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Prognostic value of aVR lead and the well-known risk factors in acute ST-segment elevated myocardial infarction

aVR 導聯和已知危險因素在伴有 ST 段上升心肌梗塞的預後价值

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Objective: The present study was designed to analyse the effect of ST segment changes in aVR lead and the well-known risk factors in ST-segment elevated myocardial infarction (STEMI) patients. ***Materials and Methods:*** A total of 250 patients who were admitted between 2009 and 2010 with STEMI and ≥1 mm ST-segment elevation in aVR lead were enrolled in the study. The patients were followed for life-threatening events like acute pulmonary oedema, atrial fibrillation, AV block, ventricular tachycardia, length of stay in hospital and death. ***Results:*** Among the enrolled patients, 222 were discharged and 28 died. Pulmonary oedema and mortality rates were significantly higher in patients with ST-segment elevation in aVR lead (both p=0.001). ***Conclusions:*** There is a correlation of ST-segment elevation in aVR lead with poor outcome in STEMI. Therefore aVR lead must be analysed as well as the other leads and well-known risk factors while it estimates the prognosis. (Hong Kong j.emerg.med. 2011;18:287-293)

目的：這個研究的設計是為了分析 aVR 導聯和已知危險因素在患有 ST 段上升心肌梗塞的病人中， ST 段的轉變情況。**方法：**參與研究的病人總數有 250 個。他們都是從 2009 年至 2010 年間患有 ST 段上升心肌梗塞和在 aVR 導聯中有 ST 段上升超過或等於 1 mm 的住院病人。觀察病人危及生命的情況例如急性肺水腫、心房顫動、房室傳導阻滯、心室性心動過速、住院的時間和死亡等。**結果：**參與的病人中，222 個病人可以出院。有 28 個病人死亡。在那些 aVR 導聯中有 ST 段上升的病人其肺水腫和死亡率明顯高於沒有 ST 段上升的病人（兩者都是 p=0.001）。**結論：**在 ST 段上升心肌梗塞的病人中， aVR 導聯中和有較差預後有關。在估計預後時，必須將 aVR 導聯跟其他導聯和已知危險因素一起分析。

Keywords: Acute coronary syndrome, electrocardiography, prognosis

關鍵詞：急性冠狀動脈綜合徵、心電圖、預後

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Introduction

ST-segment elevated acute myocardial infarction (STEMI) is a common diagnosis in emergency department (ED).[1] ECG is established as the cornerstone for early diagnosis of acute myocardial infarction (MI).[2] Patients with suspected acute coronary syndrome (ACS) are currently evaluated on the basis of 12-lead.[3] Precordial and limb leads (I, II, III, aVF and aVL) have undeniable clinical values but it seems there is a tendency that aVR lead is most commonly ignored during ECG analyses for diagnosis.[4] ECG changes in the aVR lead may play an important role in the prognosis of patients with ACS.[5] Elevation

of ST-segment in aVR indicates the possibility of significant left main coronary artery stenosis (LMCAS) or three-vessel disease.[6] However, the prognostic significance of this is unknown.

The present study is designed to investigate the relationship between aVR lead ST-segment elevation and the well known risk factors (sex, hypertension, age, hyperlipidaemia diabetes mellitus etc.) on the prognosis in patients with STEMI.

Materials and methods

Selection of participants

Approval was taken from the Human Ethics Committee of Cumhuriyet University. Written informed consent was obtained from all participants. This study included 250 patients who were admitted in the university-based ED and cardiology wards between January 2009 and May 2010 due to STEMI. Standard 12-lead ECG was taken for the patients who admitted to ED with chest pain. The patient demographic characteristics, risk factors for coronary artery disease (age, hypertension, diabetes mellitus (DM), hyperlipidaemia, gender) and physical examination result were also recorded.

