Original Article

Jeopardised Inferior Myocardium (JIM) Score: An Arithmetic Electrocardiographic Score to Predict the Infarct-Related Artery in Inferior Myocardial Infarction

Man Hong Jim, [1]*MD, FRCP*, Kin Lam Tsui, [2]*FRCP*, Kai Hang Yiu, [3]*MRCP*, Gary SH Cheung, [2]*MRCP*, Chung Wah Siu, [3]*MD, MRCP*, Hee Hwa Ho, [3]*FRCP*, Wing Hing Chow, [1]*FRCP*, Shu Kin Li, [2]*FRCP*

Abstract

Introduction: A few electrocardiographic criteria have been described to identify the infarct-related artery in inferior myocardial infarction. The aim of this study was to devise an arithmetic score to further improve the diagnostic accuracy. Materials and Methods: From 2004 to 2006, 78 patients who underwent primary angioplasty for inferior myocardial infarction within 6 hours from symptom onset were recruited for electrocardiographic and angiographic analysis. Results: The mean age of patients was 65 ± 12 years with male predominance (74%). Less ST depression in lead I and aVL, and more prominent ST depression in lead V1-3 were observed in left circumflex artery (LCX) than right coronary artery (RCA) occlusions. In addition, more prominent ST depression in lead I and ST elevation in V1 were found in proximal RCA than distal RCA occlusions. Based on the findings, the Jeopardised Inferior Myocardium (JIM) score was constructed and defined as [II–V3/III+V1– I]. The sensitivity and specificity of JIM score ≤0.5 to predict proximal RCA occlusions; 0.5 <JIM score ≤1.5 to predict distal RCA occlusions; and JIM score >1.5 to predict LCX occlusions were 58% and 85%, 69% and 68%, and 79% and 94%, respectively. The accuracy of prediction is slightly better than the 2 previously reported criteria. Conclusion: By taking into account more leads, the JIM score is capable of identifying the infarct-related artery with an improved diagnostic accuracy.

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Introduction

Inferior myocardial infarction classically manifests as ST elevations in inferior leads, together with ST changes in other leads that may be the result of concomitant ischaemia of other zones or a reciprocal image. It is exclusively caused either by left circumflex artery (LCX) or right coronary artery (RCA) occlusion, with the latter having worse prognosis owing to its association with right ventricular infarction.[1,2] There are a few reported electrocardiographic criteria capable of identifying the infarct-related artery with high accuracy.[3-6] These criteria are simple, focusing on one or two leads, and user-friendly. However, the same prediction accuracy may not be reproducible in other populations because of heterogeneity in patients' baseline characteristics and variations in the individual's coronary anatomy. Analysis of multiple electrocardiographic leads may instead plausibly minimise the errors and improve the diagnostic accuracy. The purpose of this study was to devise an arithmetic electrocardiographic score which takes into account multiple leads from a 12-lead electrocardiogram (ECG) to predict the infarct- related artery in inferior myocardial infraction.

Materials and Methods

From January 2004 to December 2006, consecutive patients with a discharge diagnosis of inferior myocardial infarction who had undergone primary angioplasty were retrospectively recruited for electrocardiographic and angiographic analysis and correlation. Inferior myocardial infarction was defined as typical chest pain of longer than 30 minutes; ST election of ≥1.0 mm in 2 inferior leads (II, III and aVF); and elevated serum creatinine phosphokinase

[1]Cardiac Medical Unit, Grantham Hospital, Hong Kong, ROC
[2]Division of Cardiology, Pamela Youde Nethersole Eastern Hospital, Hong Kong, ROC
[3]Division of Cardiology, Queen Mary Hospital, Hong Kong, ROC
Address for Correspondence: Dr Man Hong Jim, Cardiac Medical Unit, Grantham Hospital, 125 Wong Chuk Hang Road, Hong Kong, ROC.
Email: jimmanh2002@yahoo.com

level at least 2 times higher than the upper limit of normal. Patients were included only if they had no prior history of myocardial infarction, sinus rhythm on admission, symptom onset of less than 6 hours, and single vessel disease, which was defined as the absence of lesion of ≥70% diameter stenosis in vessel other than the infarct-related artery. Patients who had bundle branch block were excluded.

The study consisted of 2 parts. In the first part, the magnitude of ST displacement was compared between LCX and RCA occlusions, and between proximal and distal RCA occlusions in order to find out the leads that have discriminative value. In the second part, an arithmetic score named as Jeopardized Inferior Myocardium (JIM) score was devised based on the result of the first part to calculate the accuracy of prediction of the infarct- related artery. The prediction accuracy of JIM score were then compared with the criteria suggested by Chia et al[3] (ST elevation in II ≥III predicts LCX occlusion) and Kosuge et al[4] (ST displacement in V3/III <0.5 predicts proximal RCA; 0.5 ≤V3/III ≤1.2 predicts distal RCA; V3/III >1.2 predicts LCX occlusions) using the same study population.

