Prevalence of ST-elevation in right precordial leads in patients presenting with acute coronary syndrome without ST-elevation in standard 12-lead electrocardiography

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Abstract

Objective: The aim of this preliminary study was to determine the prevalence of isolated ST-elevation in the right precordial leads and the potential impact the addition had to risk stratification in patients with acute coronary syndrome.

Methods: Right-sided precordial leads (V4R, V5R and V6R) were routinely added to standard 12-lead electrocardiogram (ECG) on all patients presenting with acute coronary syndrome at the Tygerberg cardiac unit for a 7-month period. Patients without ST-elevation on standard 12-lead ECG were selected and evaluated for isolated right-sided ST-elevation. Demographic data, ECG-characteristics and cardiac enzymes were also recorded. Risk scoring using the TIMI-risk score was done and patients with isolated ST-elevation in right-sided leads without ST-changes (i.e. depression) in 12-lead ECG were experimentally awarded another point. Coronary angiography if performed was also noted.

Results: Seventy-seven patients were selected, among them 4 patients (5.19%) had isolated ST-elevation in right-sided ECG. Only 1 patient (1.3%) was awarded an additional point for ST-elevation in right-sided leads without ST-depression on 12-lead ECG increasing the TIMI score from 6 to 7. Angiography revealed no patients with isolated right-sided ST-elevation with non-dominant right coronary artery occlusion.

Conclusion: The addition of right-sided leads did not alter risk scoring significantly and therefore the results of this study do not support the routine addition of such leads. This study also did not prove that isolated ST-elevation occurs in right-sided leads in patients with occluded non-dominant right coronary arteries. *(Anadolu Kardiyol Derg 2007: 7 Suppl 1; 182-5)*

Key words: electrocardiography, coronary artery disease

Introduction

With the limited availability of specialist referral and equipment in developing countries like South Africa there is a continuous need to develop ready available ways of early identification of high-risk acute coronary syndrome (ACS) patients that will benefit from early referral and treatment. Due to the ready availability of electrocardiograms (ECG) in most emergency units in developing countries, electrocardiography remains an essential tool for initial risk stratification and consequently the decision on further management. Developing ways to improve risk stratification using ECG will therefore be beneficial in developing countries.

The use of right precordial leads (V4R, V5R and V6R) to identify right ventricular infarction in the setting of an inferior left ventricular ST-elevation infarction has been well studied and documented (1-6) with a sensitivity reported between 70-100% and specificity between 68-100% (7). Right myocardial infarction tends to occur in conjunction with inferior myocardial infarction (8, 9) with proximal occlusion of the right coronary artery (RCA) which can be explained on the anatomical basis of the RCA supplying both the right ventricle and inferior left ventricle in right dominant coronary circulations (1) (Fig. 1).

Approximately 25% (range 20-60%) of inferior left ventricle infarctions are complicated by right ventricular infarction (10). Due to the markedly higher occurrence of right dominant coronary circulations (89%) in the general population (11), association with left inferior ventricular infarcts is the most common presentation of right ventricular infarction (Fig. 2). The usage of right precordial leads are therefore traditionally indicated when inferior myocardial infarction is identified on standard 12-lead ECG.

Isolated right ventricular infarction does however occur but is rare (8, 9, 12) (less than 3% of myocardial infarctions). Case studies suggest that this tends to occur in patients with non-right dominant coronary circulation (12-18). Occlusion of such a RCA (Fig. 3) will lead to infarction of the right ventricle while the inferior left ventricle is perfused by the left coronary artery. Isolated right ventricular infarction with significant ST-segment elevation only in right precordial leads with little or no elevation on standard 12 lead ECGs have also been reported (19, 20).

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This study was performed as an undergraduate student assignment at the abovementioned institution

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It was this hypothesis that lead to the initiation of this study. We postulated that patients presenting with ACS without ST-elevation in standard 12-lead ECG may have isolated right ventricular infarction with ST-elevation in right precordial leads due to occlusion of a non-dominant RCA. Furthermore, we postulate that this finding could identify an additional higher risk group for further myocardial events and consequently alter risk assessment.

