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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Electrocardiogram teletransmission and teleconsultation: essential elements of the organisation of medical care for patients with ST segment elevation myocardial infarction: a single centre experience

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Abstract

Background: Optimal treatment of ST segment elevation myocardial infarction (STEMI) should be initiated immediately. System delay is considered an important indicator of quality of care in STEMI, and at the same time it is an independent predictor of clinical outcomes. It can be modified largely by introducing organisational changes. Although conditions have been created in Poland for common use of electrocardiogram (ECG) teletransmission and direct transfer of all STEMI patients to cardiac catheterisation laboratories, no uniform management algorithms have been introduced.

Aim: To summarize several years of our experience with the use of ECG teletransmission and teleconsultation system in a Polish rural region, present conclusions drawn from practical use of the suggested management algorithm, and compare effectiveness of this system in its early and established phases.

Methods: The reported network consists of a single percutaneous coronary intervention (PCI)-capable hospital, emergency medical services (EMS) system, and several local non-PCI-capable hospitals. We extensively discussed the management algorithm based on prehospital diagnosis with ECG teletransmission and teleconsultation, and direct patient transfer to a PCI-capable hospital. Delays seen immediately after the system was introduced were compared with data obtained after several years of its stable functioning.

Results: In 2005–2013, the average time to STEMI reperfusion therapy (total delay) was 282.3 (median 213) min, patient-related delay was 164.1 (median 74) min, and system delay was 116.8 (median 111) min. Primary PCI was performed in 93% of STEMI patients, with 21.1% of patients treated within 90 min after the first medical contact (FMC) and 61.1% of patients treated within 120 min after FMC. In 2006–2010, no significant change in the total delay was seen (340 min in 2006 vs. 311 min in 2010, $p = 0.1429$). A significant reduction was seen in the system delay both overall (–8.3%, $p = 0.0318$) and in hospital (–24.0%, $p < 0.0001$). Primary PCI was performed within 90 min after FMC in 14.0% of patients in 2006 and in 30.6% of patients in 2010 (+118.6%, $p = 0.0049$), and within 120 min after FMC in 55% and 62.2% of patients, respectively ($p = 0.3008$). The delay from FMC to the diagnosis decreased (–32.1%, $p = 0.0356$) but the overall EMS delay did not change (102.7 vs. 103.7 min, $p = 0.6725$). Patient transfer time to the cardiac catheterisation laboratory remained unchanged (54.8 vs. 60.1 min, $p = 0.0828$), as was the patient-related delay (161.9 vs. 150.2 min, $p = 0.2801$).

Conclusions: An ECG teletransmission and teleconsultation system reduces the system delay. ECG teletransmission systems work well in rural areas with low population density and a single large PCI-capable hospital. With increasing experience, a gradual increase in the effectiveness of management protocols involving ECG teletransmission is seen.

Key words: myocardial infarction, ECG teletransmission, direct transfer, total delay, system delay

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INTRODUCTION

Optimal timing of treatment is an important prerequisite of good outcomes in patients with acute coronary syndromes (ACS). In acute myocardial infarction (AMI), and particularly ST segment elevation myocardial infarction (STEMI), treatment delay has important consequences, as the area of necrosis increases rapidly with time [1, 2]. The biggest challenge in the organisation of healthcare is thus to minimize delays in diagnosis, patient transfer, and treatment. As suggested in the guidelines [3], the time from initial symptoms of AMI to reperfusion therapy may be divided into patient-related delay and healthcare system-related delay (system delay). Patient-related delay is the time from the onset of symptoms to first medical contact (FMC), and system delay is the time from FMC to culprit vessel opening, defined as passing a wire through the occluded culprit vessel during percutaneous coronary intervention (PCI), or initiation of fibrinolytic therapy. No effective ways to reduce patient-related delay have been devised so far, and the only hopes may be laid on appropriate public campaigns. System delay is much more amenable to modifications by organisational changes. Thus, this delay is often considered an important indicator of healthcare quality, in addition to being an independent predictor of treatment outcomes [4]. System delay depends partially on emergency medical services (EMS) and partially on the organisation of in-hospital care. EMS are responsible for rapid contact with the patient, initial diagnosis, institution of prehospital treatment, and efficient patient transfer to a PCI-capable hospital. In an optimal and target scenario, most if not all patients with AMI would be transported by EMS, and EMS ambulances would be able to consult remotely with a cardiology unit and transfer patients directly to a PCI-capable hospital regardless of the patient's whereabouts. The aim of this study was to summarize several years of our experience with the use of an electrocardiogram (ECG) teletransmission and teleconsultation system, present conclusions drawn from practical use of the management algorithm we developed, and compare effectiveness of this system in its early and established phases of functioning.