Patients with previous coronary artery bypass grafting or recent percutaneous coronary interventions (less than six months), stable angina, unstable angina or non STEMI were excluded from the study. The patients with ST-segment elevation in the first ECG were included in the study. All of the patients with STEMI were treated in coronary intensive care unit where cardiac catheterisation could be made by the cardiology service specialists in any time.

To assess the effect of aVR lead we analysed the inpatient mortality, acute pulmonary oedema, new onset AV block, new onset atrial fibrillation, ventricular tachycardia (VT) rates, and the length of stay in hospital and cardiology wards intensive care unit.

Electrocardiographic evaluation

Standard 12-lead electrocardiograms (ECG) were recorded with Nihon Kohden ECG device. Typical chest pain, ECG changes (ST elevation at least in two consecutive leads with ≥1 mm in extremity derivations and ≥2 mm in precordial derivations) and elevated cardiac marker levels (creatine kinase, creatine kinase myocardial band, troponin I) were used for MI diagnosis. ECG's were initially evaluated by an emergency physicians and then confirmed by cardiologists. Patients were divided into 3 main groups according to their localisation; anterior, inferior and lateral MI. Anteroseptal and anterolateral STEMI were included in anterior STEMI group. Inferior and inferoposterior STEMI were included in Inferior STEMI group. All of the patients with ST-segment elevation in aVR lead (minimum 1 mm ST-segment elevation) were recorded.

Statistical analysis

Data were analysed using Statistical Package for Social Science (SPSS) 16.0 for Windows (SPSS Inc., USA). Statistical analyses were performed using chi-square, relative risk (RR), odds ratio (OR), logistic regression, and Fisher's exact tests. In the statistically analysis for RR the groups without exposed risk factors (absent) were chosen as reference groups and in the gender groups men group was the reference groups. The level of significance was set as $p<0.05$.

Results

A total of 250 patients with STEMI were included in the study. Sixty-six percent (n=165) were male. Mean age (± standard deviation) was 65.98±10.53 (ranged from 44 to 88). The patients' group distribution according to their ECG localisation diagnosis were as follows; 48.4% (n=121) anterior MI, 32.0% (n=80) inferior MI and 19.6% (n=49) lateral MI. 47.2% (n=118) patients had recorded ST-segment elevation in aVR lead. When the risk factors were overviewed, 51.2% (n=128) patients had hypertension, 14.8% (n=37) had DM and 38% (n=95) had hyperlipidaemia. The complication rates recorded in ED or cardiology ward were as follows; acute pulmonary oedema 13.6% (n=34), death 11.2% (n=28), atrial fibrillation (AF) 29.2% (n=73), VT 6.4% (n=16), AV block 4% (n=10).

The mean hospitalisation time of these patients was 6.4 ±3.50 days (ranged from 1 to 17 days).

The mortality rate among the patients with and without ST-segment elevation in aVR lead was 22% (n=26) and 1.5% (n=2) (p=0.001, RR=14.542). Whereas, presence of hyperlipidaemia decreased the mortality rate significantly (p=0.02, RR=0.355). The RR for the risk factors are shown in Table 1.

The RR of acute pulmonary oedema was augmented by ST-segment elevation in aVR lead (p=0.001, RR:4.315) on the other hand hyperlipidaemia decreased the rate (p=0.003, RR=0.281). The relative risk of acute pulmonary oedema was not effected by gender, anterior MI, inferior MI, lateral MI, hypertension, age group and DM (p>0.05) (Table 2).

The RR and p values for the significant risk factors and new onset of AF were as follows: hypertension (p=0.001, RR=1.946), inferior MI (p=0.048, RR:1.483) and age (p=0.001, RR=3.089). Admission hyperlipidaemia level decreased the new onset AF rate (p=0.001, RR:0.458) (Table 3).

