Original Research

Diagnostic Accuracy of Prehospital Tele-Electrocardiography in Acute Coronary Syndrome

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Abstract

Background: Tele-electrocardiography (tele-ECG) is a powerful ally in the screening of acute ischemic lesions.

Introduction: Evidence that confirms the correlation between the diagnosis of acute coronary syndrome (ACS) determined in the prehospital setting and the confirmation of the diagnosis in the hospital setting is scarce. This study compares the presumed diagnosis of ACS in the prehospital setting based on electrocardiographic changes, such as ST-segment deviation, with the diagnosis confirmed in a hospital setting.

Materials and Methods: Retrospective, cross-sectional analysis of medical records of patients who sought emergency ambulance services of a distinguished public healthcare service in the city of Porto Alegre from September 2013 to August 2014. Data were collected from tele-ECG recordings and medical records available at the database of the Secretary of Health. The study was based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Results: Among the 1,338 prehospital examinations performed, a total of 250 admissions in tertiary hospitals were registered. There was a significant agreement (p < 0.01) of 71% of the electrocardiographic changes identified in the prehospital setting with the diagnosis of ACS confirmed in the hospital setting. These changes were more prevalent in men (p = 0.048) and in patients aged 60 years or older (p = 0.006).

Discussion: The tele-ECG allows the early diagnosis of ACS, reducing the delay to definitive treatment, be it reperfusion, chemical, or mechanical therapy.

Conclusions: Seventy-two percent of the prehospital diagnosis of ACS based on electrocardiographic changes was later confirmed in the hospital setting.

Keywords: *tele-electrocardiography, telemedicine, acute coronary syndrome, emergency medical services, chest pain*

Introduction

Chest pain or discomfort is the most common complaint of patients who seek emergency cardiac care. Chest pain may be caused by a variety of conditions, and some of them are particularly associated with an increased risk of death. One of them is acute coronary syndrome (ACS),[1] which includes a wide spectrum of clinical presentations, ranging from silent ischemia, through unstable angina, to acute myocardial infarction (AMI) with and without ST-elevation. In this context, the tele-electrocardiography (tele-ECG) is a powerful ally in the early diagnosis of ACS.[2]

Many studies have highlighted the increasing use and growing contribution of telemedicine in the interpretation of ECG.[3–9] The tele-ECG-based intervention can reduce the existing gap between the onset of AMI and its treatment.[10]

Others have performed a descriptive analysis of ECG results in distinguished healthcare centers,[11–14] and other authors have addressed the effect of prehospital ECG on the reduction of door-to-needle or door-to-balloon times.[15,16] Nonetheless, there are few studies examining the diagnostic accuracy of prehospital tele-ECG in Brazil. In the city of Porto Alegre, a 12-lead ECG system is available in all public health centers, which have been enrolled in the National Program for tele-ECG since 2009. However, there are no data available on the association of prehospital tele-ECG with the diagnosis of ACS.

Therefore, the aim of this study was to compare the presumed diagnosis of ACS determined in the prehospital setting based on electrocardiographic changes, with the diagnosis confirmed in distinguished hospital healthcare centers.

Materials and Methods

STUDY DESIGN

This was a retrospective, cross-sectional analysis of the medical records of patients who used the public emergency ambulance services (SAMU, *Serviço de Atendimento Movel de Urgencia*) in Porto Alegre from September 2013 to August 2014. Data were collected from ECG reports issued at the *Hospital do Coração (HCor)*. Prehospital records, data from the

Secretary of Health database, and hospital medical charts were also reviewed. Data of each patient were confirmed by name, date of birth, and registration number.

STUDY LOGISTICS

Once the emergency service (SAMU) number "192" is called, patients' data are recorded in a software. At the central station, a physician determines the severity of the case to send either a "basic" or "advanced" care mobile health unit. The basic care unit is responsible for >90% of the prehospital services and is equipped with a nursing technician and driver. Recordings of the ECG tests performed are sent in PDF by cell phone to the Telemedicine Center of HCor in Sao Paulo, and the reports are sent back to the ambulance and to the central station within a mean of 4 min.[17] Patients with ST-segment elevation or depression are sent to referral hospitals, whereas those without these electrocardiographic changes are sent to other emergency services for adequate diagnosis and treatment of their conditions (*Fig. 1*).