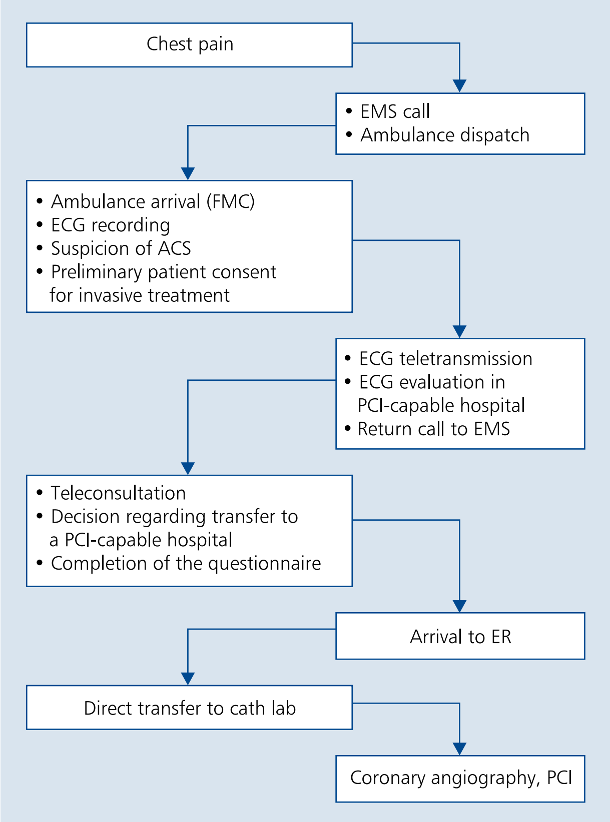

Figure 1. Management algorithm — ECG teletransmission and cardiological teleconsultation; EMS — emergency medical services; FMC — first medical contact; ECG — electrocardiogram; ACS — acute coronary syndrome; ER — emergency room; PCI — percutaneous coronary intervention

METHODS

Description of the system

Experience of our cardiology service and coronary care unit with the use of an ECG teletransmission and teleconsultation system began in the autumn of 2005. At that time, a system of early STEMI management based in ECG teletransmission was set up within an area of nine districts covering nearly 13,000 km^2 and inhabited by about 800,000 people [4]. Co-operation was established with all PCI non-capable hospitals with internal medicine or cardiology wards in this area, where patients with suspected AMI were initially referred before transfer to a PCI-capable hospital. The most important was, however, close collaboration between PCI-capable hospitals and EMS stations, including two large, independent stations and other smaller stations attached to local hospitals.

A basic management algorithm was developed (Fig. 1) and EMS ambulances were fitted with ECG transmission equipment (95% of ambulances within first 4 months). The last ambulances to be fitted with this system were those operating in the nearest vicinity of a PCI-capable hospital. ECG teletransmission receiving unit was located in our coronary care unit, with a single mobile telephone number used for direct contact with ambulance teams. At the same time, all personnel of the involved units underwent dedicated training (two 2- to 3-h sessions) that focused on prehospital ACS management and use of the equipment provided. An important part of the training was to provide the EMS personnel with basic knowledge about in-hospital AMI management, with particular reference to invasive treatment. It was deemed necessary that transfer time be used for providing patients with detailed information regarding planned invasive treatment and preparing them to give written informed consent for such treatment while already in hospital. Test ECG teletransmissions were performed to verify newly acquired skills. Only in single cases, additional training was required while the system was in operation.

With this training, highly effective system functioning was established before its actual initiation in clinical practice, and at the same medical procedures became standardised. This allowed teleconsultations to be focused on decisions regarding direct patient transfer to the PCI-capable hospital and not other management issues. Less frequent than initially expected prehospital administration of heparin and clopidogrel was related to the fact that physician members of ambulance crews were partially replaced with paramedics.

The system is coordinated by a physician in charge of the coronary care unit, and outside regular working hours by a senior physician on duty in the cardiology service, generally the one with the largest professional experience, which in practice means a board-certified cardiologist. It is assumed that he should not be given have other responsibilities which would significantly limit his availability for consultations, and in particular he should not be directly involved in the performance of invasive procedures during that time. He is the only person with direct access to the telephone unit used for teleconsultations and he must be authorised to make immediate decisions regarding patient admission. This does not constitute his only responsibilities in this regard, as when a decision is made regarding admission, he determines the expected time of patient arrival by obtaining appropriate information from the person in charge of an EMS team and is responsible for in-hospital preparations for invasive treatment. Thus, he informs the emergency department and the cardiac catheterisation laboratory, in most case by direct contact with the responsible physicians on duty. If needed, he orders elective procedures to be withheld. This is, however, rarely needed as there are two operating tables in our cardiac catheterisation laboratory. In appropriate cases, such as inability to perform PCI in STEMI or occurrence of mechanical complications of AMI, he arranges for cardiac surgical consultation in cooperation with the invasive cardiologist (a cardiac surgical ward is in operation in our hospital since 2002 and has necessary experience in emergent procedures). Urgent cardiac surgical consultations are usually required, however, not for STEMI patients but for those in shock, with non-ST segment elevation ACS (NSTE-ACS) and multivessel disease or left main coronary artery disease.

