Prognostic value of coronary anatomy and myocardial innervation imaging in cardiac disease

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Chapter 4

Relation between coronary arterial dominance and left ventricular ejection fraction after ST-segment elevation acute myocardial infarction in patients having percutaneous coronary intervention.

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ABSTRACT

Aim:

The presence of a left dominant coronary artery system is associated with worse outcome after ST-elevation myocardial infarction (STEMI) compared with right dominance or a balanced coronary artery system. However, the association between coronary arterial dominance and left ventricular (LV) function at follow-up after STEMI is unclear. The present study aimed at evaluating the relation between coronary arterial dominance and LV ejection fraction (LVEF) shortly after STEMI and at 12 months follow-up.

Methods:

A total of 741 STEMI patients (mean age 60±11 years and 77% men) were evaluated with 2-dimentional echocardiography within 48 hours of admission (baseline) and at 12 months follow-up post-STEMI. Coronary arterial dominance was assessed on the angiographic images obtained during primary percutaneous coronary intervention.

Results:

A right, left and balanced dominant coronary artery system was noted in 640 (86%), 58 (8%) and 43 (6%) patients, respectively. At baseline, significant difference in LV function was observed, with slightly lower LVEF in patients with a left dominant coronary artery system (LVEF 45 ± 8% vs. 48 ± 9% and 50 ± 9%, for left dominant, right dominant and balanced coronary artery system respectively, $P = 0.03$). However, at 12 months follow-up no differences in LV function or volumes were observed between the different coronary arterial dominance groups.

Conclusion:

In conclusion, patients with a left dominant coronary artery system had lower LVEF early after STEMI. At 12 months follow-up, differences in LVEF were no longer present between the different coronary arterial dominance groups.

INTRODUCTION

Left ventricular (LV) systolic dysfunction and remodeling have been strongly associated with short- and long-term outcomes of patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PCI).[1, 2] Independent correlates of LV systolic dysfunction and remodeling after STEMI include infarct size, heart rate, and severity of coronary artery disease.[3-6] The effect of coronary arterial dominance on LV dysfunction and remodeling at follow-up is unclear. A left dominant system, defined by the posterior descending artery raising from the left circumflex (LCx) artery, increases by approximately 13% the odds in all-cause mortality after PCI.[7] To obtain more insight into the relation between coronary arterial dominance and LV function, the present study aimed at evaluating the relation between coronary arterial dominance and LV function shortly after the index infarction and at 12 months follow-up.

METHODS

The present study population includes patients from an original cohort of patients with STEMI previously published.[8] From 1,131 patients with a first STEMI who were admitted at the Leiden University Medical Center (Leiden, The Netherlands) from 2004 to 2008, 741 patients with completed echocardiographic examination at baseline (within 48 hours of admission) and at 12-months follow-up were included in the analysis (Figure 1).

The diagnosis of STEMI was defined based on criteria of typical chest pain, elevated cardiac enzyme levels, and typical changes on the electrocardiogram.[9] All patients were treated according to the institutional STEMI protocol,[10] which includes primary PCI and optimal medical therapy initiated early during hospitalization. Circulating levels of creatine kinase and cardiac troponin T were systematically measured every 6 hours after primary PCI, until the highest levels were reached. Routine 2-dimensional echocardiography was performed within 48 hours of admission (baseline) and repeated at 12 months follow-up. The association between coronary arterial dominance, assessed during admission coronary angiography, and changes in LV volumes and ejection fraction at 12 months follow-up was evaluated.

Demographic, clinical, angiographic and echocardiographic data were prospectively collected in the departmental Cardiology Information System (EPD-Vision, Leiden University Medical Center, Leiden, the Netherlands) and retrospectively analyzed.

