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Original article

Coronary anatomy characteristics in patients with isolated right bundle branch block versus subjects with normal surface electrocardiogram

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ABSTRACT

Introduction and objective: Isolated right bundle branch block is a common finding in the general population. It may be associated with variations in detailed coronary anatomy characteristics. The aim of this study was to investigate the coronary anatomy in patients with isolated right bundle branch block and to compare that with normal individuals.
Method: In this case–control study we investigated the coronary anatomy by reviewing angiographic films in two groups of normal coronary artery patients: patients with right bundle branch block (RBBB) ($n = 92$) and those with normal electrocardiograms ($n = 184$).
Results: There was no significant difference between the two groups in terms of diminutive left anterior descending artery, dominancy, number of obtuse marginal artery, diagonal, acute marginal artery, the position of the first septal versus diagonal branch, presence of ramus artery, and size of left main artery. The number of septal branches was higher in the case group (p-value <0.001). Origination of the atrioventricular node artery from the right circulatory system was more common in both groups but cases showed more tendency to follow this pattern (p-value $= 0.021$). The frequency of the normal conus branch was higher in the cases versus controls (p-value $= 0.009$).
Conclusions: Coronary anatomy characteristics are somewhat different in subjects with RBBB compared to normal individuals.

1. Introduction

Isolated right bundle branch block (RBBB) is a common finding in the general population. Hiss et al, in a study of more than 122,000 normal males between 16 and 55 years of age, found an incidence of RBBB of 1.8 per 1000 and it increased with age.[1] RBBB may be associated with structural heart disease, but many subjects with this conduction abnormality have no evidence of an underlying heart disease.[2,3] The blood supply to the proximal part of the right bundle branch is provided by the left anterior descending artery (LAD) or atrioventricular node (AVN) artery and the distal part is mainly supplied by the branches of the LAD.[4] In an extensive internet-based search of medical literature we found no evidence supporting the relationship between the pattern of coronary anatomy and presence of RBBB. Only two small unpowered studies were conducted to evaluate the association between the left main (LM) size and the left bundle branch block.[5,6] Variations in the coronary anatomy was the subject of many studies[7–11]; nevertheless, patients with RBBB were not included in any of these investigations or at least the electrocardiogram was not used as a study material. Moreover, many of the studies on coronary variations were cadaver-based anatomical studies.[12–14] Therefore, the aim of this study was to investigate variations in the coronary anatomy in patients with isolated RBBB and to compare them with those in individuals who had normal ECGs.

2. Methods

This case–control study enrolled patients with normal coronary arteries or mild coronary artery disease who underwent coronary angiography between 2001 and 2010 in Tehran Heart Center. Data were extracted from our computerized Angiography Database. This Database includes information on demographic features, coronary risk factors, drug history, history of cardiac events, electrocardiographic interpretations, echocardiographic findings, past history of coronary or any other type of intervention and open heart surgery, and results of coronary angiographies. Patients eligible for inclusion

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were men and women at least 20 years of age with documented complete RBBB on the electrocardiogram, coronary angiography result of normal coronary arteries or mild coronary artery disease (CAD), and a normal ejection fraction (more than 50%). We defined mild CAD as some irregularities (less than 45%) seen on major epicardial coronary arteries that do not affect the normal cardiac function. Major exclusion criteria were the presence of conduction abnormalities other than RBBB, significant pulmonary disease, history of drug use affecting the heart conduction system, reduced ejection fraction, ventricular enlargement or significant valvular heart disease, congenital heart disease, history of pulmonary thromboembolism, and ischemic heart disease. Case selection was done with convenience non-probability sampling. Initially, 141 patients were selected based on the information obtained from our Angiography Database. Subsequently, the hospital records of these patients, including history of symptoms, detailed evaluation of the electrocardiogram, echocardiographic findings, and coronary angiography report sheet, were reviewed in detail. Systematically, the electrocardiogram and records were first selected for further study if the electrocardiogram satisfied the criteria previously defined for typical RBBB by the World Health Organization and the International Society and Federation for Cardiology in 1985 as follows:

1) Prolongation of QRS to 0.12 s or more;
2) An rsr', rsR' or rSR' pattern and occasionally a wide and notched R pattern in lead V_1 or V_2;
3) An S wave duration longer than the R wave duration or greater than 40 ms in leads V_6 and I; and
4) An R peak time greater than 0.05 s in lead V_1 but normal in leads V_5 and V_6.