Previous studies suggest that the addition of right precordial leads to standard 12-lead ECG improves sensitivity (by 6.7%) but decreases specificity (by 5.4%) for detecting acute myocardial infarction in patients (20, 21). It is suggested that the addition of such leads are probably only beneficial in determining prognosis and therefore risk stratification rather increased detection of infarction (21). A survey done on emergency department physicians concluded that physicians felt that the addition of such leads only adds information regarding the extent of myocardial injury rather than altering diagnostic or therapeutic issues (22). These studies however entailed the use of both posterior and single (V4R) right-sided precordial leads and assessed the use of such leads in detecting myocardial infarction and not risk stratification per se. The routine use of right-sided ECGs for determining risk stratification therefore remains an unresolved issue.
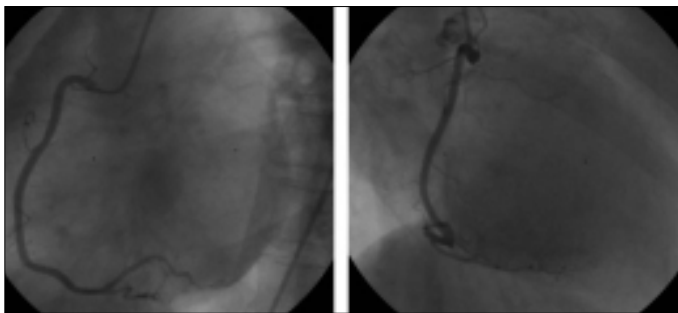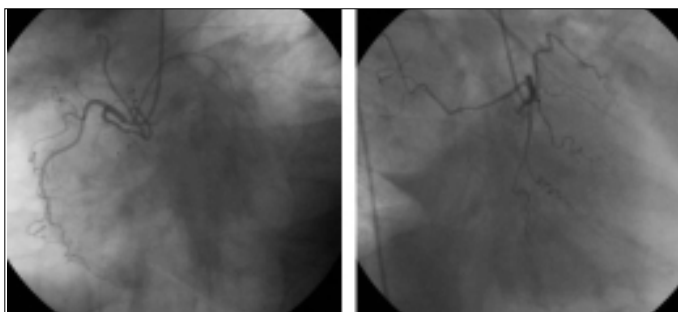

Figure 1. Example of a coronary angiogram of a patient with a dominant RCA
RCA- right coronary artery
*Dominance refers to the coronary artery from which the posterior interventricular and posterior descending branches originate

Figure 2. Example of an ECG of a patient with inferior infarction illustrated by ST-elevation in inferior leads (II, III and AVF) with right ventricular involvement as illustrated in VR4-6
ECG- electrocardiogram

Figure 3. Example of a coronary angiogram of a patient with a right non-dominant coronary artery

The aim of this pilot study was to determine the prevalence of ST-elevation in right precordial leads in patients presenting with ACS without ST-elevation in standard 12-lead ECGs (therefore unstable angina pectoris and non-ST-elevation myocardial infarction) and the impact the addition had on risk assessment. Risk scoring and prognostication by means of the TIMI risk score (23) (Table 1) for unstable angina or non-ST elevation myocardial infarction has recently been introduced and is widely implemented. The impact the addition of right-sided ECGs have on TIMI scores will be evaluated and whether it contributed towards identifying a potential group at higher risk for further events that would normally be missed. This could give an indication of the potential usefulness of performing routine right precordial leads electro-cardiography in all patients presenting with ACS.

As right-sided precordial leads are placed with little additional effort when performing standard ECGs, such routine use could be easily implemented. If the addition of right-sided leads were to alter the risk assessment in patients, it may assist the physician faced with the decision on further management of patients with ACS without ST-elevation on standard 12-lead ECG.

Methods

The study design was that of an observational study. Patients presenting to the cardiac unit of Tygerberg hospital were studied during a period of 7 months (January – July 2006). All patients admitted to the coronary unit underwent routine conventional 12-lead electrocardiography with the routine addition of right-sided precordial leads (V4R, V5R and V6R).

Patients deemed to have ACS (typical chest pain, associated symptoms) according to the attending registrar were selected but excluded if ST-elevation was present on the initial standard 12-lead ECG according to the investigator or the attending registrar. ST-elevation was considered to be present if elevation of the ST-segment was more than 1 mm (0.1mV) above the isoelectric line in two or more anatomically adjacent leads. Patients were furthermore excluded if right-sided leads were not performed on presentation, were not clearly indicated on the electrocardiogram, if the ECG was not interpretable (e.g. presence of left bundle branch block, severe arrythmias) or if the patient had chest pain due to proven other causes.

The ECGs were furthermore evaluated by a cardiologist blinded to all aspects of the patient's clinical picture and management, who confirmed the absence of ST-elevation on 12-lead ECG and either the presence or absence of ST elevation on right-sided leads.