The digitally stored images of the coronary angiography and PCI were obtained according to standardized angiographic projections.[11] All coronary angiographic images of the primary PCI were retrospectively reviewed by 2 experienced observers. As previously described, coronary arterial dominance was defined according to the following defini-

tion: a coronary artery system was classified as right dominant if the posterior descending artery (PDA) and posterolateral branch originated from the right coronary artery (RCA), left dominant if the PDA and the posterolateral branch originated from the LCx and balanced if the PDA originated from the RCA in combination with posterolateral branches originating from the LCx artery.[12, 13] The extent of CAD was expressed as the presence of 1-, 2- or 3-vessel disease (stenosis causing ≥50% luminal narrowing).

Images were obtained at rest with the patient in the left lateral decubitus position using a commercially available system (Vivid 7 and E9 [General Electric-Vingmed, Horten, Norway]). Data acquisition was performed with 3.5 MHz or M5S transducers in the standard parasternal and apical views. M-mode, 2-dimensional, and Doppler images were acquired during breath hold and saved in cine-loop format. Data analysis was performed offline with commercially available post-processing data software, EchoPac 112.0.1 (GE Medical Systems, Horten, Norway).

LV function was assessed by tracing the LV end-systolic volume and end-diastolic volume in the apical 4- and 2-chamber views. Using the biplane Simpson's method LV ejection fraction (LVEF) was calculated.[14] Subsequently, the LV was divided into 16 segments to calculate the wall motion score index (WMSI). Every segment was individually assessed and scored based on its motion and systolic thickening ([1] normokinesia, [2] hypokinesia, [3] akinesia, [4] dyskinesia). WMSI was calculated as the sum of the segment scores divided by the number of segments scored.[14]

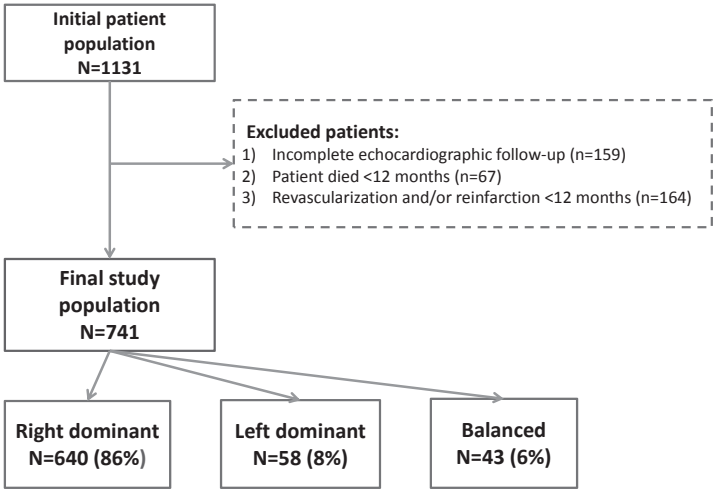

Figure 1. Patient population
Of the 1,131 patients with first STEMI of the initial patient population, 741 were finally included in the study population. The proportion of excluded patients and the reasons for exclusion did not significantly differ between different coronary arterial dominance groups (data not shown).

The continuous variables are presented as mean ± SD or as median and interquartile ranges. Categorical variables are presented as number and percentages. Differences in baseline characteristics between the 3 coronary arterial dominance groups (right dominance, left dominance and balanced) were evaluated with the chi-square and 1-way analysis of variance tests with Bonferroni post hoc analysis for significant 1-way analysis of variance p values. Changes in LV volumes and LVEF from baseline to 12-month follow-up were evaluated using linear mixed model analyses. Subsequently, mixed-effects modeling approach was used to compare differences in LV volumes and LVEF among the 3 coronary arterial dominance groups from baseline to 12-month follow-up (group-time interaction). Differences within groups at baseline and at 12 months follow-up were assessed by 1-way analysis of variance. Statistical analysis was performed using SPSS software version 20.0 (SPSS, Inc., Chicago, Illinois). A p value <0.05, by a 2-sided test, was considered statistically significant.

