Improving risk stratification after acute myocardial infarction : focus on emerging applications of echocardiography

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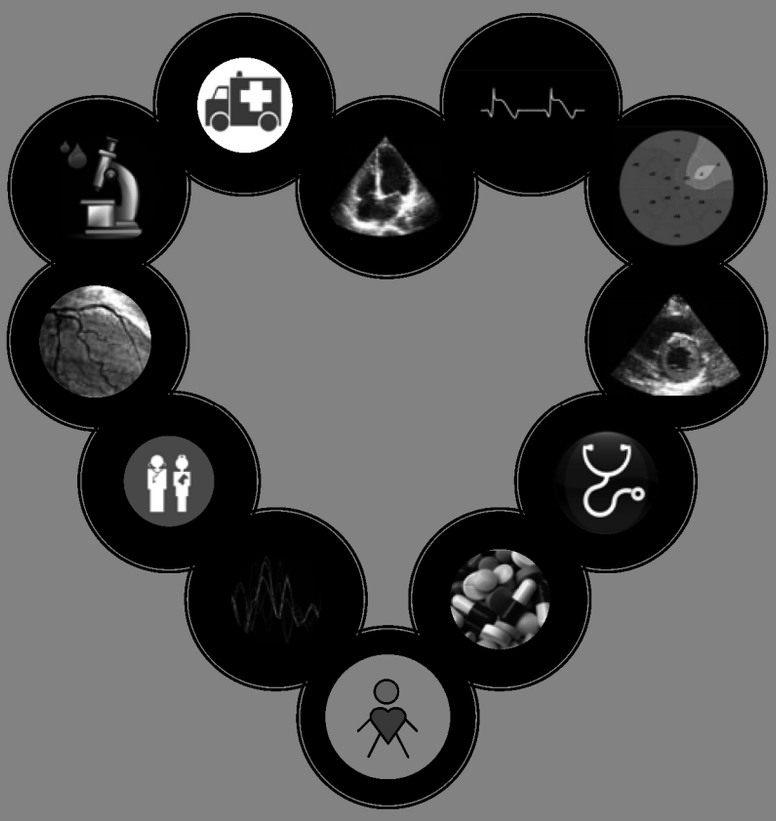
Part I

Clinical Risk Factors



Chapter 2

Distribution of Culprit Lesions in Patients with ST-Segment Elevation Acute Myocardial Infarction Treated With Primary Percutaneous Coronary Intervention

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Abstract

Objectives

Data regarding the distribution of vulnerable lesions in the coronary arteries are scarce. The aim was to evaluate the frequency and distribution of culprit lesions in patients with ST-segment elevation acute myocardial infarction (AMI). In addition, the location of culprit lesions was related to infarct size**.**

Methods and results

Consecutive patients (N = 1533, mean age 61±12 years) were evaluated. All patients were treated with primary percutaneous coronary intervention and underwent 2-dimensional echocardiography <48 hours of admission. The majority of the culprit lesions were located in the left anterior descending coronary artery (LAD, 45%), followed by the right coronary artery (RCA, 38%) and left circumflex coronary artery (LCX, 14%). Subanalysis demonstrated that patients with a culprit lesion in the LAD and LCX had significantly higher peak cardiac enzymes compared to patients with culprit lesions in the RCA. In addition, patients with proximal LAD and LCX lesions had significantly worse left ventricular function compared to patients with mid or distal lesions.

Conclusions

Plaque rupture resulting in AMI is more likely to occur in the proximal parts of the LAD and RCA. In addition, the location of culprit lesions was related to infarct size. Therefore, knowledge of the distribution of vulnerable lesions is important for identifying patients at risk for acute coronary events**.**

Introduction

Acute coronary syndromes are primarily due to rupture of an atheromatous plaque with superimposed thrombosis. Therefore, identification of vulnerable lesions which are prone to rupture is important and has been studied extensively. Previous studies have particularly focused on characteristic histomorphologic features of vulnerable lesions[1 2] Besides in the setting of randomized trials, no data have been reported regarding the distribution of culprit lesions among the different coronary arteries in patients presenting with a ST-segment elevation acute myocardial infarction (AMI).[3-5] Furthermore, data about the distribution of culprit lesions within the different segments of the coronary arteries in patients presenting with AMI are scarce.

