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ECG interpretation during the acute phase of coronary syndromes: in need of improvement?[1]

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Summary

Question under study: Emergency room (ER) interpretation of the ECG is critical to assessment of patients with acute coronary syndromes (ACS). Our aim was to assess its reliability in our institution, a tertiary teaching hospital.

Methods: Over a 6-month period all consecutive patients admitted for ACS were included in the study. ECG interpretation by emergency physicians (EPs) was recorded on a preformatted sheet and compared with the interpretation of two specialist physicians (SPs). Discrepancies between the 2 specialists were resolved by an ECG specialist.

Results: Over the 6-month period, 692 consecutive patients were admitted with suspected ACS. ECG interpretation was available in 641 cases (93%). Concordance between SPs was 87%. Interpretation of normality or abnormality of the ECG was concordant between EPs and SPs in 475 cases (74%, kappa = 0.51). Interpretation of ischaemic modifications was concordant in 69% of cases, and as many ST segment elevations were unrecognised as overdiagnosed (5% each). The same findings occurred for ST segment depressions and negative T waves (12% each).

Conclusions: Interpretation of the ECG recorded during ACS by 2 SPs was discrepant in 13% of cases. Similarly, EP interpretation was discrepant from SP interpretation in 25% of cases, equally distributed between over- and underdiagnosing of ischaemic changes. The clinical implications and impact of medical education on ECG interpretation require further study.

Key words: acute coronary syndromes; risk stratification; electrocardiogram interpretation

Introduction

Background

The emergency physician (EP) is in the front line for assessment of patients with chest pain. Rapid and reliable interpretation of the electrocardiogram (ECG) is necessary to identify patients with heart disease and eligible for specific treatment strategies. Data from the literature show that this step is missed in approx. 5% of acute myocardial infarctions. Half of these cases could have been diagnosed through improved ECG reading skills [1–3].

The ECG probably plays a very important role in the diagnosis of acute coronary syndrome (ACS) without persistent ST segment elevation (unstable angina and non Q-wave myocardial infarction). Although a normal ECG does not exclude ACS [4], ischaemic changes help physicians to stratify their patient's risk and hence early and late outcomes [5]. It is therefore used as a major criterion for classification of patients into a risk category and makes it possible to tailor treatment strategy [6–8]. As new therapeutic strategies with proven efficacy but with high costs and potentially severe side effects become available (GPIIBIIIa antagonists, low-molecular weight heparin, early percutaneous revascularisation), risk must be stratified accurately.

Importance

In this process ECG interpretation is a very important step, but little is known of the reliability of interpretation of ischaemic changes in ACS patients. Five studies have already shown discordances in ECG interpretation to exist between

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emergency physicians and cardiologists in unselected patients [9, 10], acute myocardial infarction [11] or acute chest pain [3, 12].

Goals of this evaluation

Our aim was to assess the characteristics of the interpretation of the ischaemic changes in the acute phase of ACS in the emergency room.

Patients and methods

Setting

Our institution is a urban teaching hospital treating approximately 40,000 patients per year in the multidisciplinary emergency ward (medical and surgical emergencies). The medical emergency room is staffed round the clock for a 3-month period by internist physicians in training under the supervision of fully trained internists and emergency physicians.

Study design

Over a 6-month period (1 October 2000 to 31 December 2000 and 1 February 2001 to 30 April 2001), ACS without persistent ST segment elevation were prospectively studied to assess the impact of the introduction of local guidelines [8].

Selection of participants

All patients complaining of acute chest pain and admitted to our emergency ward with suspected or established ACS without persistent ST segment elevation (unstable angina and non-Q myocardial infarction) were included.

Methods of measurement

Interpretation by the emergency physicians (EP) of the first ECG obtained after admission was collected via a preformatted sheet added to the medical chart and filled in by the EP. It assessed whether the ECG was considered normal or abnormal. If abnormal, the details of the ischaemic changes (transient elevation of ST segment >1 mm, depressed ST segment by 0.5–1 mm or >1 mm, and negative T-wave) were recorded. The experience of the various EPs was classified into two categories: physicians in training (junior doctors) or fully trained (chief residents).

