

**SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD)**

**The effect of the patient path worked out in the Northern Plain region of the National Ambulance Service and of the cardiobeeper pre-hospital decision support system on the change of morbidity and mortality rates of patients with acute coronary syndrome**

**by György Pápai, MD**

**Supervisor: Prof. István Édes MD, PhD, DSc**



**UNIVERSITY OF DEBRECEN  
DOCTORAL SCHOOL OF Kálmán Laki Doctoral School**

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Head of the **Examination Committee:** Prof. János Kappelmayer, MD, PhD, DSc

Members of the **Examination Committee:** Róbert Sepp, MD, PhD, DSc

István Lőrincz, MD, PhD

The examination takes place at the Library of Department of Internal Medicine,

Faculty of Medicine, University of Debrecen

on 6th March 2019 at 11.00 am

**Reviewers**

Prof. Kálmán Tóth, MD, PhD, DSc

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The PhD Defense takes place at the Lecture Hall of Bldg. A, Department of Internal Medicine, Faculty of Medicine, University of Debrecen

on 6th March 2019 at 1.00 pm

## **Introduction, historical overview, technical background**

The annual report of the WHO in 2011 (European health report 2011) contains that, considering the regions of the European countries, a significant improvement of the survival rates (a significant decrease of morbidity and mortality rates) was observed altogether in three geographical units in the last one-two years in the case of the cardio- and cerebrovascular diseases as well as in the case of oncological diseases. One of these three geographical units was Hungary's Northern Plain region. Perhaps this was surprising to every party concerned but this was the achievement of the hard and consequent health management work having done in the recent years, the world took notice of this small region of Hungary.

In the decrease of cardiovascular mortality the establishment of percutaneous coronary intervention (PCI) centres played an important role such as the best-quality on-site attendance of the patients by the OMSZ according to a unified protocol and the optimal patient path worked out in the region. Due to all these factors, according to the KSH's data, great decrease of mortality could be observed in the total mortality rate of the STEMI in our region (according to the KSH's data mortality of the STEMI-patients decreased by 35,0 % in the Northern Plain region in 2005-2008).

In my opinion the following factors, strengthening the cardiovascular area, could serve as the basis of this significant decrease in STEMI mortality:

- Elaboration, maintenance and system control of the patient path system based on professional bases;
- Opening PCI Centres in Debrecen, then in Nyíregyháza and Szolnok;
- Introduction of the TTECG system in the region.

In connection with the elaboration of the patient path model, complying with the professional rules, we divided the territory of Szabolcs-Szatmár-Bereg County in two. This meant that in the first three hours of the STEMI we had 60 minutes to take the patients to the PCI centre, in order to do coronary intervention successfully. In the case of complaints lasting from 3 to 12 hours, however, we had more time; we had to arrive at the Cardiologic Centre of Debrecen in 90 minutes which was the single PCI Centre of the region at that time (according to the STEMI attendance procedure valid at that time). If this was not possible or the patient refused the PCI treatment, we had to apply on-site thrombolysis. Therefore we placed the most modern thrombolytic drugs (Actylase) out to the outside territories of the country that can get

to Debrecen in more than 90 minutes and we professionally prepared the paramedic officers working there to this intervention, within the framework of a two-day accredited training and ECG training.

Through regional (specific) procurements we also managed to place medicines out to the mobile intensive care units and emergency ambulances that contain Na-heparin and clopidogrel, not standardized at the OMSZ (2-3 years before the official introduction at the Ambulance Service all over the country). We could supplement our activity by an incidental opportunity as well, because as the donation of a Hungarian service provider, in the form of a possibility financed also by the National Health Insurance Fund (OEP) we could place TTECG devices (cardiobeeper) to the high-priority vehicles, confirming with this the professional quality of the on-site attendance.

With the help of these TTECG devices we could send the ECG done about the patient on the scene to the Intensive Care Unit within one minute. On the basis of the ECG image the cardiologist colleague working there decided on providing place to the patient. Through a telephone discussion we could review the patient's parameters, symptoms, ECG deviations and the time of his/her arrival. In addition to this, the system can provide a special opportunity for consultation as well: our associates asked for the immediate therapeutic opinion of the cardiologist based on the seen ECG image several times. In Szabolcs-Szatmár-Bereg County of the OMSZ's Northern Plain region we placed TTECG device out to 1 mobile intensive care unit and 8 emergency ambulances, by the help of which as of 1<sup>st</sup> November 2006 these units started to forward the ECG images of the patients needed cardiologic therapy from the scene by transtelephonic means.

