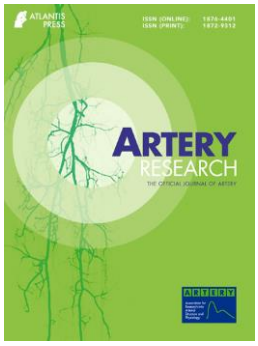

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Collaterals in right and left coronary dominance

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KEYWORDS
Collaterals;
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Rentrop score;
Outcome

Abstract *Background:* Collateral coronary flow may protect patients against myocardial ischemia. There is no data regarding the difference in collateral development in relationship to coronary dominance and potential influence on outcome. We aimed to investigate whether there is a relationship between coronary dominance, collateral development and influence on outcome.
Methods: The study population comprised all patients with single vessel disease and right or left coronary dominance (RD or LD), with a proximal stenosis above 90%. Demographic, clinical and angiographic data were compared in patients with RD and LD, as well as outcome.
Results: More patients with ST elevation myocardial infarction (STEMI) and RD demonstrated collaterals compared to LD (51% vs. 26%, $p = 0.042$) and had a higher Rentrop score (1.5 ± 0.6 vs. 1.0 ± 0, $p < 0.05$). Fewer patients died in the RD group (9% vs. 26% in the LD group, $p = 0.018$). In patients without STEMI, there was a tendency to more collateral development in the RD group (although this difference became significant in patients with totally occluded vessels 80% in RD vs. 57% in LD, $p < 0.05$). In addition, in this group of patients without STEMI, (as in the STEMI group), there were fewer deaths in the RD group over the study period (6% vs 18% in the LD group, $p < 0.01$).
Conclusions: Patients with single vessel disease and RD develop more collaterals than those with LD, and have a better outcome. In addition, in individuals with STEMI and single vessel disease with collaterals, those with RD have a higher Rentrop score.

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Introduction

Collateral vessels develop as a result of compromise of flow in the native epicardial coronary arteries. The significance of collateral flow has been studied mainly in patients with myocardial infarction (MI).[1,2] Collateral flow can protect patients against myocardial ischemia.[3] We have previously described data regarding the source of collaterals in severe coronary artery disease.[4]

The term "coronary dominance" in relation to coronary anatomy describes which of the right coronary artery (RCA) or left circumflex artery (LCX) reaches the crux of the heart and supplies the posterior descending artery (PDA) and posterolateral branches.[5] Left dominance (LD) has a prevalence of about 7%–8% in the general population.

LD has recently been identified as an independent predictor of non-fatal MI and all-cause mortality, especially in patients with significant coronary artery disease (CAD).[6]

Since coronary collaterals can protect against myocardial ischemia and patients with LD who have severe CAD may have a worse outcome compared to RD, we investigated whether collaterals differ in patients with RD or LD and whether there is any influence on outcome.

Methods

We retrospectively analyzed our computerized data base from January 2002 to August 2012. All patients with single vessel disease and RD or LD, having a stenosis of over 90% in the proximal segment, were included in the study. All angiograms were reviewed by two experienced interventional cardiologists to ascertain coronary dominance, presence of collaterals and Rentrop grade:[7] (0, no visible filling of any collateral channels; 1, collateral filling of branches of the stenosed/occluded artery without any dye reaching the epicardial segment of that vessel; 2, partial collateral filling of the epicardial vessel; or 3, complete collateral filling of the vessel). Collaterals from the RCA to the left coronary artery were assessed mainly in the cranial right anterior oblique projection and collaterals from the left coronary artery to the RCA were assessed in the cranial left anterior oblique projection. Consensus over the angiographic data was obtained in all cases.

The patients were divided into two groups according to their dominance. Since the collateral circulation is not always expressed fully in patients with STEMI, who are catheterized immediately on arrival, we further subdivided these two groups into those with and without STEMI. Demographic data collected included: age, sex, presence of hypertension, diabetes, smoking and dyslipidaemia. The duration of follow-up in each group was recorded as well as the left ventricular ejection fraction (LVEF) on admission echocardiography (echo) and on the first echo performed after discharge (in all groups). Reason for cardiac readmission was recorded up to one year following original hospitalization. In patients with STEMI, pain to balloon time and thrombolysis in myocardial infarction (TIMI) flow on initial angiography were also recorded. We further divided these patients into those with pain to balloon time of less or more than 3 h.

Statistical analysis

Continuous variables were analyzed with independent samples 2-tailed *t* test. Categorical variables were analyzed using the chi-square test. A $P < 0.05$ was defined as significant. The statistical analysis was performed with the SPSS software (version 18, SPSS Inc., Chicago, IL, USA).