Due to large patient volume in the emergency department, the latter is staffed by both cardiologists and internists. After ECG teletransmission, the cardiologist on duty in the emergency department is responsible for minimisation of in-hospital treatment delay and supervises patient transfer by the EMS directly to the cardiac catheterisation laboratory. With clear STEMI pattern in the transmitted ECG, procedures in the emergency department are limited to the necessary minimum that includes patient data entry into the hospital information system and verbal confirmation of the patient consent for invasive procedures. In an optimal scenario, the patient does not need to spend any time in the emergency department and is only transferred through it. On the way to the cardiac catheterisation laboratory, patient receives any additional information he needs in case of questions or doubts, and any required additional history is taken. The patient is transferred directly from the ambulance stretcher to the operating table in the cardiac catheterisation laboratory. Once in the cardiac catheterisation laboratory, the patient is given hospital cloths and additional necessary medications, and gives informed consent. At latest during the invasive procedure, a bed in the coronary care unit is arranged for the patient.

The emergency department plays a particularly important role when STEMI patients are brought to hospital by ambulances from the area nearest to the hospital. For obvious reasons, ECG teletransmission is not used for these patients but the emergency department is usually informed in some advance by the EMS services, allowing time to activate the same procedures as for patients whose ECG is teletransmitted. The worst scenario, although it becomes more and more rare, is when STEMI patients present themselves to the emergency room or are referred by family physicians. In all such cases, further actions are coordinated by the cardiologist on duty in the emergency department. If immediate coronary angiography is not feasible, the patient is admitted to the coronary care unit.

To allow precise monitoring of the quality of prehospital management, an obligatory questionnaire was also introduced to be filled by the person in charge of the EMS team and handed together with the patient. In particular, this questionnaire is used to document timing of the symptom onset, first patient contact with the EMS system and all subsequent actions, which allows further analyses of the delays. Full evaluation of in-hospital delays is possible using standard hospital medical records. All data are collected prospectively.

When the system was initiated, it was assumed that the maximum effectiveness would be achieved only after some duration of its stable functioning. To evaluate additional benefits from repeated performance of all planned procedures in clinical practice, from the available database we selected two groups of 100 consecutive STEMI patients admitted to our PCI-capable hospital following ECG teletransmission in 2006 and 2010, respectively. These groups did not differ in regard to gender proportions, age, and place of residence (Table 1). We analysed the size of specific components of the overall treatment delay, with particular focus on those referred to in the current guidelines (Table 2).

Statistical analysis

Statistical analysis was performed using the STATISTICA 7.1 software. Quantitative variables were reported as mean values ± standard deviation (SD). Qualitative variables were summarised in contingency tables. Qualitative variables were compared using the Mann-Whitney U test, and qualitative variables were compared using the χ^2 test. $P < 0.05$ was considered statistically significant.

Table 1. General patient characteristics (n = 200)

Parameter	2006	2010	P (χ^2 test)
Women	38 (38%)	26 (26%)	0.0689
Men	62 (62%)	74 (74%)	
Age below median (< 66 years)	46 (46%)	52 (52%)	0.3960
Age above median (> 65 years)	54 (54%)	48 (48%)	
Rural place of residence	68 (68%)	65 (65%)	0.6531
Urban place of residence	32 (32%)	35 (35%)	

RESULTS

The first successful ECG teletransmission followed by direct patient transfer to our PCI-capable hospital in Zamosc was performed on October 6, 2005. By the end of March 2013, overall more than 7,000 teletransmissions were performed, resulting in admission of nearly 1,500 STEMI patients. This amounted to about one third of all STEMI patients hospitalised in this period. The average yearly number of teletransmissions was about 830, leading to about 230 admissions of STEMI patients. Primary PCI was performed in about 93% of these patients, and some patients (about 3% of those with STEMI) were referred for cardiac surgery (Fig. 2).

In 2005–2011, the mean total treatment delay was 282.3 (median 213) min, including patient-related delay of 164.1 (median 74) min, and system delay of 116.8 (median 111) min. Primary PCI was performed within 90 min from FMC in 21.1% of patients, and within 120 min in 61.1% of patients. All evaluated components and their contribution to the total treatment delay are listed in Figure 3. Table 2 shows these delays in the patient groups selected in 2006 and 2010. These groups did not differ in regard to gender proportion, age, and the distance between patient places of residence and the PCI-capable hospital (Table 1). We did not show a significant change in the mean total treatment delay which was 340 min in 2006 and 311 min in 2010 (p = 0.1429).

Table 2. Comparison of the effectiveness of the ECG teletransmission system in its early (2006) and established (2010) phases

