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Original Scientific Paper

Telecardiology improves quality of diagnosis and reduces delay to treatment in elderly patients with acute myocardial infarction and atypical presentation

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Aim **To assess whether telemedicine technology applied to public emergency healthcare system improves overall quality of home diagnosis in case of acute myocardial infarction among elderly patients, often characterized by higher rates of atypical presentation.**

Methods **About 27 841 patients from Apulia (Italy) who called public emergency healthcare number '118' underwent home ECG evaluation. Data were transmitted with a mobile telephone support to a telecardiology 'hub' active continuously (24/7). Data from elderly patients (>70 years) were compared with younger ones.**

Results **Thirty-nine percent of patients complained of chest (or epigastric) pain; ST elevation acute myocardial infarction (STEMI) was diagnosed in 1.9% of patients enrolled; 50.2% of patients with STEMI were above 70 years of age. Among STEMI patients older than 70 years, atypical presentation was detected in 32% [95% confidence interval (CI): 26.8–38.1] of patients (vs. 11% 95% CI: 7.8–15.5, $P<0.001$). Rate of atypical STEMI presentation, immediately diagnosed, thanks to telecardiology, rose up from 9.2% (95% CI: 5–17%) in the class of age 60–69 years to 25.6% (95% CI: 20–35%) in the class of age 70–79 years, to 35.2% (95% CI: 26–45%) in the class 80–89, and to 46.1% (95% CI: 26–67%) in the class greater than 89 years of age ($P<0.01$ in all cases). Number needed to treat (to avoid a single missed STEMI diagnosis) was 9.4 (95% CI: 6.4–12.9) for patients younger than 70 years versus 3.1 (95% CI: 2.6–3.7) among those older than 70 years ($P<0.001$).**

Conclusion **Telecardiology home ECG diagnosis could significantly help in avoiding errors and delay in STEMI diagnosis in elderly patients.** ***Eur J Cardiovasc Prev Rehabil*** **17:615–620 © 2010 The European Society of Cardiology**

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Keywords: elderly, ST elevation acute myocardial infarction, telecardiology

Introduction

Home diagnosis of acute myocardial infarction (AMI) might be not easy, if ECG recording is not immediately available. Signs and symptoms suggestive for AMI seem to have a very low sensitivity and specificity, as reported by several case studies [1,2]. Furthermore, elderly patients are often characterized by higher rates of atypical presentation in case of AMI [3], and diagnosis of AMI in older patients is usually delayed in comparison with younger patients [4]. In case of AMI, the time interval between the onset of symptoms and a patient's arrival to hospital is still far from being optimal; this is especially true for older patients with diabetes, a history of coronary artery disease, or chronic atrial fibrillation [5].

Fewer data, however, are available about new scenarios drafted by telecardiology technologies, nowadays involving a growing number of areas of medicine [6]. We therefore aimed to assess whether telemedicine technology applied to a public emergency healthcare system could improve overall quality of home diagnosis in case of AMI among elderly patients.

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Methods

This telecardiology program involved 27 841 patients from all over Apulia (19 362 km^2, 4 millions inhabitants, Fig. 1), who called public emergency, free healthcare telephone number '118' from October 2004 until April 2006. '118' is a public, free service for general, either medical or surgical, emergencies, whose aim is an immediate diagnosis of critical diseases, to avoid emergency room delay-to-diagnosis. Final hospitalization is disposed by crews' physicians and '118' district central, connected by mobile phone; direct admission to critical care unit is arranged according to level of care. Patients are discharged from the ambulance and not transported at all in case of normal findings. According to Italian legislation, crews of 118 usually include a physician skilled in emergency medicine and/or nurses.

One hundred and fifty-four crews of '118' emergency number enrolled in this study were equipped with apposite devices for recording and telephone transmission of 12-lead ECG (CardioVox P12 heart-line receiving system by Aerotel, Holon, Israel); the device does not show ECG records, so ECG cannot be immediately seen by 118 crews members (paramedics and physicians).

Fig. 1

Italy, Apulia and its administrative districts.