Clinical data were obtained from patients' medical records and the Secretary of Health database. The methods of the study were based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

ETHICAL ISSUES

Privacy and confidentiality of data and anonymity of patients were guaranteed, and patients' data were used exclusively in this study. The study was approved by the local ethics committee (4877/13), and the letter of commitment to get access to patients' medical records was approved by the Secretary of Health of Porto Alegre.

STATISTICAL ANALYSES

Symmetrically distributed quantitative variables were described as mean and standard deviation, and qualitative variables were described as absolute and relative frequencies. Associations between categorical variables were assessed by the Pearson's chi-squared test, and comparisons of mean quantitative variables between the presence and absence of electrocardiographic changes were performed by the *t* test. Kappa coefficient was used to assess the agreement between electrocardiographic changes in the prehospital setting and the hospital diagnosis of ASC. Sensitivity, specificity, and 95% confidence interval were calculated, and the level of significance was set at 5%. The analyses were performed in the *Statistical Package for the Sciences* (SPSS) software, version 23.0.

Results

Among the 1,338 examinations performed by SAMU in Porto Alegre, electrocardiographic changes were more prevalent among men ($p = 0.048$) than women, and in patients aged 60 years or older ($p = 0.006$). Other characteristics of the patients are described in *Table 1*.
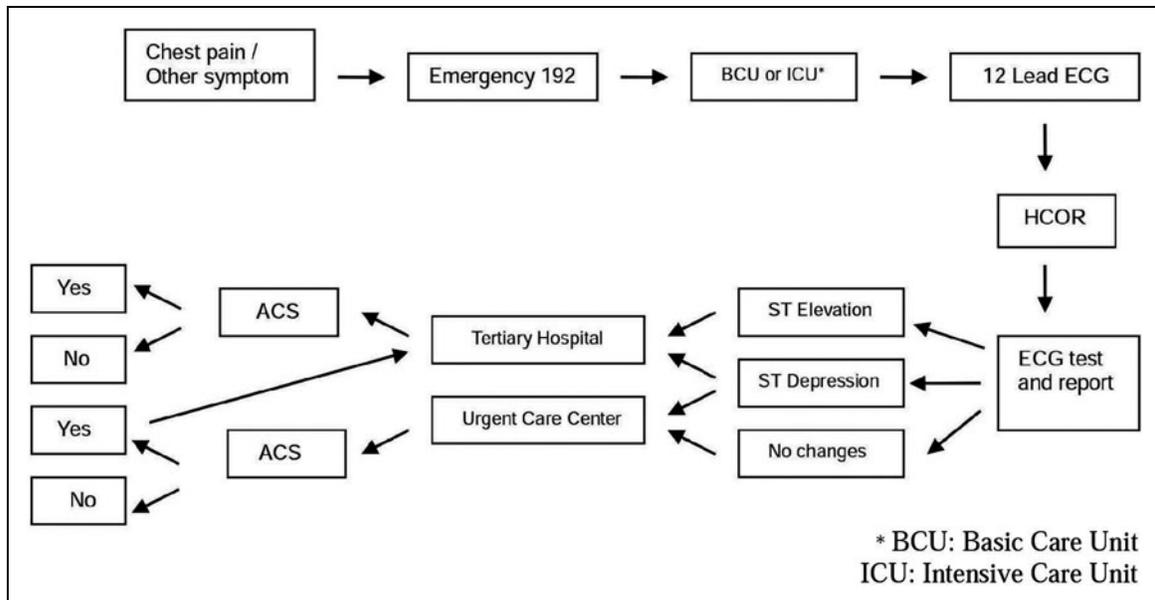
Fig. 1. Flowchart of prehospital care services, including tele-ECG. ACS, acute coronary syndrome; ECG, electrocardiography; HCor, Hospital do Coração.

