Comparison of the ability of paramedics with that of cardiologists in diagnosing ST-segment elevation acute myocardial infarction in patients with acute chest pain

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INTRODUCTION

Both percutaneous coronary intervention and intravenous thrombolysis have been shown to be most effective when given within the first 2 hours after the onset of symptoms (1-4). As further time elapses, the benefits of reperfusion therapy decline. In an effort to reduce time from symptom onset to treatment, emergency medical systems have been implementing cellular transmission of electrocardiograms (ECGs) to receiving stations in hospitals since 1987 (5,6). However, electrocardiographic transmission directly to a consulting cardiologist’s wireless hand-held device (mobile phone or pocket computer) with web-browsing capabilities has only recently become an option (7). To limit the workload associated with this on-line acute consulting function, paramedics must be able to interpret as well as acquire ECGs. The purpose of the present study was to determine the paramedics’ true-positive rate of ST elevation acute myocardial infarction (AMI) diagnosis, and to assess the influence of confounding electrocardiographic factors on the paramedics’ diagnosis.

METHODS

One hundred thirty-two consecutive patients from the Timely Intervention in Myocardial Emergency 2 trial were reviewed and analyzed retrospectively. Those included in this study were diagnosed with ST elevation AMI by paramedics based on their prehospital ECG, and transported by Guilford County Emergency Medical Services to Moses Cone Memorial Hospital during a 1-year period, from 2000 to 2001. During this time period, approximately 1,200 patients had a 12-lead ECG recorded by paramedics from this emergency medical service (personal communication). Patients were excluded when the following data were incomplete: (1) prehospital 12-lead ECG, (2) hospital admission ECG, (3) final hospital ECG, and (4) hospital data form. Only 6 patients were excluded because of an incomplete prehospital ECG, whereas 5 were excluded because of missing hospital data. The final study group consisted of 121 patients.

The hospital is a 650-bed regional medical center located in Guilford County, North Carolina, and performs percutaneous coronary intervention on a 24-hour basis as the reperfusion therapy of choice in patients with ST elevation AMI. During the 8 years that Guilford County Emergency Medical Services has been acquiring 12-lead ECGs in ambulances, paramedics have been required to attend initial and continuing education courses on cardiac care, including cardiac pathophysiology and acquisition, and interpretation of the 12-lead ECG. Paramedics must pass a written examination and demonstrate proficiency in acquisition and interpretation at least once a year.

Paramedics completed an emergency medical services case report form for each patient they considered to be eligible based on ST-segment elevation of $\geq 1$ mm in $\geq 2$
contiguous leads present on the standard 12-lead prehospital ECG (8). There was an immediate computer interpretation available to paramedics, who then confirmed or altered the interpretation. The case report form included demographic and clinical data, as well as times of symptom onset, emergency medical services call, prehospital ECG, and arrival at the emergency department. The hospital data form included type of procedure (percutaneous coronary intervention, coronary angiography, or neither), time of arrival to the catheterization laboratory, treatment times, and procedural and hospital outcomes. Data processing was performed at the Duke University ECG Core Laboratory. Digitized prehospital ECGs were recorded during transportation of patients to the hospital and later transmitted electronically to the ECG Core Laboratory and printed on an electrocardiograph machine. If digital data were not available, paper electrocardiographic copies were attached to the emergency medical services case report form and sent to the ECG Core Laboratory. ECGs obtained at hospital admission and before hospital discharge were transmitted directly to an electrocardiograph machine in the ECG Core Laboratory via an analog telephone line.

An experienced cardiologist blinded to all other clinical data analyzed all 12-lead ECGs. This clinician served as a surrogate for the local on-call cardiologist in the clinical situation in which the ECG would be transmitted directly from the ambulance to the cardiologist’s handheld device. The study coordinator ensured that the ECG analyst was blinded to all other data, and that the data analysis occurred in the following sequence: (1) Based on the prehospital ECG, it was determined whether the patient met the criteria for ST elevation AMI (8). (2) the presence of confounding factors (left/right bundle branch block, left anterior/ posterior fascicular block, left/right ventricular hypertrophy, ventricular rhythm, Wolff-Parkinson-White syndrome, poor quality [unstable baseline and lead reversal], or prior myocardial infarction [defined by the presence of abnormal Q waves (9) in leads without ST elevation]) was determined on the prehospital ECG. (3) A final electrocardiographic diagnosis based on evolution from the prehospital ECG to the predischarge ECG was performed. ST-segment resolution, Q-wave development, R- and S-wave amplitude attenuation, and inversion of T waves were considered evidence of myocardial infarction evolution (9-12).

The presence of an occlusive thrombus of a major coronary artery was determined by emergency coronary angiographic results. Catheterization was considered positive when the initial coronary obstruction (stenosis or thrombus) was ≥95%, and the Thrombolysis In Myocardial Infarction flow designation increased from 0 or 1 to either 2 or 3; otherwise it was considered negative. Patients without acute coronary angiography were considered not to have a thrombotic occlusion, unless they had serial electrocardiographic evolution as previously defined, accompanied by transient elevation in creatine kinase-MB.
The chi-square statistic was used to compare the cardiologist’s and paramedics’ true-positive rates of ST elevation AMI diagnosis, both overall and in the presence of electrocardiographic confounding factors.

RESULTS
Mean ± SD age for the 121 study patients was 65 ± 16 years. The study included 41 women (34%) and 93 Caucasians (77%). Other baseline characteristics were systemic hypertension in 48 patients (40%), diabetes mellitus in 21 (17%), history of bleeding problems in 1 (1%), prior myocardial infarction in 21 (17%), prior coronary bypass in 19 (16%), prior percutaneous coronary intervention (<6 months) in 5 (4%), current smoker in 39 (32%), and congestive heart failure/acute pulmonary edema in 8 patients (7%).

