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Original Research Article

Prediction of culprit artery from ECG in acute ST elevation myocardial infarction and correlating with coronary angiography

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ABSTRACT

Background: Acute myocardial infarction (AMI) is one of the most common diagnoses in hospitalized patients in industrialized countries. The early (30-day) mortality rate from AMI is ~30%, with more than half of these deaths occurring before the stricken individual reaches the hospital.When patients present with acute coronary syndrome, The 12-lead electrocardiogram (ECG) recorded by the alarmed general practitioner or ambulance staff is a pivotal diagnostic and triage tool since it is at the center of the decision pathway for management. In this study the accuracy of ECG in identifying the culprit artery was determined by comparing ECG finding with angiography finding which is a direct visualization procedure.
Aim: To assess the value of electrocardiogram in predicting the culprit artery in acute ST elevation MI and correlating with coronary angiogram finding.
Materials and Methods: A Cross Sectional Observational study was carried out for a period of 11months from February 2021 to December 2021 among 100 Patients admitted to ICCU, Dept of Cardiology, King George Hospital, Visakhapatnam who were diagnosed with acute ST-elevation myocardial infarction. The accuracy of ECG in identifying the culprit artery was determined by comparing ECG finding with angiography finding which is a direct visualization procedure.
Results: The sensitivity of ECG in predicting LAD as infarct related artery when compared to CAG, which was taken as standard test is 94.10%, specificity 89.79% the positive predictive value is 90.56% and the negative predictive value is 93.61%.
Conclusion: In the present study, ECG well correlated with CAG (90.56%) in predicting LAD as infarct related artery.

1. Introduction

1.1. Epidemiology

Myocardial infarction is a common presentation of ischemic heart disease. Cardiovascular diseases (CVDs) are the leading cause of death globally. An estimated 17.9 million people died from CVDs in 2019, representing 32% of all global deaths. Of these deaths, 85% were due to heart attack and stroke. Over three quarters of CVD deaths take place in low- and middle-income countries.[1]

Out of the 17 million premature deaths (under the age of 70) due to noncommunicable diseases in 2019, 38% were caused by CVDs. It is important to detect cardiovascular disease as early as possible so that management with counselling and medicines can begin.

In India, cardiovascular disease (CVD) is the leading cause of death. In India in 2016, CVDs contributed to 28·1% of total deaths and 14·1% of total disability-adjusted

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life years (DALYs) compared with 15·2% and 6·9%, respectively in 1990.[2] At present, India has the highest burden of acute coronary syndrome and ST-elevation myocardial infarction (MI). Another significant problem in India, among other CVD's, is that of hypertensive heart disease, with 261,694 deaths in 2013 (an increase of 138% in comparison with 1990).

Patients with ischemic heart disease falls into two groups

1. Patients with chronic coronary heart disease who present with stable angina
2. Patients with acute coronary syndrome The second group is composed of
   (a) Patients with acute myocardial ischaemia with ST segment elevation on their presenting electro cardiogram STEMI.
   (b) Those with unstable angina and non ST segment elevation myocardial ischaemia.

STEMI[3] occurs when coronary blood flow decreases abruptly after a thrombotic occlusion of a coronary artery previously affected by atherosclerosis. Slowly developing high-grade coronary artery stenosis does not typically precipitate STEMI because of the development of a rich collateral network. STEMI occurs when a coronary artery thrombus develops rapidly at a site of vascular injury. This injury is produced and facilitated by factors such as cigarette smoking, hypertension and lipid accumulation.

Acute myocardial infarction (AMI) usually occurs suddenly and is associated with considerably high mortality rate. The infarct-related artery in inferior wall AMI is usually located at right coronary artery (RCA), less often at left circumflex coronary artery (LCX). Inferior wall AMI occlusive site before the first right ventricular branch of RCA was more frequently associated with right ventricular infarction, which had higher incidence of bradyarrhythmia, shock, and in-hospital death. Early recognition of the site of infarct-related artery especially combination with right ventricular infarction and respond promptly may result in a significant reduction in in-hospital mortality and morbidity. There were several non-invasive methods to predict the culprit site, which including: radionuclear imaging study, echocardiography or electrocardiogram. Among these methods, electrocardiogram is one of the most simple and convenient tool. Myocardial infarction results in myocardial necrosis, injury and ischemia each of which is reflected by a different and distinctive electrocardiographic manifestation.

