Location of the Culprit Artery in Acute Myocardial Infarction using the ECG

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Abstract

This study aimed to assess the accuracy of current ECG criteria for locating the coronary artery principally involved in an acute myocardial infarction (AMI) in order to evaluate the merits of implementing AHA/ACC recommendations that require the culprit artery be reported on an ECG interpretation. 12 lead ECGs were recorded in ambulances on patients with a suspected acute coronary syndrome. These were retrospectively analysed along with coronary angiograms. Patients were included if they had a single vessel occlusion greater than 75%. ST amplitude, as measured by computer techniques, was used to test ECG criteria identified from the literature. The best criterion for predicting LAD occlusion had SE 74.1%, SP 96.1%. For RCA and LCx, the best results were SE 74.1%, SP 90.9% and SE 35.5%, SP 94.8% respectively. In conclusion, it is possible to identify the LAD and RCA as the culprit artery with a reasonable degree of sensitivity and specificity using current criteria.

1. Introduction

Current guidelines recommend that the culprit artery in an acute myocardial infarction (AMI) should be included in ECG reports generated by computer [1]. However uncertainty surrounds the feasibility of this recommendation, due to the lack of sensitivity and specificity of current algorithms in distinguishing between a right coronary artery and left circumflex occlusion.

The ability to identify the culprit artery and the site of the occlusion within the artery has multiple potential benefits. Firstly it would provide an indication of the area at risk of ischaemia and consequently its severity [2]. This information could be incorporated into current methods of initial risk stratification in primary percutaneous coronary intervention (PCI) centres. Furthermore it may be useful in situations where reperfusion therapy is contemplated, i.e. in settings far from a PCI centre.

The 12-lead ECG forms one of the three criteria required for the diagnosis of a myocardial infarction [3]. It often dictates a patient's initial management by determining the presence of an ST segment elevation. Previous studies have demonstrated the ECG's ability to predict the culprit artery (i.e. left anterior descending artery (LAD), right coronary artery (RCA) or left circumflex artery (LCx)) by analysing the amplitude of ST segment in the different leads of a 12-lead ECG [2,4-9]. However current published algorithms have only a modest degree of sensitivity and specificity, which may not be applicable in an emergency setting.

To date no study has analysed the possibility of using the initial diagnostic ECG, taken by the paramedics, to determine the culprit artery. The primary aim of this study was to investigate the reproducibility of previously published algorithms which were successful in predicting the culprit artery.

2. Method

This study was a retrospective study involving 379 patients from two hospitals, one in Copenhagen, Denmark and the other in Glasgow, Scotland. Approval was obtained from the relevant authorities in Copenhagen and Glasgow for the collection and analysis of patient data.

Patient data was obtained from the coronary care unit at both the Rigshospitalet, Copenhagen University Hospital (RCUH), and the Golden Jubilee National Hospital (GJNH), Clydebank, Glasgow. Both hospitals offer a regional PCI service. Consequently, ECGs recorded in ambulances in patients suspected of having an acute coronary event are transferred over to these centres so that decisions regarding the patient's management can be made. The ECG and presenting history of the patient are analysed by a cardiologist, on call, who decides whether the patient should be transported to the centre to receive primary PCI or referred to a local hospital for alternative treatment.

ECGs of men and women of all ages were analysed in this study if they had an occlusion greater than 75%, observed during angiography, in only one coronary vessel, and a standard 12-lead pre-hospital ECG on which the decision to perform primary PCI was based. Patients that had a documented history of a previous myocardial infarction, coronary artery bypass graft (CABG) or had insufficient data available were excluded from the study. All eligible patients were suspected as having an acute coronary event.

In all patients included in this study, relevant information regarding the patients, i.e. a digital pre-hospital 12-lead ECG, demographic and angiography information, was made available from their respective hospitals. The method of information retrieval of the cohort of patients from RCUH has been previously described [10]. The retrieval of information from the GJNH, however, involved the use of two databases. Initially ECG data sent from ambulances was extracted from the Physio-Control LIFENET patient management system situated in the coronary care unit, and then matched with another database, which contained the patient's angiography and demographic data. Data collected from both cohorts can be seen in Table 1.

2.2. ECG recordings

The defibrillator/monitor LIFEPAK 12, was used to record the ECGs in ambulances in both countries. ECGs were recorded at a speed of 25mm/s and a voltage of 10 mm/mV. ST amplitudes, at the J-point, of the 12 leads were digitally extracted using either the CODE-STAT Data Review software (Physio-Control, Inc., Redmond, Washington) or the University of Glasgow ECG analysis program so that exact measurements could be analysed. All the criteria were chosen before the ECG recordings were analysed to eliminate the possibility of a selection bias. Each criterion was tested, using each population in turn and in combination, to obtain the sensitivity (SP), specificity (SE), positive predictive value (PPV) and negative predictive value (NPV).