Two specialist physicians (SPs), a specialist in intensive care (PE) and an interventional cardiologist (JCS), then blindly reviewed these ECG with the same preformatted sheet. Discrepancies between them were resolved by an ECG specialist (JS). The ischaemic changes were then grouped according to recently published guidelines [6, 7] into four categories (no change, ST segment depressed by 0.5–1 mm or negative T-wave, depressed ST segment >1 mm, transient elevation of ST segment >1 mm).

Outcome measure

The concordance of the various interpretations was assessed, as was the strength of discordances which could have an impact on the kind of surveillance and treatment the patient might receive. The impact of EP experience was measured by repeating the analysis by training category.

Data analysis

Strength of agreement was measured by kappa test, the interpretation of which depends on the marginal frequency of the event and thus in turn on its prevalence. Hence kappa values should not be compared between events but used as an overall measure of agreement.

Since this analysis involved only an analysis of care practice, approval by our institution's ethics committee was not required.

Results

Characteristics of the patient population

In the 6-month period of the study, 6544 patients sought medical attention in our emergency room and 939 patients (14%) complained of acute chest pain. In 197 of these (21%) a coronary origin was ruled out and 50 patients (5%) presented with acute myocardial infarction. All these patients were excluded. A diagnosis of suspected or established ACS without persistent ST segment elevation was thus considered in the remaining 692 patients, who were included in the study. Because essential data were missing in the interpretation of 65 ECG (9.4%), 627 ECG were finally available for analysis. The average age of these 370 males (59%) and 257 females was 61.8 years (median 62, range 19–98). 83% had at least one positive cardiovascular risk factor (family history in 21%, hypertension in 49%, diabetes in 12%, hypercholesterolaemia in 46%, smoking history in 30%). 25% had a history of cardiac disease, 17% of myocardial infarction, 21% of coronary angiography, 12% of coronary angioplasty and 9% of cardiac surgery. Average systolic blood pressure was 146 (SD 26) mm Hg, average diastolic blood pressure 86 (SD 15) mm Hg and average cardiac rate was 82 (SD 21) beats/minute; 56% had chest pain on admission.

Main results

The results of concordance in ECG interpretation between the different specialists are shown in Table 1. Concordance in assessing whether or not the ECG was normal was better (good to very good concordance, kappa = 0.74–0.89) than in assessing ischaemic changes (fair to very good concordance, kappa = 0.56–0.82). The concordance was better between one SP and the ECG specialist than between the two SP. Concordance between final expert and EP interpretation was lower in all domains, rating as fair for assessing ischaemic

changes and moderate for diagnosing ECG normality (table 1).

The detailed distribution of the assessment of ischaemic changes by emergency physicians as compared with specialists' interpretation is shown in table 2. The importance of the differences in interpretation varied mostly by 1 category of risk: as compared with final specialist interpretation, the ischaemic changes were over-estimated by 1 category in 9.1% of cases and underestimated by 1 category in 11.2% of cases. Differences by 2 categories were recorded in 1.4% and 3.7% respectively, and by 3 categories in 2.9% in each way (table 3). Restricting the analysis to the 260 patients in whom ACS was confirmed after emergency room assessment did not change these findings.

Altogether, concordance of ECG interpretation with final specialist interpretation seemed to be experience-dependent. Fully trained physicians' concordance was 85.7%, a value which fell to 69.1% for physicians in training.

Limitations

This study was carried out at a single institution involving different teams of physicians in rotation. Other ECG changes suggesting cardiac ischaemia, such as widening of QRS, were not recorded. Further, the data collection period was split for one month by introduction of the guidelines. However, there was no observable difference in the results between the 2 periods, a fact suggesting that they are valid. Finally, diagnosis of ACS was based on emergency room assessment and not systematically confirmed by more invasive procedures.