1.2. Identification of the infarct related artery:[4,5]

Despite limitation, the ECG can help in identifying proximal occlusion of the coronary arteries, which results in more extensive and more severe myocardial infarction and guide decisions.

Thus the present study was done to assess the value of electrocardiogram in predicting the culprit artery in acute ST elevation MI and correlating with coronary angiogram finding.

2. Aim

To assess the value of electrocardiogram in predicting the culprit artery in acute ST elevation MI and correlating with coronary angiogram finding.

3. Materials and Methods

3.1. Study design

Cross Sectional Observational study.

3.2. Study duration

February 2021 to December 2021.

3.3. Study subject

100 Patients admitted to ICCU, Dept of Cardiology, KING GEORGE HOSPITAL, Visakhapatnam were diagnosed with acute ST-elevation myocardial infarction.

3.4. Inclusion criteria

1. First event of acute MI
2. ECG showing ST segment elevation
3. > 1mm in limb leads (or)
4. > 2mm in chest leads in 2 or more contiguous leads

3.5. Exclusion criteria

1. Congenital heart disease
2. Rheumatic heart disease
3. Previous coronary interventions
4. Recurrent MI

3.6. ECG was studied as follows

1. The 12 lead ECG showing most pronounced ST elevation before start of TLT was evaluated
2. The TP segment was used as isoelectric line
3. PR segment was used when the P wave & T wave merged
4. The J point was determined for each lead independently
5. Both ST ↑ & ST ↓ were measured at the J point in all leads
6. Besides ST deviation, RBBB, Q waves, T ↓ were assessed

The site of infarction was determined as follows:

1. ST elevation in leads V1-V4 anteroseptal MI

2. ST -elevation in leads V1-V6 anterior wall MI
3. ST elevation in leads V1-V6, 1 and aVL Extensive anterior wall MI
4. ST elevation in leads II, III aVF - Inferior wall MI
5. ST elevation in leads with I, aVL or V5, V6 without ST elevation in other leads -lateral wall MI o ST elevation in II, III, aVF, RV_3, RV_4 - inferior wall MI with RV MI o ST elevation in II, III aVF, ST depressions with upright T wave in V1 and V2- Inferior wall MI post wall MI
6. ST elevation inferior and anterior leads - Global MI

3.7. Coronary angiography

All patients underwent coronary angiography 5 to 7 days after the acute episode

The infarct related artery was assessed based on

1. The severity of the stenosis.
2. The Presence of Thrombus.
3. The presence of disrupting plaque.
4. The degree of flow in the artery distal to the lesion.

(a) The culprit lesion was localized in relation to take off of S1 and D1 in case of LAD , take off of OM1 in case of LCX, Take off of RV and AM branches in case of RCA.

(b) The infarct related artery was identified in coronary angiogram and it was compared with culprit artery of the ECG. Institutional ethics committee approval was obtained. The data was entered into Microsoft Excel and analyzed using SPSS Version 21. Sensitivity, Specificity, Positive Predictive value and Negative Predictive values were calculated for testing the validity between ECG and angiogram findings.

4. Results

1. Majority 74% of the study participants were males and 26% were females.
2. The youngest is 26 years and the oldest is 80 years.
3. MI is more common in the age range of 40-59 years in male subjects, in females MI is more common above the age of 50 years.
4. Most common presenting symptom is chest pain 94% followed by sweating 66% breathlessness 34%, palpitations and syncope 14%.
5. It was observed that most common risk factor associated is hypertension 50%, smoking 48%, diabetes mellitus 30%, BMI >25 was 20% ,positive family history 14% and HB < 10 gm 14%.
6. About 97.43% of RCA group 92.45% of LAD and 75% of LCX group were thrombolysed.
7. Subjects with low ejection fraction ie., 20-35 in LAD group were 6, 36-50 were 20, more than 50 were 27, in RCA group EF < 50 were 11, more than 50, in LCX all subjects were having EF more than 50.

Two were having no regional wall motion abnormality RCA group showed RWMA in all subjects.Table 2

It was observed that the incidence of conduction blocks and arrhythmias was more in RCA group.