Data recorded by '118' crews were immediately transmitted by mobile phone to a hub center where a cardiologist promptly read the ECG (Fig. 2). Logistic support for the hub center was furnished by Cardio-on-line Europe S.r.l., thanks to a grant by Pfizer; about 20 cardiologists cooperated with Cardio-on-line Europe S.r.l. providing cardiologic consultancy. Hub center, operative continuously (24/7), was furnished with 12 computer terminals, 25 telephone lines, two telephone operators continuously available to answer calls, and emergency power to provide for a 24-h service even in case of black-out.

Indications for ECG recording were presence of chest pain or epigastric pain, breathlessness, palpitations, loss of consciousness, or any suspected acute cardiovascular disease. After ECG recording, mobile telephone transmission, and ECG diagnosis, '118' district central disposed for hospitalization in coronary care unit or primary coronary angioplasty, when necessary. ECG data were archived on paper and CD ROM support.

ST segment elevation was considered significant for MI according to the American College of Cardiology/American Heart Association/European Society of Cardiology criteria published in 2000 (new or presumed new ECG alterations: ST segment elevation at the J point in two or more contiguous leads with cut-off points 0.2 mV in leads V1, V2, or V3 and 0.1 mV in other leads) [7].

Statistical analysis

Continuous variables were expressed as mean value ± standard deviation and categorical variables as percentage [± 95% confidence interval (95% CI)]. A logistic regression was performed to test whether age and sex are independent predictors of chest pain at presentation. Differences in percentage were analyzed with χ^2 test. A P value of less than 0.05 was considered statistically significant.

