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ORIGINAL ARTICLE

Emergency physician accuracy in interpreting electrocardiograms with potential ST-segment elevation myocardial infarction: Is it enough?

Giacomo Veronese[a], Federico Germini[b], Stella Ingrassia[c], Ombretta Cutuli[d], Valeria Donati[e], Luca Bonacchini[a], Maura Marcucci[b,f], Andrea Fabbri[g], and The Italian Society of Emergency Medicine (SIMEU)

[a]Department of Emergency Medicine, ASST Grande Ospedale Metropolitano Niguarda, University of Milano-Bicocca, Milan, Italy; [b]Geriatric Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; [c]Department of Emergency Medicine, ASST Papa Giovanni XXIII, Bergamo, Italy; [d]Department of Emergency Medicine, IRCCS Azienda Ospedaliera Universitaria San Martino—IST, Genova, Italy; [e]Department of Emergency Medicine, Ospedale San Donato, Arezzo, Italy; [f]Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy; [g]Department of Emergency Medicine, Ospedale Morgagni-Pierantoni, Forlì, Italy

ABSTRACT

Background: Electrocardiogram (ECG) interpretation is widely performed by emergency physicians. We aimed to determine the accuracy of interpretation of potential ST-segment elevation myocardial infarction (STEMI) ECGs by emergency physicians. **Methods:** Thirty-six ECGs resulted in putative STEMI diagnoses were selected. Participants were asked to focus on whether or not the ECG in question met the diagnostic criteria for an acutely blocked coronary artery causing a STEMI. Based on the coronary angiogram, a binary outcome of accurate versus inaccurate ECG interpretation was defined. We computed the overall sensitivity, specificity, accuracy and 95% confidence intervals (95%CIs) for ECG interpretation. Data on participant training level, working experience and place were collected. **Results:** 135 participants interpreted 4603 ECGs. Overall sensitivity to identify 'true' STEMI ECGs was 64.5% (95%CI: 62.8–66.3); specificity in determining 'false' ECGs was 78% (95%CI: 76–80.1). Overall accuracy was modest (69.1, 95%CI: 67.8–70.4). Higher accuracy in ECG interpretation was observed for attending physicians, participants working in tertiary care hospitals and those more experienced. **Conclusion:** The accuracy of interpretation of potential STEMI ECGs was modest among emergency physicians. The study supports the notion that ECG interpretation for establishing a STEMI diagnosis lacks the necessary sensitivity and specificity to be considered a reliable 'stand-alone' diagnostic test.

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Accuracy; electrocardiogram; emergency medicine; myocardial infarction

Introduction

Rapid recognition of ST-segment elevation myocardial infarction (STEMI) is of utmost importance to pursue a timely restoration of coronary blood flow (1,2). As a consequence, in order to increase the number of revascularization procedures performed within the guideline-recommended 90 min, electrocardiogram (ECG) is now widely interpreted by emergency physicians and it drives the decision to activate the catheterization laboratory, frequently in the absence of a cardiology consultation and the benefit of detailed clinical information (3–5). However, reported rates of clinical STEMI misdiagnoses range from 15% to 36% and data based on large registries indicate that over 10% of preliminary catheterization laboratory activations are not confirmed following a secondary evaluation (6,7). Moreover, the reliability of the ECG as a stand-alone diagnostic test for STEMI diagnosis has often been questioned (8). Previous reports found that the ability of physicians to accurately diagnose STEMI by ECG alone substantially varies, mostly according to the type and duration of working experience, specialty, and training level (8–10). Few studies specifically focused on the emergency medicine professionals (11). We thus aimed to determine the accuracy of interpretation of potential STEMI ECGs when only a few clinical data are available and rapid recognition is necessary, by a cohort of Italian physicians working in the emergency medicine field.

CONTACT Giacomo Veronese giacomo.veronese@ospedaleniguarda.it University of Milano-Bicocca, Department of Emergency Medicine, ASST Grande Ospedale Metropolitano Niguarda, Piazza dell'Ospedale Maggiore 3, 20162, Milano, Italy.

