Original paper

Impact of pre-hospital electrocardiogram teletransmission on time delays in ST segment elevation myocardial infarction patients: a single-centre experience

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A b s t r a c t

Introduction: Delay in diagnosis and treatment has a great influence on morbidity and mortality of ST-segment elevation myocardial infarction (STEMI) patients. Every 30 min of delay in reperfusion is associated with an 8% increase in mortality. ECG teletransmission was proved to effectively shorten time delays in STEMI treatment. In 2012 an ECG teletransmission program was introduced in the Lower Silesia region.

Aim: To assess the frequency of ECG teletransmission in STEMI patients and its influence on time delays.

Material and methods: We conducted a retrospective analysis of all patients admitted to our hospital with STEMI in 2013. Time delays, treatment and clinical characteristics of patients with and without teletransmission performed were compared.

Results: The study included 137 patients, of whom 49 (36%) had teletransmission performed. Direct transport to a percutaneous coronary intervention (PCI)-capable hospital was more frequent in patients with ECG teletransmission performed (88% vs. 63%, $p = 0.002$). In patients with teletransmission pain-emergency room time and total ischemic time were shorter (respectively 125 (91–184) min vs. 201 (113–339) min, $p = 0.001$ and 159 (136–244) min vs. 259 (170–389) min, $p < 0.001$). There were no differences in in-hospital delay, patients' characteristics, or applied therapy.

Conclusions: The percentage of STEMI patients who had ECG teletransmission performed was low. Patients with ECG teletransmission had a shorter total ischemic time and lower percentage of indirect transport to a PCI-capable hospital.

Key words: ECG teletransmission, ST-segment elevation myocardial infarction, acute myocardial infarction.

Introduction

Despite continuing improvements in invasive and pharmacological treatment, ST segment elevation myocardial infarction (STEMI) remains one of the most challenging clinical scenarios for cardiologists and emergency services (EMS). In Poland, over 50 000 patients are hospitalized with STEMI each year, and in-hospital mortality reaches 8.5% [1].

In STEMI, in contrast to most other diseases, delay in establishing diagnosis and introduction of accurate treatment has a clear influence on morbidity and mortality. Every 30 min of delay in reperfusion is associated with an 8% increase in mortality [2]. Thus, the European Society of Cardiology (ESC) recommends a target time of < 90 min from the first medical contact (FMC) to primary percutaneous intervention (pPCI) and < 30 min from FMC to administration of thrombolytic therapy [3].

Numerous actions decreasing the delay to reperfusion and reperfusion injury have been described [4, 5]. One of them is electrocardiogram (ECG) teletransmission from emergency services to a PCI-capable hospital. It has been shown that ECG teletransmission effectively shortens the system-related delay [6, 7]. In 2012, an ECG teletransmission program started in the Lower Silesia region.

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Aim

Our study was designed to assess the frequency of ECG teletransmission in daily practice and its influence on time delays in STEMI patients hospitalized in our hospital.

Material and methods

Study design

This was a single institution retrospective observational study. The study protocol was approved by the local ethics committee and was in accordance with the Declaration of Helsinki.

Study population

In our study we included all consecutive patients admitted to our hospital with a STEMI diagnosis between January 1st and December 31st 2013. The inclusion criteria were:

a) ST segment elevation in the ECG fulfilling the STEMI diagnosis criteria, as described in the ESC guidelines [3];
b) symptoms of ischemia lasting longer than 20 min;
c) time from symptom onset to first medical contact below 12 h.

After obtaining all data, patients were divided into two groups according to the presence of ECG teletransmission preceding their admission to our facility.

ECG teletransmission

ECG teletransmission has been available in the Lower Silesia region since 2012. In our hospital, the ECG transmission unit is in the Cardiac Intensive Care Unit (CICU) and is connected to the mobile phone used to contact the EMS personnel. During work hours it is operated by the CICU staff and during off-hours by a senior on-duty physician. After transmitting the ECG, EMS services contact the physician for teleconsultation. After confirming a STEMI diagnosis, the physician receiving the transmission is responsible for initiating our internal STEMI protocol, which includes informing the emergency room (ER) and catheterization laboratory staff and withholding any elective catheterization procedures. If for any reason (technical malfunction, occupied cathlab, no beds available in the CICU) urgent coronary angiography is not possible, the patient is immediately redirected to another PCI-capable hospital (there are 3 other cathlabs on duty 24/7 in Wrocław).