Delay component	2006		2010		Change		P*
	N	Mean ± SD [min]	N	Mean ± SD [min]	Absolute [min]	Relative [%]	
Symptoms to EMS contact	100	144.3 ± 172.9	100	130.7 ± 165.4	–13.6	–9.4	0.2595
Symptoms to FMC[1]	100	161.9 ± 172.3	100	150.2 ± 165.8	–11.7	–7.2	0.2801
Symptoms to ER presentation	100	245.6 ± 172.3	100	235.8 ± 173.2	–9.8	–4.0	0.2867
Symptoms to coronary angiography	100	270.7 ± 177.1	99	262.9 ± 182.6	–7.8	–2.9	0.3152
Symptoms to wire passage through the culprit lesion[2]	100	286.2 ± 178.5	98	268.7 ± 175.4	–17.5	–6.1	0.1694
Symptoms to balloon inflation	100	292.7 ± 179.1	97	274.1 ± 176.8	–18.6	–6.4	0.1492
EMS contact to FMC	100	17.3 ± 14.3	100	19.2 ± 13.4	+1.9	+11.0	0.1196
EMS contact to ER presentation	100	102.7 ± 32.2	100	103.7 ± 30.1	+1.0	+1.0	0.6725
EMS contact to coronary angiography	100	126.0 ± 36.7	99	121.9 ± 33.9	–4.1	–3.3	0.5872
EMS contact to wire passage through the culprit lesion	100	141.4 ± 37.6	99	133.1 ± 34.8	–8.3	–5.9	0.1413
EMS contact to balloon inflation	100	148.1 ± 40.3	98	137.1 ± 33.9	–11.0	–7.4	0.0731
FMC to diagnosis	100	11.2 ± 13.4	100	7.6 ± 8.1	–3.6	–32.1	**0.0356**
FMC to ER presentation	100	85.5 ± 26.7	100	84.6 ± 26.3	–0.9	–1.1	0.9289
FMC to coronary angiography	100	108.7 ± 32.4	99	102.7 ± 31.1	–6.0	–5.5	0.2706
FMC to wire passage through the culprit lesion[3]	100	124.2 ± 33.3	99	113.9 ± 32.0	–10.3	–8.3	**0.0318**
FMC to balloon inflation	100	130.8 ± 36.0	98	118.1 ± 31.7	–12.7	–9.7	**0.0155**
ER presentation to coronary angiography	100	23.3 ± 15.0	99	18.2 ± 13.6	–5.1	–21.9	**< 0.0001**
ER presentation to wire passage through the culprit lesion[4]	100	38.7 ± 18.0	99	29.4 ± 15.0	–9.3	–24.0	**< 0.0001**
ER presentation to balloon inflation	100	45.3 ± 20.5	98	34.0 ± 15.0	–11.3	–24.9	**< 0.0001**

*Mann-Whitney U test; [1]Patient-related delay; [2]Total delay; [3]System delay; [4]Hospital-related delay; SD — standard deviation; EMS — emergency medical services; FMC — first medical contact; ER — emergency room

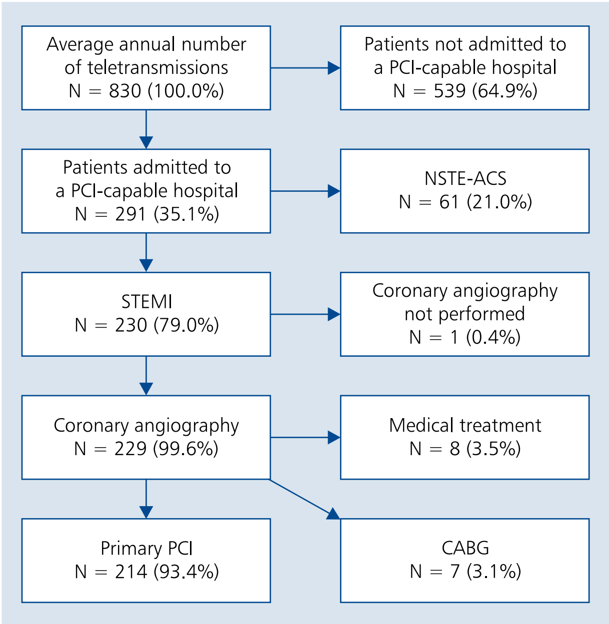

Figure 2. Average yearly patient flow within the ECG teletransmission system; NSTE-ACS — non-ST segment elevation acute coronary syndrome; STEMI — ST segment elevation myocardial infarction; PCI — percutaneous coronary intervention; CABG — coronary artery bypass grafting

However, we observed a significant reduction in the system delay, both overall (by 8.3%, $p = 0.0318$) and in relation to organisation of in-hospital care (by 24.0%, $p < 0.0001$). During that time, an increase was also seen in the proportion of patients treated within the timeframe recommended in the guidelines. In 2006, 14.0% of patients were treated within 90 min from FMC, compared to 30.6% of patients in 2010 (an absolute increase by 118.6%; $p = 0.0049$), while 55.0% and 62.2% of patients were treated within 120 min from FMC in 2006 and 2010, respectively ($p = 0.3008$). Although the time from FMC to the diagnosis also decreased (by 32.1%, $p = 0.0356$), overall EMS-related delay did not change (102.7 vs. 103.7 min, $p = 0.6725$). This delay was mostly dependent on the duration of patient transfer from FMC to emergency room arrival, which did not change (54.8 vs. 60.1 min, $p = 0.0828$).

The patient-related delay did not change significantly in the study period (mean 161.9 min in 2006 vs. 150.2 min in 2010, $p = 0.2801$).

DISCUSSION

Poland is one of few countries in which the current European Society of Cardiology (ESC) guidelines regarding organisation of STEMI treatment have been effectively put into practice.