			WITHOUT	
	TOTAL NO. (%)	WITH ST–SEGMENT	ST–SEGMENT	
VARIABLE	OR MEAN ± SD	DEVIATION $N = 125$	DEVIATION $N = 1,213$	P
Sex				0.048
Female	759 (56.7)	60 (48.0)	699 (57.6)	
Male	579 (43.3)	65 (52.0)	514 (42.4)	
Age (years)	60.3 ± 16.8	63.9 ± 15.4	59.9 ± 16.9	0.012
Age				0.006
<40	147 (11.1)	7 (5.6)	140 (11.7)*	
≥40–60	478 (36.2)	36 (28.8)	442 (37.0)	
>60	696 (52.7)	82 (65.6)*	614 (51.3)	
SAP (mmHg)	141.5 ± 35.6	140.9 ± 36.9	141.6 ± 35.4	0.841
DAP (mmHg)	85.0 ± 21.3	85.0 ± 24.8	85.0 ± 20.9	0.974
HR (bpm)	86.0 ± 24.5	80.4 ± 19.7	86.5 ± 24.9	0.010
Glucose levels†	145.5 ± 65.9	153.2 ± 71.4	144.7 ± 65.3	0.225

Table 1. Characteristics of Patients ($n = 1,338$) Who Requested the Public, Emergency Medical Ambulance Assistance in Porto Alegre from September 2013 to August 2014

*Statistically significant association by the test of residuals; significance level set at 5%.

†Measured by a glucose meter.

DAP, diastolic arterial pressure; HR, heart rate; SAP, systolic arterial pressure; SD, standard deviation.

Of the 1,338 patients who received prehospital care, 321 (24%) were referred to tertiary hospitals, 123 (9.2%) to other hospitals, 717 (53.6%) to urgent care centers, 177 (13.2%) received on-scene treatment only. A total of 250 (18.7%) admissions in tertiary hospitals were registered (Fig. 2).

Table 2 shows the degree of agreement between 71.2% of the electrocardiographic changes identified in the prehospital setting and the diagnosis of ACS confirmed in the urgent care and hospital settings ($\kappa = 0.34$, $p < 0.001$).[18] The positive predictive value (PVV) indicated that 71.9% of patients with electrocardiographic changes of acute ischemia had the diagnosis of ACS confirmed in the hospital setting.

Table 3 shows the degree of agreement between electrocardiographic changes identified in the prehospital setting and the diagnosis of ACS in the hospital setting ($\kappa = 0.44$, $p < 0.001$).[18] Vivek and Vikrant[10] tele-ECG and 24-h physician support over telephone for rural doctors can help early treatment of AMI in rural areas.

As seen in Table 3, despite statistically "moderate" ($\kappa = 0.44$),[18] the degree of agreement between electrocardiographic changes and confirmed diagnosis of ACS was higher in the hospital than in out-of-hospital settings.

Sixty-nine (43%) of 160 patients referred to tertiary hospitals and 28 (31.1%) of 90 patients referred to urgent care centers or other hospitals had the confirmed diagnosis of ACS; this difference was not statistically significant ($p = 0.083$).

Discussion

In Brazil, there are very few data on the association between electrocardiographic changes suggestive of ACS identified in the prehospital environment, making use of telemedicina, and the confirmation of the diagnosis in a hospital setting.

The telemedicine is as safe and efficacious as in-person care and can improve diagnosis and outcomes, recognizing that telemedicine is an important strategy in improving access to health.[18]

