

CORONARY ARTERY ANATOMY AND MORPHOLOGY IN THE PRESENCE OF SUPERDOMINANT RIGHT CORONARY ARTERY

SÜPERDOMİNANT SAĞ KORONER ARTER VARLIĞINDA KORONER ARTER ANATOMİ VE MORFOLOJİSİ

Hatice TOLUNAY, MD¹

¹Yenimahalle Education and Research Hospital, Cardiology Department, Ankara, Turkey

Geliş tarihi: 19/10/2017

Kabul tarihi: 25/12/2017

Yazarlar herhangi bir finansal destek kullanmamış olup yazarlar arasında çıkar çatışması yoktur.

ABSTRACT

OBJECTIVE: Having detailed information about normal coronary anatomy and its different variations provides great advantage in determining the technique to be used during percutaneous revascularization or operation. There are a lot of studies related to the coronary artery dominance in the literature, very little data related to the superdominant right coronary artery (RCA) is available. In this study, we aimed to describe anatomical features and the diameters of the coronary arteries in the presence of superdominant RCA.

MATERIAL AND METHODS: We evaluated 3454 coronary angiographies retrospectively, which were implemented in our hospital according to the diagnoses with recognized or suspicious coronary artery disease (CAD) between 2004 December and 2012 January. The cases in which the left ventricular apex is supplied by posterior descending artery (PDA) that is a branch of the right coronary artery has been deemed as superdominant right coronary artery. In 312 (9%) of 3454 patients whose angiographies had been examined, the right coronary artery was determined as superdominant. Coronary angiographies of the 312 patients whose right coronary arteries are superdominant have been evaluated. Coronary artery diameters and left main coronary artery (LMCA) lengths of the 100 patients having superdominant right coronary and showing normal coronaries in coronary angiography have been measured. Right coronary artery proximal, mid and distal diameters were measured approximately 4.45 ± 0.93 , 4.20 ± 0.99 and 3.50 ± 0.80 , respectively. Diameter of LMCA was measured approximately 4.72 ± 0.88 , 4.70 ± 0.89 and 4.72 ± 0.88 mm in proximal, mid and distal, respectively and average LMCA length was measured 12.05 ± 3.67 mm. Average LAD diameter was measured 3.64 ± 0.67 , 3.01 ± 0.72 and 2.07 ± 0.34 in the proximal, the mid and the distal, respectively and the average circumflex artery (CX) diameter was measured 2.92 ± 0.66 and 1.88 ± 0.41 in the proximal and the distal, respectively. The correlation between LMCA proximal diameter and RCA proximal diameter was found as significantly meaningful. Also, it was determined that the difference between the averages of the LAD and RCA tapering indexes had been statistically significant.

CONCLUSION: RCA proximal and distal segment diameters in the presence of the super-dominant right coronary artery are significantly larger compared to LAD and CX diameters. Antegrade tapering is not sufficient for RCA. The length of the LMCA has increased compared to the previous study data. As expected, LAD artery is underdeveloped in these cases, terminates before reaching to the apex and equally terminates in the distal with a diagonal artery that is developed frequently in the mid region. Antegrade tapering is distinct for LAD artery. In these patients, intermediate artery frequency is over the conventional rates and myocardial bridge association is lower. Sinoatrial node artery and conus branch take their origins from the right coronary artery over the conventional values.

Keywords: Superdominant right coronary artery; coronary artery anatomy, coronary dominance

Yazışma adresi/Correspondence Address: Dr. Hatice TOLUNAY, Yenimahalle Education and Research Hospital, Cardiology Department, Ankara, Turkey

Tel: 0312 587 20 00 (2359)

e-mail: drhaticearslan@gmail.com

ÖZ

AMAÇ: İskemik kalp hastalığında perkütan revaskülarizasyon veya operasyon sırasında kullanılacak tekniğin saptanması amacıyla normal koroner anatomisinin ve çeşitli varyasyonların ayrıntılı bilinmesinin yararı büyüktür. Koroner arter dominansı ile ilgili literatürde çok sayıda çalışma mevcut olup, süperdominant sağ koroner arter ile ilgili çok az veri vardır. Biz bu çalışmada süperdominant sağ koroner arteri (RCA) olan vakaların koroner arter çaplarını ölçmeyi ve anatomik özelliklerini tanımlanmayı amaçladık.