By March 2010 even more ambulance units were equipped with TTECG devices in the region on which no doctor or paramedic officer works, only a paramedic and a driver. Thus all of the 44 ambulance stations of the Northern Plain region were equipped with TTECG devices, completely covering thereby the region's life-saving map and ensuring the possibility of the equal cardiologic access to the patients in the eastern part of the country.

In the treatment of the STEMI our most important aim is to give reperfusion treatment to the patient as soon as possible, every examination, intervention, procedure and diagnostics have to be subordinated to this aim. The recent directives state that the key of the successful treatment is the diagnostics of the ACS in due time. This is especially true in the case of the STEMI-patients. In the emergency conditions related to heart diseases early diagnosis and

preventing delays are of crucial importance, as it improves the results and the outcome. In the case of the STEMI the very early stage is the most critical period, during which cardiac arrest and other complications may occur. In addition to this, the earliest is the treatment (reperfusion therapy), the bigger is the beneficial effect (“time = heart-muscle”).

In consideration of the fact that recently the establishment of the PCI centres has been planned and logistically well-founded, the ambulance units on the scene are required to give as correct diagnosis as possible and to comply with the patient paths to the PCI. One of its most important advantages is that the patient can be taken to the PCI Centre within the shortest possible time, avoiding the interim hospital. However, it is equally important not to take any patient to the centres who does not need invasive therapy since this unnecessarily burdens the healthcare services centres, the ambulance service and it means unnecessary burden to the patient and his/her family as well.

It seems that TTECG means a solution for the elimination of both problems. Generally, this system includes the direct transmission of a traditional ECG recorded on the scene by telephone which is reverted into a usual ECG image in analogue transformed format in the cardiologic centres on a computer.

At the present time, the system provided by the IMS Kft. guarantees the attendance in 18 centres with 24-hours control, covering by this the whole territory of Hungary from cardiologic telecommunication - consultation point of view. In this way we could achieve that at the present time an easily appraisable ECG sign can be sent about the patients with relevant complaints by the TTECG devices installed on every unit of the OMSZ in any period of the day, from anywhere in the country to the regionally assigned centre, where the cardiologist evaluates it immediately and renders correct therapeutic assistance via our TETRA system, through a protected line.

### **The structure of the TTECG system**

Transtelephonic ECG system is a network of transducers connected to a controlling and an analysing centre, the communication base of which is the telephone and the e-mail. On the one side of the system there is the paramedic, the paramedic officer or the ambulance doctor, the medical adviser or the physician in attendance and in many cases the patient himself/herself, while on the other side we can find the professionals of the evaluating centre (assistant, specialist).

**The most important professional indications of the device's delivery within the framework of emergency treatment:**

- Clarification of the cardiac background in every emergency condition endangering life (coma, lipothymy, syncope, hypotonia, shock, thoracic pain syndrome, etc.),
- Discovery of arrhythmias endangering life (ventricular tachycardia, high-frequency atrial fibrillation, too quick or too slow cardiac action, etc.).
- Diagnostics of acute coronary syndrome (STEMI, NSTEMI, instable angina, condition after resuscitation, etc.).

The system is excellently suitable to solve other differential-diagnostic problems and to follow up the patients as well (rare arrhythmias, proving angina, recognition of electrolyte disorder, control of interventions or conditions after heart surgeries, checking the patients, caretaking, etc.). In these cases the doctor generally gives the recording unit to the patient for 1-2 weeks in order to clarify the clinical background of the ECG when the complaint occurs.

**Aims**

The aim of this study is to examine the clinical usefulness (effectiveness) of the TTECG in the STEMI. In order to examine the clinical effectiveness of the TTECG we made several clinical studies, in the course of which we examined many different parameters:

- 1) We examined to what extent is the TTECG suitable to the control/diagnostics of the STEMI-patients (validation of the system)
- 2) We examined the clinical effectiveness of the TTECG in STEMI:
  - concerning the PCI delay times (door-to-sheath and door-to-balloon times),
  - the pre-hospital medical therapy and
  - in-hospital mortality.
- 3) By logistic regression we searched for such pre-hospital factors (TTECG, pre-hospital medical therapy, demographic data, accompanying diseases, etc.), which influenced the in-hospital mortality in STEMI from a prognostic aspect. First of all we wanted to find out how the consultation and triage based on TTECG can be considered an individual prognostic factor (predictor) in STEMI.