Among total 100 subjects, in 2 subjects normal coronaries were present. Single vessel disease was found in 49 subjects out of which, 1 was having LMCA disease, 30 LAD, 15 RCA and 3 of them were having LCX disease. In the remaing, 34 showed double vessel disease, 15 showed triple vessel disease.Table 3

53(53%) subjects showed ECG changes suggestive of LAD as culprit vessel of total 100 subjects.

Among them 48(90.56%) showed LAD, 4(7.54%) LMCA as infarct related artery.

Only 1(1.88%) subject had normal epicardial coronary.Table 4

About 39(39%) subjects showed ECG changes suggestive of RCA as culprit artery of total 100 subjects.

Among them 33(84.61%) showed RCA, 3(7.69%) LCX and 2(5.12%) LAD in CAG.

Only 1(2.56%) of RCA predicted in ECG showed normal coronaries.Table **??**

In 8(8%) of study subjects LCX was predicted in ECG.

About 4(50%) of them are showing RCA, 3(37.5%) LCX and 1(12.5%) had LAD as infarct related artery in CAG.Table 6

Among 100 subjects, ECG showed LAD in 53%, RCA in 39% and LCX in 08% subjects, CAG found LAD in 51%, RCA in 37%, LCX in 06%, LMCA in 04% and NORMAL coronaries in 02% subjects.Table 7

The sensitivity of ECG for predicting LAD, RCA, LCX was 94.1%, 89.18% and 50% respectively. The specificity of LAD, RCA, LCX was 89.79%, 90.47% and 94.68% respectively. The positive predictive value for LAD, RCA, LCX was 90.56%, 84.61% and 37.5% respectively. The negative predictive value for LAD, RCA and LCX IS 93.61%, 93.44% and 96.73% respectively.Table 8

5. Discussion

Electrocardiogram is the single most important test for diagnosing acute myocardial infarction. Apart from diagnosing, by identifying the infarct related artery in acute ST elevation myocardial infarction, ECG is useful for therapeutic triage and to anticipate complications depending on the artery involved. ECG is also useful for predicting the prognosis of the patient. A total of 100 patients who were diagnosed with acute ST Elevation MI, whose ECG which is showing most pronounced ST deviations before the start of thrombolysis therapy was selected for identifying the infarct related artery. The baseline characteristics of the patients were studied. After the acute management of the ST

Table 1: Identification of infarct related artery

Inferior Wall Myocardial infarction	
Proximal Rt. Coronary arterial occlusion	ST elevation in leads III > leads II with ST elevation in Vi, in RV_4 or both with ST depressed in I, aVL
Distal Rt. Coronary artery occlusion	ST elevation in lead III > lead II with no ST elevation but positive T wave in RV4.
Left circumflex artery artery occlusion	STE in lead II > lead III with isoelectric ST in aVL or STE in 1, aVL V_5, V_6 and negative T wave in RV4
Anterior wall myocardial infarction	
Lt. main coronary artery	ST elevation in I, aVL, Vi-V_6 with ST depression in II, III, aVF
Proximal left anterior descending artery occlusion	ST elevation in V1-V3 with STE in Vi > 2.5 mm or RBBB with Q wave or both. With ST segment depression in II, III aVF, > 1mm
Distal left anterior descending artery occlusion	ST elevation in V1-V3 with ST segment elevation in II, III, aVF or ST segment depression < 1 mm

Table 2: Distribution of study participants according to ECG and 2D ECHO RWMA

	LAD	RCA	LCX	NO RWMA
ECG	53	39	8	0
2D ECHO	52	39	7	2

Table 3: Distribution of study participants according to conduction blocks

Conduction blocks	Total %	LAD %	RCA %	LCX %
I° AV Block	5	—	5	—
Complete heart block	5	1	4	–
AF with FVR	1	—	1	—
Junctional rhythm	2	1	1	—

Table 4: ECG Diagnosis in patients with anterior wall MI

ECG Diagnosis	ECG Culprit artery	CAG Infarct related artery				
		LAD			LMCA	Normal
		Prox	MID	Distal		
Antero septal MI-9	Prox LAD	4	4		1	
Anterior MI-28	MID LAD	10	16	1		1
Extensive Anterior MI-16	Diffuse LAD	6	6	1	3	
53			48		4	1