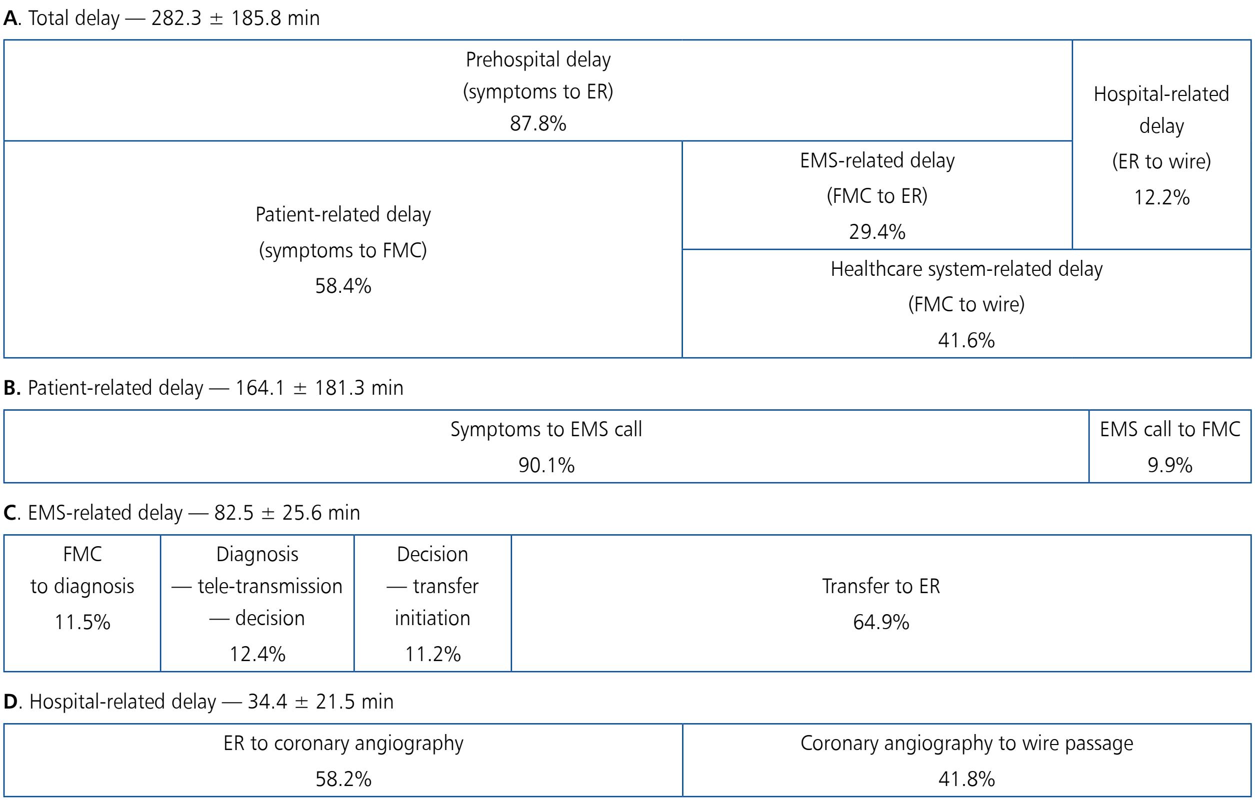

Figure 3. **A**–**D**. Components of STEMI treatment delay in 2005–2011 (n = 670) — mean ± standard deviation; STEMI — ST segment elevation myocardial infarction; ER — emergency room; FMC — first medical contact; EMS — emergency medical system

The network of PCI-capable hospitals with 24/7 duties is dense enough, and most EMS teams are fitted with ECG teletransmission equipment. No larger-scale studies have been performed on the relation between use of ECG teletransmission and patient outcomes, and no uniform management algorithm is in operation regarding these issues. Currently, the Polish Society of Emergency Medicine and Polish Cardiac Society have undertook collaboration to develop an agreed management protocol for ECG teletransmission by EMS teams caring for patients with suspected AMI [6].

The major purpose and value of this study was to present and discuss a complete and clinically established STEMI management protocol from the occurrence of chest pain to revascularisation of an epicardial coronary artery. Such a summary, based on an analysis of current guidelines and our own experiences, is shown in Table 3.

Occurrence of chest pain, particularly of typical nature and location, persisting for several minutes despite cessation of effort and sometimes also administration of a short-acting nitrate, should prompt urgent contact with the EMS system. However, this continues to be a rare scenario and thus the patient-related delay is an invariably large part of the total treatment delay. Reasons for this patient-related delay are mostly related to poor patient knowledge regarding AMI, its risk factors, and recommended actions in response to the occurrence of chest discomfort [7–9]. Available publications usually suggest appropriately designed public campaigns to improve this situation, but there is no convincing evidence that such efforts are effective [10].

The telephone contact by the patient or other witnessing person activates EMS. After taking brief history, the EMS dispatcher makes a decision whether to dispatch an EMS team. The ambulance need not be necessarily staffed by a physician, as well-trained paramedics provide appropriate quality of pre-hospital AMI management [11]. The only problem may be related to the lack of uniform interpretation of the range of activities undertaken independently by a paramedic [12]. For this reason, and despite the fact that the previous agreements in this regard were upheld, we currently observe less frequent administration of heparin and clopidogrel in the ambulance than it was initially seen when the system was introduced. There is no sufficient legal and financial support for routine administration of fibrinolysis by EMS teams in Poland and such treatment was not administered in our area.

