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ECG pre-hospital teletransmission by emergency teams staffed with an emergency physician and paramedics and its impact on transportation and hospital admission

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Abstract

Electrocardiography (ECG) is essential to detect and diagnose life threatening cardiac conditions and to determine further treatment. Correct interpretation of an ECG can be challenging, especially in the out-of-hospital setting and by less experienced emergency team members.

The aim of this study was to compare the rate of ECG transmission from an out-of-hospital emergency scene to an in-hospital cardiologist on call in EMS-B and EMS-S providers and its impact on direct transportation to a cardiac catheterization laboratory and hospital admission.

The study was designed as an observational study. Data from 3 separate emergency medical service teams were collected. Two teams are staffed by paramedics only (EMT-B), while another specialized team is staffed with an emergency physician (EMT-S). 5864 out-of-hospital emergencies were performed during a 12-month period and were analyzed for this study.

In 124 out of 5864 (2.1%) out-of-hospital emergencies, an ECG transmission from the out-of-hospital scene to an in-hospital cardiologist on call was performed. Rate of transmission was similar between both teams (EMT-B n = 70, 2.2% vs EMT-S n = 54, 2.0%, $P = .054$). After coordinating with the cardiologist on call, 11 patients (15.7%) of the EMT-B (15.7%) and 24 patients (44.4%) of the EMT-S were directly transported from the scene of emergency to a cardiac catheterization laboratory ($P < .001$). Overall, 80% of patients treated by EMT-S, compared to 52.5% treated by the EMT-B required subsequent hospital admission ($P < .05$).

Transmission of ECG from the out-of-hospital emergency scene to the in-hospital cardiologist is infrequently performed. The rate of STEMI in transmitted ECG's by emergency teams staffed with an emergency physician was higher compared to emergency teams staffed with paramedics only.

Abbreviations: ACS = acute coronary syndrome, BP = blood pressure, Cath lab = catheterization laboratory, ECG = electrocardiography, ED = emergency department, EMT = emergency medical service teams, EMT-B = the basic team staffed with paramedics only, EMT-S = the specialized team staffed also with an emergency physician, STEMI = ST-segment elevation myocardial infarction.

Keywords: cardiovascular diseases, electrocardiography, emergency medical team, tele transmission

1. Introduction

Cardiovascular diseases are the most frequent causes of death worldwide.[1,2] One of the main causes of death in adult patients in Poland is cardiovascular disease.[3] Several studies showed that direct transportation for invasive treatment may decrease the mortality of the patients with acute myocardial infarction while the delated treatment of myocardial infarction increases mortality.[4]

Cardiac complains including chest pain, shortness of breath, and arrhythmias are within the most frequent causes of out-of-hospital emergency medical services (EMS) activations.[5] Once a patient is suffering cardiac complains, it is essential to avoid any delay between onset of cardiac symptoms, EMS activation, and initiation of early and adequate treatment, as this is clearly associated with improved outcome.[6–8] Electrocardiography (ECG) is essential to detect potentially life threatening cardiac arrhythmias and should be used to continuously monitor the heart rhythm.[9,10] Although the ECG is non-invasive and easy to perform, correct interpretation of cardiac pathologies including

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for example an ST elevation myocardial infarction (STEMI) can be challenging, especially by less to moderately skilled and experienced EMS team members.[11] Early diagnosis and fast revascularization of a STEMI is imperative and potentially life-saving. Consequently, transmission of ECG's from the out-of-hospital emergency scene to an in-hospital cardiologist has been implemented in order to decrease number of missed diagnosis and to avoid any delay until revascularization.[12–14]

The ECG teletransmission system was introduced in several countries to improve the quality of ECG interpretation and reduce the time to specialized treatment especially in STEMI cases hence the magnitude of myocardial necrosis is time-dependent. One of the main problems is the correct transfer to a specialized center with catheterization laboratory instead of referral to emergency department or a hospital without a technical possibility to perform percutaneous coronary intervention, or fibrinolytic therapy implementation, however, it has not always been shown that prehospital ECG transmission had an effect on time to reperfusion.[15]