GEREÇ VE YÖNTEMLER: Hastanemizde Aralık 2004 ve Ocak 2012 tarihleri arasında bilinen ya da şüpheli koroner arter hastalığı (KAH) tanıları ile yapılan 3454 koroner anjiyografi retrospektif olarak değerlendirildi. Sol ventrikül apeksinin, sağ koroner arterin dalı olan posterior descending arter (PDA) tarafınca beslendiği vakalar süperdominant sağ koroner arter olarak kabul edildi. Anjiyografisi incelenen 3454 hastanın 312'sinde (%9) sağ koroner arter süperdominant olarak saptandı. Sağ koroner arteri süperdominant olan 312 hastanın koroner anjiyografileri (KAG) değerlendirildi. Süperdominant sağ koroneri olan ve koroner anjiyografide normal koronerler saptanan 100 hastanın koroner arter çapları ve sol ana koroner arter (LMCA) uzunlukları ölçüldü. Sağ koroner arter proksimal, mid, distal çapları ortalama $4.45\pm 0,93$, $4.20\pm 0,99$, $3.50\pm 0,80$ mm ölçüldü. LMCA çapı proksimal, mid ve distalde ortalama $4.72\pm 0,88$, $4,70\pm 0,89$, $4,72\pm 0,88$ mm ve ortalama LMCA uzunluğu $12,05\pm 3,67$ mm idi. Ortalama LAD çapı proksimal, mid ve distalde $3.64\pm 0,67$, $3.01\pm 0,72$, $2.07\pm 0,34$ mm olup, sirkümfleks arter (CX) ortalama proksimal ve distal çapı $2.92\pm 0,66$ ve $1,88\pm 0,41$ mm idi. LMCA proksimal çapı ile RCA proksimal çapı arasındaki ilişki istatistiksel olarak anlamlı bulundu. LAD ve RCA tapering indekslerinin ortalamaları arasındaki farkın istatistiksel olarak anlamlı olduğu belirlendi.

SONUÇ: Süperdominant sağ koroner arter varlığında RCA proksimal ve distal segment çapları, LAD ve CX çapları ile karşılaştırıldığında anlamlı olarak RCA'nın daha geniştir. RCA için antegrade tapering yetersizdir. LMCA uzunluğu daha önceki çalışma verilerine göre artmıştır. LAD arter beklenildiği üzere bu vakalarda az gelişmiş olup apekse ulaşmadan sonlanmakta ve sıklıkla mid bölgede gelişmiş bir diyagonal arterle distalde eşit sonlanmaktadır. LAD arter için antegrade tapering belirgindir. Bu hastalarda intermediate arter sıklığı bilinen oranların üzerinde olup myokardiyal bridge birlikteliği düşüktür. Sinoatriyal nod arter ve konus dalı bilinen değerlerin daha üzerinde sağ koroner arterden köken almaktadır.

Anahtar Kelimeler: Süperdominant sağ koroner arter, koroner arter anatomi, koroner dominans

INTRODUCTION

Right and left coronary artery dominance was first described by Schelinger in 1940 (1). The artery supplying diaphragmatic side of the left ventricular and posterior diaphragmatic part of the interventricular septum was defined as dominant. Various anatomical variations of the Posterior Descending Artery (PDA) were noticed. RCA is designated as superdominant when it gives rise to the PDA supplying left ventricular apex and in these cases, it was detected that LAD appears relatively short and terminates before reaching to the apex. The broadest study on this subject evaluated 431 patients in 1983, and two anatomical groups were defined; one group terminated at the apex and the other shortly terminated before reaching to the apex. In that study, 44 of the 431 patients (10.2 %) had posterior

descending branch of the RCA supplying left ventricular apex and other characteristics of these patients have not been examined except incidence (2).

There are a great number of clinical studies related to the coronary artery dominance. However, the studies examining coronary anatomical features in the presence of the super-dominant right coronary artery which is seen with approximately 10 % frequency are not available in the literature.

Therefore we wanted to extend the results of the autopsy study applied on these 19 patients by examining anatomical features determined in the coronary angiography of the patients having 100 superdominant right coronary arteries.

MATERIAL AND METHODS

Patients (n=3454) undergoing selective coronary angiography between 2004 December and 2012 January were retrospectively evaluated in Ankara Atatürk Education and Research Hospital. Coronary angiography was performed in the context of chest pain. While measuring coronary diameters, coronary artery dimension was measured by taking the catheter diameter as reference through automatic edge determination technique and the catheter used for the angiography. Absolute diameter was measured in millimeters (mm) by using software analysis (AngoraViewer Win32.1.54) with the aid of computer.

The cases in which the left ventricular apex is supplied by the PDA branch of the RCA and where the LAD terminates shortly before the cardiac apex have been determined as superdominant RCA. The dominance of the coronary arteries and the presence of superdominant RCA were determined by evaluating left anterior oblique (LAO) and right anterior oblique (RAO) projections. 100 patients having both superdominant RCA and normal coronaries in coronary angiography were included. Patients using medication with coroner vasodilator effect were excluded in the study.

LMCA proximal, mid and distal diameters, LMCA lengths, LAD and RCA proximal, mid and distal, CX proximal and distal coronary diameters were measured. Moreover, the presence of the intermediate artery, number and average diameters of the diagonal artery and obtuse marginalis were evaluated. While evaluating the LMCA diameters and lengths, especially measurement through RAO (15-45°) projections were executed.