All the patients in the study underwent coronary angiography. Angiographic findings were reviewed only by the consultant interventional cardiologist performing the angiogram, who made the decision of which artery was the culprit.

Several on-line databases were searched to identify any past and present literature. Papers identified were those by: Wagner et al [1], Tierala et al [2], Hasdai et al [4], Fiol et al [5,6], Herz et al [7], Bairey et al [8] and Kanei [9]. Criteria referring to additional leads were not analysed since these leads were not available. All criteria identified were programmed into Microsoft Excel so that analysis was automated.

Table 1. Demographic information for both groups. The values for RCUH were compared with those for GJNH and p-values obtained. Other risk factors included: in the RCUH group, atrial fibrillation, ventricular fibrillation, heart failure, ischemic heart disease, obesity, chronic obstructive lung disease and stomach infection, and in the GJNH group, smoking, obesity and chronic lung disease.

Characteristic	RCUH	GJNH	Overall	p-value
ECGs	183	196	379	
Age(years)				
Mean age	60.6	60.4	60.5	p=0.874
Sex				
Male	133	136	269	0.481
Female	50	60	110	0.481
Ethnicity				
Caucasian	183	194	377	0.171
Other	0	2	2	0.171
Risk factors				
Diabetes	11	17	28	0.322
Hypertension	45	75	120	0.004
Hyper-lipidaemia	91	66	157	0.002
Other	42	136	178	<0.0005
Culprit Artery				
LAD	77	70	147	0.204
RCA	76	94	170	0.209
LCx	16	15	31	0.699
Other	14	17	31	0.716

2.3. Statistical analysis

SE, SP, PPV and NPV were derived using Microsoft Excel. Criteria with a SE greater than 70% and SP greater than 90% were considered to be reasonable for locating the culprit artery. All other analysis was performed using the statistical software's PASW 18 and Minitab 15. A χ^2-test, Mann-Whitney test and ANOVA (Krusal-Wallis) were performed, where possible, to identify any differences between the groups. All p-values less than 0.05 were considered significant.

3. Results

3355 pre-hospital ECGs were made available for this study, of which 1000 ECGs were from RCUH and the remaining 2355 ECGs from GJNH. Of these only 183 ECGs from RCUH and 196 ECGs from GJNH patients were eligible for the study.

Both groups of patients were similar across the characteristics analysed, although differences were observed with regards to a few risk factors, namely hypertension, hyperlipidaemia and other (see Table 1). Of the 379 patients analysed, 71.0% were men, and 29.0% were women. The average age of a patient was 60.5 years (95% CI, 59.2 to 61.8 years). Angiographic results showed 147 LAD occlusions (38.8%), 170 RCA occlusions (44.9%), 31 LCx occlusions (8.2%) and 31 other occlusions (8.2%). Other occlusions included those with occlusions in the first diagonal, second diagonal, first obtuse marginal and second obtuse marginal branches.

In total, 51 criteria were analysed from 8 papers [1, 2, 4-9] identified in the literature review. Publications used ranged over 3 decades (1987-2009). 4 criteria [1,2] were for LAD occlusions, and the remaining 47 criteria [2, 4-9] were designed to distinguish LCx and RCA occlusions. The criteria that distinguished each artery with the greatest SE and SP in the overall study population are presented in Table 2, along with some alternative criteria that performed well for the separate cohorts.

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3.1. Study population criteria analysis

The criterion, ST elevation in two contiguous leads (threshold value of 2mm in V2, V3 and 1mm in all other leads) and maximal ST elevation in leads V2, V3, V4, suggested by Tierala et al [2] predicted the LAD most accurately (SE 74.1%, SP 96.1%, PPV 92.4%, NPV 85.4%), in our sample of 379 ECGs. It also remained the most effective when the two cohorts were individually analysed - RCUH (SE 76.6%, SP 93.4%, PPV 89.4%, NPV 84.6%) and GJNH (SE 71.4%, SP 98.4%, PPV 96.2%, NPV 86.1%).