Standard 12-lead ECGs were recorded at a speed of 25 mm/s and with waves or deflections amplitude of 10 mm/mV at the emergency room or the coronary care unit. ECGs were magnified 2-fold by photocopier and reviewed by an independent investigator blinded to patients' clinical and angiographic data. The ST changes were measured at 80 ms from the J point using a caliper. Measurements were made to the nearest 0.5 mm (0.05 mV). The preceding TP segment was used as an isoelectric line.

Coronary angiography and primary angioplasty were performed by experienced operators. Angiographic findings were evaluated by an independent investigator blinded to patients' clinical and electrocardiographic data. The infarct-related lesion was identified either by (i) total occlusion or a significant stenosis (≥70% of diameter narrowing) of the LCX or RCA or their branches, or (ii) angiographic evidence of an intraluminal thrombus. Proximal RCA was defined as the coronary segment that lay proximal to the first RV branch based on the American College of Cardiology/American Heart Association guidelines.[7]

Data were presented as mean value ±1 standard deviation for continuous variables, and absolute values (%) for discrete variables. For continuous variables, statistical significance of difference between two groups was analysed by unpaired Student's t test. A *P* value of <0.05 was considered statistically significant. Sensitivity, specificity, positive predictive value and negative predictive value were calculated for various diagnostic criteria.

Results

There were altogether 78 patients who met the inclusion criteria and included within the study period. All patients were of Chinese ethnicity, the mean age was 65 ± 12 years with male predominance (74%). The average time of presentation from symptom onset to ECG recording was 2.2 ± 1.5 hours; the mean left ventricular ejection fraction was 48 ± 8%; the peak creatinine phosphokinase level was 2694 ± 2145 U/L.

In the comparison of LCX and RCA occlusions, the former group had significantly more ST depression in lead V1 to V3, and ST elevation in lead V6; whereas the latter group had more ST depression in lead I and aVL (Table 1). In the comparison of proximal and distal RCA occlusions, the

Table 1. Comparison of ST Segment Displacement between Right Coronary Artery (RCA) and Left Circumflex Artery (LCX) Occlusions

Lead	RCA Occlusions (n = 64)	LCX Occlusions (n = 14)	*P* value
I	– 1.27 ± 0.83	– 0.21 ± 1.07	<0.01
II	2.50 ± 1.63	2.82 ± 1.48	0.48
III	3.87 ± 1.91	3.14 ± 1.49	0.13
aVF	3.27 ± 0.76	2.93 ± 1.47	0.45
aVL	– 2.55 ± 1.39	– 1.61 ± 0.40	0.04
aVR	– 0.36 ± 0.83	– 0.89 ± 1.02	0.09
V1	0.08 ± 1.12	– 1.93 ± 1.64	<0.01
V2	– 1.16 ± 2.13	– 3.57 ± 2.56	<0.01
V3	– 0.85 ± 2.30	– 3.43 ± 2.84	<0.01
V4	– 0.84 ± 2.09	– 1.79 ± 2.34	0.18
V5	– 0.35 ± 1.62	0.21 ± 1.91	0.32
V6	0.10 ± 1.34	1.21 ± 1.50	0.02

Table 2. Comparison of ST Segment Displacement between Proximal and Distal Right Coronary Artery (RCA) Occlusions

Lead	Proximal RCA Occlusions (n = 38)	Distal RCA Occlusions (n = 26)	*P* value
I	– 1.57 ± 0.86	– 0.83 ± 0.57	<0.01
II	2.47 ± 1.58	2.54 ± 1.74	0.88
III	4.00 ± 1.88	3.67 ± 1.96	0.51
aVF	3.29 ± 1.72	3.25 ± 1.87	0.93
aVL	– 2.71 ± 1.45	– 2.31 ± 1.30	0.25
aVR	– 0.18 ± 0.79	– 0.62 ± 0.83	0.04
V1	0.51 ± 0.98	– 0.56 ± 1.02	<0.01
V2	– 1.00 ± 2.35	– 1.40 ± 1.79	0.44
V3	– 0.73 ± 2.67	– 1.04 ± 1.64	0.56
V4	– 0.84 ± 2.42	– 0.83 ± 1.53	0.98
V5	– 0.46 ± 1.72	– 0.19 ± 1.47	0.51
V6	– 0.07 ± 1.28	0.35 ± 1.41	0.24

Table 3. Distribution of JIM Score According to the Infarct Locations

JIM Score [II–V3/III+V1–I]	**Proximal RCA (n = 38)**	**Distal RCA (n = 26)**	**LCX (n = 14)**
Total score	0.55 ± 0.53*	0.89 ± 0.61*†	4.23 ± 3.94†
JIM score ≤0.5	22	6	0
0.5 < JIM score ≤1.5	14	18	3
JIM score >1.5	2	2	11