The RR and statistically results between AV block and the presence of inferior or anterior MI were p=0.001, RR=8.500 (CI:1.847-39.119) and p=0.013, RR=0.118 (CI:0.015-0.921) respectively. The RR between the age group and AV block could not be calculated inspite of the significiant p value while the number of the patients in the age group below 65 years was zero. On the other hand, aVR lead ST-segment elevation, gender, lateral MI, hypertension, DM and hyperlipidaemia had no statistically significant effect on the AV block rate (p>0.05).

Age, sex, anterior MI, inferior MI, lateral MI, ST-segment elevation in aVR lead, HT, DM and hyperlipidaemia did not have statistically significant effect on the VT among the STEMI patients (p>0.05).

Table 1. Relationship between the risk factors and mortality

		Mortality						
		Present	Absent	Total			95% CI for RR	
		n (%)	n (%)	n	p value	RR	Lower	Upper
Group	elevated aVR	26 (22)	92 (78.0)	118	0.001*	14.542	3.527	59.961
	normal aVR	2 (1.5)	130 (98.5)	132				
Sex	female	6 (7.1)	79 (92.9)	85	0.136	0.529	0.223	1.256
	male	22 (13.3)	143 (86.7)	165				
Anterior	present	16 (13.2)	105 (86.8)	121	0.326	1.421	0.702	2.880
	absent	12 (9.3)	117 (90.7)	129				
Inferior	present	9 (11.3)	71 (88.7)	80	0.986	1.007	0.477	2.125
	absent	19 (11.2)	151 (88.8)	170				
Lateral	present	3 (6.1)	46 (93.9)	49	0.209	0.492	0.155	1.564
	absent	25 (12.4)	176 (87.6)	201				
HT	present	13 (10.2)	115 (89.8)	128	0.592	0.826	0.410	1.664
	absent	15 (12.3)	107 (87.7)	122				
DM	present	7 (18.9)	30 (81.1)	37	0.107	1.919	0.879	4.190
	absent	21 (9.9)	192 (90.1)	213				
HL	present	5 (5.3)	90 (94.7)	95	0.020*	0.355	0.140	0.902
	absent	23 (14.8)	132 (85.2)	155				
Age	>65	18 (14.0)	111 (86.0)	129	0.421	1.688	0.812	3.511
	≤65	10 (8.3)	111 (91.7)	121				

CI=confidence interval, DM=diabetes mellitus, HL=hyperlipidaemia, HT=hypertension, RR=relative risk

*p<0.05

Table 2 Relationship between the risk factors and frequency of new-onset pulmonary oedema

		Pulmonary oedema						
		Present n (%)	Absent n (%)	Total n	p value	RR	95% CI for RR Lower	Upper
Group	elevated aVR	27 (22.9)	91 (77.1)	118	0.001*	4.315	1.952	9.539
	normal aVR	7 (5.3)	125 (94.7)	132				
Sex	female	7 (8.2)	78 (91.8)	85	0.076	0.503	0.229	1.108
	male	27 (16.4)	138 (83.6)	165				
Anterior	present	16 (13.2)	105 (86.8)	121	0.866	0.948	0.507	1.772
	absent	18(14.0)	111 (86.0)	129				
Inferior	present	12 (15.0)	68 (85.0)	80	0.658	1.159	0.604	2.223
	absent	22 (12.9)	148 (87.1)	170				
Lateral	present	6 (12.2)	43 (87.8)	49	0.758	0.879	0.385	2.005
	absent	28 (13.9)	173 (86.1)	201				
HT	present	20 (15.6)	108 (84.4)	128	0.339	1.362	0.721	2.573
	absent	14 (11.5)	108 (88.5)	122				
DM	present	7 (18.9)	30 (81.1)	37	0.307	1.492	0.702	3.174
	absent	27 (12.7)	186 (87.3)	213				
HL	present	5 (5.3)	90 (94.7)	95	0.003*	0.281	0.118	0.702
	absent	29 (18.7)	126 (81.3)	155				
Age	>65	23 (17.8)	106 (82.2)	129	0.09	1.961	0.999	3.849
	≤65	11 (9.1)	110 (90.9)	121				