Risk scoring was done retrospectively according to the TIMI risk scoring system (23) (Table 1) using the standard 12-lead ECG. This includes scoring a point if ST-segment changes (i.e. depression more than 0.5mm) occurred. Patients were experimentally awarded another point if ST-elevation of more than 1mm (0.1mV) was present in more than 2 adjacent right-sided leads without any ST-changes in standard 12-lead ECG (i.e. ST-depression >0.5mm).

The age, sex, characteristics of the ECG (rhythm, axis, P-waves, PR interval, QRS-complex, ST-segment, T-waves and QT time) of the standard 12-lead electrocardiograms, initial cardiac enzymes (troponin-I and creatinine kinase) and coronary angiography (if performed) were also recorded.

Results

Overall, 109 patients were selected but 32 were excluded for the following reasons: 3 were proven to have other diagnoses than ACS, 1 had an uninterpretable rhythm, 16 had a left bundle branch

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block, right-sided leads were not appropriately indicated in 3 patients and 9 patients had ST-elevation on the standard 12-lead ECG (verified by a cardiologist). Seventy-seven patients were therefore selected and initial electrocardiograms were evaluated for the presence of ST-elevation in the right precordial leads.

The mean age of the patients was 62.15±12.05 years with an age rage from 28 to 89 years. Gender distribution was slightly shifted towards male with 54.4% of patients being male and 45.5% female. Among 77 patients 63 (81.8%) had positive cardiac enzyme markers contributing a point to the TIMI-risk score and 29 of the 77 patients (37.7%) had ST-segment changes contributing towards TIMI-risk scoring. In 48 patients (62.3%) ECG changes did not contribute to risk scoring. Of 77 patients 52 (67.5%) of the study group underwent coronary angiography. A summary of the data is presented in Table 2.

Patients were stratified in all 8 the TIMI score-groups (0-7) with the majority of patients stratified in the intermediate risk group. TIMI scores are summarized in Table 3 and graphically represented in Figure 4.

Four patients (5.19%) had isolated ST-elevation in right-sided leads (Fig. 5). All four patients had positive cardiac markers. In 3 of the 4 patients ST-segment depression occurred in the standard 12-leads. Two of patients' (50%) scores were 4 points and 2 patients' (50%) - were 6 points. Therefore, only 1 patient was awarded an additional point where ST-depression was absent in the 12-lead ECG but right-sided ST-elevation was present in the right-sided leads. This increased the patient's score from 6 to 7. Angiography on this patient was not justified due to end stage ischemic disease previously demonstrated and was therefore unavailable. The addition of the right-sided leads therefore only altered risk scoring in 1 patient (1.30%). Three of the 4 patients underwent coronary angiography.

Coronary angiography findings in the remaining 3 patients are as follows: the first patient had a moderately obstructed left anterior descending artery (LAD) with an unobstructed non-dominant RCA (Fig. 3). The second patient revealed a totally occluded left circumflex coronary artery, proximal stenosis of the LAD and a critical lesion in a dominant RCA occluding one of the right ventricular branches (Fig. 6). The last patient had a complex angiogram with evidence of a previous coronary artery bypass with complete occlusion of the left circumflex artery and LAD with diffuse disease of the RCA.

Discussion

Experience from this study showed that the probability of having right-sided precordial leads available in patients with ACS is increased by performing right-sided ECGs routinely on all patients presenting to an emergency unit. This is done with little additional effort and cost.

However, only a small percentage (5.19%) of patients presenting with ACS have isolated ST-elevation in right precordial leads. This addition minimally contributed to risk stratification as experimentally set out in our study design. In only one patient (1.30%) did the addition alter risk scoring and this did not change the risk group for this patient who was stratified already into the high risk group with a TIMI score of 6 before the addition of right- sided precordial leads was made.

The study did not support our hypothesis that isolated ST-elevation in right-sided leads occurs in patients with occluded non-dominant right coronary arteries, as none of the patients with isolated right-sided ST-elevation revealed to have such pathology on angiography. Angiographic data however suggested the possibility that occlusion in a dominant RCA, which involves right ventricular branches could also manifest as isolated right-sided ST-elevation or that isolated right sided ST-elevation may be a non-specific finding. This is however a topic for future research.

