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Transtelephonic electrocardiography in the management of patients with acute coronary syndrome☆

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Abstract

Background, purpose: The efficacy of the transtelephonic ECG system (TTECG) in the management of ST segment elevation myocardial infarction (STEMI) was examined with regard to the ambulance service- and percutaneous coronary intervention (PCI)-related delay times, the prehospital medical therapy and the in-hospital mortality rate.

Methods: The study was conducted as a collaborative effort between the University of Debrecen and the Hungarian National Ambulance Service. Altogether 397 patients were recruited in the TTECG group, while 378 patients transported to the PCI centre without TTECG served as controls.

Results: More accurate prehospital medical therapy was achieved in the TTECG group. The PCI-related delay times were significantly shorter, while the in-hospital mortality rate was significantly lower in the TTECG group than among the controls.

Conclusions: The findings illustrate that TTECG is a valuable tool which may potentially improve the regional management of STEMI patients.

Keywords: Transtelephonic ECG; Acute coronary syndrome; STEMI; Emergency medical services

Introduction

Recent guidelines [1] state that the timely diagnosis of acute coronary syndrome (ACS) is the key to successful management. This is especially true for patients with ST segment elevation myocardial infarction (STEMI). In cardiac emergency situations, an early diagnosis and the prevention of delay are critical as concerns the outcome. The very early phase of STEMI is the most critical time, during which the patient is liable to suffer a cardiac arrest and other complications. Moreover, the earlier the treatment (reperfusion therapy) is commenced, the greater the beneficial effect ("time is muscle").

The prehospital primary diagnosis of STEMI is usually based on the medical history, the physical examination and especially the electrocardiogram (ECG) [2], as biochemical cardiac marker measurements are not readily available in most cases. Consequently, the correct interpretation of ECGs in cardiac emergency patients with chest pain is of utmost importance as the cornerstone of the diagnosis. On the other hand, cardiac emergencies may occur far from specialist hospitals (this is especially true in Hungary), and staff at many healthcare services, emergency services, geriatric centres, or general and private practices are not sufficiently expert or not qualified to interpret ECGs in detail.

One approach to overcome this problem is the use of the transtelephonic ECG (TTECG). This usually involves the direct transmission of a locally recorded conventional ECG by telephone, which is decoded to a standard ECG on a computer in a cardiac centre [3], where everything is available for an immediate professional ECG evaluation and interpretation. The usefulness of different TTECG and ECG monitoring systems has already been established in the diagnosis and follow-up of various forms of ischemic heart disease [4–7], in the management of out-of-hospital chest pain emergencies [8,9] and for the detection of atrial fibrillation and other arrhythmias in different clinical situations [10–12].

In 2008, a pilot developmental project was initiated in the north-eastern region of Hungary (about 1.5 million people),

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in which the Hungarian National Ambulance Service was uniformly equipped with a TTECG system which is extensively used in all cardiac emergencies. A 24-hour service network was established between the ambulance service units and the regional cardiac centre (the Institute of Cardiology at the University of Debrecen) and the locally registered ECGs are immediately transmitted by phone to the centre.

The aim of the present study is to examine the efficacy of the TTECG system, in combination with consultation with the cardiologist, in the diagnosis and management of patients with acute chest pain, with special focus on STEMI. Consideration is given to the ambulance service contact and transport times, the percutaneous coronary intervention (PCI)-related delay times (door to sheath insertion and door to balloon times), the prehospital medical therapy and the in-hospital mortality rate.

Methods

The study was conducted between January 1, 2009 and December 31, 2010 in the north-eastern region of Hungary as a collaborative effort between the Institute of Cardiology in Debrecen and the Hungarian National Ambulance Service. A total of 48 ambulance units provided emergency services throughout the region to a population of approximately 1 500 000 residents.

All units had been uniformly equipped with both conventional ECG and battery-operated 12 lead, portable TTECG system (HeartView P12/8 Plus, Aerotel Medical Systems). The conventional ECG machine recorded 12 leads in 4 consecutive steps (3 leads simultaneously) at a standard paper speed (25 mm/sec) and voltage setting (10 mm/mV). The HeartView P12/8 Plus device was supplemented with 3 external, cable-connected electrodes, which were placed on the left and right arms and on the left side of the waist. In addition, 4 embedded electrodes were located on the back of the main unit. This arrangement of electrodes allows the recording of both the limb and precordial leads, by placing the main unit in 3 different positions on the chest. A 2.5 second interval of each lead and a 10 second interval of the rhythm strip (lead II) were recorded with a sampling rate of 375 samples/second (least significant bit voltage resolution of 39 μV), resulting in a standard 12 lead ECG layout with every lead separated by 1 mV calibration signals. The electrode positions for the conventional ECG machine and the TTECG system were similar.