Of these criteria, the first three should be present for the diagnosis to be made. When a notched dominant R pattern is present in V_1, criterion 4 should be satisfied as well.[15]

Of the initial 141 patients selected, 49 subjects who did not meet the inclusion criteria were excluded. Finally, a total of 92 subjects were entered in the final analysis. Control subjects were randomly extracted from the Angiography Database of patients with normal coronary arteries or mild coronary artery disease and with normal electrocardiograms who underwent coronary angiography during the same period. The controls were matched by age and sex to the cases with a 2:1 ratio. The inclusion criteria, other than the electrocardiography findings, were the same as those for the cases. Subsequently, for each study group, the coronary angiography, recorded on CD, was studied to determine the pattern and characteristics of the coronary anatomy. Variables investigated were defined as follows:

1. Whether the LAD is diminutive or not: the LAD was considered diminutive if it was grossly short in length, had a small diameter, and terminated before reaching the apex of the heart, thus supplying less than 2/3 of the distance between base and apex.
2. Type of dominancy: the classification described by Pompa was used to define the dominant coronary circulation[16]:
   a. In a right dominant circulation, the posterior descending artery (PDA) and at least one posterolateral branch (PLB) originate from the right coronary artery (RCA);
   b. In a left dominant circulation, the PDA and all of the PLBs originate from the left coronary artery;
   c. In a co-dominant circulation, the PDA originates from the RCA and all of the PLBs originate from the left coronary artery.
3. Number of OM branches: number of OM branches was determined by reviewing the right anterior oblique (RAO) projection with caudal angulation of the left circumflex (LCX) artery;
4. Number of diagonal branches: number of diagonal branches was determined by reviewing multiple angiographic views of the LAD artery, including the RAO and left anterior oblique (LAO) projection, with cranial and caudal angulation;
5. Number of septal branches: number of septal branches was determined by reviewing multiple angiographic views of the LAD artery, including the RAO with cranial angulation, LAO projection with cranial angulation, and lateral projection. Only the septal branches originating before the mid-portion of the LAD artery were included in this numbering;
6. The position of the first septal branch whether it was before or after the diagonal branch was a variable most precisely evaluated in the LAO projection with caudal angulation;
7. The origin of the AVN artery: in order to determine the origin of the AVN artery, first the dominant artery was ascertained. Based on the learning that the AVN artery most commonly originates from the crux,[17] the latter in the dominant artery was evaluated to ascertain whether it gave off a branch to the AVN region and if it did, it was considered as the AVN artery. If such a branch was not detected, the other segments of the dominant artery and thereafter the non-dominant artery were evaluated in multiple views. Subsequently, the origin of the AVN artery was classified to be from the right, left, or dual circulation (if both circulatory systems gave rise to the AVN blood supply);
8. The size of the conus branch: this variable was determined by visual inspection of the conus branch and described as small size, normal size, or developed conus branch;
9. Number of acute marginal (AM) branches: number of the AM branches was determined by reviewing the LAO and RAO projections of the RCA;
10. Presence of the ramus branch: the ramus branch was detected as the third divided branch of the LM artery originating between the LCX branch and LAD branch and was best viewed in the LAO projection with caudal angulation of the LM artery; and
11. The size of the LM trunk: this variable was determined by visual inspection of the LM trunk in the anteroposterior projection with caudal angulation and described to be short, medium, or large.

This investigation was approved by the Ethics Committee of our institution. Because of the retrospective nature of the study, requirement for informed consent was waived.

3. Statistical analysis

The statistical analyses were conducted using SPSS version 15.0 software. The results for the quantitative variables are reported as mean $\pm$ standard deviation and for the qualitative variables as frequencies. The mean values of the quantitative variables of the two study groups were compared using the Independent two-sample *t*-test. The frequency distributions of the qualitative variables, obtained from the two study groups, were compared using the chi-square test. A p-value ≤ 0.05 was considered a significant statistical difference.

4. Results

The present study included 276 patients, who were divided into the case group, comprising 92 (33.3%) patients, and control group, comprised of 184 (66.7%) patients. The case and control patients were matched for age and gender and were also similar in terms of coronary risk factors and angiographic results (Table 1).

Table 1
Characteristics of study patients and controls.