## Methods

### Validation of the TTECG system

In the period from 01.01.2008 to 30.06.2008 we examined for the clinical validation how well the TTECG calls sent can be evaluated. In the examined period the number of transtelephonic calls was 11,052, which were received not only from the OMSZ but the signs were given mainly from the devices placed out to the patients. From the 11,052 calls only 378 (3,44%) were received from the OMSZ.

### Clinical effectiveness of the TTECG in STEMI

We examined the clinical usefulness (effectiveness) of the TTECG in STEMI in the period from 1<sup>st</sup> January 2009 to 31<sup>st</sup> December 2010 in the Northern Plain region of Hungary (approximately 1.500.000 inhabitants), with the collaboration of the University of Debrecen and the OMSZ. The group supported by TTECG contained 397 patients altogether (TTECG group), while the control group consisted of 379 patients who were taken to the PCI centre without doing TTECG.

During this period altogether 48 ambulance units rendered emergency treatment supported by TTECG in the region. Every unit was equally equipped both with traditional ECG and with accumulator-driven 12-lead portable TTECG system (HeartView P12/8 Plus (Aerotel). Medical attendance took place in the ambulance units by a team led by a physician or a paramedic officer who earlier was trained in high-quality emergency cardiologic treatment at an appropriate level. It was not compulsory to do and send a TTECG to the PCI centre, it was based on the decision of the leader of the ambulance unit.

After applying the TTECG, the leader of the ambulance service unit and the specialists of the PCI centre made the decision on the diagnosis, therapy and direct transport jointly. Recording and forwarding the TTECG took about 3 minutes. After forwarding the ECG sign (approximately within 50 seconds) they discussed every important clinical data of the patient (including the TTECG results), the planned medication and the circumstances of the patient's transportation during a short consultation. Every TTECG-sign data transmission was made via the radio system of OMSZ (TETRA). After the arrival at the PCI centre, the patient was examined by a cardiologist immediately and in most cases the diagnosis of the STEMI was confirmed. Then the patients were taken to the catheterization laboratory immediately, for a primary PCI intervention.

During the term of the study altogether 1564 patients were examined with chest pain, among them STEMI was diagnosed in 801 cases before the transportation to hospital. Finally, from this number the final diagnosis of the STEMI was stated in the case of 776 patients. In the case of the other 25 patients the ST-segment elevation was caused by other reasons (coronary spasm, myocarditis etc.). We excluded these 25 patients from the examination and finally 397 patients were involved in the TTECG group and 379 patients were involved in the control group.

#### Examination of the prognostic factors of in-hospital mortality in the STEMI

For the logistic clinical examinations we divided the same STEMI data base in two other groups, namely:

- the patients died in the hospital ( $n=49$ ) and the
- hospital survivors (control,  $n=726$ ).

During the logistic clinical examinations the acute heart failure (AHF) was stated according to the Killip classification. The coronary flow of the vein responsible for the infarct (TIMI grade) was determined visually directly before the PCI.

## Results

### Validation of the TTECG system

In the early period we examined how well the sent transtelephonic calls can be evaluated and in the period from 01.01.2008 to 30.06.2008 the results were as follows. In the examined period the number of transtelephonic calls was 11,052, from these calls 378 were received from the OMSZ (3,44%). The number of the processed, non-repeated calls that contained appraisable data was 338, in 33 cases repeated signalling was necessary.

The patient paths were as follows:

- After sending a transtelephonic ECG, admission to the clinic: 56 cases (16,6%)
- Regional hospital and the patient was not transported further: 246 cases (72,7%)
- Regional hospital, then the patient was taken over by the Clinic: 28 cases (8,3%)
- We do not know what happened to the patient after that: 8 cases (2,4%)

The number of the patients that were directly taken to the clinic was 56. In these cases the evaluation of the TTECG sign was as follows:



- Can be evaluated well: 27 cases (48,2 %)
- Can be evaluated to a limited extent: 23 cases (41,1%)
- Can be evaluated with difficulty / cannot be evaluated: 6 cases (10,7%)

In the case of the TTECG that could be evaluated well STEMI occurred in 24 cases, from these coronarography took place in 23 cases. From these there was only 1 case when there was no significant deviation on the coronary, in 22 cases culprit lesion dilatation and stent implantation happened. On the ECGs that could be evaluated well there was other pathological deviation in 3 cases (atrium-chamber dissociation, newly formed right Tawara-branch block, ventricular tachycardia).