Table 5: ECG Diagnosis in patients with inferior wall MI

ECG Diagnosis	ECG Culprit artery	CAG Infarct related Artery						LAD	Normal
		RCA			LCX				
		Prox	MID	Distal	PROX	MID	Distal		
Inferior (12)	RCA	2	4	2		1		2	1
Infero posterior (21)	RCA	9	6	4		2			
True Posterior (1)	RCA		1						
Inferior RV MI (5)	Prox RCA	2	3						
39			33			3		2	1

Table 6: ECG Diagnosis in patients with lateral wall MI

ECG Diagnosis	ECG Culprit artery	CAG Infarct related Artery						LAD
		RCA			LCX			
		Prox	MID	Distal	Prox	MID	Distal	
Antero Lateral-2	LCX		1					1
Infero Lateral-3	LCX	1			1	1		
Postero Lateral-3	LCX		2			1		
8			4			3		1

Table 7: ECG Diagnosis Vs CAG infarct related artery

ECG diagnosis	CAG infarct related artery				
	LAD	RCA	LCX	LMCA	Normal
Anterior MI LAD-53%	48%			4%	1%
Inferior MI RCA-39%	2%	33%	3%	-	1%
Lateral MI LCX-08%	1%	4%	3%	-	-
100%	51%	37%	06%	04%	02%

Table 8: Comparison of ECG findings with CAG infarct related artery

Infarct related artery	ECG	CAG	Sensitivity (%)	specificity (%)	Positive predicted value (%)	Negative predicted value (%)
LAD	53	51	94.1	89.79	90.56	93.61
RCA	39	37	89.18	90.47	84.61	93.44
LCX	8	6	50	94.68	37.5	96.73
	100	94				

Elevation MI patients were subjected to coronary angiogram 5-7 days after the admission. In coronary angiogram the infarct related artery was identified based on the following features

1. The degree of stenosis.
2. The flow in the artery distal to the stenosis.
3. The presence of thrombus.
4. The presence of disrupting plaque obstructing the flow.

The culprit artery was located in relation to the first septal and first diagonal branch in case of left anterior descending artery, obtuse marginal branch in case of left circumflex artery, right ventricular and acute marginal branches in case of right coronary artery among total 100 study subjects, males are 74% and female subjects were 26%. The ratio of male to female is almost 3:1In the present study, (44%) the most common age group presented with acute STEMI are in between the age of 40-60 years in (74%) male subjects. In female subjects (26%), most of them (20%) were presented above the age of 50 years.

Among the presenting symptoms, the most common presenting symptom is chest pain 94% followed by sweating 66%, breathlessness 34%, palpitations 14%.

The most common associated risk factor is presence of hypertension which was observed in 50% of subjects followed by smoking 48 % followed by diabetes mellitus 30%, positive family history of CAD 14%, BMI >25 is 20%. Most of the subjects were admitted to ICCU, with window period <4hrs 27% in LAD, 18% in RCA and 2% in LCX groups. Window period with 4-24hrs 18% in LAD, 15% in RCA and 4% in LCX. Subjects with window period >24hrs 8% in LAD, 6% in RCA and 2% in LCX group.

It was observed that subjects presented with window period <4hrs were more in LAD group. In subjects presented earlier there may be good correlation with CAG finding because there are less chances of spontaneous revascularisation or opening up of collateral circulation.

Incidence of conduction blocks (i.e) 1A V block was observed in 5 subject in RCA group. Complete heart block was observed in 4 subjects in RCA group and one in LAD group, AF was observed 1 subject of LAD group, Junctional rhythm was observed in 1of LAD and 1 of RCA group. It was observed the incidence of conduction blocks and arrhythmias was more in RCA group. Among total 100 subjects,49 out of 53 (92.45%) were subjected to thrombolysis therapy in LAD group, 38 out of 39(97.43%) in RCA group 6 out of 8 (75%) in LCX group.