The prehospital diagnosis of AMI, enabled by telemedicine, is an American Heart Association and European Society of Cardiology class I recommendation. The 12-lead ECG is crucial in the initial assessment of patients with suggestive symptoms of ACS,[17,19] and should be conducted within 10 min of the emergency service contact.[2] When correctly performed, this examination can identify suspected cases of ACS and provide valuable data for the adequate transport of patients to definitive care and early initiation of reperfusion therapy.[9] Therefore, the benefits of the availability of ECG in emergency ambulance units are undeniable.
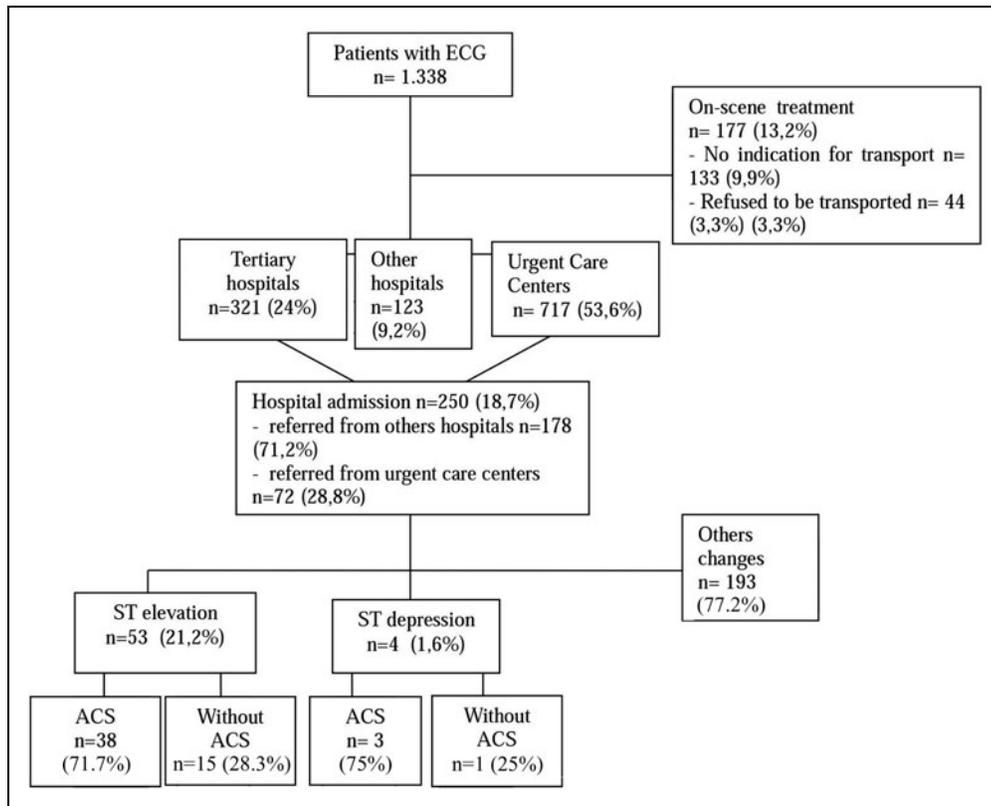
Fig. 2. Flowchart of the study.

The diagnosis of ACS was confirmed in 38 (72%) of the 53 patients with ST-segment elevation myocardial infarction (STEMI) ($n=53$) (*Fig. 2*), which corroborates the importance of the telecardiology in the early diagnosis of AMI, reducing the delay to definitive treatment. Electrocardiographic changes of STEMI were more frequent among men and patients aged older than 60 years. This was similar to the results of an Italian study on 27,841 patients who sought prehospital healthcare services from October 2004 to April 2006. Of the 534 patients with ST-segment elevation, 65.5% were men and 50.2% were older than 70 years.[4] On the contrary, in a Danish study[19] that evaluated 15,992 patients using tele-ECG in a prehospital setting from 2008 to 2011, the diagnosis of STEMI was confirmed in only 4.8% of the sample.