Table 1

Concordance of ECG interpretation between specialists and emergency physicians (kappa values, n = 627). Concordance was better, if not perfect, between specialists than between emergency room physicians and specialists.

	specialist 1	specialist 2	specialist 3
a) ECG normality			
Emergency room physician	0.506	0.456	0.479
Specialist 1		0.735	0.802
Specialist 2			0.890
b) Ischaemic changes			
Emergency room physician	0.318	0.338	0.363
Specialist 1		0.573	0.644
Specialist 2			0.824

Table 2

Distribution of ischaemic ECG changes between emergency physicians and final specialist interpretation for patients with suspected ACS (n = 627). The distribution of discrepancies between emergency room physicians' and specialists' interpretation of ECG involved both over- and underdiagnoses of ischaemic changes.

Emergency physicians	final specialist interpretation				
	no change	**depressed ST 0.5–1 mm / negative T**	**depressed ST >1 mm**	**transient elevated ST >1 mm**	**total**
No change	352 (56.1)	62 (9.9)	12 (1.9)	18 (2.9)	444 (70.8)
Depressed ST 0.5–1 mm / negative T	44 (7.0)	46 (7.3)	5 (0.8)	11 (1.8)	106 (16.9)
Depressed ST >1 mm	2 (0.3)	7 (1.1)	13 (2.1)	3 (0.5)	25 (4.0)
Transient elevated ST segment >1 mm	18 (2.9)	7 (1.1)	6 (1.0)	21 (3.3)	52 (8.3)
Total	416 (66.3)	122 (19.4)	36 (5.8)	53 (8.5)	627 (100.0)

Table 3

Importance of discrepancies between emergency physicians and final expert interpretation on patient risk stratification. Most of the discrepancies in ECG interpretation between emergency room physicians and specialists were limited to one category, except when the ECG was considered normal or when the ST segment was considered elevated.

Emergency room interpretation	difference in risk categories	final expert interpretation				
		no change	**ST segment depression 0.5–1.0 mm / negative T wave**	**ST segment depression >1 mm**	**transient ST segment elevation >1 mm**	**total**
Overdiagnosis	–3 categories	18 (4.3)				18 (2.9)
	–2 categories	2 (0.5)	7 (5.7)			9 (1.4)
	–1 category	44 (10.6)	7 (5.7)	6 (16.7)		57 (9.1)
Concordance	0 category	352 (84.6)	46 (37.7)	13 (36.1)	21 (39.6)	432 (68.9)
Underdiagnosis	+1 category		62 (50.8)	5 (13.9)	3 (5.7)	70 (11.2)
	+2 categories			12 (33.3)	11 (20.8)	23 (3.7)
	+3 categories				18 (34.0)	18 (2.9)
Total		416 (100.0)	122 (100.0)	36 (100.0)	53 (100.0)	627 (100.0)

Discussion

Our study shows that emergency physicians' ECG interpretation during the acute phase of suspected or established ACS was not fully concordant with specialists', and that the specialists were not in total agreement among themselves either.

These results are in accordance with those observed by Holmvang et al. [11], who in a large multicentre trial involving 516 patients compared cardiologists' on-site interpretation of admission ECGs of patients with unstable angina pectoris or non-Q wave myocardial infarction with core laboratory results. They found moderate correlation on normality of the ECG (101 on-site vs 135 core, k = 0.42), good agreement on T wave inversion (306 on-site vs 280 core, k = 0.63), fair agreement on ST depressions (158 on-site vs 64 core, k = 0.38), but poor agreement on ST elevation (17 on-site vs 92 core, k = 0.05). Independent variables such as creatine kinase-MB blood levels were more closely related to core laboratory than on-site ECG interpretation.

Our results extend to ACS the findings of Brady et al. [12], who retrospectively assessed the causes of ST segment abnormality in emergency department patients presenting with chest pain. Of the 902 patients meeting entry criteria, 202 (22.4%) had ST segment elevation. Agreement between EPs and a cardiologist reviewer varied between 60% and 100%, depending on the final diagnosis. Only 15% of these 202 patients had acute myocardial infarction requiring immediate reperfusion. In this case, concordance of ECG interpretation was 94%. These findings highlight the potential risk linked with unnecessary administration of effective drugs with potent side effects.