In subjects in whom there is effective thrombolysis, there are less chances of correlation due to dissolution of thrombus. In the present study, subjects with low ejection fraction i.e. EF < 50% were 26, EF > 50% 29, in LAD group. In RCA group, EF < 50% were 11, EF > 50% were 26. Subjects with EF<50% were 0, and EF>50% were 8 in LCX group. Most of the subjects with low ejection fraction were observed in LAD group, which implies that pump failure is common in subjects with LAD infarct when compared to RCA and LCX infarcts. It was observed that RWMA(regional wall motion abnormality), in 2D ECHO was found in 52% subjects in LAD group, 39 % in RCA group, 7% in LCX group. So 2D ECHO well correlated with the ECG identification of infarct related artery.

Out of total 100 subjects, anterior MI was found in 53. In this anterior group, it was observed that 9 were having anteroseptal MI, 28 - anterior wall MI, and16%were found to have extensive anterior wall MI in whom LAD was identified as infarct related artery in the ECG. In 9 (100%) anteroseptal MI, as per CAG, it was found that 4(44.4%) were having proximal LAD lesion, 4(44.4%) MID LAD, distal LAD 0%, 1(11.1%) LMCA, 0% RCA and 0% LCX lesion.

In 28(100%) anterior MI wall, 10(35.7%) were found to have prox LAD lesion, 16(57.14%) mid LAD lesion, 1(3.57%) distal LAD lesion, 0% RCA, 0% LCX, 0% LMCA and 1 (3.57%) normal coronaries. In 16 (100%) of

extensive anterior wall MI, in whom LAD was found to have culprit artery in ECG, CAG showed proximal LAD lesion in 6(37.5%), mid LAD lesion in 6(37.5%), 1(6.25%) in distal LAD, 0% RCA, 0% LCX, 3(18.75%) LMCA and 0% normal coronaries. In 53(100%) of anterior MI, in whom LAD was predicted as culprit vessel, 48 (90.56%) showed LAD as infarct related artery in CAG, out of which MID LAD segment 26 (49.05%) is the most common lesion localised. In the remaining, 0% showed RCA, 0% showed LCX, 4(7.54%) LMCA and 1 (1.88%) normal coronaries.

In the present study, ECG well correlated with CAG (90.56%) in predicting LAD as infarct related artery. The sensitivity of ECG in predicting LAD as infarct related artery when compared to CAG, which was taken as standard test is 94.10%, specificity 89.79% the positive predictive value is 90.56% and the negative predictive value is 93.61%.

Out of total 100 subjects, inferior MI group were 39 %, in which RCA was predicted as culprit artery according to ECG. Out of 39%, isolated inferior wall MI were 12%, infero-posterior were 21%, true posterior was 1%, and R V MI were 5%, in all of them RCA was predicted as infarct related artery. In 12(100%) isolated inferior wall MI, 2(16.66%) were found to have proximal RCA lesion, 4(33.33%) had lesion in mid RCA, 2 (16.66%) had distal RCA lesion, 2(16.66%) LAD lesion, 1(8.33%) LCX lesion, 0% LMCA, and 1(8.33%) had normal coronaries. In 21(100%) infero posterior wall MI, 9(42.85%) were having proximal RCA lesion, 6(28.57%) were having mid RCA lesion, 4 (19.04%) had distal RCA lesion, 0% LAD, 2(9.52%) had LCX lesion, 0% LMCA, 0% normal coronaries. In 1(100%) true posterior MI, 0% were found to have proximal RCA, 1(100%) had mid RCA lesion, 0% distal RCA, 0% LAD, 0% LCX, 0% LMCA, and 0% normal coronaries.

In 5(100%) R V MI, 2(40%) had proximal RCA lesion, 3(60%) had mid RCA lesion, 0% distal RCA, 0% LAD, 0% LCX, 0% LMCA, and 0% with normal coronaries. Among 39(100%) inferior MI subjects, most of them were found to have mid RCA lesion 14(35.89%), proximal RCA lesion in 13 (33.33%), 6(15.38%) had distal RCA lesion, 2(5.12%) LAD, 3(7.69%) had LCX lesion, 0% LMCA and 1(2.56%) was having normal coronaries. There is 33(84.61%), out of 39(100%) positive correlation in subjects with RCA predicted by ECG, compared to coronary angiogram. The sensitivity of ECG in identifying RCA as infarct related artery compared to CAG is 89.18%, specificity is 90.47%, the positive predictive value is 84.61%, the negative predictive value is 93.44%. Among total 100 cases, lateral wall MI was diagnosed in 8 subjects, in whom LCX was predicted as infarct related artery .Out of these inferolateral wall MI were 3, anterolateral wall MI were 2 and lateral wall MI were 3.