Accordingly, the aim of the current study was to evaluate the frequency and distribution of culprit lesions within the 3 coronary arteries and within the different segments of the coronary arteries in a large population of patients presenting with ST-segment elevation AMI. In addition, the location of the culprit lesions was related to infarct size as assessed with peak cardiac enzymes and residual left ventricular (LV) systolic function.

Methods

Since February 2004, all patients admitted with ST-segment elevation AMI were identified and included in an ongoing registry (MISSION!).[6] The diagnosis ST-segment elevation AMI was defined based on criteria of typical chest pain, elevated cardiac enzyme levels, and typical changes on the electrocardiogram.[7] All patients underwent immediate coronary angiography to identify the location of the culprit lesion followed by primary percutaneous coronary intervention (PCI). Patient data were prospectively collected in the departmental Cardiology Information System (EPD-Vision®, Leiden University Medical Center, Leiden, the Netherlands) and analyzed retrospectively.[8 9] Standardized angiographic projections were chosen for the visual classification of the coronary artery map into segments according to the guidelines of the American College of Cardiology/American Heart Association.[10 11] The infarct-related vessel was determined on the coronary artery territory subtended by the regions of acute electrocardiographic changes. If the culprit vessel had more than 2 lesions, the most severe proximal stenosis or a stenosis identified with thrombus was considered as the culprit lesion. Patients were not included if no clear culprit

lesion could be identified on coronary angiography. Patients were treated according to the institutional AMI protocol, which includes 2-dimensional echocardiography performed within 48 hours of admission to assess residual LV function using LV ejection fraction calculated by the biplane Simpson's technique from the apical 2- and 4-chamber views.[6 12] Continuous data are presented as mean ± standard deviation and categorical data are presented as frequencies and percentages. Differences in baseline characteristics between the 3 coronary arteries or the different segments of the coronary arteries were evaluated with 1-way analysis of variance or chi-square test, as appropriate. Of note, patients with a bypass graft identified as culprit vessel were not included in these analyses. Post-hoc comparisons were performed using the Bonferroni adjustments for multiple comparisons. For all tests, a p value <0.05 was considered statistically significant.

Results

A total of 1533 consecutive patients were evaluated. Mean age of the patient population was 61.3 ± 12.2 years and mean LV ejection fraction was 45.8 ± 8.6% (Table 1). Before primary PCI, mean TIMI flow of all patients was 0.6 ± 1.0. Among the 1533 culprit lesions studied, the majority of the patients showed a 100% stenosis (1013 patients, 66%) or 99% stenosis (279 patients, 18%). Only 6 (0.4%) patients showed a culprit lesion with 50% stenosis, 78 (5%) patients with 75% stenosis and 157 (10%) patients with 90% stenosis as determined by semiquantitative grading.

Table 2 shows the distribution of the culprit lesions. The majority of the culprit lesions were located in the left anterior descending coronary artery (LAD, 668 patients, 45%) and the right coronary artery (RCA, 588 patients, 38%) and only a small number of culprit lesions were located in the left circumflex coronary artery (LCX, 214 patients, 14%). Culprit lesions were not uniformly distributed, but tended to be clustered in the proximal or mid vessel segments. In addition, a relatively high percentage was located in the first obtuse marginal branch (41 patients, 19% of all LCX lesions). No differences in baseline characteristics were observed between lesion localization within the coronary arteries except for prior myocardial infarction. Patients with prior myocardial infarction more often had the culprit lesion located in the distal part of the coronary artery compared to the mid and proximal parts (17% vs. 7% and 8%, respectively, $p = 0.002$).

Table 1. Baseline characteristics of the patient population

	All patients (N = 1533)
Clinical characteristics	
Age (years)	61.3 ± 12.2
Male gender	1158 (76%)
Medical History	
Current smoking	715 (47%)
Diabetes	182 (12%)
Family history of coronary artery disease	618 (40%)
Hyperlipidemia	299 (20%)
Hypertension	533 (35%)
Prior myocardial infarction	140 (9%)
Infarct size	
Peak creatine phosphokinase level (U/l)	2229 ± 2890
Peak cardiac troponin T level (µg/l)	5.9 ± 6.5
TIMI flow pre-intervention	0.6 ± 1.0
Final TIMI flow	2.9 ± 0.4
Percentage diameter stenosis (%)	97 ± 7
Multivessel disease	718 (54%)
Left ventricular ejection fraction (%)	45.8 ± 8.6

TIMI: Thrombolysis in myocardial infarction.

