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ORIGINAL ARTICLE / TELEDIAGNOSIS

All for one, one for all: Remote telemedicine hub pre-hospital triage for public Emergency Medical Service 1-1-8 in a regional network for primary PCI in Apulia, Italy



Tous pour un, un pour tous : triage pré-hospitalier à distance avec la télémedecine pour le service d'aide médicale urgente 1-1-8 dans un réseau régional pour l'angioplastie primaire dans les Pouilles, en Italie

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Summary

Background. – Pre-hospital triage supported by electrocardiogram assessment and telemedicine was used to shorten time to reperfusion in subjects with acute myocardial infarction (AMI). Timely treatment of AMI presupposes huge geographical areas covered by one primary angioplasty network, one emergency medical service (EMS), and that pre-hospital electrocardiograms are interpreted by a physician, preferably a cardiologist.

Methods. – We report preliminary data on a telemedicine network which provides remote interpretation of pre-hospital triage EMS electrocardiograms for Apulia, Southern Italy

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(4 million inhabitants): the region is served by one public health care service, one public EMS, one hospital network and one telemedicine service provider.

Results. — From October 2004 to September 2013, 598,140 electrocardiograms were read by the telemedicine hub. Fifty percent of subjects triaged via the pre-hospital telemedicine electrocardiogram network were male, 50% were aged over 70 years, 36% were triaged during night shift. Fifteen percent of electrocardiograms in subjects with chest pain were abnormal, therefore requiring direct access to the cath-lab or hospitalization. Frontline diagnosis was ST-elevation in 6178 subjects, while 40,106 electrocardiograms showed arrhythmias other than premature contraction or sinus rhythm. Typical chest pain was found in less than 50% of subjects diagnosed with ST-elevation AMI.

Conclusions. — The region of Apulia (4 million inhabitants, Southern Italy) is served by a unique combination of one telemedicine hub that reads pre-hospital electrocardiograms and provides cardiology consultations, one EMS, one hospital network for primary angioplasty in ST-elevation AMI. More than half a million electrocardiograms have been interpreted since 2004.

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MOTS CLÉS

Télé-cardiologie ;
Service médical
d'urgence ;
Service de santé
publique

Résumé

Contexte. — L'orientation et le triage pré-hospitaliers par le biais d'une évaluation électrocardiogramme et la télémédecine ont été utilisées pour raccourcir le délai de reperfusion chez des sujets atteint d'un infarctus du myocarde aigu (IMA). Un traitement de l'IMA en temps opportun suppose de vastes zones couvertes par un seul réseau pour l'angioplastie primaire, un seul service d'aide médicale urgente (Samu), et que les électrocardiogrammes pré-hospitaliers soient interprétés par un médecin, de préférence un cardiologue.

Méthodes. — Nous présentons des données préliminaires sur un réseau de télémédecine qui fournit l'interprétation à distance des électrocardiogrammes pré-hospitaliers pour le Samu de l'Apulia, une région dans le sud de l'Italie (4 millions d'habitants) : la région est desservie par un seul service de santé publique, un seul Samu, un seul réseau hospitalier pour l'angioplastie primaire et un seul fournisseur de services de télémédecine.

Résultats. — D'octobre 2004 jusqu'à septembre 2013, 598 140 électrocardiogrammes ont été lus par le centre de télémédecine. Cinquante pour cent des sujets orientés par le télé-ECG pré-hospitalier étaient des hommes, 50% avaient plus de 70 ans et 36% ont été évalués pendant la période de nuit. Quinze pour cent des ECG chez les sujets atteints de douleurs thoraciques étaient anormaux, nécessitant donc un transfert direct au centre de cathétérisme ou alors une hospitalisation. Un diagnostic de sus-décalage du segment ST était posé chez 6178 patients, tandis que 40 106 ECG ont démontré des arythmies autres qu'extrasystoles ventriculaires ou le rythme sinusal. Une douleur thoracique typique a été trouvée pour moins de 50% des sujets atteints d'un sus-décalage du segment ST.

Conclusions. — La région d'Apulia est servie par une combinaison unique d'un seul centre de télémédecine pour l'interprétation des ECG pré-hospitaliers et la consultation par un cardiologue, un seul Samu, un réseau hospitalier pour l'angioplastie primaire de l'IMA avec sus-décalage du segment ST. Plus d'un demi-million d'ECG ont été interprétés depuis 2004.