Materials and methods

Study population and data collection

Italian physicians were recruited to participate in this study during a scientific session of the European Society of Emergency Medicine (EuSEM) 2015 congress (Torino, Italy) (12). Participants were asked to respond to a survey including a total of 36 12-lead ECGs used in a previous study aimed at determining the inter-reader agreement and accuracy in the interpretation of potential STEMI ECGs of a sample of physicians from different medical specialties (8). According to the original study, the survey included an introductory statement explaining that all ECGs belonged to patients with moderate risk of acute coronary syndrome and asking to focus on whether or not the ECG in question met the diagnostic criteria for an acutely blocked coronary artery (STEMI). No additional clinical details were provided. Respondents were not informed that each ECG was obtained from patients referred for emergent angiography. Emergency coronary arteriography (reference standard) was compatible with a diagnosis of STEMI in 24 (67%) of the 36 cases (positive ECG), while in 12 cases (33%) the angiography showed no culprit lesion and a thrombolysis in myocardial infarction (TIMI) grade III flow in all coronary arteries, consistent with a lack of STEMI (negative ECG). All survey ECGs were available as online supplementary material of the original study (8). For the purpose of this study, they were directly downloaded from the website in an electronic format and then shown to the participants in the congress hall using a high quality video projector. To represent an emergency situation better, all participants were given 60 s to define each ECG using a standardized form. Data on participant training level, working experience and working place were collected. Responses to survey questions were collected anonymously. The present study conforms to the ethical guidelines of the 1975 Declaration of Helsinki and its later amendments.

Statistical analysis

Based on the coronary angiogram, a binary outcome of accurate versus inaccurate ECG interpretation was defined and used as dependent variable in generalized estimating equations accounting for nested and repeated measures. We computed the sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), accuracy and their 95%CIs for ECG interpretation for the whole cohort. In order to assess the impact of participant-related factors, we then calculated and compared the diagnostic performance according to the reader level of training, working experience and the hospital level of care. All statistical analyses were performed using Stata version 12 (StataCorp, College Station, Texas, USA).

Results

Participant characteristics are listed in Table 1. 135 participants (47.4% male) interpreted 4603 ECGs. 67 (49.6%) respondents were fully licensed physicians ('attending') and 63 (48.5%) were emergency medicine residents. The majority of participants ($n = 49$, 36.3%) declared to work in a tertiary care emergency department (ED), 31.8% in a secondary care ED, and

Table 1. Emergency physician's sensitivity, specificity, positive and negative predictive value in interpreting potential STEMI ECGs.

	n (%)	ECGs read[a]	Sensitivity	Specificity	PPV	NPV
Overall	135	4603	64.5 (62.8–66.3)	78.0 (76.0–80.1)	85.2 (83.8–86.7)	52.8 (50.8–54.9)
Training level						
Resident	63 (48.5)	2171	63.2 (60.7–65.7)	77.8 (74.8–80.9)	84.8 (82.7–87.1)	51.9 (48.9–54.8)
Attending	67 (51.5)	2354	65.9 (63.5–68.4)	78.7 (74.8–81.4)	85.7 (83.8–87.7)	53.4 (50.5–56.2)
Working place						
Level 1 ED	7 (6.0)	225	56.8 (48.8–64.7)	76.6 (67.2–86.1)	82.4 (75.0–89.8)	48.0 (39.1–56.8)
Level 2 ED	43 (36.7)	1481	64.4 (61.4–67.4)	79.9 (76.4–83.4)	86.4 (83.9–88.9)	53.1 (49.6–56.7)
Level 3 ED	49 (41.9)	1721	67.0 (64.3–69.7)	78.7 (75.2–82.2)	86.2 (83.9–88.4)	54.6 (51.2–58.0)
Working experience						
0–5 years	62 (64.6)	2177	64.3 (61.8–66.8)	74.6 (71.3–77.9)	83.4 (81.2–85.6)	51.3 (48.3–54.3)
6–10 years	15 (15.6)	539	63.6 (57.3–69.9)	82.1 (75.7–88.5)	87.7 (83.8–91.7)	52.9 (47.0–58.7)
> 10 years	19 (19.8)	642	64.9 (60.4–69.5)	81.3 (76.1–86.5)	87.4 (83.8–91.1)	53.7 (46.2–53.9)

STEMI, ST-segment elevation myocardial infarction; ECG, electrocardiogram; PPV, positive predictive value; NPV, negative predictive value; ED, emergency department.
[a]Overall number of ECGs interpreted by the participating physicians.