On the ECGs that could be evaluated to a limited extent STEMI occurred in 20 cases, NSTEMI in 2 cases and ventricular tachycardia could be diagnosed in 1 case. Coronarography was made in 21 cases, in the case of STEMI ECG culprit lesion dilatation and stent implantation took place in 18 cases. During the examination no significant deviation was on the coronary in 1 patient and on 1 occasion we found a highly conductive stent. In the case of NSTEMI ECG culprit lesion dilatation and stent implantation was the solution on 1 occasion.

The transtelephonic sign could not been evaluated but from the 6 patients that were taken to the clinic based on a consultation STEMI was proved on the ECG in each case. For the total revascularization PCI and stent implantation was necessary in everyone.

### **Clinical effectiveness of the TTECG in STEMI**

The TTECG group and the control group were relatively well assorted, including the risk factors and the previous case history. The number of the patients with a previous cardiac infarction in their case history was a bit higher in the control group as compared to the TTECG group but the difference was not significant ( $p=0,0885$ ).

Every patient in both groups underwent immediate heart catheterization and PCI was made in the case of 381 patients in the TTECG group (93,5%), while in the control group intervention was necessary in the case of 351 patients (92,6%). From the patients in the case of whom PCI was not made 7 patients were sent to a coronary bypass surgery later and further conservative medical therapy was recommended to the other patients. Thrombolytic therapy was applied in none of the patients and none of the patients needed emergency bypass surgery.

Stents were applied in 93,5% of the patients, while glycoprotein IIb/IIIa receptor inhibitor (GP IIb/IIIa inhibitors) treatment was necessary in 25,7% of the patients (25,0% in the TTECG group and 26,0% in the control group). As regards the stent implantation, there was no significant difference between the two groups. In the TTECG group Na-heparin (5000 NE) and narcotic pain-killers were applied more frequently than in the control group. At the same time, nitrates were applied in much greater proportion in the control group. In the case of the other treatments (aspirin, and/or clopidogrel, atropine and beta-blockers) there was no significant difference between the two groups.

The distance from the PCI centre was significantly longer in the TTECG group as compared to the control group ( $55,2 \pm 34,2$  vs.  $39,4 \pm 32,2$  km). Accordingly, we found significantly longer transportation time in the TTECG group. However, when we calculated the distance/transportation time rates, in point of fact the transportation speed of the ambulance units was slightly higher in the TTECG group than in the control group (1,03 vs. 0,96 km/minute).

The examination of the time of delays related to the PCI showed that both the door-to-sheath and the door-to-balloon time were slightly but significantly shorter in the TTECG group than in the control group. The average length of staying in hospital was 6,99 days in the case of the patients in the TTECG group, while in the case of the patients in the control group it was 6,94 days ( $p=0,8146$ ). The in-hospital mortality rate was 4,28% in the TTECG group as compared to the 8,44% in the control group.

### **The examination of the prognostic factors of in-hospital mortality in STEMI**

Altogether we involved 775 STEMI patients in this study (49 patients in the group of those who died in the hospital and 726 patients in the control group). The two groups fit together relatively well, including the risk factors and the previous case history as well. However, the patients in the group of those who died in the hospital were significantly ( $p=0.0006$ ) older as compared to control group. If we look at the proportions, significantly ( $p=0.0361$ ) more TTECG-based consultations were carried on in the control group than in the group of the patients died in the hospital.

As we expected, pre-hospital AHF and successful resuscitation occurred in a significantly greater proportion in the group of those died in the hospital than in the control group. In connection with the pre-hospital medical treatment the leaders of the ambulance units or the cardiologists applied significantly more acetyl-salicylic acid (ASA)/clopidogrel, Na-

heparin (5000 NE bolus), low-dosage nitro-glycerine infusion and GP IIb/IIIa inhibitor (eptifibatide) in the control group. In most of the cases GP IIb/IIIa inhibitor was applied (>90%) in the catheterization laboratory. At the same time, in the group of the patients died in the hospital significantly more atropine and intravenous inotropic medicines were applied before their admission to the hospital than in the control group.