Since September 2006 3 different types of EMS teams operate in the out-of-hospital setting in Poland. The basic team (EMT-B) is staffed with paramedics only, whereas specialized teams (EMT-S) as well as the medical air service are staffed with an emergency physician. All teams are basically trained in performing and interpreting an ECG, and all teams have the opportunity to transmit ECG's to an in-hospital cardiologist on call.[11]

Consequently, the aim of this retrospective study was to compare the rate of ECG transmission from an out-of-hospital emergency scene to an in-hospital cardiologist on call its impact on direct transportation to a cardiac catheterization laboratory and hospital admission between the EMS-B and EMS-S providers.

2. Methods

The study protocol was approved by the institutional review board of the Polish Society of Disaster Medicine (approval No.: 12.04.2017.IRB). The study was designed as an observational study. Data from 3 separate EMS teams stationed in Miechowski poviat, Poland were retrospectively collected and analyzed for this study. Two EMS teams are stationed at the St. Anna Hospital in Miechów, 1 staffed with an emergency physician (EMS-S) and 1 staffed with paramedics only (EMS-B). The third team is stationed in Książ Wielki and is staffed with paramedics only (EMS-B). All 3 EMS teams are covering mostly rural areas, characterized by long distances and prolonged time from EMS activation until first patient contact. As there is no cardiac catheterization laboratory in Miechów poviat, patients suffering from an acute coronary syndrome need to be transferred to the John Paul II Specialist Hospital in Krakow, which is located 38 km away from the St. Anna hospital. As this transfer is logistically challenging and expensive, this should be limited to correctly identified patients suffering from potentially live-threating cardiac pathologies including STEMI.

The inclusion criteria for this study included adult patients with out-of-hospital emergency requiring EMS intervention. All out-of-hospital emergencies during the 12-month study period lasting from 01.01.2016 until 31.12.2016 were included into this study. Paper based case report forms were collected and analyzed. The leading clinical diagnosis was assessed and the rate of ECG transmission from the out-of-hospital emergency scene was analyzed. Rate of subsequent transfer to a cardiac catheterization laboratory or to the emergency department was furthermore investigated. The primary outcome was the rate of ECG transmission from the out-of-hospital emergency scene to the in-hospital cardiologist. The secondary outcomes of the study were the percentage of direct transportation to a cardiac catheterization and hospital admission in EMS-B and EMS-S providers groups.

Categorical variables are presented as absolute numbers and percentages. The Chi-Square test and Yates amendment was performed for univariate analysis. A P value $<.05$ was assumed to be statistically significant. The analyses were performed using the Statistica PL 10 software (Statsoft Inc., Tulusa, OK, USA).

3. Results

Overall 6115 emergency missions were dispatched to the 3 EMS teams involved in this study. 251 mission (4.1%) were excluded from analysis because of mission canceled by the medical dispatcher (n = 157), no patient found on scene (n = 46), patients refused treatment by the EMS (n = 36), or patients were transported by other services (e.g. air ambulance) (n = 14). Therefore, data of 5864 EMS activations, 3390 by EMT-B and 2474 covered by EMT-S were included in this study and underwent further analysis.

Cardiovascular disease was the leading diagnosis in 1958 emergencies (33.4%) and chest pain was the leading symptom in 526 cases (9%). 1041 of these emergencies were covered by EMT-S, while 917 emergencies were covered by EMT-B. EMT-S were more often dispatched to cardiac emergencies compared to EMT-B (42.1% vs 27.1%; $P = .012$).