Results

During the study period, 27,377 patients underwent coronary angiography. Four hundred and thirty-eight patients were found to have isolated single vessel disease with RD or LD, with a stenosis of over 90% in the proximal segment and these constituted the study group. Patients with a codominant circulation were excluded. Of the study group, 180 patients underwent primary percutaneous coronary intervention (PPCI) for STEMI and the remaining 258 patients were catheterized for other indications (acute coronary syndromes excluding STEMI and stable angina pectoris).

STEMI patients

Among the 180 STEMI patients, 161 (89%) had RD and the remainder (19 patients, 11%) had LD.

In STEMI patients, regarding demographic data, the only difference between RD and LD was the occurrence of diabetes more frequently in RD (37% vs. 17%, $p = 0.03$) (Table 1).

Although there was no difference regarding pain to balloon times between RD and LD, more patients with a pain to balloon time of over 3 h were found in the LD group (85% vs. 52%, $p = 0.025$) (Table 1).

The RCA was found to be the culprit artery more frequently in RD, while the left anterior descending artery (LAD) was more frequent in LD (Table 1).

The TIMI flow in the culprit artery did not differ between the two groups of dominance (Table 1).

The presence of collaterals was more frequently found in the RD group (51% vs. 26% in the LD group, $p = 0.042$). This finding was also observed in patients with a totally occluded vessel (60% vs. 31% in the LD group, $p = 0.04$).

In RD, the LAD was more frequently the origin of collaterals while in LD, the LCX was the commonest origin of collaterals ($p < 0.01$) (Table 1).

The mean Rentrop score in patients with collaterals was higher in RD compared to LD (1.5 ± 0.6 vs. 1.0 ± 0, $p < 0.05$).

There was no difference between RD and LD regarding the initial TIMI flow and the presence of total occlusion.

Over the study period, fifteen patients (9%) of the group with RD died, and five patients (26%) in the LD group died, ($p = 0.018$). In the RD group, 9 died from cardiac death (60%), and in the LD group, 3 died from cardiac death (60%). Of the RD patients who died, 11 (73%) had either no collaterals or Rentrop score 1. All of the LD patients who died had no collaterals demonstrated on catheterization.

Mean follow-up time amongst the RD patients was 4.7 ± 3 years vs. 5.6 ± 4 in the LD patients ($p = 0.2$). LVEF on admission was found to be $46 \pm 9\%$ in the RD group, vs. $41 \pm 10\%$ in the LD group ($p = 0.02$). Follow-up echo

Table 1 Baseline, clinical and angiographic characteristics — STEMI patients.

		Right dominance ($n = 161$)	Left Dominance ($n = 19$)	*P* value
Baseline and clinical characteristics				
Age (years ± SD)		55 ± 13	55 ± 14	0.97
Male gender *n*, (%)		122(76)	17 (89)	0.85
Dyslipidemia *n*, (%)		108 (67)	10 (53)	0.42
Smoking *n*, (%)		122(76)	14 (74)	0.84
Hypertension *n*, (%)		47 (33)	10 (53)	0.11
Diabetes mellitus *n*, (%)		27 (17)	7 (37)	0.03
Pain to Balloon (min ± SD)		327 ± 602	389 ± 325	0.71
Pain to Balloon >3h (%)		84 (52)	16 (85)	0.025
Angiographic characteristics				
Culprit artery (%)	LAD	29	63	<0.001
	RCA	62	11	
	LCX	9	26	
Collaterals (%)		51	26	0.042
Origin of collaterals (%)	LAD	73	20	<0.001
	RCA	16	20	
	LCX	11	60	
Rentrop score (%)	1	52	100	<0.001
	2	43	0	
	3	5	0	
Rentrop score (mean ± SD)		1.5 ± 0.6	1 ± 0	<0.05
Initial TIMI flow (%)	0	73	68	0.75
	1	5	11	
	2	14	16	
	3	8	5	
Patients with total occlusion (%)		122 (76)	14(73)	0.97

demonstrated LVEF of 48 ± 11% in the RD group, vs. 45 ± 13% in the LD group ($p = 0.59$).

At one year of follow-up, 25 of the RD patients were rehospitalized for cardiac reasons (16%): 12 for STEMI, 8 for unstable angina pectoris, 3 for heart failure and 2 for non-ST elevation myocardial infarction (NSTEMI). In the LD group, 6 were readmitted over 1 year (32%): 3 for STEMI, 2 for arrhythmias and 1 for NSTEMI.

Patients without STEMI

Among the 258 patients without STEMI, 214 (83%) had RD and the remainder (44 patients, 17%) had LD.

There were no differences between the RD and LD groups regarding demographic data, although there was a tendency to more smoking in the RD group (58% vs. 43% in the LD group, $p = 0.06$) (Table 2).

There were no differences between the RD and LD groups regarding the culprit artery and source of collaterals. There was a tendency to more collaterals in RD (37% vs. 23%, $p = 0.06$). However, in patients with totally occluded vessels, there was a significant difference (80% in RD vs. 57% in LD, $p < 0.05$) (Table 2).