**P* = 0.02 for the comparison of JIM score between proximal and distal RCA occlusion

†*P* <0.001 for the comparison of JIM score between distal RCA and LCX occlusion

Table 4. Sensitivity, Specificity and Accuracy of JIM Score, Ratio of II/III, and Ratio of V3/III in the Prediction of Infarct Location

	Sensitivity (%)	**Specificity (%)**	**PPV (%)**	**NPV (%)**
JIM score ≤0.5 predicts proximal RCA occlusion	58	85	79	68
0.5 < JIM score ≤1.5 predicts distal RCA occlusion	69	68	52	82
JIM score >1.5 predicts LCX occlusion	79	94	73	95
II ≥III predicts LCX occlusion	57	100	100	91
V3/III <0.5 predicts proximal RCA occlusion	50	50	49	51
0.5 ≤V3/III ≤1.2 predicts distal RCA occlusion	31	58	27	63
V3/III >1.2 predicts LCX occlusion	43	95	67	88

PPV: positive predictive value; NPV: negative predictive value

former group had more ST depression in lead I and more ST elevation in lead V1 (Table 2).

Based on the results, the JIM score was constructed and defined as [II–V3/III+V1–I]. The distribution of JIM score according to the infarct location is listed in Table 3. The mean score in proximal RCA occlusions is significantly lower than distal RCA occlusions (*P* = 0.02), which is in turn also lower than in LCX occlusions (*P* <0.001). Using the cut-off points as shown in Table 3, the sensitivity and specificity of JIM score ≤0.5 predicts proximal RCA occlusions; 0.5 < JIM score ≤1.5 predicts distal RCA occlusions, and JIM score >1.5 predicts LCX occlusions are 58% and 85%, 69% and 68%, and 79% and 94%, respectively (Table 4). The typical ECG presentation of LCX infarct is shown in Figure 1; the infarct-related artery is correctly predicted by the JIM score. The accuracy of JIM score in identifying the infarct-related artery is generally higher than the criteria devised by Chia et al[3] and Kosuge et al[4] using the same study population (Table 4). The algorithm is clearly illustrated by the flowchart in Figure 2.

Discussion

In most cases, the RCA terminates into a posterior descending artery and a few posterolateral branches to supply the inferior myocardium and the inferior part of the inferoposterior wall, respectively; whereas the LCX gives off a number of obtuse marginal branches to supply the posterior part of the inferoposterior as well as posterolateral wall. As a result, the vector of injury current is directed more to the right and inferior in RCA occlusions, and more to the left and posterior in LCX occlusions.[4] This minor difference in vector direction forms the basis of electrocardiographic differentiation between LCX and RCA occlusions.[3-6] Lead III and aVF are pointing more to inferior and thereby ST elevation is found more prominent in these leads in RCA

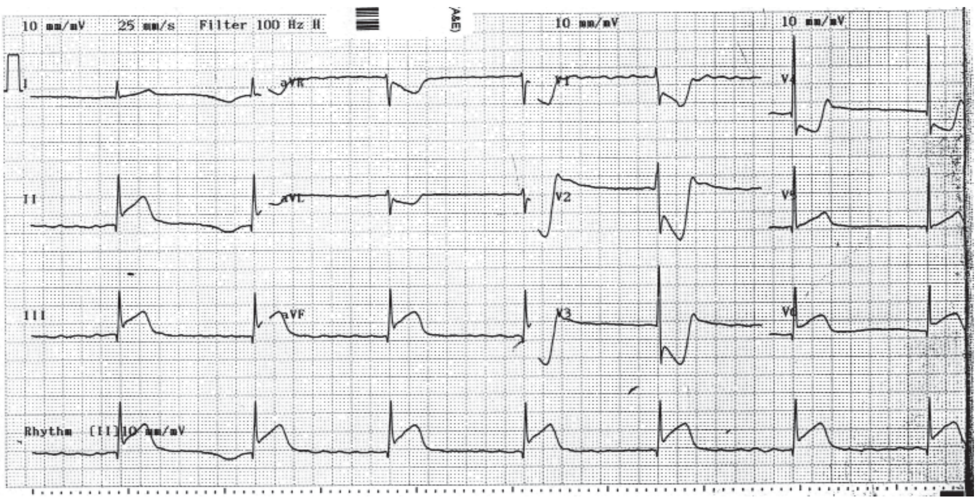

Fig. 1. ECG showing LCX infarct with ST elevation in lead I, V6 and inferior leads, and ST depression in V1-4. JIM score is 26.