The paramedics’ diagnosis of ST elevation AMI was confirmed in 55 patients (45.5%) by acute angiography. In an additional 4 patients (3.5%) who did not undergo angiography due to high-risk assessment or other causes, the diagnosis was confirmed clinically by typical electrocardiographic changes in evolving ST elevation AMI accompanied by transient elevation of creatine kinase-MB. Thus, the paramedics’ true-positive rate was 49% (n = 59).

The paramedics’ decision was not confirmed in the 23 patients (19%) with no thrombus at angiography, and in the 38 (31%) who did not undergo coronary angiography because the attending cardiologist judged them not to have an evolving ST elevation AMI. One patient had an indeterminate catheterization because the initial infarctrelated artery stenosis was 70%. The false-positive rate by paramedics was 51% (n = 62).

The presence and type of confounders, as well as the percentage of patients with confirmed ST elevation AMI by confounder type, are listed in Table 1. The paramedics’ true-positive rate of ST elevation AMI diagnosis was 36% in the group with confounders versus 60% in the group without confounding factors (p = 0.010). In comparison, the cardiologist’s overall true-positive rate was 88%, and thus significantly higher than that of the paramedics (p <0.0001). Unlike the paramedics, the cardiologist’s true-positive rate of ST elevation AMI was similar in groups with and without electrocardiographic confounding factors (89% vs 87%) (p = 0.71).

<table>
<thead>
<tr>
<th>ST Elevation AMI (true positive)</th>
<th>36%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrocardiographic confounder</td>
<td>56  (46%)</td>
</tr>
<tr>
<td>Prior AMI</td>
<td>15  (12%)</td>
</tr>
<tr>
<td>Poor quality ECG</td>
<td>13  (11%)</td>
</tr>
<tr>
<td>Right bundle branch block</td>
<td>9   (7%)</td>
</tr>
<tr>
<td>Left anterior fascicular block</td>
<td>8   (7%)</td>
</tr>
<tr>
<td>Left bundle branch block</td>
<td>6   (5%)</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>4   (3%)</td>
</tr>
<tr>
<td>Pacemaker</td>
<td>1   (1%)</td>
</tr>
</tbody>
</table>

Table 1: Presence and Type of Confounding Factors, and the Percentage of Patients With Confirmed ST Elevation AMI by Type of Confounding Factor (n = 121)
The incidence of poor quality ECGs recorded by the paramedics was calculated to determine the paramedics’ performance in electrocardiographic acquisition. In 13 of 124 patients (10.5%), the ECGs were characterized as poor quality (unstable baseline or lead reversal). In 6 of 11 patients excluded from this study, the cause was an incomplete baseline ECG recorded by paramedics.

**DISCUSSION**

Prehospital electrocardiographic acquisition and transmission is essential to further reduce time from symptom onset to treatment in patients with ST elevation AMI. The system of electrocardiographic transmission directly to the on-call cardiologist’s wireless hand-held device provides parallel transmission to the emergency department and the cardiologist. This technology will be tested in the Timely Intervention in Myocardial Emergency 2 trial in Guilford County, North Carolina. It is the hypothesis of this study that primary percutaneous coronary intervention will be more rapidly initiated when the responsible cardiologist has support for the reperfusion therapy decision via immediate access to patient data, including a standard 12-lead ECG. This study is the first to systematically examine the ability of paramedics to acquire and interpret ECGs to enable accurate diagnosis of patients with ST elevation AMI in preparation for systematically transmission directly to a cardiologist.

The paramedics’ true-positive rate of ST elevation AMI diagnosis (verified by angiography and subsequent electrocardiographic evolution as the “gold standard”) in patients with acute chest pain was good in those presenting without confounding factors, but was diminished when the ECG was abnormal due to pathologic conditions such as prior myocardial infarction, left bundle branch block, or left ventricular hypertrophy. These results for paramedics were in direct contrast to those for the cardiologist, whose level of performance was higher and was not affected by confounders. The incidence of poor quality ECGs in the study population was acceptable at 10.5%.

Paramedics diagnosed over half of patients as having ST elevation AMI, when in fact they did not. One reason for this may be that the paramedics were concerned about missing patients with this condition. The number of false-positive diagnoses may also have been increased due to the problem of differentiating ST elevation AMI from other electrocardiographic abnormalities that result in ST-segment elevation (13-15). Zhou et al (16) developed an algorithm to distinguish ST elevation AMI from benign early repolarization or acute pericarditis. Employment of such an algorithm may assist paramedics in differentiating among these 3 conditions. Left bundle branch block is 1 of the factors that causes difficulty when diagnosing ST elevation AMI, because it conceals electrocardiographic changes in ST elevation AMI. Further training of paramedics to include more sophisticated algorithms, such as those available for concomitant left bundle branch block (17), may be
of value in the future. Thus, enhancement of the paramedics’ skills and knowledge that focus on these and other 12-lead electrocardiographic abnormalities is essential to reduce the number of patients with false-positive results observed in this study.

CONCLUSION

This study concludes that paramedics’ true-positive rate of ST elevation AMI diagnosis is high in patients presenting without confounding factors, but decreases when the ECG has confounding factors. This is in contrast to an experienced cardiologist whose true-positive rate was high and not affected by confounding factors. The results demonstrate that before implementation of electrocardiographic transmission directly to a cardiologist’s handheld device, there is a need to provide education and training to paramedics responsible for acquiring and interpreting prehospital ECGs, with special emphasis on confounders.

ACKNOWLEDGMENTS

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9. Selvester RH, Wagner GS, Hindman NB. The Selvester QRS scoring system for estimating myocardial infarct