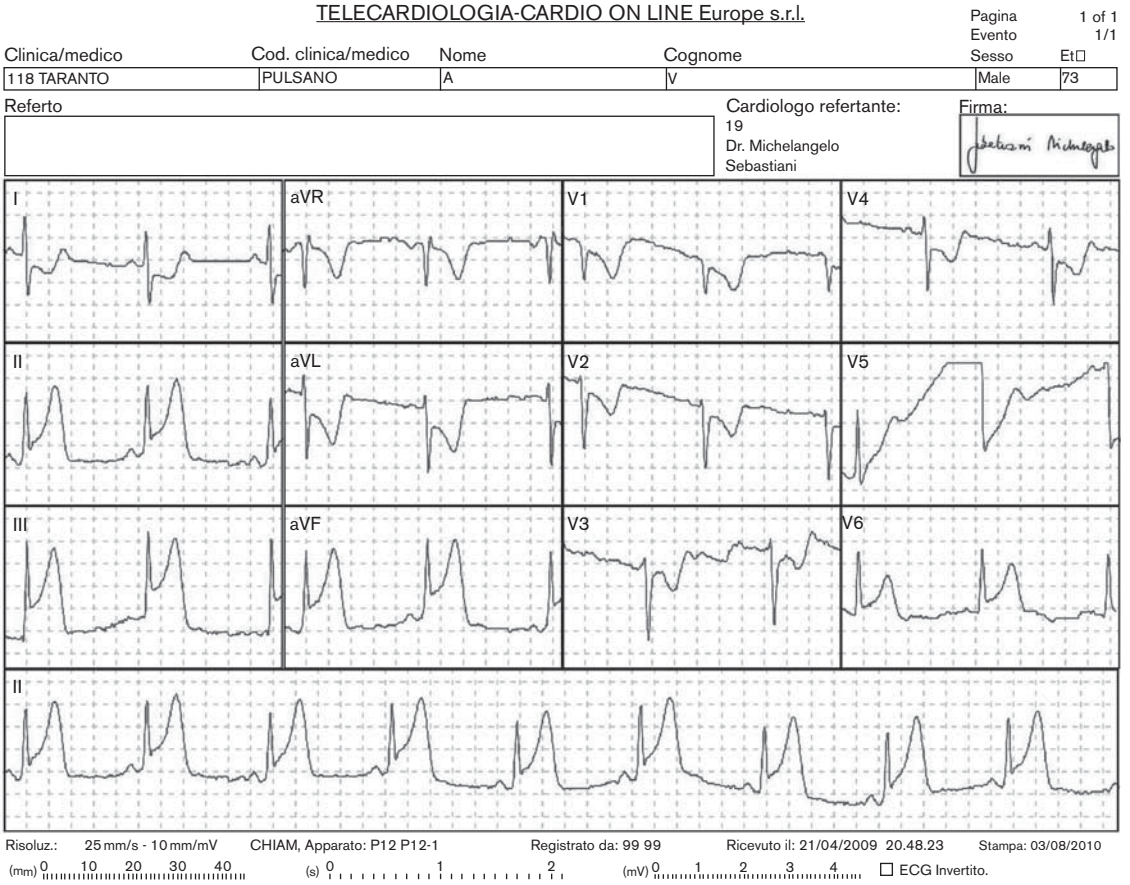
Results

Out of 27 841 patients enrolled, 49.2% were male, about 51.4% were older than 70 years, and 39.3% complained of chest or epigastric pain; ST elevation acute myocardial infarction (STEMI) was diagnosed upon ECG findings in 534 patients (1.9%), 3.8% of patients with chest pain.

Out of 534 patients with STEMI, 65.5% were male, 50.2% were older than 70 years, and 21.1% complained of atypical symptoms. Seasonal incidence of STEMI is reported in Fig. 3. Peaks of incidence were detected in winter months.

Symptoms reported by patients significantly differed on comparing patients older than 70 years with younger ones (Figs 4 and 5). Among patients older than 70 years, 68.5% (95% CI: 61.9–73.2%) complained of chest pain (vs. 89.0%, 95% CI: 84.5–92.2%, $P < 0.001$); breathlessness was present in 7.6% (95% CI: 4.3–10.6%) (vs. 1.9%, 95% CI: 2.4–3.5%, $P < 0.01$), palpitations in 0.8% (95% CI: −0.4 to 1.8%)

Fig. 2



Telecardiology ECG showing signs of an inferior wall acute myocardial infarction.

(vs. 0.4%, 95% CI: −0.4 to 1.1%, *P* value NS), consciousness disturbance in 13.6% (95% CI: 9.3–17.5%) (vs. 3.0%, 95% CI: 0.9–5.1%, $P < 0.001$), and other symptoms in 9.5% (95% CI: 5.8–12.8%) (vs. 5.3%, 95% CI: 2.6–8.0%, $P = 0.07$) (Fig. 5). In a logistic regression analysis, age was an independent predictor of atypical presentation of STEMI (hazard ratio 1.04, 95% CI: 1.02–1.05 per single age year).

Incidence of atypical presentation of STEMI significantly increased with increasing classes of age from 9.2% (95% CI: 5–17%) in the class of age 60–69 years to 25.6% (95% CI: 20–35%) in the class of age 70–79 years, to 35.2% (95% CI: 26–45%) in the class of age 80–89 years, and to 46.1% (95% CI: 26–67%) in the class of age greater than 89 years. Sensitivity for STEMI owned by chest pain symptom decreased with age ($P < 0.01$ for 70s, $P < 0.001$ for 80s and 90s when compared with 60s) (Fig. 6); this happened in both sexes, without significant differences.