Infarct size was assessed with peak cardiac enzymes (peak creatine phosphokinase (CPK) level and peak cardiac troponin T (cTnT) level) and residual LV function. Both peak CPK level and peak cTnT level were significantly lower in patients with a RCA culprit lesion compared to patients with a LAD culprit lesion (1634 ± 3424 U/l vs. 2674 ± 2565 U/l, p <0.001 and 4.0 ± 4.2 µg/l vs. 7.2 ± 7.4 µg/l, p <0.001, respectively) or a LCX culprit lesion (1634 ± 3424 U/l vs. 2282 ± 1830 U/l, p = 0.02 and 4.0 ± 4.2 µg/l vs. 6.0 ± 5.3 µg/l, p <0.001, respectively). No significant differences in peak cardiac enzymes were observed between patients with a LAD and LCX infarction. In addition, the level of peak cardiac enzymes was evaluated for the proximal, mid and distal segments of the coronary arteries. The RCA and LCX demonstrated no significant differences for the proximal, mid or distal culprit lesions (RCA: p = 0.71 and p = 0.37 and LCX: p = 0.11 and p = 0.07 for peak CPK level and peak cTnT level, respectively).

Table 2. Distribution of culprit lesions

Vessel segment	*Number of lesions*	*LV ejection fraction (%)*
Left main (segment 11)	16 (1%)	37.1 ± 8.1
Ramus intermedius (segment 28)	15 (1%)	47.9 ± 7.5
LAD	688 (45%)	44.6 ± 8.9
Proximal (segment 12)	401 (58%)	43.7 ± 8.8
Mid (segment 13)	243 (35%)	45.5 ± 8.9
Distal (segment 14)	20 (3%)	45.6 ± 11.2
Diagonal 1 branch (segment 15)	23 (3%)	50.5 ± 7.3
Diagonal 2 branches (segment 16)	1 (0.1%)	48.0 ± 0
RCA	588 (38%)	46.8 ± 8.2
Proximal (segment 1)	249 (42%)	46.2 ± 8.4
Mid (segment 2)	218 (37%)	47.2 ± 7.7
Distal (segment 3)	96 (16%)	47.2 ± 8.0
Posterior descending (segment 4)	14 (2%)	48.7 ± 11.2
Posterior lateral (segment 6)	11 (2%)	43.8 ± 9.3
LCX	214 (14%)	47.4 ± 7.8
Proximal (segment 18)	82 (38%)	45.1 ± 8.7
Mid (segment 19)	81 (38%)	48.8 ± 6.9
Distal segment 19a)	3 (1%)	47.7 ± 2.9
Obtuse marginal 1 (segment 20)	41 (19%)	48.9 ± 7.0
Obtuse marginal 2 (segment 21)	7 (3%)	49.4 ± 7.3
Bypass graft	12 (0.8%)	44.3 ± 8.6

LAD: left anterior descending coronary artery; LCX: left circumflex artery; RCA: right coronary artery and LV: left ventricular.

However, LAD proximal culprit lesions resulted in significant higher peak cardiac enzymes compared to lesions in the mid part (3192 ± 2886 U/l vs. 2092 ± 1885 U/l, p <0.001 and 8.4 ± 8.0 µg/l vs. 5.8 ± 6.5 µg /l, p <0.001) or the distal part of the LAD (3192 ± 2886 U/l vs. 1261 ± 1219 U/l, p = 0.005 and 8.4 ± 8.0 µg/l vs. 4.0 ± 4.2 µg/l, p = 0.04).
Residual LV function assessed with LV ejection fraction differed significantly between patients with different culprit vessels (ANOVA p <0.001) (Table 1). Post-hoc analysis demonstrated that patients with the LAD as culprit vessel had significantly lower LV ejection fraction as compared to patients with the RCA or LCX as culprit vessel (44.6 ±