In the present study, although the requests for prehospital medical services were more commonly made by women, the electrocardiographic changes were more prevalent among

Table 2. Relationship Between Electrocardiographic Changes Identified in the Prehospital Setting and the Diagnosis of Acute Coronary Syndrome Confirmed in the Urgent Care and Hospital Settings ($n=250$)

	ELECTROCARDIOGRAPHIC CHANGES IN THE PREHOSPITAL SETTING (ST DEVIATION)	ACS DIAGNOSIS (URGENT CARE CENTER AND HOSPITALS)
No. (%)	57 (22.8)	97 (38.8)
Agreement (%)	71.2 (95% CI: 65.4–76.6)	
Sensitivity (%)	42.3 (95% CI: 32.7–52.3)	
Specificity (%)	89.5 (95% CI: 83.1–93.7)	
PPV (%)	71.9 (95% CI: 59.3–82.4)	
NPV (%)	71.0 (95% CI: 64.3–77.1)	
Kappa	0.34 (95% CI: 0.23–0.46)	

ACS, acute coronary syndrome; CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

Table 3. Relationship Between Electrocardiographic Changes Identified in the Prehospital Setting and the Diagnosis of Acute Coronary Syndrome Confirmed in the Hospital Setting ($n=160$)

	ELECTROCARDIOGRAPHIC CHANGES IN THE PREHOSPITAL SETTING (ST DEVIATION)	ACS DIAGNOSIS (HOSPITAL SETTING)
No. (%)	52 (32.5)	69 (43.1)
Agreement (%)	73.1 (CI 95%: 65.9–79.6)	
Sensitivity (%)	56.5 (CI 44.7–67.8)	
Specificity (%)	85.7 (CI 77.4–91.8)	
PPV (%)	75.0 (CI 95%: 62.0–85.3)	
NPV (%)	72.2 (CI 95%: 63.2–80.1)	
Kappa	0.44 (CI 95%: 0.30–0.57)	

men older than 60 years. Other studies have also reported higher prevalence of electrocardiographic changes in male patients at older ages.[4,19,20]

In addition, the diagnosis of ACS was confirmed in 71.9% of patients when both ST-segment elevation and depression were considered electrocardiographic changes. There was a significant agreement (κ coefficient of 0.34, $p < 0.001$) between electrocardiographic changes and the diagnosis of ACS in patients who required hospitalization (*Table 2*). This was higher in the hospital setting than in urgent care centers. Patients with ST-segment elevation at initial ECG and at potentially greater risk were referred to hospitals for highly complex care (*Table 3*).

In our sample, the diagnostic sensitivity for ACS based on electrocardiographic changes was 56.5%, which is in agreement with the V Brazilian Cardiology Society Guidelines on the treatment of STEMI that reports that nearly 50% of these cases are undiagnosed or have a normal ECG. The low sensitivity of the examination (45–60% for AMI diagnosis), along with the dynamic nature of the thrombotic coronary occlusion process, suggests the necessity for a more careful monitoring of the ST-segment by serial ECG, which can be performed in urgent care centers.

Bassan et al.[21] found a 49% diagnostic sensitivity of admission ECG for AMI, and a PVV of 79% when the ST-segment elevation is used as the diagnostic criteria. In our study, these values were 56.5% and 75%, respectively (*Table 3*).

Therefore, the tele-ECG allows the early diagnosis of ACS, reducing the delay to definitive treatment, be it reperfusion, chemical, or mechanical therapy.[2,16] In our study, the diagnostic specificity of ECG for AMI was 85.7%, indicating the usefulness of the method. Thanks to the test, 69% of patients referred to an urgent care center were not diagnosed with ACS and were not transferred to tertiary hospitals. In this way, financial resources were optimized and directed to patients at potentially high risk, preventing the overcrowding of emergency rooms in these hospitals and increase in the costs of the public health system.

LIMITATIONS OF THE STUDY

Results of this retrospective study based on the medical records of patients who called for emergency ambulance services in Porto Alegre, Brazil, are not conclusive. Many patients also go to hospital emergency departments for nonemergency conditions, and others seek prehospital medical care in private centers. However, the credibility of our study is supported by the fact that all ECG reports were issued in a prominent healthcare center by two independent observers.

Authors' Contributions

A.L.A.M.: Collected data, elaborated the project, participated in writing the article. M.C.I.: Reviewed the article and participated in the writing of the article. S.G.: Reviewed the article and participated in the final written essay of the article.

Disclosure Statement

The authors declare that there is no conflict of interest regarding the publication of this article. None of the authors of this article had financial or any other relationship that may lead to a conflict of interest.

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