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Background

The treatment of acute myocardial infarction (AMI) involves shortening time to reperfusion; the lower the ischemic time, the smaller the necrotic zone [1] and the better the prognosis [2]. This goal could be achieved in several ways, oriented at keeping reperfusion time within the benchmark "golden hour" [3–5].

Pre-hospital triage supported by electrocardiogram assessment [6] and telemedicine support [7–9] were used to shorten time to reperfusion in cases of AMI. Nevertheless, both field triage and telecardiology are doomed to fail, if other links in the chain leading to timely reperfusion are flawed. Telemedicine potential is best exploited when a network aimed at treating AMI runs like a well-oiled machine.

Several models of networks for primary treatment of AMI by coronary angioplasty (PCI) have been therefore implemented so far, ranging from relatively small geographic areas [10] to large state-wide extension [11,12].

In most cases, paramedics are employed for electrocardiogram interpretation and cath-lab alerts, often supported by computer algorithms that identify the signs of AMI [13,14].

Despite this, automated electrocardiogram interpretation is inaccurate [15,16] and current guidelines require a physician to interpret and confirm the electrocardiogram after automated interpretation [17].

In other cases, the efficacy of medical networks aimed at timely treatment of AMI is hindered by the fragmentation of either the local Emergency Medical

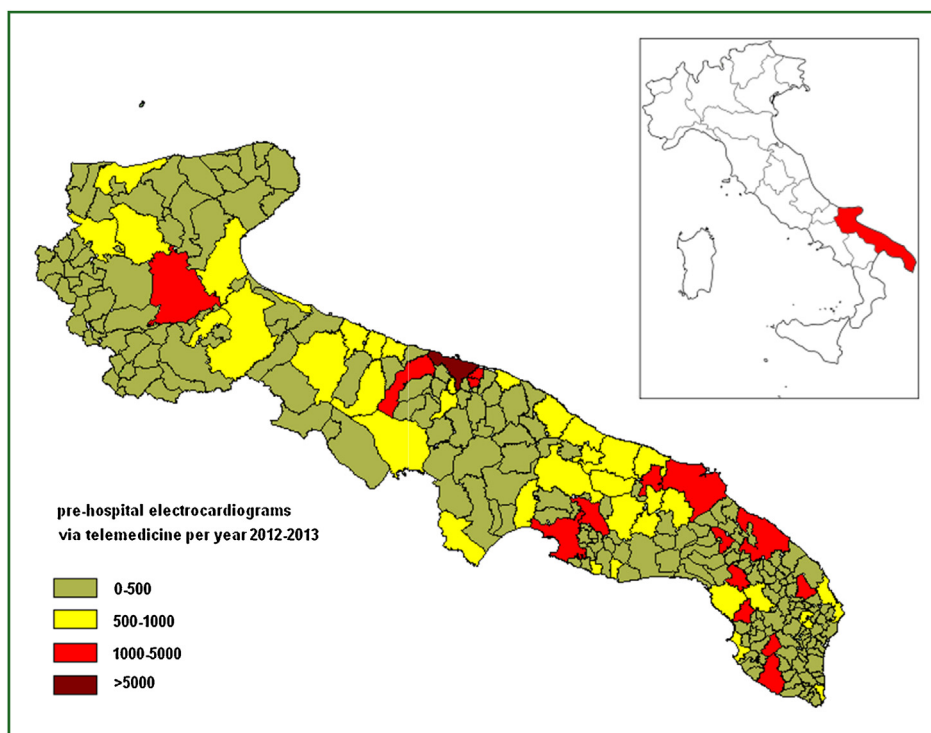


Figure 1. Apulia, Southern Italy, 4,050,300 inhabitants and 19,358 km². Pre-hospital electrocardiograms via telemedicine per town October 2012–September 2013.

Apulia, Italie du Sud, 4 050 300 habitants et une superficie de 19 359 km². Les ECG pré-hospitaliers réalisés par télémedecine par ville entre octobre 2012 et septembre 2013.

Service (EMS) provider or hospital and healthcare networks.