Time delays

We defined several time intervals that the overall STEMI treatment delay consists of:

a) pain-ER – time from symptom onset to admission to the ER in a PCI-capable hospital;
b) ER-cathlab – time from admission to the ER to the beginning of coronary angiography;
c) cathlab-balloon – time from the start of coronary angiography to restoring the flow in the coronary artery;
d) ER-balloon (door-to-balloon, in-hospital delay) – time from admission to the ER to restoring the flow in the coronary artery;
e) pain-balloon (total ischemic time) – time from symptom onset to restoring the flow in the coronary artery.

In-hospital management

The procedure of admitting STEMI patients to the ER and catheterization laboratory in our facility is precisely described in an internal document called "STEMI protocol". After presenting in the ER, if the diagnosis is clear, no further tests are conducted. The patient receives loading doses of antiplatelets and unfractionated heparin (unless already administered by the EMS) and is directly transported to the catheterization laboratory. The primary PCI is performed only by experienced operators according to current standards. The radial artery is the first choice access site; femoral access is used only if securing radial access is not possible. Choice of adjunctive therapy during the procedure (manual thrombectomy, GP2b3a inhibitors) as well as stent type was left at the operator's discretion. After the procedure, all patients were monitored in the CICU for at least 24 h.

Statistical analysis

Continuous variables with normal distribution were presented as mean ± standard deviation. Continuous variables with skewed distribution were presented as median with interquartile range. Categorical variables were presented as numbers and percentages. For continuous variables intergroup differences were compared using Student's *t* test or the Mann-Whitney *U* test, depending on the type of distribution. The χ^2 test was used to compare categorical variables. A *p*-value < 0.05 was considered statistically significant. All statistical analyses were performed using the Statistica 10.0 (StatSoft, USA) software.

Results

Clinical and demographic characteristics

The study included 137 patients, of whom 49 (36%) had teletransmission performed. Seventy percent of patients were admitted during off-hours (holidays, weekends and weekdays from 15:00 to 7:30). There were no differences in patients' clinical and demographic characteristics between the two studied groups (Table I).

Transport and time delays

All data regarding time delays were obtained from patients' medical data. Unfortunately, current EMS documentation handed over after hospital admission rarely indicates the exact time of first medical contact. Therefore this parameter could not be included in our analysis.

Table I. Baseline clinical and laboratory characteristics of STEMI patients with and without teletransmission performed

Parameter	All patients	Teletransmission present	Teletransmission absent	Value of *p*
Number	137 (100%)	49 (36%)	88 (64%)	
Men	81 (59%)	27 (55%)	54 (61%)	NS
Age [years]	66 ±14	67 ±13	66 ±15	NS
Hypertension	89 (65%)	30 (61%)	59 (67%)	NS
Diabetes	30 (21%)	13 (27%)	17 (19%)	NS
Hyperlipidemia	58 (42%)	24 (49%)	34 (39%)	NS
HFREF	14 (10%)	7 (14%)	7 (8%)	NS
IHD in anamnesis	29 (21%)	7 (14%)	22 (25%)	NS
History of ACS	21 (15%)	7 (14%)	14 (16%)	NS
History of stroke	4 (3%)	1 (2%)	3 (3%)	NS
Direct transport to PCI-capable hospital	98 (71%)	43 (88%)	55 (63%)	0.002
Off-hours admission	96 (70%)	31 (63%)	65 (74%)	NS
hsTnI at admission [ng/ml]	0.4 (0.1–2.1)	0.6 (0.1–1.5)	0.4 (0.1–2.5)	NS
hsTnI maximal [ng/ml]	40.2 (18.9–108.3)	59.4 (26.5–109.8)	32.1 (13.1–84.4)	NS
LVEF [%]	50 (40–55)	48 (35–55)	50 (40–55)	NS

Data are presented as numbers and percentages for categorical variables, mean ± standard deviation for continuous variables with normal distribution, and median with interquartile range for continuous variables with skewed distribution. NS – not significant, HFREF – heart failure with reduced ejection fraction, IHD – ischemic heart disease, ACS – acute coronary syndrome, PCI – percutaneous coronary intervention, hsTnI – highly sensitive troponin I, LVEF – left ventricle ejection fraction.

Direct transport to a PCI-capable hospital was performed in 71% of the patients and was more frequent in patients with ECG teletransmission (88% vs. 63%, $p = 0.002$). Six patients in the teletransmission (+) group (12%) had the ECG sent to our hospital during transport from the FMC site (PCI incapable hospital, primary care physician office). Therefore, avoiding indirect transport was *a priori* impossible.