The examination of the coronary artery angiograms showed that the percentage proportion of the total occlusion before PCI was significantly higher in the group of patients died in the hospital as compared to the control group ( $p=0,0462$ ). The majority of the total occlusions (>90%) could be opened during PCI in both groups. Similarly to the total occlusions, the number of thrombi within the coronary artery before the PCI also was higher in the group of the patients died in the hospital than in the control group (80,03% vs. 64,81%,  $p=0,0883$ ) but the difference was not significant. The door-to-sheath and the door-to-balloon times were significantly longer in the group of the patients died in the hospital.

During the comparison of the groups, in the case of the parameters showing significant ( $p<0.05$ ) difference from the point of view of in-hospital mortality we calculated the risk rates (by univariate logistic regression) and the 95% confidence interval. With this statistical approach we found that the different medicinal therapeutic interventions, the application of the TTECG and other data significantly affect the risk of in-hospital mortality. In particular, the application of Na-heparin, ASA/clopidogrel, low dosage nitrate infusion, eptifibatide and the TTECG-based triage decreased the risk of in-hospital mortality. At the same time, our data analysis showed that the age, the presence of AHF, the successful resuscitation, the application of atropine, positive inotropes, the door-to-sheath and the door-to-balloon times and the total occlusion of the infarct-related coronary artery before PCI significantly increased the risk of in-hospital mortality.

In the case of the variables that showed significant deviation with the univariate logistic regression ( $p<0.05$ ) we made the multivariate logistic regression in order to determine which parameters can be considered individual prognostic factors (predictors). On the basis of our results, from the point of view of the pre-hospital medicinal therapy, the application of the ASA/clopidogrel (risk ratio is 0,36, CI 0,15-0,89,  $p<0,0271$ ) and the GP IIb/IIIa inhibitor (risk ratio is 0,49, CI 0,24-0,99,  $p=0,0476$ ) proved individual predictors to decrease the in-hospital mortality. The TTECG-based triage also proved an individual prognostic factor and it decreased the risk of in-hospital mortality (risk ratio is 0,48, CI 0,25-0,92,  $p=0,0261$ ).

At the same time the age (risk ratio is 2,33, CI 1,58-3,43,  $p=0,0001$ ), the AHF (risk ratio is 3,98, CI 1,55-10,22,  $p=0,0041$ ) and the successful pre-hospital resuscitation (risk ratio is 5,85, CI 2,28-15,04,  $p=0,0002$ ) proved individual negative predictors (they increased the number of the patients died in the hospital). Every other examined parameter (Na-heparin, atropine, positive inotropic drugs and nitrate infusion) did not prove individual predictors.

Finally, examining the data of the PCI procedure (total occlusion, thrombus within the coronary artery, TIMI flow, door-to-sheath and the door-to-balloon times) we found that the most important independent predictor of in-hospital mortality was the total occlusion of the infarct-related coronary artery before PCI (risk ratio is 5,92, CI 1,03-33,70,  $p=0,0448$ ).

## **Discussion**

### Validation of the TTECG system

On the basis of the experiences of the examined period we can declare that the application of the system unequivocally proved its *raison d'être* since: 1) it optimized the patient paths (the patients could be taken to the best-quality health service centres), 2) released the ambulance service and the patient from the kilometres taken unnecessarily to a great extent (by the more rational selection of the final health service centre), 3) in addition to this, it relieved the intervention centre as well, by screening the unjustified transportations.

The advantages resulted from the use of the system in the acute cardiologic treatment can be summarized as follows:

- The number of the false diagnoses decreases;
- The patient paths can be optimized;
- The patient's placement / acceptance in the PCI centre can be ensured directly;
- The time from the patient's arrival at the hospital to starting the procedure becomes shorter;
- In the case of patients in longer distances (>90 minutes) decision on systemic thrombolysis;
- Possibility of consultation on the medicinal/other treatment
- In the case of special arrhythmias possibility of consultation with an electrophysiologist

## The clinical effectiveness of the TTECG in STEMI

In our examination we found that the regional STEMI treatment model, in which the workers of the ambulance service took the patients to the PCI centre either individually or after a TTECG consultation, worked quickly and properly. Interestingly, we noticed an unexpected difference in the in-hospital mortality of the two groups (TTECG group 4,28% and control group 8,44%), which we can hardly explain. We thought about two important factors: 1) the TTECG-based consultation improved the pre-hospital medicinal treatment and 2) the treatment accelerated in the TTECG group (the door-to-sheath and the door-to-balloon times became better).