Ideally, large geographical areas should be covered by a single primary angioplasty network [11], a single EMS provider, a network comprising “hub” hospitals with 24/7 cath-lab able to realize primary angioplasty and “spoke” hospitals or emergency departments ready for immediate transfer to a hub-hospital. Pre-hospital electrocardiograms should be interpreted by a physician, preferably a cardiologist [18–20].

We therefore report the preliminary data on a telemedicine network which provides remote interpretation of pre-hospital electrocardiograms for EMS in Apulia, Southern Italy (Fig. 1): the region is served by a single public health care service, a single public EMS, a single hospital network and a single telemedicine service provider.

Methods

The region of Apulia has 4,050,300 inhabitants and comprises 19,358 km². The regional network for primary PCI in STEMI was established in Apulia in January 2012. There are 15 PCI intervention laboratories providing a 24/7 service across the region.

The regional EMS is activated by calling 118, the free Italian public service telephone number for general medical or surgical emergencies, the aim of which is an immediate diagnosis of critical diseases in order to avoid emergency room delay-to-diagnosis. Final hospitalization is arranged by teams of physicians and a regional 118 service,

connected by mobile phone: direct admission to a critical care unit is arranged according to the level of care. Patients are discharged from the ambulance and not transported at all in case of normal findings. According to Italian legislation, 118 crews usually include an emergency medicine physician and/or nurses and the electrocardiogram should be preferably interpreted by a cardiologist.

All regional 118 EMS crews (more than 200) are equipped with a CardioVox P12 12-lead electrocardiogram recorder (Aerotel™, Holon, Israel) (Fig. 2): the devices can record a complete 12-lead ECG read by a cardiologist available 24/7 following mobile phone or telephone transmission to a unique regional telemedicine support “hub”, located in Bari, capital city of Apulia. One hundred and eighteen paramedics and physicians can receive ECG results on smartphones connected to the telecardiology hub. Logistic support for the telemedicine hub was provided by Cardio-online Europe S.r.l., Bari, Italy. A cardiologist available 24/7 within the telecardiology hub promptly reads the electrocardiograms sent by the EMS personnel from the entire region of Apulia. In cases of STEMI, the patients are immediately addressed to the nearest cath-lab for appropriate treatment.

The telemedicine service has been established since October 2004 by Cardio-on-line Europe S.r.l., a telemedicine company certified in UNI EN ISO 9001:2008 (quality certification) and UNI CEI ISO/IEC 27001:2006 (security data certification). The telecardiology hub for the entire region, operative 24/7, has two cardiologists on duty for electrocardiogram interpretation, 12 computer terminals, 25 telephone lines, 2 call center operators available 24/7, 20



Figure 2. Telemetry device for remote electrocardiogram recording and its use.
Un dispositif de télécardiologie pour l'enregistrement des ECG à distance et son utilisation.

alternating, on duty cardiologists and an emergency power system in case of electrical power outage.

All center services and the entire network are shielded from virus threats by a combination of hardware and software firewalls, and a comprehensive antivirus, in addition to software back-up procedures. A comprehensive network management program ensures that all systems have real-time updates and that the latest security patches are installed as soon as they are released.

All data are electronically stored in computers using a unique identification number for the center and individual, in compliance with the Italian Privacy and Personal Information Protection Act (D. Lgs. 196/2003).

The regional EMS and telemetry provider made a preliminary agreement on indications for ECG recording: presence of chest pain or epigastric pain, breathlessness, palpitations, dizziness/fainting, or any suspected acute cardiovascular disease.

The study was authorized by local Health Authority and is in accordance with the declaration of Helsinki.

Results

From October 2004 to September 2013, 598,140 electrocardiograms were read by the telemedicine hub (Fig. 3): peaks can be observed during the summer months, when Apulia attracts tourists from all over the world.