Table 1. TIMI risk score for unstable angina/non-ST elevation myocardial infarction (adapted from www.timi.org)

Historical	Points
Age ≥65 years	1
≥3 Coronary artery disease risk factors (family history, hypertension, hypercholesterolemia, diabetes mellitus, active smoker)	1
Known coronary artery disease (more than 50% stenosis)	1
Aspirin use in past 7 days	1
Presentation	
Recent (≤24 hours) severe angina	1
Raised cardiac markers	1
ST-deviation ≥0.5 mm	1
TOTAL SCORE = TOTAL POINTS (0-7)	

Table 2. Summary of patient data

Number of patients	77
Age range, years	28-89
Mean age, years	62.15±12.05
Males, n (%)	42(54.5)
Females, n (%)	35 (45.5)
Patients with ST-segment changes on standard 12- lead ECG, n (%)	29 (37.7)
Enzyme markers positive, n (%)	63 (81.8)
Patients that underwent coronary angiography, n (%)	52 (67.5)

ECG- electrocardiogram

Table 3. Summary of TIMI-scores

TIMI score	0	1	2	3	4	5	6	7
All patients (n=77), n (%)	1 (1.30)	8 (10.39)	15 (19.40)	19 (24.68)	21 (27.27)	7 9.09)	4 (5.19)	2 (2.60)
Patients without right-sided ST-elevation (n=73), n (%)	1 (1.37)	8 (10.96)	15 (20.55)	19 (26.03)	19 (26.03)	7 (9.59)	2 (2.74)	2 (2.74)
Patients with right-sided ST-elevation (n=4), n (%)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (50.00)	0 (00.00)	2 (50.00)	0 (0.00)

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Due to the low yield of significant findings, this study does not support the routine use of right-sided electrocardiography in emergency units for risk stratification if the initial ECG does not show ST-elevation. However due to low cost and low effort involved in performing such ECGs routinely and the previously reported increased sensitivity for identifying myocardial infarction by performing routine right-sided ECGs, routine addition of right-sided ECG to standard 12-lead ECG cannot be discouraged.

Study limitations

The principle investigator was not a cardiologist with limited experience in assessing ECGs and was not blinded to the patient's clinical picture or management, and could therefore have lead to selection bias. All ECGs were however evaluated by a blinded cardiologist in order limit such error.
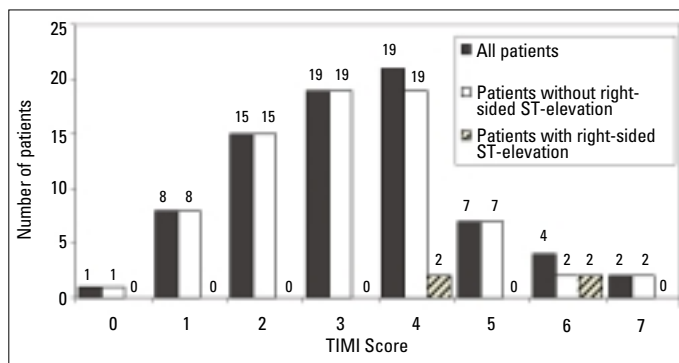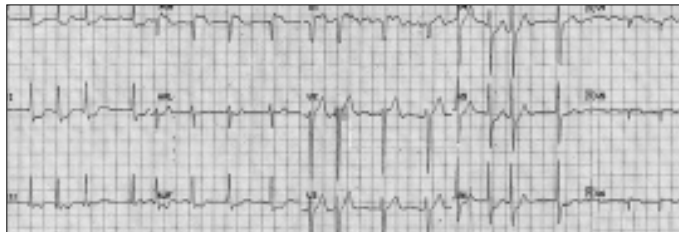

Figure 4. Graphic representation of TIMI scores

Figure 5. Example of one patient's ECG with isolated right-sided ST-elevation

ECG- electrocardiogram

Figure 6. Angiogram of a patient with stenosis of the right coronary artery occluding a right ventricular branch