In our examination we noticed significant differences among the groups in the medicinal treatment prior to the hospitalization initiated by the ambulance units. The Na-heparin and the narcotic pain-killers were applied after the TTECG-based consultation more often. It seemed that the consultation with a specialist confirmed the presumed diagnosis of the STEMI and then the ambulance unit applied more aggressive medical therapy. Na-heparin and pain-killer were used in the control group less (without a TTECG-based consultation) but nitrates were applied excessively.

According to our data, quicker in-hospital treatment could be observed in the TTECG group as compared to the control group. The decreased delay times related to PCI probably were due to the quicker decision-making / transport and to the quick preparation in catheterization laboratory. Interestingly, the ambulance units applied the TTECG more frequently when the patient's location was farther from the PCI centre.

Summarized, in our examination we proved that the application of the TTECG and the TTECG-based consultation between the professionals of the ambulance service and the specialists significantly improved the following factors among the majority of the STEMI patients ( $n=775$ ):

- medical treatment before the delivery to the hospital,
- the PCI delay times and
- the rate of in-hospital mortality.

## Examination of the prognostic factors of in-hospital mortality in STEMI

We assumed that the decreased number of the patients who died in the hospital can be explained by the fact that the TTECG triage accelerates medical attendance and improves the pre-hospital therapy. According to the data of this survey we found that the optimal pre-hospital medicinal therapy (ASA/clopidogrel, GP IIb/IIIa inhibitor and giving low dosage nitrate) decreased: 1) the total occlusion of the infarct-related coronary artery and 2) the risk of in-hospital mortality. Furthermore, we found that the ASA/clopidogrel, the GP IIb/IIIa inhibitor and the total occlusion of the infarct-related coronary artery proved individual predictors of the decrease of in-hospital mortality.

It is generally accepted that the total occlusion of the coronary artery and the intracoronary thrombus formation decrease the coronary flow, which results in the damage of heart muscle and loss of function. In this survey we also found that the improper use of the Na-heparin, ASA and/or clopidogrel and GP IIb/IIIa inhibitors enhances the disposition to total coronary occlusion.

Previous studies connect the improved mortality rate with the pre-hospital attendance improved due to the TTECG and the triage (time=heart muscle). According to our own data base we also found that the TTECG-based triage is an individual independent prognostic factor (predictor) and it decreases in-hospital mortality significantly.

In this study we found that successful resuscitation and the AHF (Killip class>2) are individual independent predictors of in-hospital mortality. These observations correspond to the previous publications. The routine medicinal treatment applied during the process of resuscitation explains why atropine and venous positive inotrope drugs were applied much more frequently in the group of the patients died in the hospital.

Our summarized results show that in-hospital mortality in STEMI can be significantly decreased by TTECG-based consultation and triage (which improves the pre-hospital medicinal treatment and the coronary flow). According to our data: 1) TTECG-based triage, 2) the optimal antithrombotic treatment (ASA and/or clopidogrel and GP IIb/IIIa inhibitors) as well as 3) perfusion of the infarct-related coronary artery before PCI are important independent, individual predictors of a lower in-hospital mortality rate in STEMI.

## Summary of the results

*Aim 1. To what extent is the TTECG suitable to the control/diagnostics of the STEMI-patients (validation of the system)?*

After the regional introduction of the TTECG on the Northern Plain, in the period from 1<sup>st</sup> January 2008 to 30<sup>th</sup> June 2008 we evaluated the data of the patients transported by the OMSZ with ACS or chest pain assumed diagnosis. Altogether 56 cases were directly transported. The quality of the made TTECG was excellent in 50 cases and the patient was controlled based on the TTECG. The quality of the TTECG proved strongly limited in the case of six patients, in these cases we made the decision on the patient paths based on consultation. Efficiency of the TTECG proved excellent, as ACS, malign arrhythmia or other cardiologic disease causing ST elevation were confirmed in 50/50 cases.