Fifty percent of subjects triaged via the pre-hospital telemedicine electrocardiogram were male, 50% were older than 70 years, 36% were triaged during night shift (8 p.m. – 8 a.m.). Indications for pre-hospital triage via telecardiology electrocardiogram examination were acute chest pain in 24% of cases, dizziness or fainting in 21%, palpitations in 7%, breathlessness in 9%. Fifteen percent of electrocardiograms in subjects with chest pain were abnormal, therefore

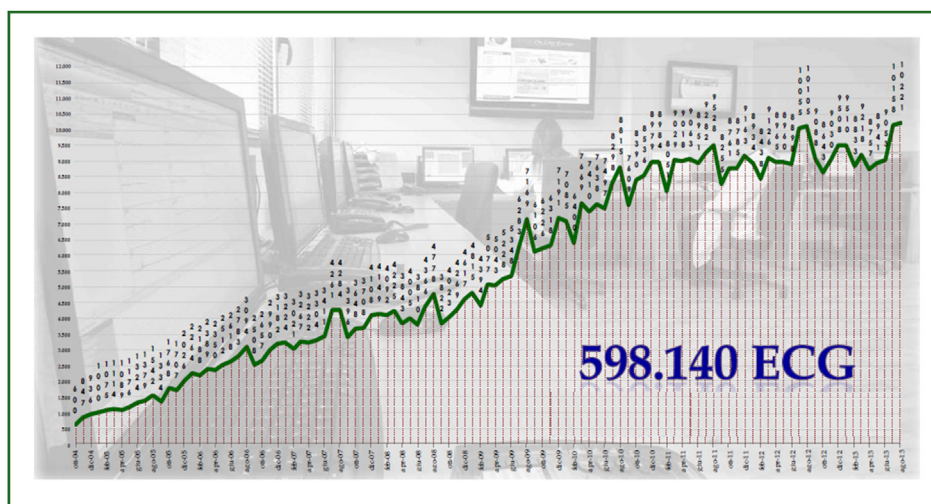


Figure 3. Electrocardiograms read by telemedicine hub since 2004.
Le nombre de ECG interprétés par le centre de télémedecine depuis 2004.

requiring direct access to cath-lab or hospitalization. The frontline diagnosis was ST-elevation in 6178 subjects, while 40,106 electrocardiograms showed arrhythmias other than premature contraction or sinus rhythm. ST anomalies suggested further assessment in 22,288 cases. Typical chest pain was found in fewer than 50% of subjects diagnosed with ST-elevation AMI.

Discussion

We report nine-year data on large telemedicine network supporting the public 118 EMS in a region with a hospital network for treatment of ST-elevation AMI with primary angioplasty. The telemedicine service in Apulia was also used for pre-hospital diagnosis of arrhythmias in syncope [21], atypical atrial fibrillation [22] and in primary [23] and secondary prevention of cardiovascular disease [24].

Telemedicine support was also implemented in routine triage in local penitentiaries in cases of suspected acute heart disease [25] and even in fast track emergency room triage [26].

Data on logistic requirements [7] and diagnostic findings from Apulia telecardiology network were previously published [8,9].

A larger network aimed at pre-hospital triage of STEMI was also implemented in other Italian areas (Lombard-IMA [27]): field triage was associated with a trend in reduced 30-day mortality (5.3% vs 7.9%) [28]. However, telemedicine support for the 118 EMS in Apulia is characterized by remote consultation between on scene 118 personnel and telemedicine hub cardiologist, which could further improve the accuracy of pre-hospital triage. Indeed, there is evidence that when paramedics are involved in pre-hospital electrocardiogram reading, a further consultation is often required [29].

Moreover, pre-hospital triage in Apulia with telemedicine support was used in very high rates of 118 patients (up to 50%), while pre-hospital electrocardiogram were available just in 12% of patients from the Lombard-IMA registry.

Despite the fact that pre-hospital 12-lead electrocardiogram assessment in case of suspected IMA has been advocated and recommended by guidelines [30,31] and scientific statements [32], it is still little used [33].

However, other than shorter time to treatment [33–36], pre-hospital electrocardiogram triage by-passing emergency department delay was shown to be associated with lower STEMI mortality [34,35]. Relative reduction in STEMI mortality reached about 60% in recent studies [37]. Mortality was reduced thanks to pre-hospital triage even in cases of cardiogenic shock [38] and higher left ventricular ejection fraction was maintained after field electrocardiogram triage [38].

Rural areas benefit the most from telemedicine support [39]; pre-hospital electrocardiogram triage enables people living far from a PCI facility to achieve a time to treatment comparable with those living closer [19].

According to current guidelines on STEMI treatment, ideally a consultation between a cardiologist and frontline EMS personnel should be pursued [30] and all electrocardiograms should be read by a cardiologist.