References

1. Lopez-Sendon J, Coma-Canella I, Alcasena S, Seoane J, Gamallo C. Electrocardiographic findings in acute right ventricular infarction: sensitivity and specificity of electrocardiographic alterations in right precordial leads V4R, V3R, V1, V2 and V3. J Am Coll Cardiol 1985; 6: 1273-9.
2. Morgera T, Alberti E, Silvestri F, Pandullo C, Della Mea MT, Camerini F. Right precordial ST and QRS changes in the diagnosis of right ventricular infarction Am Heart J 1984; 108:13-8.
3. Braat SH, Brugada P, den Dulk K, Van Ommen V, Wellens HJ. Value of lead V4R for recognition of the infarct coronary artery in acute inferior myocardial infarction. Am J Cardiol 1984; 53: 1538-41.
4. Klein HO, Tordjman T, Ninio R, Sareli P, Oren V, Lang R, et al. The early recognition of right ventricular infarction: diagnostic accuracy of the electrocardiographic V4R lead. Circulation 1983; 67: 558-65.
5. Croft CH, Nicod P, Corbett JR, Lewis SE, Huxly R, Mukharji J, et al. Detection of acute right ventricular infarction by right precordial electrocardiography. Am J Cardiol 1982; 50: 421-7.
6. Erhardt LR, Sjorgen A, Wahlberg I. Single right-sided precordial lead in the diagnosis of right ventricular involvement in inferior myocardial infarction. Am Heart J 1976; 91: 571-6.
7. Fijewski TR, Pollack ML, Chan TC, Brady WJ. Electrocardiographic manifestations: Right ventricular infarction. J Emerg Med 2002; 22: 189-94.
8. Andersen HR, Falk E, Nielsen D. Right ventricular infarction: frequency, size and topography in coronary heart disease: a prospective study compromising 107 consecutive autopsies from a coronary care unit. J Am Coll Cardiol 1987; 10: 1223-32.
9. Wartman WB, Hellerstein HK. Incidence of heart disease in 2000 consecutive autopsies Ann Intern Med 1948; 28: 41-65.
10. Moye S, Carney MF, Holstege C, Mattu A, Brady WJ. The electrocardiogram in right ventricular myocardial infarction. Am J Emerg Med 2005; 23: 793-9.
11. Nerantzis CE, Papachristos JC, Gribizi JE, Voudris VA, Infantis GP, Koroxenidis GT. Functional dominance of the right coronary artery: incidence in the human heart. Clin Anat 1996; 9: 10-3.
12. Finn AV, Antman EM. Images in clinical medicine. Isolated right ventricular infarction. New Engl J Med 2003; 349: 1636.
13. Caroll R, Sharma N, Butt A, Hussain KM. Unusual electrographic presentation of an isolated right ventricular myocardial infarction secondary to thrombotic occlusion of a non-dominant right coronary artery – a case report and brief review of literature. Angiology 2003; 54: 119-24.
14. Porter A, Herz I, Strasburg B. Isolated right ventricular infarction presenting as anterior wall myocardial infarction on electrocardiography. Clin Cardiol 1997; 20: 971-3.
15. Inoue K, Matsuoka H, Kawakam H, Koyama Y, Nishimura K, Ito T. Pure right ventricular infarction. Circ J 2002; 66: 213-5.
16. Zientek DM, Eybel CE. Isolated right ventricular infarction. Ann Intern Med 1993; 119: 1053.
17. Moreya AE, Wajnberg A, Byra W. Non-dominant right coronary artery occlusion presenting with isolated right ventricular infarction. Am J Med 1986; 18: 146-8.
18. Gregory SA, Desai AS, Fifer MA. Images in cardiovascular medicine. Isolated right ventricular infarction resulting from occlusion of a nondominant right coronary artery. Circulation 2004; 110: e500-1.
19. Mittal SR, Khanna S, Mathur D. Isolated infarctions of the right ventricle. J Electrocardiol 1997; 30: 157-8.
20. Zalenski RJ, Rydman RJ, Sloan EP, Hahn KH, Cooke D, Fagan J, et al. Value of posterior and right ventricular leads in comparison to the standard 12 –lead electrocardiogram in evaluation of ST-segment elevation in suspected acute myocardial infarction. Am J Cardiol 1997; 79: 1579-85.
21. Zalenski RJ, Rydman RJ, Sloan EP, Hahn K, Cooke D, Tucker J, et al. ST segment-elevation and the prediction of hospital life-threatening complications. J Electrocardiol 1998; 31 (Suppl): 164-71.
22. Brady WJ, Hwang V, Sullivan R, Chang N, Beagle C, Carter CT, et al. A comparison in ED chest pain patients: Impact on diagnosis, therapy and disposition. Am J Emerg Med 2000; 18: 239-43.
23. Antman EM, Chohen M, Bernink PJLM, McCabe CH, Horacek T, Papuchis G, et al. The TIMI risk score for unstable angina/Non-ST elevation MI. JAMA 2000; 284: 835-41.