8.9% vs. 46.8 ± 8.2%, p <0.001 and 44.6 ± 8.9% vs. 47.4 ± 7.8%, p = 0.001, respectively). Further subanalysis of the different segments per culprit vessel revealed that patients with proximal culprit lesions in the LAD and LCX had significantly worse LV function compared to patients with mid and distal lesions (43.7 ± 8.8% vs. 45.5 ± 8.9% and 45.6 ± 11.2%, p = 0.04 for proximal, mid and distal LAD lesions and 45.1 ± 8.7% vs. 48.8 ± 6.9% and 47.7 ± 2.9%, p = 0.02 for proximal, mid and distal LCX lesions). However, no differences in LV function were observed for the different locations of culprit lesions in the RCA (p = 0.37).

Discussion

Patients with ST-segment elevation AMI treated with primary PCI were more likely to have a LAD or RCA culprit lesion than a LCX culprit lesion. However, infarct size assessed with peak cardiac enzymes demonstrated no significant differences between LAD and LCX infarctions, whereas RCA infarctions were significantly smaller. In addition, patients with proximal lesions in the LAD or LCX demonstrated worse LV function as compared to patients with lesions in the mid and distal parts, whereas no significant difference was observed between patients with proximal, mid or distal occlusions of the RCA.

The results of the present study provide further evidence for what has been described in smaller populations.[11] Wang et al. determined the location of coronary lesions in 208 consecutive patients with ST-segment elevation AMI.[11 13] The authors showed that culprit lesions tended to cluster within the proximal third of the coronary vessels. However, the distance from the ostium to the lesion depended upon which coronary artery was involved. Gibson et al. described that median distances from the ostium to the culprit lesion differed according to the coronary artery and the distance was the smallest in the LAD, followed by the LCX and the RCA.[13] Interestingly, the same phenomenon has been observed in a large population of 30,386 patients with non-ST elevation AMI undergoing PCI described by Dixon et al, and thus, the current findings may be generalized for all culprit lesions including those of patients with unstable angina.[14]

Although information about the distribution of culprit lesions is important, understanding why plaque ruptures are less likely to occur in the LCX and why proximal occlusions are more prone to rupture remains challenging. To some extent, these observations may be

explained by the fact that ischemic events of the LCX artery are underdiagnosed due to limited sensitivity of the 12-lead ECG for detection of ischemia on the lateral and posterior walls.[15 16] Previous studies have reported that only 33% of patients with a LCX occlusion present with ST-segment elevation on the ECG.[17] Recently, From et al. confirmed this hypothesis by demonstrating that in a group of 1500 patients with ST-segment elevation and non-ST-segment elevation AMI, patients with a LCX occlusion were less likely to present with ST-segment elevation on ECG and were referred less frequently for primary PCI.[15] However, among the group of patients presenting with non-ST-segment elevation AMI, patients with a LCX occlusion had the highest peak enzymes. Another explanation for the lower frequency of culprit lesions observed in the LCX may be the greater variation in anatomy as compared to the LAD and RCA. In a large proportion of the population, the LCX is relatively small with few pronounced side-branches, which may also explain why patients with an occlusion of the LCX may be more likely to present with a non-ST-segment elevation AMI or without any changes on the ECG.[15 17] Moreover, since vessel diameter plays an important role in the development of atherosclerosis, it is conceivable that as a consequence also plaque rupture may differ among the coronary arteries. The anatomy of the LCX may result in lower wall shear stress, whereas proximal segments of the coronary arteries conversely may be areas of high shear stress which determine the risk of plaque rupture. Finally, although the present study is the first to describe the distribution of culprit lesions in a large population of ST-segment elevation AMI outside a randomized setting, previous clinical trials have reported that the LAD and RCA are more frequently identified as the culprit vessel as compared with the LCX[3-5]. Therefore, the main limitation of the current study is that the results are mostly confirmatory of what has been previously described in randomized trials.[3-5]

Conclusions

The present study demonstrates that plaque rupture resulting in ST-segment elevation AMI is more likely to occur in the proximal parts of the LAD and RCA. In addition, the location of the culprit lesions in the different coronary arteries was related to infarct size. Therefore, knowledge of the distribution of vulnerable lesions is important for the identification of patients at risk for acute coronary events.

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