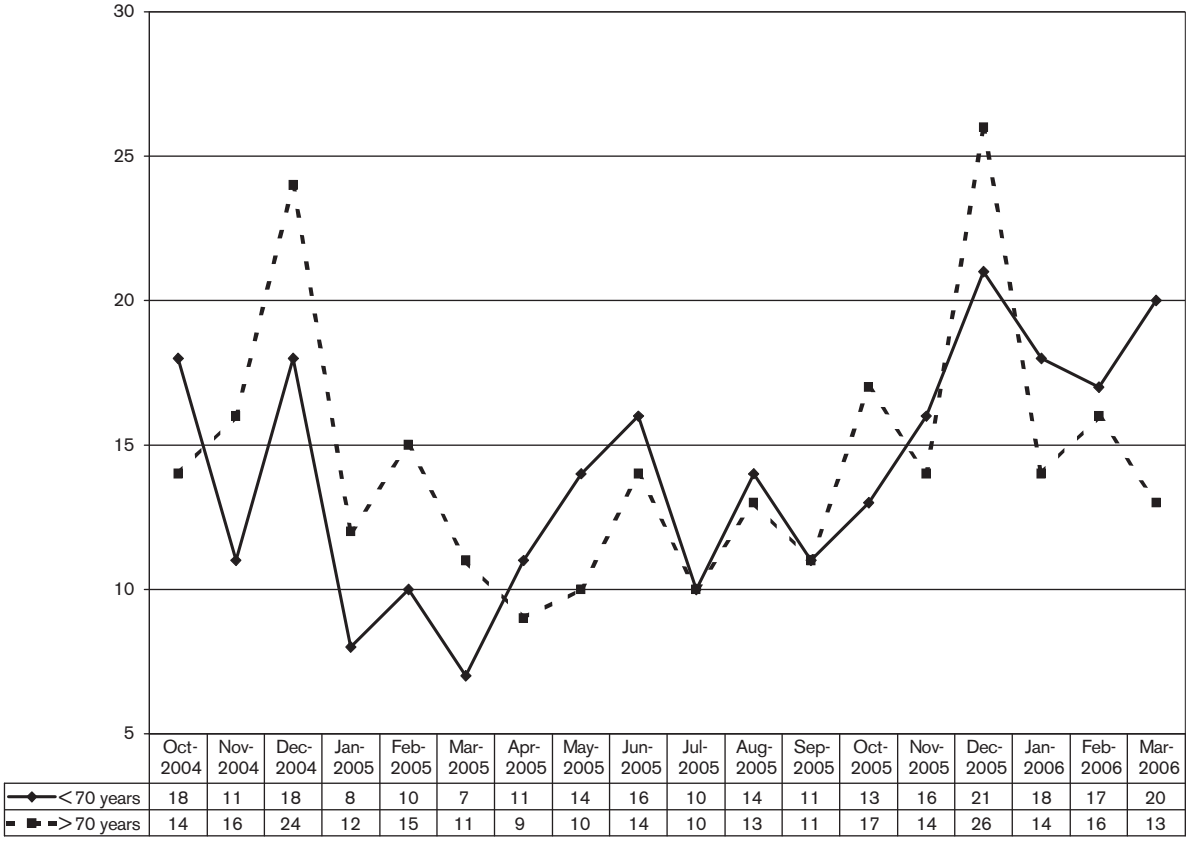
The number of patients who benefited from telecardiology services, as atypical presentation of STEMI could have led to a wrong or delayed diagnosis, increased from 10–11% (95% CI: 2.8–19.7%) (95% CI: 4.7–17.2%) in the class of age 50–60 years to 27.7–35.2% (95% CI: 20.1–35.3%) (95% CI: 25.9–44.5%) in the class of age 70–80 years ($P < 0.01$). A total number of 111 wrong or delayed diagnoses (21.1% out of 534 STEMI) were therefore avoided. A single potentially missed diagnosis of STEMI per age class was avoided (number needed to treat) for every 9.4 (95% CI: 6.4–12.9) screened patients with an age less than 70 years versus 3.1 (95% CI: 2.6–3.7) among those older than 70 years (total 4.8, 95% CI: 3.9–5.4) ($P < 0.001$) (Fig. 7).

Time to diagnosis showed significant differences comparing patients older than 70 years with younger ones; 41.8% of patients above 70 years of age were diagnosed of STEMI within 30 min since the onset of chest pain (vs. 47.1% in younger patients, *P* value NS) and 78.2% within 3 h (vs. 90.8% in younger patients, $P < 0.01$).

Discussion

Feasibility and reliability of telecardiology technologies applied to a public emergency health service have already been shown in previous studies [8,9]. This report, however, is the largest and the longest experience of