Table 2 Baseline, clinical and angiographic characteristics — patients without STEMI.

		Right dominance ($n = 214$)	Left dominance ($n = 44$)	*P* value
Baseline and clinical characteristics				
Age (years ± SD)		60 ± 12	61 ± 14	0.70
Male gender *n*, (%)		159 (74)	32 (73)	0.84
Dyslipidemia *n*, (%)		152 (71)	32 (73)	0.82
Smoking *n*, (%)		124 (58)	19 (43)	0.06
Hypertension *n*, (%)		109 (51)	18 (41)	0.22
Diabetes mellitus *n*, (%)		64 (30)	10 (23)	0.34
Angiographic characteristics				
Culprit artery (%)	LAD	33	41	0.57
	RCA	25	23	
	LCX	42	36	
Collaterals (%)		37	23	0.06
Origin of collaterals (%)	LAD	16	6	0.26
	RCA	38	40	
	LCX	54	31	
Rentrop score (%)	1	28	10	<0.01
	2	30	80	
	3	42	10	
Rentrop score (mean ± SD)		2.2 ± 0.8	2 ± 0.4	0.82
Patients with total occlusion (%)		77(36)	14 (32)	0.84

The mean Rentrop score did not differ between both dominances.

Over the study period, twelve patients (6%) of the group with RD died, and eight patients (18%) in the LD group died ($p < 0.01$). In the RD group, 7 died from cardiac death (58%), and in the LD group, 6 died from cardiac death (75%). Of the RD patients who died, 9 (75%) had either no collaterals or Rentrop score 1. Of the LD patients who died, 9 (82%) had no collaterals demonstrated on catheterization.

Mean follow-up time amongst the RD patients was 5.1 ± 3 years vs. 5.8 ± 3.5 in the LD patients ($p = 0.17$). LVEF on admission was found to be 51 ± 9% in the RD group, vs. 50 ± 11% in the LD group ($p = 0.52$). Follow-up echo demonstrated LVEF of 52 ± 11% in the RD group, vs. 46 ± 15% in the LD group ($p = 0.22$).

At one year of follow-up, 32 of the RD patients were rehospitalized for cardiac reasons (15%): 13 for unstable angina pectoris or chest pain, 7 for STEMI, 7 for NSTEMI, 4 for arrhythmia, and 1 case of sudden death. In the LD group, 6 were readmitted over 1 year (14%): 2 for heart failure, 2 for unstable angina, 1 for STEMI and 1 for NSTEMI.

Discussion

The present study is the first to address the relationship between coronary dominance and the existence of collaterals and outcome.

We investigated only patients with proximal single vessel disease, in order to realize the maximal expression of collateral development, which may be clouded in multivessel disease.

The main finding in our study was that in patients with STEMI, more collaterals were observed at catheterization in patients with RD compared to those with LD. This interesting finding is further strengthened by the fact that more patients in the LD group were catheterized beyond 3 h from pain onset (which should have encouraged the appearance of collaterals). Another important finding was that where the collaterals were demonstrated, the Rentrop grade was higher (i.e. better collateral flow) in RD compared to LD. Another pertinent point is the observation that the LVEF in those with RD was significantly higher than in those with LD. This may be due to better collateral presence in RD or not related. Regardless as to whether or not the lower LVEF in LD is due to poorer collateral presence, this finding is also a contributing factor to the higher mortality in this group.

Except for the study by Veltman et al.,[6] who recently identified LD as an independent predictor of non-fatal MI and all-cause mortality in patients with significant CAD, there is a paucity of data regarding the relevance of coronary dominance in CAD.

We have previously described a poor outcome in patients with STEMI undergoing PPCI due to occlusion of the proximal portion of a dominant LCX.[8] We attributed these findings to the large amount of myocardium supplied by this vessel.

In patients without STEMI, we found a tendency to the same observations, (i.e. more collaterals in RD in comparison to LD). This tendency became significant when looking only at patients with totally occluded vessels. Nevertheless, there was a significantly lower mortality rate in RD patients compared to LD patients, in the whole group of patients without STEMI, hinting at a possible relationship to the presence of collaterals. The fact that there was no significant difference observed in LVEF between RD and LD groups further strengthens this possible relationship.

The reason for the difference in the development of collaterals between RD and LD patients is not known. A possible explanation is that the RCA in general is usually a major recipient and supplier of collaterals.[4] However, in patients with a small non-dominant RCA this may not be the case.

Despite the small numbers involved in the LD groups, a possible clinical implication of these findings may be the need to consider a more invasive strategy in patients with significant coronary disease and LD.

In conclusion, patients with single vessel disease and RD develop more collaterals than those with LD, and have a better outcome. In addition, in individuals with STEMI and single vessel disease with collaterals, those with RD have a higher Rentrop score.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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