The advantages resulted from the use of the system in the acute cardiologic treatment can be summarized as follows: 1) the number of false ECG diagnosis decreased, the patient paths can be optimized, 2) the patient's placement / acceptance in the PCI centre can be ensured directly and 3) the TTECG system provides an opportunity for consultation about the medicinal / other treatment.

*Aim 2. We examined the clinical effectiveness of the TTECG in STEMI:*

- *concerning the PCI delay times (door-to-sheath and door-to-balloon times),*
- *the pre-hospital medical therapy and*
- *in-hospital mortality.*

In our survey we proved that the application of the TTECG and the TTECG-based consultation between the professionals of the ambulance service and the specialists significantly improved

- *the pre-hospital medical treatment (pre-hospital medicinal treatment improved),*
- *the PCI delay times,*
- *the rate of in-hospital mortality*

*in a big group of STEMI-patients (n=775).*

*Aim 3. With logistic regression we searched for such pre-hospital factors (TTECG, pre-hospital medicinal therapy, demographic data, accompanying diseases, etc.), which affected in-hospital mortality in STEMI from prognostic aspect. First of all, we wanted to know to what extent*

*TTECG-based consultation and triage can be deemed individual prognostic factors (predictors) in STEMI.*

Our results show that in-hospital mortality in STEMI can be significantly decreased by TTECG-based consultation and triage (which improves the pre-hospital medicinal treatment and the coronary flow).

According to our data: 1) the TTECG-based triage, 2) the optimal antithrombotic treatment (ASA and/or clopidogrel and GP IIb/IIIa inhibitors) as well as 3) perfusion of the infarct-related coronary artery before PCI are independent, individual predictors of a lower in-hospital mortality rate in STEMI.

### **Conclusions:**

In summary, our findings indicate that:

- 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 is feasible and fast,
- confirmation of the diagnosis of STEMI by the specialist improved the medical therapy initiated by the paramedics and
- TTECG significantly shortened the PCI-related delay times and improved the in-hospital mortality rate.

In this study, we demonstrated that the successful pre-hospital resuscitation of STEMI patients and acute heart failure (Killip class>2) are important independent predictors of in-hospital death.

In summary, our findings indicate that a previously published higher in-hospital survival rate of STEMI patients elicited by TTECG-based consultation is associated with better coronary flow in response to an improved pre-hospital medical therapy.

According to our data:

- an early, TTECG-facilitated diagnosis of STEMI and a triage of patients
- optimal pre-hospital antithrombotic therapy (administration of ASA and/or clopidogrel and GP IIb/IIIa inhibitor) and
- the patency and better perfusion of the infarct-related artery before PCI are



**important independent predictors of a lower in-hospital mortality rate (i.e. higher survival rate).**

## **Summary**

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 contact and transport times, percutaneous coronary intervention (PCI)-related delay times, prehospital medical therapy and in-hospital mortality rate. The study was conducted in the north-eastern region of Hungary, as a collaborative effort between the University of Debrecen and the Hungarian National Ambulance Service. Out of the 776 patients recruited, the TTECG group comprised 397 patients, while 379 patients transported to the PCI centre without TTECG served as controls. The ambulance service contact and transport times demonstrated that recording and transmission of TTECG was feasible and fast. Significantly more patients received sodium heparin and narcotics in the TTECG group than among controls.

The door to sheath insertion and door to balloon times were both significantly shorter for the TTECG group than for controls. The in-hospital mortality rate was significantly lower in the TTECG group compared to controls. The findings clearly illustrate the value of TTECG in the regional management of STEMI patients, with significant shortening of the PCI-related delay times and improvements of the prehospital medical therapy and in-hospital mortality rate.

TTECG was hypothesized that the higher in-hospital survival rate could be due to improved TTECG-based pre-hospital management and consequently, better coronary perfusion of patients at the time of hospital admission. To test this hypothesis, our database of STEMI patients was evaluated retrospectively for predictors (including TTECG) that may influence in-hospital survival. The STEMI patients were divided into two groups, namely 1) hospital death patients ( $n=49$ ) and 2) hospital survivors (control,  $n=726$ ). Regarding pre-hospital medical management, the TTECG-based triage and the administration optimal pre-hospital medical therapy (acetylsalicylic acid and/or clopidogrel, GP IIb/IIIa inhibitor and low-dose nitroglycerin infusion) were the most important independent predictors for a decreased hazard in our model. At the same time, age, acute heart failure [Killip class  $>2$ ], successful pre-hospital resuscitation and total occlusion of the infarct-related coronary artery before PCI were the most important independent predictors for an increased hazard of in-hospital mortality.