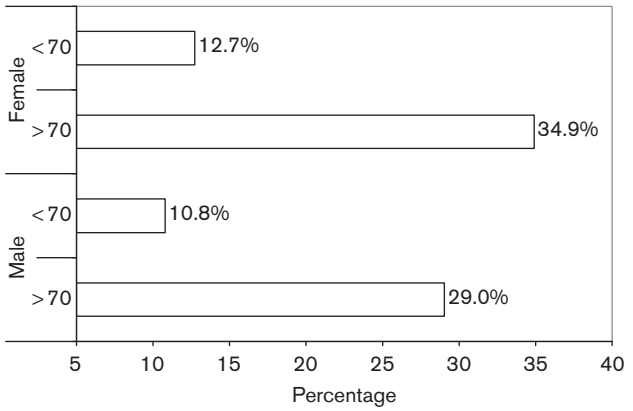
Fig. 3



	Oct-2004	Nov-2004	Dec-2004	Jan-2005	Feb-2005	Mar-2005	Apr-2005	May-2005	Jun-2005	Jul-2005	Aug-2005	Sep-2005	Oct-2005	Nov-2005	Dec-2005	Jan-2006	Feb-2006	Mar-2006
<70 years	18	11	18	8	10	7	11	14	16	10	14	11	13	16	21	18	17	20
>70 years	14	16	24	12	15	11	9	10	14	10	13	11	17	14	26	14	16	13

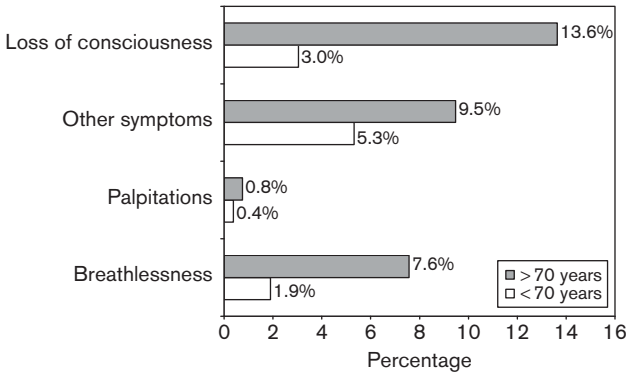
Observed seasonal incidence of ST elevation acute myocardial infarction.

Fig. 4



Atypical presentation of ST-elevation acute myocardial infarction per age and gender.

Fig. 5

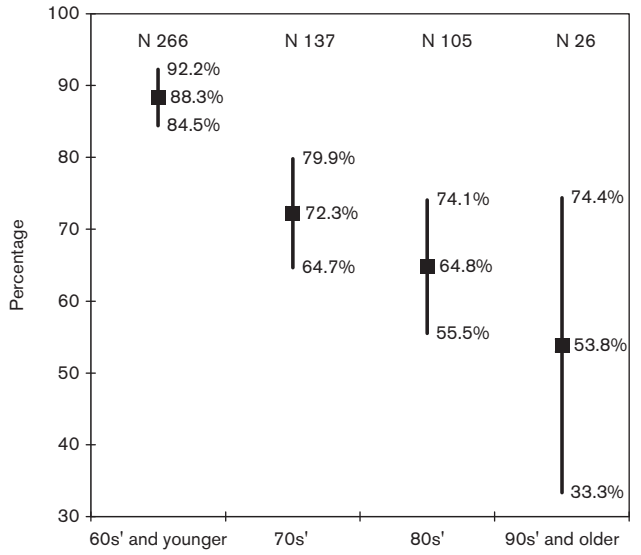


Symptom presentation of ST elevation acute myocardial infarction per age.

telecardiology applied to a region-wide public emergency healthcare network. Lower number of improper hospitalizations and shorter delay in diagnosis process point out benefits that can be obtained by applying telemedicine protocols to large public emergency healthcare networks.

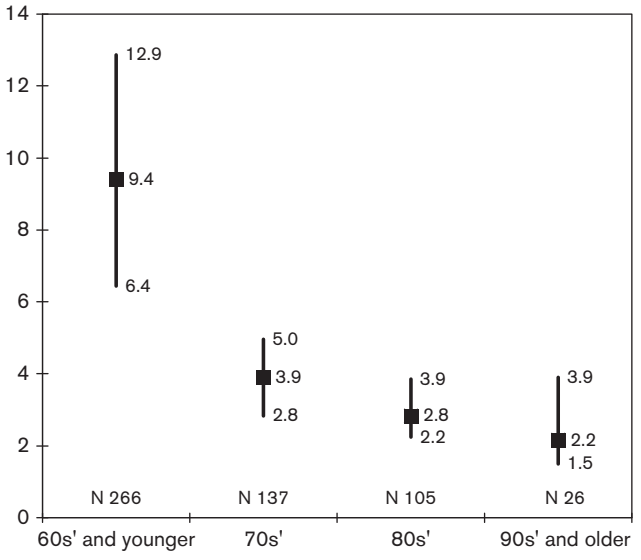
Seasonal trends in the incidence of complained symptoms suggestive of heart disease could be observed by analyzing telecardiology databases; trends from our study are similar to those reported by other studies [9,10]. A higher rate in the incidence of heart disease has been

Fig. 6



Sensitivity of chest pain for ST elevation acute myocardial infarction per age class.