The ambulance units were staffed with either a doctor or a primary-care paramedic trained for emergency cardiac service and advanced cardiovascular life support. Before the study, the ambulance staff participating in the trial were instructed how to evaluate patients with chest pain (with a presumptive diagnosis of ACS) at the scene and administer acetylsalicylic acid, sodium heparin, nitroglycerine and narcotics if necessary. It was also routine practice for the ambulance service units to record a 12-lead ECG with a conventional ECG machine at the scene. The recording and transmission of the TTECG to the PCI centre were not mandatory, but were at the discretion of the paramedics. The farthest point of service from the primary PCI centre (the Institute of Cardiology at the University of Debrecen) was about 110 km.

The units were instructed how to triage patients with chest pain, independently if possible, and to transport all eligible patients with a prehospital diagnosis of STEMI directly to the PCI centre, bypassing the emergency departments at the county hospitals. Patients with an onset of typical symptoms <12 hours and an ST segment elevation of ≥ 1 mm in ≥ 2 contiguous leads on the prehospital 12-lead ECG were considered eligible. The prehospital diagnosis of STEMI was established exclusively by the ambulance team.

Recording and transmission of the TTECG required about 3 minutes and, after transmission of the ECG signal (in about 50 seconds) following digital-analogue conversion (FM tone), all of the important clinical data on the patient (including the ECG findings) and the patient's transport were discussed in a brief consultation. The standard protocol of the consultation included registration of the patient's personal data, reception of the recorded ECG and a brief patient referral revealing relevant clinical data. All TTECG data transmission was carried out via the radiotelephone system of the National Ambulance Service (Tetra). Upon arrival at the PCI centre, all patients were immediately interviewed and examined by a cardiologist and the diagnosis of STEMI was confirmed. The patients were then immediately transferred to the catheterization laboratory for primary PCI. All conventional and necessary drug treatment for the patients was allowed and the decisions as to treatment were made by the medical team at the PCI centre.

The TTECG-assisted group referred by the ambulance service consisted of 397 patients with STEMI (TTECG group). The control group comprised a cohort of 378 patients with STEMI who were transported by the ambulance service to the PCI centre without TTECG. As concerns the controls, the ECGs, the clinical evaluations and the transport decision, together with the medical therapy provided, were carried out by the ambulance service staff without consultation by TTECG. In these cases, the PCI centre was given only a brief notice about the patient transfer via the regular telephone. All emergency patients for whom the final diagnosis was other than STEMI were excluded from the database of the present study.

The primary efficacy outcomes were the ambulance service contact and transport times and the PCI-related delay times (door to sheath insertion and door to balloon times). The ambulance service contact time was defined as the time spent at the scene by the ambulance unit (from the first medical contact to the departure from the scene to the PCI centre). The transport time was the duration of the journey from the scene to the cardiac centre. The door to sheath insertion and door to balloon times were defined as the time between the arrival of the ambulance service unit at the PCI centre and the insertion of the sheath or balloon in the catheterization laboratory. The key secondary efficacy outcome was the in-hospital mortality rate.

Data were collected for the study with the written approval of the patients. Data handling and collection were approved by the institutional review boards of the Institute of Cardiology at the University of Debrecen and the Hungarian National Ambulance Service.

Statistical analysis was carried out with the GB-Stat v8.0 program. Depending on the type of variable (qualitative or quantitative parameters), the descriptive method applied involved the calculation of absolute and relative frequencies, or the calculation of mean and standard deviation (S.D.). Normally distributed continuous variables were compared by Student's *t* test at an α level of 5%. The parameters that were at least ordinal were compared by means of the Wilcoxon rank-sum test at an α level of 5%. For the cumulative survival analysis, the Cox regression model (conditional logistic regression) was used. The risk of death curves were plotted by the Kaplan-Meier technique.

Results

Altogether 1564 ambulance-attended patients were screened for chest pain during the study period of whom 800 were diagnosed as having STEMI in the prehospital stage. The patient flow is depicted in Fig. 1. The final diagnosis of STEMI was established in 775 patients. In the remaining 25 patients, the ST segment elevation was due to other reasons (vasospasm, myocarditis, etc.). All 25 patients without STEMI were excluded from the study database.