Analyzing the primary outcome - the rate of ECG transmission from the out-of-hospital emergency scene to the in-hospital cardiologist on call it was revealed that ECG transmission from the emergency scene was performed in 124 emergencies (2.1%). EMT-B used the ECG transmission in 70 emergencies (2.0%), while EMT-S transmitted the ECG in 54 emergencies (2.2%, $P = .054$). Chest pain was the leading indication for ECG tele transmission for both teams. All indications are reported in Table 1.

In 15 emergencies (11.1%), the transmission of the ECG was unsuccessful due to technical reasons. In these emergencies, the EMS decided to transport the patient to the nearest emergency department (n = 12), or to contact the cardiologist on call by phone and subsequently transport the patient to the catheterization laboratory (n = 3).

The secondary outcome of the study was hospital admission in EMS-B and EMS-S providers groups. It was revealed that out of the 124 emergencies with ECG transmission, 34 patients

Table 1

Type of complaints reported by emergency medical service team.

Parameter	EMT P	EMT S	*P* value
Chest pain	63.4%	70.4%	<.001
Arrythmia	5.7%	1.8%	.076
Blood pressure changes	1.4%	0%	<.001
Dist. of consciousness	11.4%	13.0%	<.001
Dyspnea	11.4%	5.6%	<.001
Asympt. ECG change	1.4%	0%	<.001
Abdominal pain	3.0%	1.8%	<.001
Cardiac Arrest	1.4%	7.4%	<.001

EMT-B = the basic team staffed with paramedics only, EMT-S = the specialized team staffed also with an emergency physician.

Table 2

Further management of patients after diagnostics in emergency department.

Parameter	EMT P	EMT S	*P* value
Catheterization laboratory	10.2%	10.0%	.912
Admitted to hospital	52.5%	80.0%	.013
Discharged home	37.3%	10.0%	.021

EMT-B = the basic team staffed with paramedics only, EMT-S = the specialized team staffed also with an emergency physician.

suffering a STEMI were correctly identified and subsequently transferred to the cardiac catheterization laboratory. Rate of STEMI of transmitted ECG's was 44.4% in EMT-S, compared to 15.7% of EMT-B ($P < .001$). The remaining 90 patients were transported to the nearest emergency department. More patients with ECG transmission by EMT-S required subsequent hospital admission (80% vs 52.5%, $P < .05$), whereas more patients of EMT-B were discharged after completed diagnostics in the emergency department (10% vs 37.3%; $P < .05$) (Table 2).

The vast majority of patients with cardiovascular disease were transported to the emergency room, without ECG transmission. One out of these patients, treated by the EMT-B was later diagnosed with a STEMI at the emergency department. In another 23 patients, a non-STEMI or an unstable angina pectoris was diagnosed at the emergency department. All of these 24 patients underwent a revascularization therapy in the course of hospital admission.

4. Discussion

International medical societies like the European Resuscitation Council, the American Cardiac Society, and the European Society of Cardiology emphasize the importance of performing a 12-lead in the out-of-hospital emergency scene.[16,17] It should be performed within 10 minutes from the first contact of the patient with the EMS and should be evaluated by a skilled provider, at best by a cardiologist.[18] Transmission to an experienced cardiologist in case of any clinical doubt or concern was reported to be beneficial for patients potentially suffering from an acute coronary syndrome.[19,20]