Ambulance arrival time (i.e., time between EMS system call and FMC) is regulated by the law in Poland [13]. Its upper limit (15 and 20 min, respectively, for urban and rural locations) was exceeded in our study group in 15.6% of EMS ambulance dispatches to urban locations and 31.2% of dispatches to rural locations. Median arrival times, however, were acceptable at 6 and 15 min, respectively, and thus within recommended times of 8 and 15 min, respectively. It seems that reducing ambulance arrival time would only be possible by increasing the density of EMS station network.

Immediate ECG recording by the EMS team is the basis of prehospital diagnosis in all patients with chest pain [14]. The target acceptable delay suggested by the ESC, i.e. 10 min from FMC, was met in most cases already at the time when the system was initiated, and this delay even became shorter with more stable functioning of the system which indicates that the expected behaviours of the EMS teams were indeed established and practiced. Currently, our EMS teams need on average 9 min since FMC to record an ECG and inform the PCI-capable hospital that AMI is suspected and ECG teletransmission is planned. This direct telephone contact before teletransmission allows initial provision of the most important clinical data by the EMS team. At the same time, the physician responsible for receiving the transmission is provided time to reach the receiving unit in the coronary care unit if due to some other duties he or she is located elsewhere within the hospital. In this way, a return telephone contact is made immediately after the ECG is printed in the receiving unit, and any delay results only from technical issues, mostly limited mobile phone signal strength due to local terrain obstructions or low urbanisation level.

After patient-related delays were excluded from the analysis, the main contributor to the total delay was the patient transfer time from the location of FMC to the PCI-capable hospital. The mean patient transfer time was 54.1 min, which was mostly related to large distances travelled by EMS ambulances (mean 64 km, maximum 140 km). Due to adverse weather conditions, patient transfer time was increased in the winter months (50.7 min in summer vs. 58.5 min in winter, $p = 0.0009$). According to the guidelines, direct patient transfer to a PCI-capable hospital is indicated if PCI may be performed within 120 min from FMC [3]. This condition seemed possible to be fulfilled and was one basic assumption when designing our ECG teletransmission and teleconsultation system. In practice, it was fulfilled in about 61% of cases. We believe that this relatively low proportion resulted from a large size of the area covered by the system, its rural farmland character, and poor quality of local roads. Of note, however, our patients originated from outside the nearest vicinity of the hospital and would likely be offered no reperfusion therapy at all if direct transfer were not attempted, or the delay to reperfusion therapy would be even larger. With largest distances, airborne patient transfer should be employed more frequently, particularly for high-risk patients with large anterior infarct. Such decisions are made individually by EMS teams and may not be forced by the personnel of a PCI-capable hospital.

Introduction of ECG teletransmission in our hospital reduced not only pre-hospital but also in-hospital delay. The latter was gradually reduced in subsequent years, which was more related to shortening duration of invasive procedures, resulting in turn from growing skills and experience of invasive

Table 3. Management algorithm for patients with chest pain

Event	Description/action	Expected effects	Desired timing
Chest pain	Chest pain lasting ≥ 20 min, not alleviated by NTG.	Phone call for qualified medical help — by the patient or other persons.	As fast as possible after the onset of pain, within 3–5 min after sublingual administration of a NTG dose of the pain does not subside.
Call for ambulance	In Poland, call 999 more frequently than 112. Description of pain, history of CAD, pain radiation to neck, jaw, or left arm, if present.	Rapid history taking by an EMS dispatcher, ambulance dispatch.	1–2 min for making the call; 1–2 min for ambulance dispatch.
First medical contact	Initial evaluation by a paramedic or physician, in particular vital signs, relevant additional history, early treatment initiation as needed.	Stabilisation of the patient condition if necessary, rapid initial diagnosis, obtaining an initial ECG.	As fast as possible, within 15 min from dispatch in urban locations, within 20 min in rural locations.
Initial diagnosis	Obtaining an ECG and initial automated interpretation (by a physician if present in the ambulance).	With suspected STEMI, immediate initiation of ECG monitoring (using defibrillator), provision of a venous access.	As fast as possible, within 10 min from FMC.
	ECG teletransmission to a PCI-capable hospital with 24/7 duty in all patients with chest pain (after previous notification by phone and reporting history and other relevant patient information). In suspected STEMI, obtaining a preliminary verbal consent for invasive evaluation and treatment.	ECG interpreted immediately by a physician in charge of the coronary care unit (within regular working hours) or a senior cardiologist on duty. Confirmation of STEMI diagnosis.**	As fast as possible, within 10 min from FMC.
Final diagnosis*	Teleconsultation — return call to EMS team, additional history of necessary, decision regarding transfer to a PCI-capable hospital or the nearest hospital. If direct transfer to a PCI-capable hospital, estimation of expected arrival time.	Cardiologist responsible for teletransmission coordinates hospital preparation for arrival of a STEMI patient, in particular arranges a bed in the coronary care unit, notifies ER and cath lab about expected arrival time, and modifies the schedule of elective procedures if necessary.	As fast as possible, within 1–2 min if ST elevation.
Transfer to a PCI-capable hospital*	Patient transport by an ambulance with a defibrillator and ALS-trained team.	Minimisation of transfer time to the PCI-capable hospital, airborne transport in individual cases. Drug therapy as indicated.	As fast as possible, depending on the distance to a PCI-capable hospital and external conditions.
Hospital admission	Patient transport by the EMS team (on the same stretches) to cath lab without ER involvement, supervised by a cardiologist on duty in ER. Immediate patient data entry into the hospital information system, obtaining necessary consents and signatures during transfer. Change into hospital clothes when transferring onto the operating table in cath lab.	Minimisation of delay from patient arrival to ER and primary PCI (door-to-balloon).	As fast as possible, up to 60 min.