In the whole cohort, median pain-ER time was 174 (103–301) min and was significantly shorter in patients with teletransmission. The absolute and relative difference in pre-hospital delay was 112 min and 38% respectively ($p = 0.001$). Median ER-cathlab time was 19 (14–27) min and 25 (19–31) min for cathlab-balloon time. Median in-hospital delay was 46 (38–58) min and did not differ between the two groups at any studied period. Total ischemic time was significantly shorter in patients with ECG teletransmission performed, with 127 min and 35% absolute and relative difference respectively ($p = 0.0003$) (Table II).

Additional analyses did not show significant differences in time delays depending on time of patient's admission (work vs. off-hours), which were 157 (106–241) min vs. 181 (99–315) min for pain-ER time, 17 (14–26) min vs. 19 (14–28) min for ER-cathlab time and 24 (18–30) min vs. 25 (20–32) min for cathlab-balloon time (all $p > 0.05$).

Treatment

All patients underwent coronary angiography. The radial access site was used in 128 patients (123 right and 5 left), which constituted 93% of the studied population. Femoral access was necessary in only 9 (7%) patients.

Revascularization, thrombus aspiration and administration of GP2b3a inhibitors were performed in 96%, 79%, and 87% of patients respectively. Drug-eluting stents (DES) were implanted in 58% of the patients, while 37% of patients received bare metal stents (BMS). The vast majority of patients who were administered GP2b3a inhibitors received abciximab (88%). There were no differences in applied therapy between the two groups (Table III).

Discussion

Teletransmission was implemented in Wroclaw in 2012. Wrocław EMS stations provide services to over 1 000 000 inhabitants. In 2013, the ECG transmission system was still in the development phase, and the rate of ECG teletransmission preceding STEMI patient admission to our hospital was relatively low (36%). However, this was comparable to other regions in Poland [8, 9]. Currently, most patients with suspicion of acute myocardial infarction (AMI) should have ECG transmission performed. This together with a following teleconsultation with a cardiologist may result in direct, urgent transport to a PCI-capable hospital of not only STEMI, but also high-risk non-ST segment elevation myocardial infarction (NSTEMI) patients. On the other hand, if the STEMI diagnosis is clear, performing the ECG teletransmission may cause unnecessary delay. In this situation a short teleconsultation with the information of the STEMI patient being on the way to the PCI-capable hospital seems sufficient.

A crucial factor influencing treatment outcomes in STEMI patients is the total ischemic time, defined as the time from symptom onset to reperfusion [10]. A significant relationship between total ischemic time and the extent of reversible and irreversible myocardial injury was observed [11]. Furthermore, it was proved that it strongly correlates with in-hospital mortality [12, 13]. Delay in reperfusion lasting more than 4 h is also considered as an independent predictor of 1-year mortality [2, 14]. Total delay is often divided into patient- and system-related. More than three quarters of pre-hospital delay may be attributed to the patients' decision to postpone the call to emergency services, despite persistent chest pain [15]. Unfortunately, it has been shown that even large educational campaigns fail to shorten the patient-related delay [16]. Therefore, most efforts to decrease the delay in reperfusion focus on the functioning of the emergency services and in-hospital delay. As a result, time delays in STEMI became a valuable indicator of healthcare system efficacy in a given region [17]. In our study median total ischemic time was 222 min, which is slightly shorter than the delay reported in other regions of Poland [8]. Most importantly, patients with teletransmission performed had over 120 min shorter total ischemic time, which was mainly due to the higher rate of direct transport to a PCI-capable hospital (88% vs. 63%, $p = 0.002$). Moreover, besides decreasing total ischemic time, Le May *et al.* proved the correlation between direct transport and a decrease in 180-day mortality [18].

It has been shown that ECG teletransmission also shortens in-hospital delay in Poland [8]. We did not confirm this observation in our study. We hypothesize that the impact of teletransmission could be partially diminished by our previous efforts to minimize in-hospital delay in our facility. In 2012 we implemented the internal "STEMI protocol," which included a reorganization of the ER, and established clear rules for admitting STEMI patients. We were able to significantly shorten the median in-hospital delay, from 65 min in 2010/2011 to 45 min in 2013 ($p < 0.05$). However, this did not influence the total ischemic time (unpublished data). Moreover, the experience and results of our colleagues showed us that there is still room for improvement in this matter [8].