Variable		Study group ($n = 92$)	Control group ($n = 184$)	P-value
Mean age (years)		59.19 ± 10.93	59.29 ± 10.94	0.923
Gender [n (%)]	Male	55 (59.8)	115 (62.5)	0.662
	Female	37 (40.2)	69 (37.5)	
Risk factors [n (%)]	Diabetes	16 (17.4)	35 (19.0)	0.742
	Hypertension	33 (35.9)	76 (41.3)	0.384
	Dyslipidemia	35 (38.0)	76 (41.3)	0.602
	Smoking	24 (26.1)	35 (19.0)	0.177
	Family history of coronary heart disease	21 (22.8)	30 (16.3)	0.188
Angiographic result [n (%)]	Normal	68 (73.9)	141 (76.6)	0.620
	Minimal coronary artery disease	24 (26.1)	43 (23.4)	

The results of the coronary artery characteristics and the comparison between the two study groups are summarized in Table 2, which shows no significant difference between the study groups with regard to dominancy. In the study population, 75.0% of the cases versus 76.6% of the controls had right dominant, 12.0% of the cases versus 16.3% of the controls had left dominant, and 13.0% of the cases versus 7.1% of the controls had co-dominant circulations; these differences, however, were not statistically significant. In terms of diminutive LAD and the position of the first septal branch versus the diagonal branch, there was no significant difference between the two groups.

The average numbers of the OM, diagonal, and AM arteries did not differ significantly between the two groups, but the number of the septal branch was significantly higher in the case group (p value <0.001).

In the evaluation of the AVN artery origin, three possible types were first defined for this variable: right, left, and dual origin. In one patient, the AVN origin was undetermined; probably because it was a very small branch that could not be visualized. Only a minority of the patients had an AVN artery with a dual origin (2 of the cases and one of the controls). Reasonably, these special cases were omitted from the subsequent analysis of the AVN origin because of the very small number of such cases, but not from the analysis of the other variables. Origination of the AVN artery from the right circulatory system was more common than from the left circulatory system in both groups (82.0% of the cases and 68.9% of the controls), but the cases showed more tendency to follow this pattern. In other words, the prevalence of the right origin of the AVN artery was significantly higher in the cases than that in the controls (p value $= 0.021$).

Another variable analyzed was the size of the conus branch, which was categorized as normal, small, and developed. Only a minority of the patients (overall 4) had a developed conus branch. Consequently, in order to conduct a proper analysis, it seemed necessary to merge the two groups of patients with normal and developed conus branches and the new group was renamed as normal conus branch. Reanalysis of the results showed a significant difference between the study groups in terms of the conus branch size: The frequency of the normal conus branch was significantly higher in the cases than in the controls (91.3% versus 78.8% respectively, p value $= 0.009$).

The two groups were not different with regard to the presence or absence of the ramus artery (p value $= 0.384$) and the LM size (p value $= 0.133$). The ramus artery was present in 39.6% of our total study population. The LM artery was most commonly medium in size in both study groups.

Table 2
Comparison of coronary artery characteristics in case patients and controls.

Variable		Study group ($n = 92$)	Control group ($n = 184$)	P-value
Diminutive LAD [n (%)]		15 (16.3)	22 (12.0)	0.318
Dominancy [n (%)]	Right	69 (75.0)	141 (76.6)	0.200
	Left	11 (12.0)	30 (16.3)	
	Co	12 (13.0)	13 (7.1)	
Mean number of OM branches		1.93 ± 0.85	1.76 ± 0.73	0.079
Mean number of diagonal branches		1.82 ± 0.69	1.91 ± 0.66	0.253
Mean number of AM		1.13 ± 0.52	1.13 ± 0.52	0.935
Mean number of septal branches		3.27 ± 0.95	2.47 ± 0.66	<0.001
The position of the first septal branch versus the diagonal branch [n (%)]	Diagonal before septal	54 (58.7)	95 (51.6)	0.267
	Septal before diagonal	38 (41.3)	89 (48.4)	
Size of conus branch [n (%)]	Normal	84 (91.3)	145 (78.8)	0.009
	Small	8 (8.7)	39 (21.2)	
AVN origin[a] [n (%)]	Left	16 (18.0)	57 (31.1)	0.021
	Right	73 (82.0)	126 (68.9)	
Presence of ramus branch [n (%)]		33 (35.9)	76 (41.3)	0.384
Size of LM [n (%)]	Short	24 (26.1)	50 (27.2)	0.133
	Medium	56 (60.9)	123 (66.8)	
	Long	12 (13.0)	11 (6.0)	

Abbreviations: LAD, left anterior descending artery; OM, obtuse marginal artery; AM, acute marginal artery; AVN, atrioventricular node; LM, left main artery.
[a] 89 cases and 183 controls were included in this analysis.

5. Discussion

Anatomical variation in the coronary artery circulation has been the subject of many anatomical, angiographic, and radiologic studies.[7–14,18–22] None of these studies, however, evaluated the possible relationship between the coronary anatomy and the RBBB and our study is the first of its kind to assess such a relationship and to determine whether there is any significant difference in the coronary artery characteristics between subjects with the RBBB and normal individuals.