Widespread use of pre-hospital electrocardiogram and a direct referral for primary PCI by-passing the emergency department could be better implemented with a single regional EMS [30] and a single telemedicine hub with electrocardiograms read by a cardiologist. All for one, one for all: you get it in Apulia.

Limitations

These are preliminary observational non-randomized data on a 9-year experience with telecardiology support for the public EMS.

Conclusions

The region of Apulia (4 million inhabitants, Southern Italy) is served by a unique combination of one telemedicine hub

interpreting pre-hospital electrocardiograms and providing cardiology consultations, one EMS, one network for primary PCI in ST-elevation AMI, one public health care service. More than half a million electrocardiograms have been read so far since 2004.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

- [1] Francone M, Bucciarelli-Ducci C, Carbone I, Canali E, Scardala R, Calabrese FA, et al. Impact of primary coronary angioplasty delay on myocardial salvage, infarct size, and microvascular damage in patients with ST-segment elevation myocardial infarction: insight from cardiovascular magnetic resonance. *J Am Coll Cardiol* 2009;54:2145–53.
- [2] Rollando D, Puggioni E, Robotti S, De Lisi A, Ferrari Bravo M, Vardanega A, et al. Symptom onset-to-balloon time and mortality in the first seven years after STEMI treated with primary percutaneous coronary intervention. *Heart* 2012;98:1738–42.
- [3] Bradley EH, Herrin J, Wang Y, Barton BA, Webster TR, Mattera JA, et al. Strategies for reducing the door-to-balloon time in acute myocardial infarction. *N Engl J Med* 2006;355:2308–20.
- [4] Welsh RC, Armstrong PW. It's a matter of time: contemporary pre-hospital management of acute ST elevation myocardial infarction. *Heart* 2005;91:1524–6.
- [5] Giugliano RP, Braunwald E, TIMI Study Group. Selecting the best reperfusion strategy in ST-elevation myocardial infarction: it's all a matter of time. *Circulation* 2003;108:2828–30.
- [6] Curtis JP, Portnay EL, Wang Y, McNamara RL, Herrin J, Bradley EH, et al. National Registry of Myocardial Infarction-4. The pre-hospital electrocardiogram and time to reperfusion in patients with acute myocardial infarction, 2000–2002: findings from the National Registry of Myocardial Infarction-4. *J Am Coll Cardiol* 2006;47:1544–52.
- [7] Brunetti ND, De Gennaro L, Dellegrottaglie G, Amoroso D, Antonelli G, Di Biase M. A regional prehospital electrocardiogram network with a single telecardiology “hub” for public emergency medical service: technical requirements, logistics, manpower, and preliminary results. *Telemed J E Health* 2011;17:727–33.
- [8] Brunetti ND, De Gennaro L, Amodio G, Dellegrottaglie G, Pellegrino PL, Di Biase M, et al. Telecardiology improves quality of diagnosis and reduces delay to treatment in elderly patients with acute myocardial infarction and atypical presentation. *Eur J Cardiovasc Prev Rehabil* 2010;17:615–20.
- [9] Brunetti ND, Amodio G, De Gennaro L, Dellegrottaglie G, Pellegrino PL, Di Biase M, et al. Telecardiology applied to a region-wide public emergency health-care service. *J Thromb Thrombolysis* 2009;28:23–30.
- [10] Le May MR, So DY, Dionne R, Glover CA, Froeschl MP, Wells GA, et al. A citywide protocol for primary PCI in ST-segment elevation myocardial infarction. *N Engl J Med* 2008;358:231–40.
- [11] Jollis JG, Roettig ML, Aluko AO, Anstrom KJ, Applegate RJ, Babb JD, et al. Implementation of a statewide system for coronary reperfusion for ST-segment elevation myocardial infarction. *JAMA* 2007;298:2371–80.
- [12] Fosbol EL, Granger CB, Jollis JG, Monk L, Lin L, Lytle BL, et al. The impact of a statewide pre-hospital STEMI strategy to bypass hospitals without percutaneous coronary intervention capability on treatment times. *Circulation* 2013;127:604–12.