*Patients from the area nearest to the PCI-capable hospital are transferred without ECG teletransmission; ER is notified about the suspicion of STEMI by the EMS dispatcher, and patient care is coordinated by the cardiologist on duty in ER.
**Patients without confirmed STEMI may be individually selected for direct transfer if one of the following criteria is present: haemodynamic instability, complex ventricular arrhythmia, large ST segment depression or dynamic changes, severe typical pain, diabetes. Decision regarding PCI is usually made after initial evaluation in the coronary care unit.
NTG — nitroglycerin; CAD — coronary artery disease; EMS — emergency medical services; ECG — electrocardiogram; FMC — first medical contact; STEMI — ST segment myocardial infarction; ALS — advanced life support; ER — emergency room; PCI — percutaneous coronary intervention

cardiologists, than to shortening of the patient transfer time to the cardiac catheterisation laboratory. In the recent years, a general trend for reduction of the door-to-balloon time have been seen [15], and thus this parameter loses its previous importance as the main indicator of appropriate organisation of STEMI patient care, being replaced in this regard by overall system delay [4]. Current guidelines do not specify acceptable delay of primary PCI in STEMI patients admitted following previous ECG teletransmission. Rather, quite liberal recommendations have been given for all patients presenting to a hospital, stating that primary PCI should always be feasible within 60 min from the moment the cardiac catheterisation laboratory is notified about a STEMI patient [3]. Use of teletransmission and prehospital confirmation of the diagnosis of STEMI reduces this time by allowing advance preparation of the cardiac catheterisation laboratory and direct patient transfer without involvement of the emergency department [16–18]. In practice, as also evidenced by our data, this is not always associated with a reduction of total treatment delay which is most important for patient outcomes. Thus, further efforts are needed to reduce the system delay (and preferably the total treatment delay) and its components [19, 20].

The presented system, initiated in our hospital in 2005, is generally compatible with the assumptions of a later Polish program of interventional treatment of myocardial infarction in 2010–2011 [21]. One major difference is related to the suggested role of an invasive cardiologist, who in our system is not directly involved in decisions regarding direct patient transfer, and is a member of a team lead by a senior cardiologist on duty. This seemed obvious in a centre where the cardiac catheterisation laboratory is an integral part of the cardiology service, and responsibilities of the invasive cardiologist make him a suboptimal candidate to be an effective system coordinator as he may just not be sufficiently available. In addition, he may also lack necessary general clinical experience for this purpose. Another major difference is the fact that we also allowed direct transfer of patients without ST segment elevation but with features of high risk found by the EMS team (Table 3). This must be, however, dictated by current availability of hospital beds for such patients and such decisions must be made individually. In most cases, such patients are initially admitted to a coronary care unit and decisions regarding coronary angiography are made later. Smaller regional hospitals often cannot provide adequate facilities for or are unwilling to investigate such patients in the emergency room, and hospital admission is often associated with a delayed transfer to a PCI-capable hospital.

Data from the Polish Registry of Acute Coronary Syndromes (PL-ACS) for 2003–2006, before ECG teletransmission was introduced, indicate that reperfusion therapy was used at that time in 63.3% of STEMI patients (including fibrinolytic treatment in 7.8%, primary PCI in 54.1%, and fibrinolytic treatment followed by PCI in 1.4%), which is consistent with findings from other European registries. Median total delay to the first balloon inflation was 310 min, and the door-to-balloon time was 50 min [22]. Thus, introduction of ECG teletransmission and teleconsultation not only reduced the system delay but also improved availability of invasive treatment of AMI. This improvement is also evidenced by the national data: according to the PL-ACS registry, primary PCI was performed in 87% of STEMI patients in 2011, which seems to be related not only to an increase in the number of PCI-capable hospitals but also to appropriate changes in the organisation of healthcare.

CONCLUSIONS

1. An ECG teletransmission and teleconsultation system reduces the system delay in the treatment of AMI.
2. ECG teletransmission systems work well in rural areas with low population density, a single large PCI-capable regional hospital and an network of smaller non-PCI-capable local hospitals.
3. The learning curve effect was responsible for a gradual increase in the effectiveness of management protocols involving ECG teletransmission in subsequent years of system functioning.