5% in a primary care centre. 62 participants (45.9%) had less than five years of working experience in an ED, 15 (11.1%) between five and 10 years, 19 (14.1%) more than 10 years. Overall and stratified results by training level, level of care and working experience are outlined in Table 1. The overall sensitivity to identify 'true' STEMI ECGs was 64.5% (95%CI: 62.8–66.3) while participants' specificity in determining 'false' ECGs was 78% (95%CI: 76–80.1). The PPV of a STEMI interpretation among all readers was 85.2% (95%CI: 83.8–86.7) and the NPV was 52.8% (95%CI: 50.8–54.9). Overall accuracy among readers, namely the ability to discriminate 'true' STEMI pattern from 'false' STEMI ECG, was 69.1 (95%CI: 67.8–70.4). There was a non-statistically significant trend toward a higher accuracy in ECG interpretation for attending physicians, participants working in tertiary care ED and those having more than 10 years of experience compared with, respectively, residents, participants working in different settings, and participants with less years of experience (Table 2).

Discussion

The present study aimed to evaluate the accuracy of interpretations of ECGs with features concerning for STEMI in a cohort of Italian physicians working within the emergency medicine field. Additionally, the participants were analysed in terms of their working experience, hospital level of care and training level.

A modest diagnostic accuracy was found in the present cohort of participants. As we used the same ECGs of the original report and we enrolled a similar number of participants, we can assume our results to be comparable with those found in the original report (8). Overall specificity, sensitivity, as well as accuracy, are strongly in keeping with the original findings (8). Accuracy was similar in the two cohorts of emergency physicians (0.69 versus 0.71). This finding is particularly relevant if interpreted within the local context, given the fact that most of the Italian emergency professionals are not board certified emergency medicine physicians (i.e. a five-year emergency medicine residency programme started in 2009), as their American counterparts. In line with the original study (8), emergency physicians were slightly less accurate than cardiologists in determining accurate STEMI diagnosis. However, as shown in multivariable analyses, the odds of an accurate diagnosis of STEMI were not significantly different when considering different specialty training, thus limiting the widespread belief of cardiologists as the gold standard for ECG interpretation (8). When assessing the impact of participant-related factors in the diagnostic process, we found a trend for a higher accuracy in ECG interpretation for attending physicians, participants working in tertiary care ED and those having more than 10 years of experience compared with, respectively, residents, participants working in different settings, and participants with less years of experience. Our study has several strengths. First, each ECG is from a real STEMI team activation and each corresponding patient underwent diagnostic angiography, which was used as reference standard. The decision to provide 60 s for each ECG interpretation represents an additional strength of the present study as it was aimed at simulating a real-world emergency setting, in which often only a few clinical data are available and rapid recognition is necessary. The study has limitations too. As the survey was administered during the EuSEM congress, no cardiologists were present and thus, no direct comparison between specialties could be performed. However, as we reproduced a previous study, indirect comparison was possible. Additionally, as stated in the original study (8), it is known that culprit coronary occlusions may on occasion resolve spontaneously leading to discrepancy between the initial ECG and the subsequent coronary angiography. This possibility was addressed by accepting non-occlusive thrombotic coronary lesions or reduced TIMI blood flow without apparent

Table 2. Accuracy of physicians' STEMI diagnosis stratified by training level, working place and working experience.

	n (%)	ECGs read[a]	Accuracy
Overall	135	4603	69.1 (67.8–70.4)
Training level			
Resident	63 (48.5)	2171	68.1 (66.2–70.1)
Attending	67 (51.5)	2354	69.9 (68.1–71.8)
Working place			
Level 1 ED	7 (6.0)	225	65.9 (62.3–69.6)
Level 2 ED	43 (36.7)	1481	69.6 (67.2–71.9)
Level 3 ED	49 (41.9)	1721	70.9 (68.8–73.1)
Working experience			
0–5 years	62 (64.6)	2177	67.7 (65.7–69.7)
6–10 years	15 (15.6)	539	69.7 (65.8–73.6)
> 10 years	19 (19.8)	642	70.4 (66.8–73.9)

STEMI, ST-segment elevation myocardial infarction; ECG, electrocardiogram; ED, emergency department.
[a]Overall number of ECGs interpreted by the participating physicians.

culprit lesion as consistent with a STEMI diagnosis. On purpose, specific clinical scenarios were not given to the readers in order to focus solely on physicians' ECG interpretations.