In STEMI patients, 1) an early TTECG-based consultation and triage 2) optimal pre-hospital antithrombotic medical therapy and 3) the patency and better perfusion of the infarct-

related coronary artery on hospital admission are important predictors of a lower in-hospital mortality rate.

**Tárgyszavak: (keywords in hungarian)** Transztelefonkus EKG, kardiovaszkuláris betegségek, akut koronária szindróma, mentőszolgálat, szívelégtelenség, ST elevációs miokardiális infarktus, szívkatéterezés, koronária áramlás, a halálozás klinikai prognosztikai tényezője,

**Keywords:** Transtelephonic ECG, cardiovascular disease, acute coronary syndrome, emergency medical services, congestive heart failure, STEMI, percutaneous coronary intervention, coronary artery flow, clinical predictors of mortality,

### **List of own publications**

#### **S1.** We would have lost this patient if ... (case study)

Pápai G, Rácz I, Mártai I, Gorove L, Göndöcs Z, Tóth G, Édes I. *Cardiologica Hungarica*, 41: 3-5, 2011.

#### **S2.** Early experiences gained with the transtelephonic ECG system during the pre-hospital treatment of acute coronary syndrome in the region of the Northern Plain.

Pápai G, Rácz I, Szabó G, Tóth G, Muzsik B, Mártai I, Göndöcs Z, Édes I. *Cardiologica Hungarica*. 40: 268-271, 2010.

#### **S3.** Transtelephonic electrocardiography in the management of patients with acute coronary syndrome.

Papai G, Racz I, Czuriga D, Szabo G, Edes IF, Edes I. *J Electrocardiol* 47: 294-299, 2014.

#### **S4.** The transtelephonic ECG-based triage is an independent predictor of decreased hospital mortality in patients with ST segment elevation myocardial infarction treated with primary percutaneous coronary intervention.

Papai G, Csato G, Racz I, Szabo G, Barany T, Racz A, Szokol M, Sarman B, Edes IF, Czuriga D, Kolozsvari R, Edes I. *J. Telemedicine Telecare*. in press 2018.

#### **S5.** Analysing the pre-hospital delay time of patients treated with cardiac infarction.

Jánosi A, Csató G, Pach F, Pápai G, Erdős G, Andréka P. in press 2018.

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### List of publications related to the dissertation

1. **Pápai, G.**, Csató, G., Rác, I., Szabó, G. T., Bárány, T., Rác, Á., Szokol, M., Sármán, B., Édes, I. F., Czuriga, D., Kolozsvári, R., Édes, I.: The transtelephonic ECG-based triage is an independent predictor of decreased hospital mortality in patients with ST segment elevation myocardial infarction treated with primary percutaneous coronary intervention. *J. Telemed. Telecare. "Accepted by Publisher"*, 2018.  
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2. **Pápai, G.**, Rác, I., Czuriga, D., Szabó, G., Édes, I. F., Édes, I.: Transtelephonic electrocardiography in the management of patients with acute coronary syndrome. *J. Electrocardiol.* 47 (3), 294-299, 2014.  
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### List of other publications

3. **Pápai, G.**, Rácz, I., Szilágyi, S., Szokol, M., Mártai, I., Gorove, L., Göndöcs, Z., Tóth, G., Hegedűs, J., Muzsik, B., Édes, I.: Ezt a beteget elvesztettük volna...  
*Cardiol. Hung.* 41, 3-5, 2011.
4. **Pápai, G.**, Rácz, I., Szabó, G. T., Tóth, G., Muzsik, B., Mártai, I., Göndöcs, Z., Édes, I.: A transztelefonikus EKG-rendszerrel szerzett kezdeti tapasztalatok az akut koronária szindróma prehospitális ellátása során az észak-alföldi régióban.  
*Cardiol. Hung.* 40 (4), 268-271, 2010.

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