In 3(100%) infero lateral wall MI 2(66.66%) subjects showed LCX as infarct related artery, 1(33.33%) had RCA lesion, 0% LAD, 0%LMCA and 0%normal coronaries.

In 2(100%) antero lateral wall MI, 0%showed LCX as infarct related artery, 1(50%) had RCA lesion, 1(50%) had LAD lesion, 0 LMCA, 0% normal CAG. In 3(100%) cases of lateral wall MI, 1(33.33%) had LCX lesion, 2 (66.66%) had RCA lesion, 0% LAD, 0% LMCA, 0% normal CAG. Among total 8(100%) LCX predicted by ECG, only 3(37.5%) had LCX lesion, remaining 1(12.5%) had LAD lesion and 4(50%) had RCA lesion. In LCX predicted by ECG, there is poor correlation compared to RCA and LAD. The sensitivity of ECG in predicting LCX as culprit artery, compared with coronary angiogram is 50%, specificity is 94.68% , the positive predictive value is 37.5%, the negative predictive value is 96.73% Out of LAD, RCA and LCX, LAD showed good correlation with CAG when compared to RCA.

The possible causes of poor correlation for LCX are

1. Due to variation in the dominance of RCA and LCX from individual to individual
2. Due to overlap of arterial segments of LCX with both RCA and LAD
3. Due to establishment of collateral circulation
4. Due to presence of multiple vessel disease

Identifying the patients with LAD occlusion, that too proximal LAD, who need more aggressive approach to revascularisation to prevent extensive myocardial damage resulting in pump failure, the possible development of sub AV nodal conduction disturbances and the occurrence of life threatening ventricular arrhythmias in the second and third week after AMI.

Identifying the patients with RCA occlusion is important because there are more chances of haemodynamic instability, which alerts the attending the primary care personal to stabilize the patient and also to identify the risk of development of complete heart block.

A study done by Dr WA Dijk et al.,[6] from Netherlands, in which the results showed that the sensitivity of ECG in predicting LAD was 63.8%, the specificity was 94.5%. In our study for LAD the sensitivity was 94.1% and specificity was 89.79%.

For RCA, the sensitivity and specificity were 60.9% and 81.8% respectively, where as in our study, RCA sensitivity was 89.18% and specificity was 90.47%.

For LCX, the sensitivity and specificity were 17.8% and 73.3% respectively. In our study the sensitivity and specificity for LCX were 50% and 94.68%.

The variation in the sensitivity and specificity values for each arterial territory between WA Dijk et al., study and in the present study may be due to the selected subjects retrospectively (i.e) that is patients with single vessel disease as per CAG whose ECGs were analysed. In the present study we selected the subjects based on ECG (i.e) patients with acute STEMI. In WA Dijk, study,[6] they did not consider the

thrombolysis whereas in the present study we selected the ECG before the thrombolysis therapy.

In WA Dijk study,[6] for identifying the culprit artery, they based on algorithms according to Fiol et al[7] and Tierala et al.[8] They analysed the ECGs with four commercially available ECG programs-megacare, muse, escribe, tracemaster.

In the present study, for identifying the culprit artery, ECG criteria were selected from the HURST text book of cardiology.[9]

In WA Dijk study, the accuracy of diagnosing the LAD as culprit artery exceeded that of diagnosing the RCA and LCX as the artery with culprit lesion which is matching with the present study result.

6. Limitations

1. ECG interpretation might have been confounded by the presence of multiple number of diseased vessels, development of collateral circulation.
2. CAG finding might have been affected either by thrombolysis or spontaneous revascularization.

7. Conclusions

1. The sensitivity of ECG for predicting LAD, RCA, LCX was 94.1%, 89.18% and 50% respectively
2. The specificity of LAD, RCA, LCX was 89.79%, 90.47% and 94.68% respectively.
3. The positive predictive value for LAD, RCA, LCX was 90.56%, 84.61% and 37.5% respectively.
4. The negative predictive value for LAD, RCA and LCX is 93.61%, 93.44% and 96.73% respectively.

8. Conflict of Interest

None.

9. Source of Funding

None.

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