- [13] Youngquist ST, Kaji AH, Lipsky AM, Koenig WJ, Niemann JT. A Bayesian sensitivity analysis of out-of-hospital 12-lead electrocardiograms: implications for regionalization of cardiac care. *Acad Emerg Med* 2007;14:1165–71.
- [14] Brown JP, Mahmud E, Dunford JV, Ben-Yehuda O. Effect of prehospital 12-lead electrocardiogram on activation of the cardiac catheterization laboratory and door-to-balloon time in ST-segment elevation acute myocardial infarction. *Am J Cardiol* 2008;101:158–61.
- [15] Camp-Rogers T, Dante S, Kontos MC, Roberts CS, Kreisa L, Kurz MC. The impact of prehospital activation of the cardiac catheterization team on time to treatment for patients presenting with ST-segment-elevation myocardial infarction. *Am J Emerg Med* 2011;29:1117–24.
- [16] Willems JL, Abreu-Lima C, Arnaud P, van Bommel JH, Brohet C, Degani R, et al. The diagnostic performance of computer programs for the interpretation of electrocardiograms. *N Engl J Med* 1991;325:1767–73.
- [17] Kligfield P, Gettes LS, Bailey JJ, Childers R, Deal BJ, Hancock EW, et al. American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; American College of Cardiology Foundation; Heart Rhythm Society Recommendations for the standardization and interpretation of the electrocardiogram: part I: the electrocardiogram and its technology a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society endorsed by the International Society for Computerized Electrocardiology. *J Am Coll Cardiol* 2007;49:1109–27.
- [18] Terkelsen CJ, Lassen JF, Nørgaard BL, Gerdes JC, Poulsen SH, Bendix K, et al. Reduction of treatment delay in patients with ST-elevation myocardial infarction: impact of pre-hospital diagnosis and direct referral to primary percutaneous coronary intervention. *Eur Heart J* 2005;26:770–7.
- [19] Sørensen JT, Terkelsen CJ, Nørgaard BL, Trautner S, Hansen TM, Bøtker HE, et al. Urban and rural implementation of pre-hospital diagnosis and direct referral for primary percutaneous coronary intervention in patients with acute ST-elevation myocardial infarction. *Eur Heart J* 2011;32:430–6.
- [20] Sejersten M, Sillesen M, Hansen PR, Nielsen SL, Nielsen H, Trautner S, et al. Effect on treatment delay of prehospital teletransmission of 12-lead electrocardiogram to a cardiologist for immediate triage and direct referral of patients with ST-segment elevation acute myocardial infarction to primary percutaneous coronary intervention. *Am J Cardiol* 2008;101:941–6.
- [21] Brunetti ND, De Gennaro L, Dellegrottaglie G, Antonelli G, Amoroso D, Di Biase M. Prevalence of cardiac arrhythmias in pre-hospital tele-cardiology electrocardiograms of emergency medical service patients referred for syncope. *J Electrocardiol* 2012;45:727–32.
- [22] Brunetti ND, De Gennaro L, Pellegrino PL, Dellegrottaglie G, Antonelli G, Di Biase M. Atrial fibrillation with symptoms other than palpitations: incremental diagnostic sensitivity with at-home tele-cardiology assessment for emergency medical service. *Eur J Prev Cardiol* 2012;19:306–13.
- [23] Brunetti ND, Conoscitore AR, Dellegrottaglie G, Di Giuseppe G, De Gennaro L, Antonelli G, et al. Exercise training and obesity in Italian children directly assessed by primary school teachers with tele-cardiology support: a pilot experience. *Int J Cardiol* 2013;168:1699–702.
- [24] Brunetti ND, De Gennaro L, Dellegrottaglie G, Straziota E, Novielli V, Antonelli G, et al. Rationale and design for a cardiovascular screening and prevention study with tele-cardiology in Mediterranean Italy: the CAPITAL study (Cardiovascular Prevention with Telecardiology in Apulia). *Int J Cardiol* 2011;149:130–3.