RESULTS

A total of 741 patients with baseline and 12-month follow-up echocardiography were included. A right dominant coronary artery system was noted in 640 patients (86%), 58 patients (8%) had a left dominant coronary artery system and 43 patients (6%) a balanced coronary artery system. Baseline characteristics and angiographic data of the patient cohort, categorized by coronary arterial dominance, are presented in Table 1. Mean age was 60 ± 11 years and most patients were men (n = 568, 77%). Overall, baseline characteristics were similar between coronary arterial dominance groups. In addition, in patients with a right dominant coronary artery system the RCA was more often the culprit vessel than in patients with a left dominant or balanced coronary artery system (P<0.01). On the contrary, in patients with a left dominant system, the left anterior descending (LAD) artery and LCx artery were more frequently affected than in patients with a right dominant system (P<0.01 and P=0.02 for the LAD and LCx artery, respectively). Only 10% of the total patient population showed 3-vessel disease. Patients with a balanced coronary artery system had a higher prevalence of 3-vessel disease compared with patients with a right or left dominant coronary artery system (21% vs. 10% and 5%, respectively, P=0.02).

Table 2 lists the comparison of LV function and volumes at baseline and 12-month follow-up between patients with right dominant, left dominant and balanced coronary artery system. At baseline, patients with a left dominant coronary artery system showed significantly lower LVEF compared with patients with a right dominant or balanced coronary artery system (LVEF 45 ± 8% vs. 48 ± 9% and 50 ± 9% for left dominant, right dominant and balanced coronary artery system, respectively, P = 0.03). This difference among groups was mainly based on the difference between patients with a left dominant and a balanced

coronary artery system (P = 0.025). However, at 12 months follow-up, no differences in LVEF or LV volumes were observed between the different coronary arterial dominance groups (Table 2). Similar improvement in LVEF and WMSI was noted between patients with a right dominant, left dominant and balanced coronary artery system (group-time interaction P = 0.181 and P=0.355 for LVEF and WMSI, respectively; Figure 2). Although LV end-systolic volume significantly decreased at 12-month follow-up in patients with a right and left dominant coronary artery system (Table 2), the linear mixed model analysis indicated that changes in LV end-systolic volume did not differ between groups (P=0.073, Figure 2C). In addition, the within group analysis showed that patients with a right dominant system had a significant increase in LV end-diastolic volume at 12-month follow-up, whereas, in patients with a left dominant or balanced system no change was noted (Table 2). However, the linear mixed model analysis showed no significant changes in LV end-diastolic volume over time between coronary arterial dominance groups (P = 0.106, Figure 2D).

Table 1. Baseline characteristics

Variable	Total (n=741)	Right dominant (n=640)	Left dominant (n=58)	Balanced (n=43)	P-value
Men	568 (77%)	494 (77%)	41 (71%)	33 (77%)	0.53
Age (years)	60 ± 11	60 ± 11	60 ± 10	59 ± 10	0.88
Diabetes mellitus	67 (9%)	55 (9%)	6 (10%)	6 (14%)	0.46
Hypercholesterolemia*	126 (17%)	108 (17%)	10 (17%)	8 (19%)	0.96
Hypertension†	224 (30%)	186 (29%)	25 (43%)	13 (30%)	0.08
Current smoker	365 (49%)	310 (48%)	31 (53%)	24 (56%)	0.52
Glomerular filtration rate (mL/min/1.73m^2)	102 ± 32	102 ± 33	103 ± 31	105 ± 27	0.80
Glomerular filtration rate ≤60 mL/min/1.73m^2	61 (8%)	57 (9%)	2 (3%)	2 (5%)	0.24
Peak cardiac troponin T level (µg/L)	5.8 ± 5.8	5.7 ± 5.8	5.6 ± 5.5	6.4 ± 6.3	0.77
Peak cardiac troponin T level ≥3.5 µg/L	402 (54%)	346 (54%)	30 (52%)	26 (61%)	0.66
Presenting in Killip class≥2 during STEMI	26 (4%)	21 (3%)	2 (3%)	3 (4%)	0.44
Culprit coronary artery					
Left main artery	1 (0.1%)	1 (0.2%)	0 (0%)	0 (0%)	0.92
Right coronary artery	280 (38%)	268 (42%)	0 (0%)	12 (28%)	<0.01
Left anterior descending artery	346 (47%)	282 (44%)	43 (74%)	21 (49%)	<0.01
Left circumflex artery	114 (15%)	89 (14%)	15 (26%)	10 (23%)	0.02
No. of coronary arteries narrowed:					
1	458 (62%)	393 (61%)	42 (72%)	23 (54%)	0.52
2	210 (28%)	186 (29%)	13 (22%)	11 (26%)	0.13
3	73 (10%)	61 (10%)	3 (5%)	9 (21%)	0.02