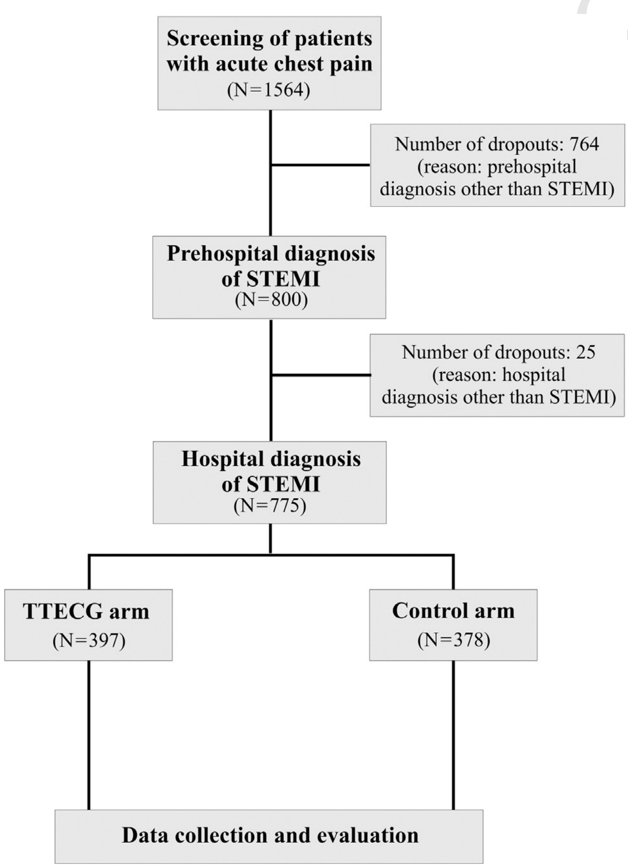


Fig. 1. CONSORT diagram showing the flow of patients at each stage of the data collection.

Table 1
Baseline characteristics of patients.

	TTECG group (N = 397)	Control group (N = 378)	p value
General			
Age (y)	60.18 ± 12.10	61.75 ± 11.46	0.0642
Men (%)	67.42	67.12	0.8669
Anterior myocardial infarction (%)	45.65	50.13	0.1429
Proportion of patients (%) with a previous history of			
Myocardial infarction	9.82	9.52	0.8878
Stroke	3.28	4.26	0.4733
Congestive heart failure	7.57	11.14	0.0885
PCI	8.61	7.18	0.4635
Coronary bypass surgery	1.51	1.06	0.5795
Proportion of patients (%) with previous cardiac risk factors			
Hypertension	66.16	69.14	0.4214
Diabetes mellitus	19.95	24.93	0.0967
Smoking	51.64	45.89	0.1284
Hypercholesterolemia	47.72	44.56	0.3779

Values are means ± S.D. or percentages of subjects. PCI = percutaneous coronary intervention.

Finally, there were 397 patients in the TTECG group and 378 patients in the control group.

The baseline characteristics of the patients in the two groups are listed in Table 1. The two groups were relatively well matched as regards risk factors and previous medical history. There was a trend towards more patients with a history of previous congestive heart failure in the control group (p = 0.0885), but the difference was not significant.

All patients in both groups underwent immediate cardiac catheterization, and PCI was performed in 381 patients (96%) in the TTECG group and in 351 patients (92.9%) in the control group. Among the patients in whom PCI was not performed, 7 patients were later referred for coronary bypass surgery and medical therapy was recommended for the remaining patients. Thrombolytic therapy was not prescribed to any patient. Moreover, no patient required emergency bypass surgery.

Stents were deployed in 94.5% of the patients (Table 2) and platelet glycoprotein IIb/IIIa receptor inhibitors were used in 25.5% (25% in the TTECG group and 26% in the control group). There was no significant difference between the two groups in the stent procedural details (Table 2). Angiographic success was achieved in 94% of the patients (93% in the TTECG group and 95% in the control group) who underwent primary PCI.

Details of the prehospital medical therapy are presented in Table 2. In the TTECG group significantly more sodium heparin (5000 U) and narcotics were administered. On the other hand, nitrates were used more frequently in the controls. In the cases of the other medications (acetylsalicylic acid and/or clopidogrel, atropine and beta-blockers), there was no significant difference between the two groups.

Data on the distance from the PCI centre, the ambulance service contact and transport times and the PCI-related delay times (door to sheath insertion and door to balloon times) are to be seen in Table 3. The distance from the PCI centre was

Table 2
Stent procedural details and prehospital medical therapy.

