which could not be controlled by the researcher.

Conclusion

The telecardiology and pre-hospital ECG in patients suspected of STEMI by EMS staff and its interpretation by the physician, followed by the direct transport of patients to the angioplasty ward, effectively improve the outcome of patients with MI by shortening the pre-hospital delay time. The present study suggests that the use of telecardiology is an effective way to improve the outcome of patients with MI.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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