CI=confidence interval, DM=diabetes mellitus, HL=hyperlipidaemia, HT=hypertension, RR=relative risk
*p<0.05

Table 3 Relationship between the risk factors and atrial fibrillation

		Atrial fibrillation						
		Present n (%)	Absent n (%)	Total n	p value	RR	95% CI for RR Lower	Upper
Group	elevated aVR	31 (26.3)	87 (73.7)	118	0.336	0.826	0.558	1.222
	normal aVR	42 (31.8)	90 (68.2)	132				
Sex	female	28 (32.9)	57 (67.1)	85	0.350	1.208	0.816	1.788
	male	45 (27.3)	120 (72.7)	165				
Anterior	present	34 (28.1)	87 (71.9)	121	0.711	0.929	0.631	1.369
	absent	39 (30.2)	90 (69.8)	129				
Inferior	present	30 (37.5)	50 (62.5)	80	0.048*	1.483	1.011	2.175
	absent	43 (25.3)	127 (74.7)	170				
Lateral	present	9 (18.4)	40 (81.6)	49	0.063	0.577	0.309	1.077
	absent	64 (31.8)	137 (68.2)	201				
HT	present	49 (38.3)	79 (61.7)	128	0.001*	1.946	1.278	2.964
	absent	24 (19.7)	98 (80.3)	122				
DM	present	14 (37.8)	23 (62.2)	37	0.211	1.366	0.857	2.178
	absent	59 (27.7)	154 (72.3)	213				
HL	present	16 (16.8)	79 (83.2)	95	0.001*	0.458	0.280	0.749
	absent	57 (36.8)	98 (63.2)	155				
Age	>65	56 (43.4)	73 (56.6)	129	0.001*	3.089	1.907	5.007
	≤65	17 (14.0)	104 (86.0)	121				

CI=confidence interval, DM=diabetes mellitus, HL=hyperlipidaemia, HT=hypertension, RR=relative risk
*p<0.05

Age, sex, anterior MI, inferior MI, lateral MI, ST-segment elevation in aVR lead, HT, DM and hyperlipidaemia did not effected the length of hospital stay (p>0.05).

The RR for the patients aVR ST-segment elevated group concomitant with pulmonary oedema increased when compared with the mortality rate in the isolated ST-segment elevated aVR group (p=0.001, RR=3.025 CI:1.964-4.659). VT occurrence has a significant effect on the mortality (p=0.009 RR:3.179 CI: 1.395-7.247) Ventricular tachycardia occurrence also increased the pulmonary oedema rate (p=0.004 RR=3.134 CI:1.523-6.450).

Finally we made a multivariate analyse according to the risk factors which were in Table 1 and mortality. ST-segment elevation in aVR lead has increased the mortality 18.388 fold (p=0.001). Whereas admission hyperlipidaemia level had an negative effect on the mortality rate (p=0.031, OR=0.318) (Table 4).

Discussion

The aVR lead is commonly unnoticed by most clinicians during ECG analyses and is generally accepted only as a lead which shows the right top position of myocardium. However, many clues in aVR lead may help in many cases.[7] Pahlm et al obtained 12-lead ECG with an aVR mirror image and showed to 35 reviewers, 94% of them did not recognised this mistake.[8] This evidence per se makes it clear that the aVR lead is neglected during ECG analyses. Therefore the present study was designed to determine the correlations between the clinical complications and aVR lead ST-segment elevation among the patients with STEMI.