- [25] Brunetti ND, Dellegrottaglie G, Di Giuseppe G, De Gennaro L, Di Biase M. Prison break: remote tele-cardiology support for cardiology emergency in Italian penitentiaries. *Int J Cardiol* 2013;168:3138–40.
- [26] Brunetti ND, De Gennaro L, Dellegrottaglie GB, Procacci V, Di Biase M. Fast and furious: telecardiology in acute myocardial infarction triage in the emergency room setting. *Eur Res Telemed* 2013;2:75–8.
- [27] Politi A, Martinoni A, Klugmann S, Zanini R, Onofri M, Guagliumi G, et al. LombardIMA: a regional registry for coronary angioplasty in ST-elevation myocardial infarction. *J Cardiovasc Med* 2011;12:43–50.
- [28] Martinoni A, De Servi S, Boschetti E, Zanini R, Palmerini T, Politi A, et al. Importance and limits of pre-hospital electrocardiogram in patients with ST elevation myocardial infarction undergoing percutaneous coronary angioplasty. *Eur J Cardiovasc Prev Rehabil* 2011;18:526–32.
- [29] Dieker HJ, Liem SS, El Aidi H, van Grunsven P, Aengevaeren WR, Brouwer MA, et al. Pre-hospital triage for primary angioplasty: direct referral to the intervention center versus interhospital transport. *JACC Cardiovasc Interv* 2010;3:705–11.
- [30] Steg PG, James SK, Atar D, Badano LP, Blömmstrom-Lundqvist C, Borger MA, et al. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. *Eur Heart J* 2012;33:2569–619.
- [31] Antman EM, Hand M, Armstrong PW, Bates ER, Green LA, Halasyamani LK, et al. 2007 focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the Canadian Cardiovascular Society, endorsed by the American Academy of Family Physicians: 2007 writing group to review new evidence and update the acc/aha 2004 guidelines for the management of patients with st-elevation myocardial infarction, writing on behalf of the 2004 writing committee. *Circulation* 2008;117:296–329.
- [32] Garvey JL, MacLeod BA, Sopko G, Hand MM, On behalf of the National Heart Attack Alert Program (NHAAP) Coordinating Committee. Pre-hospital 12-lead electrocardiography programs. A call for implementation by emergency medical services systems providing advanced life support—National Heart Attack Alert Program (NHAAP) Coordinating Committee; National Heart, Lung, and Blood Institute (NHLBI); National Institutes of Health. *J Am Coll Cardiol* 2006;47:485–91.
- [33] Diercks DB, Kontos MC, Chen AY, Pollack CV, Wiviott SD, Rumsfeld JS, et al. Utilization and impact of prehospital electrocardiograms for patients with acute STsegment elevation myocardial infarction: data from the National Cardiovascular Data Registry (NCDR) Acute Coronary Treatment and Intervention Outcomes Network (ACTION) Registry. *J Am Coll Cardiol* 2009;53:161–6.
- [34] Carstensen S, Nelson GCI, Hansen PS, Macken L, Irons S, Flynn M, et al. Field triage to primary angioplasty combined with emergency department bypass reduces treatment delays and is associated with improved outcome. *Eur Heart J* 2007;28:2313–9.
- [35] Sivagangabalan G, Ong ATL, Narayan A, Sadick N, Hansen PS, Nelson GCI, et al. Effect of prehospital triage on revascularization times, left ventricular function, and survival in patients with ST-elevation myocardial infarction. *Am J Cardiol* 2009;103:907–12.
- [36] Pedersen SH, Galatius S, Hansen PR, Mogelvang R, Abilstrom SZ, Sorensen R, et al. Field triage reduces treatment delay and improves long-term clinical outcome in patients with acute ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention. *J Am Coll Cardiol* 2009;54:2296–302.
- [37] Chan AW, Kornder J, Elliott H, Brown RI, Dorval JF, Charania J, et al. Improved survival associated with pre-hospital triage strategy in a large regional ST-segment elevation myocardial infarction program. *JACC Cardiovasc Interv* 2012;5:1239–46.
- [38] Ortolani P, Marzocchi A, Marrozzini C, Palmerini T, Saia F, Serantoni C, et al. Clinical impact of direct referral to primary percutaneous coronary intervention following pre-hospital diagnosis of ST-elevation myocardial infarction. *Eur Heart J* 2006;27:1550–7.
- [39] Rezaee ME, Conley SM, Anderson TA, Brown JR, Yanofsky NN, Niles NW. Primary percutaneous coronary intervention for patients presenting with ST-elevation myocardial infarction: process improvements in rural prehospital care delivered by emergency medical services. *Prog Cardiovasc Dis* 2010;53:210–8.