Conclusion

Emergency physician ECG interpretation of potential STEMI patients can be difficult, given the scant clinical data often available and the need of rapid decision. The use of ECG as the sole test to diagnose a STEMI and drive the decision to activate the catheterization laboratory still remains controversial. Accurate diagnosis is essential for the benefit of patients and to avoid unnecessary activations of cardiac catheterization teams. The study shows that the accuracy of the Italian medical staff working within the emergency medicine in interpreting potential STEMI ECGs demonstrates only a modest sensitivity and specificity. Accuracy seems to improve with working experience (both in terms of training and year of practice), and centre's level of care. The study reinforces the notion that ECG interpretation for establishing a STEMI diagnosis lacks the necessary sensitivity and specificity to be considered a reliable 'stand-alone' diagnostic test. Our findings underline the relevance of early adjuvant factors (e.g. history, clinical characteristics, echocardiographic pattern) when establishing a STEMI diagnosis and support the role of targeted educational efforts towards the younger emergency medicine professionals and those working in non-referral centres.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Steg PG, James SK, Atar D, Badano LP, Blömstrom-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.
2. Krumholz HM, Bradley EH, Nallamothu BK, Ting HH, Batchelor WB, Kline-Rogers E, et al. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-balloon: an alliance for quality. JACC Cardiovasc Interv. 2008;1:97–104.
3. Afolabi BA, Novaro GM, Pinski SL, Fromkin KR, Bush HS. Use of the prehospital ECG improves door-to-balloon times in ST segment elevation myocardial infarction irrespective of time of day or day of week. Emerg Med J. 2007;24:588–91.
4. Douglas PS, Eckel RH, Gray DT, Loeb JM, Straube BM. Coming together to achieve quality cardiovascular care. J Am Coll Cardiol. 2006;47:266–67.
5. 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.
6. McCabe JM, Armstrong EJ, Kulkarni A, Hoffmayer KS, Bhave PD, Garg S, et al. Prevalence and factors associated with false-positive ST-segment elevation myocardial infarction diagnoses at primary percutaneous coronary intervention-capable centers: A report from the activate-SF registry. Arch Intern Med. 2012;172:864–71.
7. Larson DM, Menssen KM, Sharkey SW, Duval S, Schwartz RS, Harris J, et al. 'False-positive' cardiac catheterization laboratory activation among patients with suspected ST-segment elevation myocardial infarction. JAMA 2007;298:2754–60.
8. McCabe JM, Armstrong EJ, Ku I, Kulkarni A, Hoffmayer KS, Bhave PD, et al. Physician accuracy in interpreting potential ST-segment elevation myocardial infarction electrocardiograms. J Am Heart Assoc. 2013;2:e000268.
9. Huitema AA, Zhu T, Alemayehu M, Lavi S. Diagnostic accuracy of ST-segment elevation myocardial infarction by various healthcare providers. Int J Cardiol. 2014; 177:825–9.
10. Trivedi K, Schuur JD, Cone DC. Can paramedics read ST-segment elevation myocardial infarction on prehospital 12-lead electrocardiograms? Prehosp Emerg Care 2009;13:207–14.
11. Kontos MC, Kurz MC, Roberts CS, Joyner SE, Kreisa L, Ornato JP, et al. An evaluation of the accuracy of emergency physician activation of the cardiac catheterization laboratory for patients with suspected ST-segment elevation myocardial infarction. Ann Emerg Med. 2010;55:423–30.
12. 9th European Congress on Emergency Medicine. Available at: http://www.eusemcongress.org/en/ (accessed 13 May 2016).