Diagnosis of acute ischaemia has always been difficult. In a recent meta-analysis reviewing the performance of the different instruments available for this task [13], ECG had a sensitivity of 76% and a specificity of 88%. New biomarkers such as troponin had a sensitivity of 39%, which increased to 90–100% when the dosage was repeated, and 93% specificity. Combination of these diagnostic instruments thus allows rapid risk stratification. The need for more than one diagnostic tool may explain why ECG interpretation differed between EPs, who could use other data such as patient history, physical examination and biomarker blood levels, and SPs, who were aware that the ECG recording belonged to a patient presenting with suspicion of ACS but were blind to other clinical data. This particular setting may be the reason why they identified more ischaemic alterations than EPs did, while at the same time they described some ECGs as normal when EPs did not.

On the other hand, experience has already been shown to influence ECG interpretation [10]. This was also the case in our study, since physicians in training were less concordant with final specialist interpretation than fully-trained physicians.

The clinical implications of these findings are probably not important, since few ECGs with major prognostic features such as ST segment elevation (5%) or depression (3%) were overlooked. These results do not differ from those previously published in the literature for acute myocardial infarction [1–3]. The most important group of unrecognised changes were negative T-waves (8%), which are less important in terms of clinical outcome since they correspond to patients in the intermediate risk category. On the other hand, a large proportion of the discrepancies consisted of over-diagnosed ECG changes. Among these, slight depressions of the ST segment (0.5–1 mm) were the most frequent (7%). This probably arises from EPs being overcautious and preferring overdiagnosis in order to minimise the likelihood of undertreatment and subsequent adverse patient outcomes.

ECG interpretation seems to be a difficult task, as evidenced by the presence of discrepancies between our two SPs. In addition, the emergency ward is a particularly difficult setting where human, time and hierarchic stress factors further complicate medical assessment. Finally, most of the physicians handling patients in our hospital are in training. It is therefore not surprising that we found experience to have an impact on the accuracy of the ECG analysis in ACS, with fully-trained physicians making interpretations concordant with the specialists' in 86% instead of 69% for physicians in training. In consequence, we may need to devote time and energy to improving this step in risk stratification in these patients in daily practice. A recent position paper of the American College of Physicians [14] stated that "physicians of all specialities and levels of training, as well as computer software for interpreting ECGs, frequently made errors in interpreting ECGs when compared to expert electrocardiographers" (4–33%). "There was also substantial disagreement on interpretations between cardiologists. Adverse patient outcomes occurred infrequently when ECGs were incorrectly interpreted" (less than 1%). Associated recommendations [15] emphasised that "training in ECG interpretation during residency should provide physicians with knowledge of the pathophysiology of electrocardiographic abnormalities; the skills to recognise common normal, abnormal, and technical artefact patterns; and the opportunity to apply this knowledge in bedside decision making. Determination of initial competency in ECG interpretation at the end of residency training should be based on periodic objective assessment and documentation of resident interpretation skills in a clinical context rather than completion of a

minimum number of interpretations". Further research should focus on the impact of ECG training courses on EPs, and on the implications such discrepancies between EPs and SPs may have for patient treatment and outcome.

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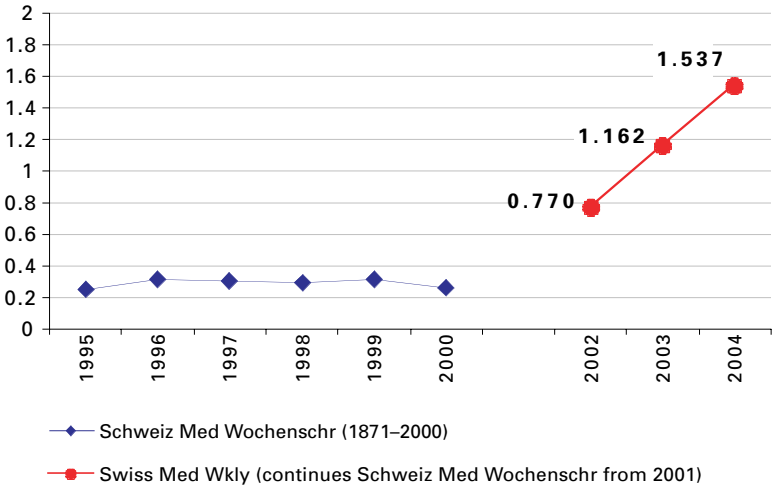

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