Fig. 7



Number needed to treat, number of patients with ST elevation acute myocardial infarction (STEMI) to be screened with home ECG to avoid a single missed diagnosis of STEMI per age class.

reported by several authors in winter and autumn, which has been explained with the influence of several factors such as wide spreading of flu during winter months [10–12].

In this study, telecardiology improved quality of diagnosis of STEMI, significantly reducing the number of wrong diagnosis in patients with an atypical symptom presentation. AMI associated with atypical symptoms is not an uncommon finding. According to Gupta *et al.* [13], of 721 cases of diagnosed AMI, only 53% of patients presented with chest pain. The frequency of other complaints was shortness of breath (17%) dizziness/weakness/syncope (4%), and other. The risk of a presentation without chest pain in a patient with AMI increased with age [13]. The characteristic with the highest risk for a presentation without chest pain in patients with AMI was age above 84 years. Presentation with painless AMI occurs in older patients with increased degrees of pulmonary congestion on admission [14].

An atypical presentation in case of AMI was related to a worse prognosis and an increased mortality [15]. This may result, in part, from a failure to use beneficial treatment strategies [16]. Results by Canto *et al.* [17] suggested that patients without chest pain on presentation represent a large segment of the AMI population and are at increased risk for delays in seeking medical attention, less aggressive treatments, and in-hospital mortality. Older patients presenting to the emergency department with AMI receive lower-quality medical care than younger patients [18]. Elderly patients are less likely to receive guideline-indicated therapies when hospitalized with AMI [19]. Therefore, telecardiology technologies could significantly help in reducing neglected diagnosis of AMI. Telecardiology support is particularly cost-effective when applied to elderly patients, as confirmed by the very low number needed to treat found in this study (3.2), because of higher prevalence of atypical STEMI presentation among these patients. An immediate home ECG screening might therefore increase diagnosis rate by approximately 50%, in case STEMI affects older patients.

Furthermore, telecardiology support could significantly reduce delay to treatment of heart disease. Delay to treatment has been reported as one of the principal outcome determinants in coronary heart disease, both in case of primary percutaneous coronary intervention (PCI) [20,21] and in case of fibrinolysis [22]. However, delay to treatment is still significant in developed countries as well. In recent studies, door-to-balloon times for transfer patients undergoing primary PCI in the United States rarely achieved guideline-recommended benchmarks [23]. Telecardiology was shown as being effective in lowering time to PCI in patients with STEMI [24], and prehospital diagnosis is associated with a two-third reduction of in-hospital mortality in the case of STEMI complicated by cardiogenic shock [25]. In a study by Schuler *et al.* [26], prehospital time in patients with AMI above 75 years of age was prolonged (2.8 vs. 2 h) with respect to patients below 75 years of age. Data from National Registry of Myocardial Infarction-4 showed a geometric mean time of 83–103 min from the onset of symptoms to hospital arrivals [27].

Despite this, in our study, 41.8% of patients with STEMI older than 70 years received an ECG within 30 min since the onset of chest pain and 78.2% within 3 h, thus significantly benefiting from immediate diagnosis of STEMI, particularly in case of atypical presentation. Delay to treatment previously observed in elderly patients could therefore be presumably because of logistic problems, as time-to-ECG did not differ comparing older patients with younger ones in a telecardiology setting.

A wide application of telecardiology technologies might thus be effective in reducing time-to-diagnosis in patients with STEMI and, in combination with an effective network of tertiary care centers ready for primary PCI or at-home thrombolysis, significantly reduce time to reperfusion [28,29].

Conclusion

Telecardiology may prove useful in avoiding delay to treatment and wrong diagnosis in case of STEMI; benefit increases with elderly patients, who often present with symptoms other than chest pain.

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