	TTECG group (N = 397)	Control group (N = 378)	p value
Stent procedural details			
Stent/patient (mean ± S.D.)	1.31 ± 0.88	1.28 ± 0.57	0.5658
Drug-eluting stent (%)	4.53	5.03	0.7423
*LAD (%)	50.87	52.56	0.7136
*CX (%)	16.76	16.31	0.8936
*RCA (%)	43.35	41.39	0.7430
Proportion of patients (%) receiving the following prehospital medical therapy			
Acetylsalicylic acid and/or clopidogrel	80.51	75.93	0.1453
Sodium heparin	84.30	59.10	<0.0001
Nitroglycerine	4.81	13.75	<0.0001
Narcotics	56.99	13.76	<0.0001
Atropine	6.84	4.23	0.1148
Beta-blocker	4.23	3.70	0.3571
Proportion of patients resuscitated (%)	8.56	8.27	0.8818

Values are means ± S.D. or percentages of subjects. *Patients may have had interventions on more than one vessel. LAD indicates left anterior descending; CX, left circumflex; RCA, right coronary artery. “Patients resuscitated” are the patients in whom defibrillation was needed during the first medical contact and/or transport.

significantly longer for the TTECG group than for the controls (55.2 ± 34.2 vs. 39.4 ± 32.2 km). Consequently, the transport time proved to be slightly, but significantly longer in the TTECG group. However, when the distance/transport time ratios were calculated, the speed of the service was somewhat better in the TTECG group as compared with the controls (1.03 vs. 0.96 km/min).

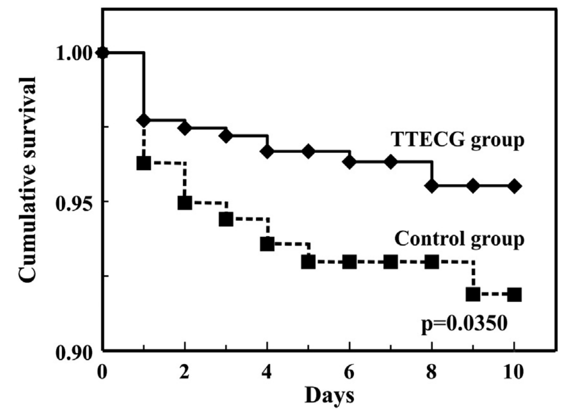
Both the door to sheath insertion and door to balloon times were slightly, but significantly shorter in the TTECG group relative to the controls (Table 3).

The mean length of the hospital stay for the patients in the TTECG group was 6.99 days versus 6.94 days for those in the control group ($p = 0.8146$). The in-hospital mortality rate was 4.28% in the TTECG group, as compared with 8.44% in the control group. The Kaplan-Meier curves indicated that there was a significant survival benefit for cumulative survival at 10 days (log rank test, $p = 0.0350$; Fig. 2) in the TTECG group in comparison with the controls.

Table 3
Primary efficacy outcome and mortality data for the study population.

	TTECG group (N = 397)	Control group (N = 378)	p value
Distance from PCI centre (km)	55.2 ± 34.2	39.4 ± 32.2	<0.0001
Contact time (min)	29.31 ± 10.67	24.13 ± 13.23	<0.0001
Transport time (min)	53.75 ± 32.97	40.78 ± 21.30	<0.0001
Time from symptom onset to first medical contact (min)	224.41 ± 395.59	259.95 ± 323.51	0.2581
Door to sheath insertion time (min)	43.37 ± 18.57	46.95 ± 17.75	0.0124
Door to balloon time (min)	60.31 ± 19.50	63.73 ± 21.13	0.0426
Hospitalisation (days)	6.99 ± 3.45	6.94 ± 3.48	0.8146
In-hospital mortality rate (%)	4.28	8.44	0.0350

Values are means ± S.D. or percentages of subjects.



Number at risk

TTECG	397	397	380	376	370	355	282	190	120	74	50
Control	378	378	362	350	341	312	255	183	122	85	63

Fig. 2. Kaplan-Meier curves depicting in-hospital survival at 10 days in the two groups. The number at risk indicates the number of in-hospital patients at a given time point in the TTECG and control groups, respectively.