In our study no patient received fibrinolysis, either in our centre or in any other hospital where he or she was previously diagnosed. Large clinical trials proved the

Table II. Time delays of STEMI patients with and without teletransmission performed

Delay	All patients		Teletransmission present		Teletransmission absent		Difference		Value of *p*
	Mean ± SD [min]	Median (Q1–Q3) [min]	Mean ± SD [min]	Median (Q1–Q3) [min]	Mean ± SD [min]	Median (Q1–Q3) [min]	Absolute [min]	Relative [%]	
Pain-ER	254 ±304	174 (103–301)	182 ±199	125 (91–184)	294 ±343	201 (113–339)	–112	–38	0.001
ER-cathlab	25 ±26	19 (14–27)	21 ±13	18 (13–23)	27 ±31	20 (15–28)	–6	–24	NS
Cathlab-balloon	28 ±13	25 (19–31)	28 ±14	23 (19–31)	28 ±12	26 (20–33)	0	0	NS
ER-balloon	51 ±21	46 (38–58)	48 ±18	43 (37–56)	52 ±22	46 (40–61)	–4	–7	NS
Pain-balloon	311 ±317	222 (148–361)	231 ±210	159 (136–244)	358 ±357	259 (170–389)	–127	–35	0.0003

Data are presented as arithmetic mean ± standard deviation and median with interquartile range. SD – standard deviation, Q1 – lower quartile, Q3 – upper quartile, ER – emergency room, NS – not significant.

Table III. In-hospital diagnostics and treatment of STEMI patients with and without teletransmission performed

Parameter	All patients *n* (%)	Teletransmission present *n* (%)	Teletransmission absent *n* (%)	Value of *p*
Coronarography	137 (100)	49 (100)	88 (100)	NS
Primary PCI	132 (96)	48 (98)	84 (96)	NS
Manual thrombectomy	104 (79)	40 (83)	64 (75)	NS
Administration of GP2b3a inhibitors	116 (87)	43 (88)	73 (83)	NS
Abciximab	102 (88)	39 (91)	63 (86)	NS
Eptifibatide	14 (12)	4 (9)	10 (14)	NS
DES implantation	76 (58)	26 (54)	50 (58)	NS
BMS implantation	49 (37)	18 (38)	31 (36)	NS

N – Number, PCI – percutaneous coronary intervention, DES – drug-eluting stent, BMS – bare metal stent, NS – not significant.

superiority of pPCI over fibrinolysis [19]. Also ESC guidelines state that pPCI is the preferred type of reperfusion if it can be performed in a timely manner (< 120 min from FMC) [3]. A dense network of cathlabs in Poland enables this recommendation to be fulfilled in virtually any part of the country, especially when helicopter transport is considered. Moreover, EMS ambulances are not staffed and equipped properly to perform fibrinolysis. Therefore our results are consistent with the trend observed in our country where fibrinolysis is being side-tracked. On the other hand, in our analysis nearly 30% of patients were transported indirectly through smaller, PCI-incapable hospitals. To eliminate this situation in future, our primary aim should be to continue the development of the STEMI network (for example by increasing the number of ECG teletransmissions). However, implementing fibrinolysis (under conditions mentioned in the guidelines) in PCI-incapable centres may be beneficial for some of the STEMI patients who, despite all efforts, were not directly transported to a PCI-capable centre [20].

Lately, large trials have shown that patients admitted to a PCI-capable hospital during off-hours had longer door-to-balloon time [21]. Moreover, one meta-analysis showed that any patient admitted at that time with AMI had higher 30-day mortality [22]. In our study, we did not observe any differences between time delays depending on the day and hour of admission. Discrepancies in observations may be explained by difference in the organization of cathlabs between western countries and Poland, where a complete on-duty staff is present in the hospital 24/7. In our hospital during off-hours, when only one cathlab is open, an efficient system of informing about STEMI patients on the way (mainly via ECG teletransmission) allows us to effectively withhold elective procedures or refer the patient to another PCI-capable hospital when urgent coronary angiography is not possible.

This was a single-centre, retrospective, observational study, and therefore (almost by definition) it has some substantial limitations. The main limitation is the lack of information about the FMC time. As a result we were not able to include the FMC-balloon time in our analysis. Sadly we observed that medical documentation provided by the emergency services very often does not contain this essential information. We were also not able to obtain information about the whole number of ECG teletransmissions performed by emergency services during the study period. Therefore we do not know how useful the ECG teletransmission was in establishing the STEMI diagnosis and how often it was used incorrectly.

Conclusions

The percentage of STEMI patients who had ECG transmission performed before admission to our hospital in 2013 was low. Pain-balloon time, the most important factor predicting outcomes in STEMI patients, was shorter in patients with ECG teletransmission performed. ECG teletransmission helps to eliminate transporting STEMI patients to PCI-incapable hospitals. Time of admission (work vs. off-hours) to a PCI-capable hospital in urban areas in Poland has no influence on the time delay in implementing reperfusion therapy in STEMI patients.

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Conflict of interest

The authors declare no conflict of interest.

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