Conflict of interest: *none declared*

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System teletransmisji EKG i telekonsultacji kardiologicznej podstawowym elementem organizacji opieki medycznej nad pacjentami z zawałem serca z uniesieniem odcinka ST: doświadczenia własne

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Streszczenie

Wstęp: Istotnym warunkiem uzyskania dobrego wyniku leczenia jest w przypadku ostrego zespołu wieńcowego jego podjęcie w optymalnym czasie. Z tego też względu ważnym zadaniem organizatorów opieki zdrowotnej jest minimalizacja opóźnienia systemowego: od pierwszego kontaktu medycznego (FMC) do reperfuzji — wprowadzenia prowadnika w trakcie pierwotnej angioplastyki wieńcowej (PCI), a w konsekwencji opóźnienia całkowitego: od początku objawów do PCI. Na opóźnienie systemowe można stosunkowo łatwo wpływać, wdrażając odpowiednie zmiany organizacyjne. Jego czas trwania bywa traktowany jako jeden z istotnych wskaźników jakości opieki w zawale serca z uniesieniem odcinka ST (STEMI), będąc przy tym niezależnym czynnikiem predykcyjnym wyników terapii. Za docelowe uważa się korzystanie przez wszystkich chorych z ostrym zawałem serca (AMI) z systemów ratownictwa medycznego (EMS), konsultowanie się przez zespoły EMS z referencyjnymi ośrodkami kardiologicznymi i bezpośredni transport chorych ze STEMI do ośrodków kardiologii inwazyjnej (OKI), niezależnie od miejsca zachorowania. Choć w Polsce istnieją już warunki do powszechnego stosowania teletransmisji i bezpośredniego transportu wszystkich pacjentów ze STEMI do OKI, to nie wprowadzono w tym zakresie powszechnie obowiązujących zasad postępowania.

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Cel: Celem pracy była prezentacja własnych, kilkuletnich doświadczeń z funkcjonowania w polskich warunkach systemu teletransmisji EKG i telekonsultacji, wniosków płynących z praktycznego zastosowania zaproponowanego algorytmu postępowania oraz porównanie efektywności systemu w początkowej i ustabilizowanej fazie jego działania.

Metody: Przedstawiono system funkcjonujący w rolniczym regionie Polski, utworzony przez pojedynczy OKI oraz sieć okolicznych stacji EMS i szpitali nieposiadających możliwości inwazyjnego leczenia AMI. Omówiono szczegółowo zastosowany algorytm postępowania w STEMI, opierający się na przedszpitalnym rozpoznaniu z wykorzystaniem teletransmisji i telekonsultacji oraz bezpośrednim transporcie chorych do OKI. Oceniono czas trwania poszczególnych składowych opóźnienia całkowitego. Porównano opóźnienia z okresu bezpośrednio po wprowadzeniu systemu z rejestrowanymi po kilku latach jego stabilnego działania. Wyniki poddano analizie statystycznej za pomocą testów χ^2 i U Manna-Whitneya.

Wyniki: W latach 2005–2013 opóźnienie całkowite wynosiło średnio 282,3 min (mediana 213), opóźnienie pacjenta 164,1 min (mediana 74), a opóźnienie systemu 116,8 min (mediana 111). Dla porównania w latach 2003–2006, czyli przed erą teletransmisji, mediana opóźnienia całkowitego wynosiła w Polsce 310 min. Pierwotną PCI wykonano u 93% przyjętych pacjentów, przy średniej dla Polski 54,1% w latach 2003–2006 oraz 87% w 2011 r. Pierwotna PCI była dostępna w ciągu 90 min od FMC dla 21,1% chorych, a w ciągu 120 min dla 61,1%. Między rokiem 2006 a 2010 nie zaszły istotne zmiany w czasie trwania opóźnienia całkowitego, które w 2006 r. wynosiło średnio 340 min, a w 2010 r. — 311 min ($p = 0{,}1429$). Zaobserwowano istotne zmniejszenie się opóźnienia systemowego, zarówno w całości (o 8,3%; $p = 0{,}0318$), jak i w części zależnej od organizacji opieki szpitalnej (o 24,0%; $p < 0{,}0001$). W czasie do 90 min od FMC w 2006 r. leczono 14,0% osób, a w 2010 r. — 30,6% pacjentów (różnica względna +118,6%; $p = 0{,}0049$), a do 120 min, odpowiednio 55,0% i 62,2% (brak istotnej różnicy; $p = 0{,}3008$). Czas od FMC do postawienia diagnozy uległ skróceniu (o 32,1%; $p = 0{,}0356$), jednak czas trwania całego opóźnienia zależnego od EMS (102,7 *vs*. 103,7 min; $p = 0{,}6725$) nie zmienił się. Nie uległ zmianie czas transportu z miejsca zachorowania do OKI (54,8 *vs*. 60,1 min; $p = 0{,}0828$). Opóźnienie w analizowanym okresie nie zmieniło się istotnie (wynosiło śr. 161,9 min w 2006 r. i 150,2 min w 2010 r.; $p = 0{,}2801$).

Wnioski: System teletransmisji i telekonsultacji skraca opóźnienie leczenia AMI w tej części, która nie zależy od pacjenta. Systemy teletransmisji EKG dobrze sprawdzają się w rejonach wiejskich, z małą gęstością zaludnienia, pojedynczym dużym OKI i siecią mniejszych szpitali bez możliwości interwencyjnej terapii AMI. W kolejnych latach stosowania rośnie skuteczność wprowadzonych algorytmów postępowania z wykorzystaniem teletransmisji EKG (tzw. „krzywa uczenia”).

Słowa kluczowe: zawał serca, teletransmisja EKG, transport bezpośredni, opóźnienie całkowite, opóźnienie systemowe

Kardiol Pol 2014; 72, 4: 345–354