Discussion

ECG changes in acute myocardial infarction are highly dynamic. The very early acquisition and transmission of ECG data in acute myocardial infarction can therefore provide valuable, time-sensitive data that can help increase the accuracy of diagnosis by showing serial ECG changes starting at an earlier point in time than would otherwise be possible. It clearly emerged from this study that an integrated multidisciplinary regional approach in which paramedics, either independently or after TTECG-based consultation with cardiologists, perform triage and transport patients with STEMI to a designated PCI centre for primary PCI, is feasible and fast. Interestingly, the study revealed a significantly lower in-hospital mortality rate for the TTECG group. This somewhat unexpected finding was probably due to improved prehospital medical therapy, and at least in part to the faster in-hospital reperfusion (improved PCI-related delay times).

In accordance with previous observations [13], independently from a consultation with the cardiologist (TTECG group), the paramedics interpreted the ECG with an acceptable degree of accuracy and transported the patients immediately to the designated centre for primary PCI. However, significant differences between the groups were noted in the prehospital medical therapy initiated by the paramedics. Sodium heparin and narcotics were used more frequently after the TTECG-based consultation. It seems that the consultation with the specialist rather supported the presumptive diagnosis of STEMI, and the ambulance service unit accordingly initiated more aggressive medical therapy. In the controls (without TTECG-based consultation), there tended to be an underuse of sodium heparin and narcotics, and an overuse of nitrates, and it is hypothesised that the latter might have been a therapeutic excuse.

The ASSENT-4 PCI trial [14] highlighted that the suboptimum antithrombotic prehospital co-therapy (underuse of sodium heparin and other antithrombotic drugs) in the facilitated PCI arm was responsible for the poorer clinical outcome in these patients. The ASSENT-4 PCI trial drew attention to the importance of adequate antithrombotic prehospital therapy. Consequently, it appears likely that the suboptimum antithrombotic treatment was responsible at least in part for the increased mortality rate noted in the present study among the control patients. Interestingly, a significantly higher proportion of the control group received nitrates than that in the TTECG group (13.75% vs. 4.81%). However, previous large clinical trials (GISSI-3 and ISIS-4) clearly showed that nitrates did not affect the mortality rate [15,16].

Hypothetically, an increased number of ventricular fibrillation episodes requiring cardiopulmonary resuscitation (CPR) in the control group would have provided a plausible explanation for the higher mortality rate among these patients, and could also have been the reason for the paramedic team deciding against TTECG consultation, while transferring the patients immediately to the PCI centre for invasive investigation. However, our evaluation of the occurrence of ventricular fibrillation did not reveal a significantly higher level in the control group than in the TTECG group (Table 2). Another explanation for the more cautious use of sodium heparin might have been the higher number of unconscious patients and/or the need for assisted respiration in the control group (subarachnoid haemorrhage can manifest as sudden loss of consciousness, even in the presence of an ST segment elevation [17]). However, the database did not indicate any significant differences between the two groups from these aspects.

Faster in-hospital reperfusion was noted in the TTECG group than in the controls (Table 3). The improved PCI-related delay times were likely to be due to faster decision-making, transfer and preparation of the patient for primary PCI in the catheterization laboratory. Interestingly, TTECG was used more frequently by the paramedics if the scene of the patients was more distant from the PCI centre. Upon inquiry, the ambulance service personnel explained this as “the longer the distance from the PCI centre, the more important it is to make a proper diagnosis”.

In summary, our findings indicate that 1) the recording and transmission of TTECG and the TTECG-based consultation between the paramedics and the cardiologists during the first medical contact with STEMI patients are feasible and fast, 2) confirmation of the diagnosis of STEMI by the specialist improved the medical therapy initiated by the paramedics, and 3) TTECG significantly shortened the PCI-related delay times and may improve the in-hospital mortality rate.

Limitations of the study

One limitation of our study is the fact that the database was not randomised and a selection bias could have influenced the results. We guarded against this possibility in different ways. Firstly, the decision to obtain TTECG was based on the discretion of the paramedics. Some teams obtained and transferred TTECG from all patients and other teams made it only if they had problems with the clinical diagnosis and/or with the interpretation of the ECG. Secondly, the two groups (TTECG and control) were relatively well matched, including risk factors, previous medical history, CPR, assisted respiration and cardiogenic shock. Thirdly, all patients with a hospital diagnosis of STEMI underwent cardiac catheterization independently from the study arm. This measure aimed against any effect modifier bias of the TTECG consultation. Finally, a relatively long inclusion time (2 years) was involved in the study and all patients with a hospital diagnosis of STEMI were included in the database. Overall, the lack of randomisation and the limited number of patients render it difficult to make comparisons and to draw firm conclusions from this study; nonetheless, some benefits of the regional management of STEMI patients by TTECG have been demonstrated.

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