*Serum total cholesterol ≥230 mg/dl and/or serum triglycerides ≥200 mg/dl or treatment with lipid lowering drugs.

†Defined as systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg and/or the use of antihypertensive medication.

Table 2. Left ventricular function and volumes at discharge and 12-months follow-up according to coronary arterial dominance

Variable	Right dominant (n=640)	Left dominant (n=58)	Balanced (n=43)	P-value
Discharge echocardiography				
Left ventricular end-systolic volume (mL)	55 ± 21	59 ± 21	50 ± 21	0.10
Left ventricular end-diastolic volume (mL)	104 ± 33	107 ± 31	98 ± 31	0.35
Left ventricular ejection fraction (%)	48 ± 9	45 ± 8	50 ± 9	0.03*
Wall motion score index	1.47 ± 0.30	1.51 ± 0.28	1.48 ± 0.29	0.60
12-month follow-up echocardiography				
Left ventricular end-systolic volume (mL)	51 ± 25†	51 ± 28†	51 ± 31	0.97
Left ventricular end-diastolic volume (mL)	109 ± 36†	104 ± 34	105 ± 39	0.49
Left ventricular ejection fraction (%)	54 ± 10†	53 ± 11†	54 ± 11†	0.67
Wall motion score index	1.26 ± 0.32†	1.24 ± 0.31†	1.27 ± 0.34†	0.87

* The difference between groups is based on the difference between patients with a left dominant and a balanced coronary artery system (P=0.025), as is shown with Bonferonni correction.
† P<0.01 for change over time: baseline vs. 12-months follow-up.