It is shown that ST-segment elevation in aVR lead among the patients admitted with STEMI has a correlation with disease severity and prognosis.[9] ST-segment elevation in aVR reflects transmural ischaemia of interventricular septum basal segment.[6] There is also a relationship between the severity of coronary artery disease and aVR lead ST-segment elevation.[10]

Kosuge et al have shown that ST-segment elevation in aVR lead and increased troponin T (TnT) levels, has a high correlation with 3 vessel coronary arteries occlusion, left main coronary arterial stenosis and major clinical complications within 90 days.[11] Barrabes et al evaluated 775 non STEMI patients ECG and found that the mortality rates were higher among the patients with ST-segment elevation in aVR lead.[12] Moreover Yan et al reported in their study that the mortality rates were higher in non STEMI acute coronary syndrome patients who had aVR lead ST-segment elevation.[13] The present study demonstrated that ST-segment elevation in aVR lead increased the mortality. This led us to conclude that ST-segment elevation is associated with higher severity of coronary artery disease which boosts the mortality rate.

Hyperlipidaemia is accepted as a risk factor for acute coronary syndromes and mortality. Whereas we found that hyperlipidaemia has decreased the rates of mortality, pulmonary oedema and AF. Hyperlipidaemia level and mortality rates were analysed in many studies.[14-16] Pres et al did not found significiant mortality difference among hyperlipidemic and normolipidemic ST-segment elevated myocardial infarction patients without diabetes mellitus.[14] Wang et al found that a history of hypercholesterolemia was associated with lower in-hospital mortality (OR: 0.71; 95% CI: 0.66, 0.76).[15] Also Granger et al evaluated in-hospital

Table 4. Multivariate Analysis of the significant risk factors and mortality

					95% CI for OR	
Significant risk factors	**Coefficient**	**Standart error**	**p**	**OR**	**Lower**	**Upper**
HL	-1.145	0.531	0.031*	0.318	0.112	0.901
ST segment elevation in aVR lead group	2.912	0.749	0.001*	18.388	4.237	79.809
Constant	-2.706	0.950	0.004	0.067		

HL=hyperlipidaemia, OR=odds ratio, CI=confidence interval
*p<0.05

mortality rates according to baseline characteristics and found that the rate was significiant lower among the patients with hyperlipidaemia (p=0.02).[16] Kang et al analysed obesity and ST-segment elevated myocardial infarction patients. They used the Killip classification for pulmonary oedema and found that the number of the patients with pulmonary oedema over class 2 decreased as the BMI and hyperlipidaemia has increased.[17] In our study we found that hyperlipidaemia had a protective effect on pulmonary oedema occurrence and in hospital mortality.

Kosuge et al reported a lower ventricular ejection fraction among ACS patients with elevated ST-segment in aVR lead. This finding suggests us that patients with elevated ST-segment in aVR lead has a wider infarct size and increased heart failure rate.[18] Similarly, this study indicated that ST-segment elevation in aVR presence in STEMI patients was increased and the RR for pulmonary oedema was 4.315. This may be an indicator of severe coronary artery disease.

Although it is noted that risk factors like inferior MI, hypertension, and age in STEMI patients increases the rate of atrial fibrillation, there was not a significant relation between ST-segment elevation in aVR lead and atrial fibrillation. In addition, the present study demonstrated that over 65 years patients group, inferior MI, and HT were risk factors for the development of AV block, but ST-segment elevation in aVR lead was not a risk factor for the development of AV block.

Szymanski et al referred to the prognostic significance of aVR lead ST-segment elevation and pointed out that it can be used as a risk factor in addition to the well-known risk factors.[19] In the present study ST-segment elevation in aVR lead identified the association with pulmonary oedema and mortality rate which was better than other risk factors in patients with ACS. This suggests that ST-segment changes in aVR lead ECG can be used as a risk factor variable.

Several limitations should be acknowledged in relation to the present study. For instance, this study was made in a single centre with a small patient group and the patients were not divided according to their treatment characteristics, a multi-centric study with more patients stratified according to their treatments and with a long-term follow-up can uncover the importance of aVR lead.

In conclusion, during ECG analyses aVR lead should not be disregarded by the physicians for the diagnosis, while the changes in aVR lead ST-segment herald a poor prognosis and therefore, these patients need close follow up.

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