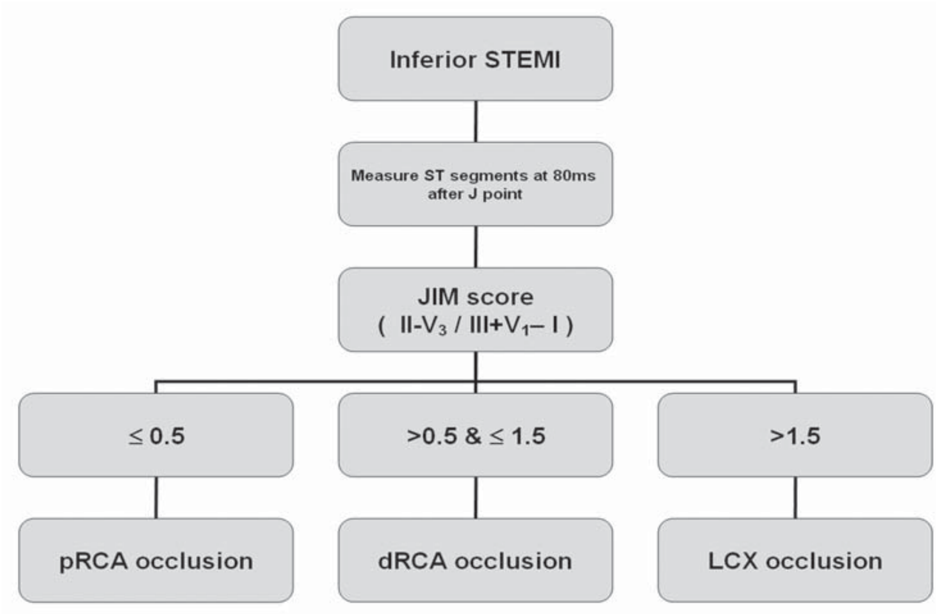

Fig. 2. A flowchart illustrating the algorithm of JIM score and its implications.

occlusions.[4] On the other hand, lead I and aVL are oriented more to lateral, and ST depression is less prominent or even ST elevation is present in these leads in LCX occlusions.[8]

Precordial leads (V1-3) ST depression is common in inferior myocardial infraction, and explained either by reciprocal changes or various degrees of inferoposterior ischaemia.[9-11] The relation of vector direction between anterior and posterior wall is more strongly opposed than that between anterior and inferior wall.[4] Therefore, LCX occlusions produce more prominent precordial ST depression than distal or proximal RCA occlusions;[4] indeed, the latter is known to be associated with precordial ST elevation due to inadvertent detection of right ventricular infarction by the precordial leads.[12-14] In the context of inferior myocardial infarction, ST changes in precordial leads are vector summation of right ventricular as well as the inferoposterior ischaemia. Lead V1 (equivalent to lead V2R) is closest to the right ventricle and more sensitive in picking up right ventricular infarction.[15] The degree of ST elevation is significantly higher in proximal than distal RCA occlusions in this study and being used as a tool to distinguish the 2 conditions.

In reality, there are great variations in coronary anatomy amongst individuals, such as the relative size of vessels and the degree of dominance. Acute occlusion in a segment of a coronary artery may not produce the "expected" changes in a particular lead because of other anatomical opposing factors. By combining several leads, the error caused by variations in a single lead may be plausibly minimised. The construction of JIM score [II–V3/III+V1–I] is based on the ratio of II/III suggested by Chia et al[3] and Herz et al.[5] It is chosen as a backbone because they are positive numbers by definition of inferior ST elevation myocardial infarction. The leads that are found to be of discriminative value (differentiate from RCA and LCX occlusion and from proximal and distal RCA occlusion) are either added to or subtracted from the numerator and/or the denominator. The subtraction of lead V3 from lead II in the numerator exaggerates the influence of LCX occlusion; whereas the addition of lead V1 to and subtraction of lead I from lead III in the denominator increase the effect of proximal RCA occlusion and reduce that of distal RCA occlusion. The JIM score is capable of identifying the infarct-related artery with a modestly superior accuracy compared with the old ones.[3,4]

The major limitations of this study are the relatively small number of patients and the anatomical variations of individuals. A patient who had dominant LCX occlusion is one of the false negatives of the criterion of JIM score >1.5 predicts LCX occlusion. Patients are not uncommonly bearing more than 1 sizable RV or acute marginal branches. Occlusion at a segment between the first and second right ventricular branch was classified as distal RCA occlusion but in effect, still caused right ventricular infarction and functioned as a proximal RCA occlusion. Moreover, this study lacks a validation cohort. As a result, the performance is likely to be overestimated as compared with techniques developed in other studies.

Conclusion

By incorporating more ECG leads, the newly devised JIM score is capable of identifying the infarct-related artery with fair accuracy in inferior myocardial infarction.

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