Results of our study indicate that ECG was transmitted in 2.2% of all patients and this rate was comparable in EMT-B (2.0%) and EMT-S (2.2%) groups. A transport directly to the cardiac catheterization laboratory bypassing the emergency department can save critical time and is therefore indicated in patients with STEMI.[21–23] Adams et al showed that the median time to balloon dilatation in the group of patients with successful ECG transmission was 50 minutes and was significantly shorter than without transmission – 101 minutes.[23] These findings are in line with many other studies.[24,25] Emergency physicians working in the EMT-S more accurately identified patients for ECG transmission. 44% of these patients were directly transported from the emergency scene to the cardiac catheterization laboratory. Regarding to EMT-B, ECG transmissions from the emergency scene were performed in somewhat more "exaggerated" way. Only 15.7% of patients had a STEMI and were subsequently transferred to the cardiac catheterization laboratory. This finding is not surprising, as adequate and correct ECG diagnosis depends on personal skills and experience, as previously reported. For example, Mencl et al examined the ability to interpret various heart disorders among 472 EMS providers with varying levels of professional experience %.[26] Only 3% of them correctly interpreted all cardiac disorders. Correct diagnosis of STEMI varied between 51% (posterior wall infarction), 78% (anterior wall infarction), and 96% (lower wall infarction). Correct interpretations of other cardiac disorders including arrhythmias varied between 34% and 53%.[26] In comparison, 46% of Swedish nurses were able to correctly identify ECG pathologies.[27] Honarbakhsh et al in a randomized controlled trial revealed that there was a 98% correlation between the paramedics' ECG diagnosis of supraventricular tachycardia and that of 2 electrophysiologists.[28] ECG interpretation skills were also examined among Polish EMS providers. The results of the Competition in Medical Rescue Krakow 2014, which consisted of interpretation of 5 different records depicting STEMI, atrial fibrillation, supraventricular tachycardia, third degree atrioventricular block were later analyzed. For example, only 9% of the EMT-P correctly identified atrial fibrillation.[29] Consequently, our results therefore confirm these previous findings, that non-physicians lack appropriate identification of ECG pathologies. This might be based on individual training and expertise, but is still an alarming signal for decision makers in healthcare policy.[30] Telemedicine can also help to detect arrhythmia in primary care patients.[31]

In the group of patients with cardiac disorders, EMT-B decided to perform an ECG transmission more often (7.6%) than EMT-S (5.2%). Disorders and symptoms reported by the patients slightly differed between EMT-B and EMS-S. EMT-S were more often dispatched to patients reporting chest pain and shortness of breath, and 3 times more often (6.6% vs 2%) to patients in whom the emergency activation indicated the possibility of cardiac arrest. Many patients with cardiac problems do not report chest pain typically for an acute coronary syndrome. Patients often report shortness of breath, nausea, vomiting, and fainting as the leading symptoms.[25]

Cannon et al showed, that nearly 12% of the patients with an acute coronary syndrome did not have typical symptoms, resulting in a delay of ECG diagnosis and time to revascularization.[30] Consequently, performing an ECG and transmission to an expert is indicated also in patients, without the classical ACS sign of chest pain.

ECG transmission to an in-hospital expert was repeatedly reported to be beneficial for the patients including patients with pacemakers. For example, Chao et al investigated the effectiveness of a traditional telephone conversation between the out-of-hospital staff and the cardiologist in the cardiac catheterization laboratory compared to sending an ECG image using the app via smartphone. This latter method more effectively reduced the time from ECG interpretation to the implementation of the final treatment in patients with STEMI.[32] This finding is in line with several other studies, including the study by Astarcioglu et al[33] ECG transmission in our study failed in 11.2% due to technical reasons. Felzen et al analyzed clinical values of the transmitted pictures and videos during EMS routine care in Germany.[34] Transmission success rates achieved 93% for 12-lead ECG transmission. Given the fact, that ECG transmission is potentially life-saving, this is an unacceptable high rate.

Our study may indicate, that paramedics need further intense training in ECG interpretation and ECG should be transmitted more often by paramedics, in order to avoid any missed diagnosis of serious cardiac pathologies including STEMI.

Results of our study are limited by the retrospective design. There is considerable risk of reporting bias, although quality of

data management on the case report forms was considerable well. Furthermore, the EMT services included in this study cover a mostly rural area, and results of more urban EMT's might differ.

5. Conclusions

Transmission of ECG's from the out-of-hospital emergency scene to in-hospital cardiologists is infrequently performed by Polish EMS. The rate of STEMI in transmitted ECG's by emergency teams staffed with an emergency physician was higher compared to emergency teams staffed with paramedics only.

Author contributions

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