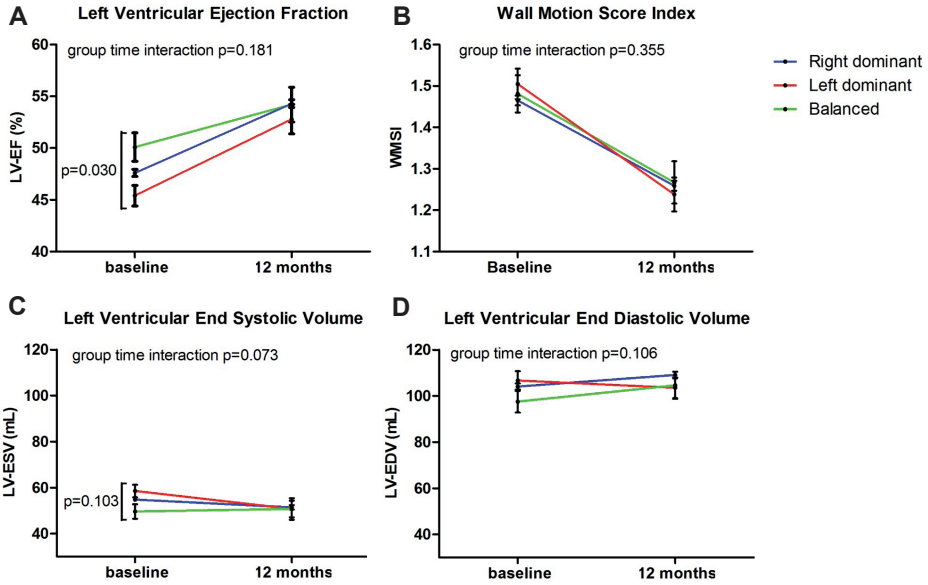

Figure 2. Change in left ventricular function and volumes over time in the 3 different coronary arterial dominance groups.
Similar improvement in LVEF and WMSI was noted among patients with a right dominant, left dominant and balanced coronary artery system (*A* and *B*). In addition, the decrease in LV end-systolic volume during the 12-month follow-up did not differ among groups €. Moreover, linear mixed model analysis showed no significant changes in LV end-diastolic volume over time between coronary arterial dominance groups (*D*).

DISCUSSION

The present study demonstrated a significant difference in LV function shortly after STEMI among different coronary arterial dominance groups, with slightly lower LV ejection fraction in patients with a left dominant coronary artery system. Furthermore, an overall improvement of LV function was observed during the first year after STEMI, independent of coronary arterial dominance. At 12-month follow-up after STEMI, LV function was comparable between the 3 coronary arterial dominance groups.

Previous literature has shown the prognostic importance of coronary arterial dominance with worse outcome in patients with a left dominant coronary system after PCI[7, 15]. In addition, a more recent investigation by our group showed an increase in 30-day mortality after STEMI in patients with a left dominant coronary artery system[8].

LV function is one of the most important parameters determining long-term survival after acute infarction.[16-18] However, the influence of coronary arterial dominance on LV function in patients with STEMI was unclear. The similar LVEF at 12 months among patients with different coronary arterial dominance is not surprising because final infarct size (as estimated by cardiac enzymes) was similar among the different groups, and infarct size is the main determinant of LVEF late after infarction.[18] The difference in LVEF measured acutely after infarction among the coronary arterial dominance groups however, is of interest. The reduced LV function acutely after infarction is related to the combination of necrosis and stunning. Particularly, occlusion of the LAD coronary artery results in a larger area of stunning as compared to RCA or LCx coronary artery occlusions.[19] A left dominant coronary artery system may be a less well-balanced circulation than the other systems resulting in a larger area of myocardium at risk during acute coronary syndromes. Furthermore, in the present study, patients with a left dominant coronary artery system had higher frequency of LAD STEMI as compared with the other subgroups. This may lead to larger areas of stunning early after STEMI and lower LVEF compared to their counterparts.

Parikh et al also showed in a recent registry including 207,926 patients with an acute coronary syndrome that among patients with a left dominant system, the culprit lesion was more frequently observed in the LAD.[15] Because the RCA is not likely to be the culprit in patients with STEMI with left dominance, the distribution of the culprit lesions shifts towards the LAD and LCx artery in these patients. The greater prevalence of LAD artery infarctions in patients with left dominant coronary artery system may have resulted in larger areas of stunning, resulting in the lower LVEF in the patients with a left dominant coronary system. LV dysfunction caused by stunning is (partially) reversible, and it is of interest to note that despite the differences in LVEF acutely after infarction, the LVEF at 12 months post-infarction is the same in the different coronary arterial dominance groups. This suggests that more improvement in function occurs in the patients with a left dominant coronary system.

Several limitations should be acknowledged. The present evaluation included patients who had complete echocardiographic follow-up (at baseline and 12-month). Patients with prior myocardial infarction or revascularization and patients who experienced repeat acute coronary syndrome or died during follow-up were excluded. Therefore, the present study population may represent a relatively low-risk population. Accordingly, the influence of coronary arterial dominance on LV function after STEMI in patients with more severe coronary artery disease and possibly more associated comorbidities remains to be determined. Furthermore, imaging data on precise infarct size and area of stunned myocardium, which can be measured with contrast-enhanced magnetic resonance imaging, were not available. This information would have been important to further explore the relation between stunning, infarct size, coronary artery dominance and LV function recovery at 12 months follow-up.

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