RCA and LCx occlusion were most accurately predicted by the three step algorithm of Fiol et al [6]. In the overall study sample, RCA occlusions were predicted with SE 74.1%. SP 90.9%, PPV 86.9% and NPV 81.2% and LCx occlusions were predicted with SE 35.5%, SP 94.8%, PPV 37.9%, NPV 94.3%. When the two cohorts were individually analysed with this algorithm, RCA occlusion was predicted with SE 83.0%, SP 90.2%, PPV 88.6%, NPV 85.2% in the GJNH cohort and SE 63.2%, SP 91.6%, PPV 84.2%, NPV 77.8% in the RCUH cohort, while the LCx was predicted with SP 46.7%, SP 94.5%, PPV 41.2%, NPV 95.5% in the GJNH cohort and SE 25.0%, SP 95.2%, PPV 33.3%, NPV 93.0% in the RCUH cohort.

3.2. Cohort criteria analysis

SE, SP, PPV and NPV obtained for LCx occlusions from the algorithm by Fiol et al [6], in the GJNH cohort, were exactly the same (Table 2) as those obtained from the algorithm by Tierala et al [2] (see reference for details). However, two criteria by Herz et al [7] gave a higher SE of 86.2% while maintaining SP. These criteria, namely inferior ST elevation and ST elevation greater in lead III than lead II, or ST elevation greater in lead aVL than lead I predicted RCA as the culprit. However, differences in the results obtained for the algorithm by

Table 2 shows the criteria that were most effective in distinguishing the culprit artery (LAD, RCA and LCx) in the study population, and alternative criteria that performed well for the separate cohorts.

Group	Culprit	Author	Criteria	SE(%)	SP(%)	PPV(%)	NPV(%)
Both (n = 379)	LAD	Tierala et al	a) ST segment elevation in 2 contiguous leads >= 0.2mV in V2-V3, >= 0.1mV in all others b) Maximal ST elevation in leads V2,V3,V4	74.1	96.1	92.4	85.4
	RCA	Fiol et al	See [6] for details	74.1	90.9	86.9	81.2
	LCX	Fiol et al	See [6] for details	35.5	94.8	37.9	94.3
RCUH (n= 183)	RCA	Tierala et al	See [2] for details	30.3	97.2	88.5	66.2
	RCA	Herz et al	c) ST elevation >= 0.1mV in >= 2 of inferior leads (II,III or aVF) d) STdepression in lead aVL > lead I	73.7	86.9	80.0	82.3
	LCx	Bairey et al	e) ST elevation >= 0.1mV in >= 2 of inferior leads (II,III or aVF) f) ST depression >= 0.1mV in >= 1 lead V1-V4	75.0	82.6	29.3	97.2
GJNH (n = 196)	RCA	Herz et al	g) ST elevation >= 0.1mV in >= 2 of inferior leads (II,III or aVF) h) ST elevation in lead III > lead II	86.2	90.2	89.0	87.6
	LCx	Tierala et al	See [2] for details	46.7	94.5	41.2	95.5
	LCx	Fiol et al	See [6] for details	46.7	94.5	41.2	95.5

Fiol et al [6] and criteria by Herz et al [7] were not significant (p>0.05).

In the RCUH cohort, LCx occlusions were detected with high SE and SP when using the criterion, inferior ST elevation and ST depression greater than 1mm in one or more of leads V1, V2, V3, V4, by Bairey et al [8]. Although the SE obtained with this criterion was significantly higher ($p<0.05$) the SP was significantly lower ($p<0.05$). On the contrary, when using the algorithm by Tierala et al [2], to detect RCA obstructions in the RCUH cohort, the SE was significantly lower although the SP was significantly higher.

4. Discussion and conclusion

The key finding in this retrospective study is that, in patients presenting with a suspected acute coronary syndrome, it is possible to identify the LAD and RCA as the culprit artery with a reasonable degree of sensitivity (i.e. >70%) and specificity (i.e. >90%) using current criteria from the literature. However, sensitivities of criteria obtained for LCx obstructions were significantly lower when compared to those for RCA and LAD occlusions.

Results obtained for the two cohorts, RCUH and GJNH, also differed, which may have been due to significant differences in ST amplitude that were observed in leads I, V1, V2, V3 and V4 between the two groups, and which may have been due to using two programs to measure the ST amplitude.

To the best of our knowledge, this is the first study to have used 12 leads ECGs taken at the point at which the decision regarding the patient's future management was made (i.e. whether the patient should be taken to the PCI centre or local hospital). It was felt to be the most appropriate ECG to be analysed since it dictated the patient's management.

However, whether the SP and SE are high enough to be used in an emergency setting to guide treatments remains open to discussion. There is also clear need for new criteria that can identify the LCx with a greater sensitivity.

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