One of the anatomic variables frequently studied is coronary artery dominancy. Table 3 indicates that in most of the relevant studies, the most common dominant system is the right coronary circulation. We found similar results in our total study population. Our study, however, failed to show different dominancy patterns in the subjects with the RBBB compared with the normal individuals.

Our analysis of the origin of the AVN artery revealed significant differences between the two study groups: Although origination from the right circulatory system was more common in both groups (82.0% of the cases and 68.9% of the controls), the prevalence of the right origin of the AVN artery was significantly higher in the cases than in the controls. We found no explanation for this observation, however. Table 4 depicts the results of the previous studies on the AVN artery origins. All of these studies showed that the AVN artery

Table 3
Dominancy patterns reported by various authors.

Author	Study date	Sample size	Dominancy (%)		
			Right	Left	Co-
Vieweg et al[9]	1975	118	66.1	7.6	26.3
Hadziselimović[18]	1978	200	63	13	24
Saremi et al[10]	2008	102	87	11	2
Cademartiri et al[7]	2008	543	86.6	9.2	4.2
Eren et al[8]	2008	325	70	12.5	17.5
Ramanathan[11]	2009	300	53.66	22.33	24
Gawlikowska et al[12]	2010	102	21.56	11.76	66.6
Fazliogullari et al[13]	2010	50	42	14	44
The present study		276	76.1	14.9	9.1

Table 4
Origin of AVN artery reported by various authors.

Author	Study date	Sample size	Origin of AVN artery (%)		
			RCA	LCX	Dual
Vieweg et al[9]	1975	118	84	8	
Hutchison[14]	1978	40	80	20	
Hadziselimović[18]	1978	200	85	13	2
Krupa[19]	1993	120	90	10	–
Futami et al[22]	2003	30	80	10	10
Saremi et al[10]	2008	102	87	11	2
Ramanathan et al[11]	2009	300	72	28	0
The present study		276	72.1	26.4	1.1

originated most commonly from the RCA, which was the most common dominant system, and concluded that the AVN artery usually branched from the dominant artery. In contrast, we observed some cases of the AVN arteries originating from the non-dominant artery, with these out-of-the-rule variants being more common in the control group (15% of the controls versus 1% of the cases and 10% of the total study population). The results of the current study in regard to this variable were very close to the results of Ramanathan's angiography-based study on an Indian population[11] and somewhat different from other studies suggesting that race might be a potential factor influencing the anatomic variables of the coronary artery. Three percent of the total population investigated in the Ramanathan et al study had origination of the AVN artery from the non-dominant artery. Vieweg et al, in an angiographic based study, aimed to determine the origin of the AVN artery in different dominant patterns[9]: The RCA was the origin of the AVN in 98.7% of right dominant, 74.2% of co-dominant, and 0% of left dominant emphasis systems, which chimes in with the results of our study: as a whole, 86.2% of right dominant, 60% of co-dominant, and 7% of left dominant emphasis systems. Different from other studies, Futami et al showed a higher frequency of dual-source AVN artery supply reaching 10%,[22] while in our study this frequency was 1.1%.

Two other variations shown in the present study to be associated with the RBBB were a higher number of septal branches and a larger conus branch. It remains questionable whether these arterial branches contribute to the blood supply of the right bundle branch and, if so, whether these anatomic properties present since birth or they form following the development of the RBBB perhaps to be a compensatory mechanism in response to a defected right bundle branch.

We found the ramus branch frequently present in both study groups (39.6% of our total study population) and its presence or absence was not related to the formation of the RBBB. The size of the left main artery did not seem to be related to the presence of the RBBB: in both our RBBB patients and normal subjects, the left main artery was most commonly medium in size. Similarly, Mots et al, in a small case–control study, aimed to evaluate whether there was an association between the coronary anatomy and the left bundle branch block and showed that patients with left bundle branch block compared to normal subjects were not different in terms of the size of the LM artery.[6]

6. Conclusion

Our study revealed no relationship between the dominancy of coronary arteries and the presence of the RBBB in subjects with normal coronary arteries. The prevalence of the right origin of the AVN artery was significantly higher in the cases than in the controls, although the origination of the AVN artery from the right circulatory system was more common in both groups. The number of the septal branches was significantly higher in the cases than in the controls. Our case subjects had a normal conus branch more frequently than did our controls, and the probability of having a small conus artery was higher in the controls. Our study showed that some of the coronary characteristics were different between the subjects with the RBBB and those with normal ECGs.

Conflicts of Interest

All authors have none to declare.

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