Statistical analysis: In the study, SPSS (Statistical Package for Social Sciences for Windows 15) program was used for the statistical analyses (SPSS Inc., Chicago, II, USA). Standard values were given as average \pm standard deviation; categorical data were given as percentage (%). Since normality hypothesis had been provided for three variables during searching the correlation among RCA proximal diameter, LMCA length and LMCA proximal diameter, Pearson's Coefficient was used as a correlation coefficient. Corresponding p-values were taken into consideration before interpreting the correlation coefficients. P-value less than 0.05 were considered statistically significant. Before mak-

ing comparison of LAD, CX, RCA proximal-distal diameters and making comparison of LAD and RCA tapering indexes (TIs), the condition that whether the measurement values hereof met the normality hypothesis was tested by means of Kolmogorov-Smirnov Normality Test and t-test (paired samples t-test) was implemented for two dependent samples as a parametric method in the comparisons.

RESULTS

When RCA proximal and distal segment diameters are compared with LAD and CX diameters in the presence of the superdominant RCA, those of RCA are significantly larger. Antegrade tapering of superdominant RCA is insufficient. The length of the LMCA has increased compared to the previous studies which were evaluated regardless of the dominance. This is a finding that supports the defined correlation between the coronary dominance and the LMCA length. As expected, the LAD artery appears relatively short in these cases and terminates before reaching to the apex and equally terminates in the distal with a diagonal artery that is developed frequently in the mid region. Antegrade tapering is evident for LAD artery. In these patients, intermediate artery frequency is over the conventional rates and myocardial bridge association is lower. SAN artery and conus branch get their origins from the right coronary artery over the conventional values.

The right coronary artery was detected as superdominant in 312 (9%) of 3454 patients (Figure 1a, 1b). 100 of 312 patients (53 females, 47 males, average of age 60.27 ± 9.60) having normal coronary arteries were included in the study. Demographical features of the patients are summarized in Table 1.

Figure 1a: View of the superdominant right coronary artery from LAO projection



Figure 1b: View of the superdominant right coronary artery from RAO projection

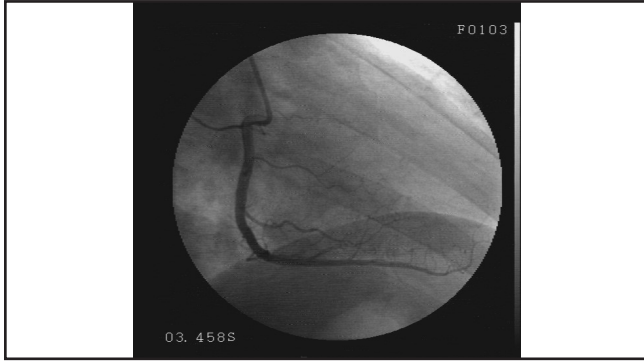


Figure 2: View of the left coronary arteries from the LAO projection, in the presence of the superdominant right coronary artery

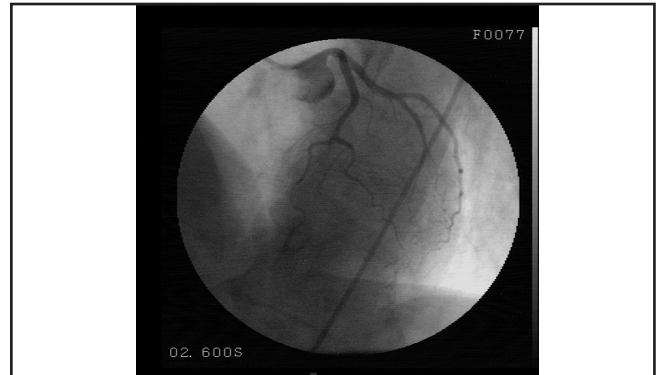


Table 1: Baseline characteristics of 100 participants with normal coronary artery and super dominant RCA

Age	60.27±9.60
Gender (woman)	53%
Hypertension	74%
Diabetes mellitus	27%
Hyperlipidemia	45%
Cigarette	36%
Family history	30%

Mean diameters of the RCA proximal, mid and distal were 4.45 ± 0.93 , 4.20 ± 0.99 and 3.50 ± 0.80 mm, respectively. Mean diameters of the PDA and posterolateral artery (PLA) were measured as 2.79 ± 0.52 and 2.31 ± 0.39 mm. Mean LMCA diameters in the proximal, the mid and the distal were 4.72 ± 0.88 , 4.70 ± 0.89 , 4.72 ± 0.88 mm and mean length of the LMCA was 12.05 ± 3.67 mm. As it is expected, LAD artery was underdeveloped in these cases and terminated shortly not until reaching to the apex and mean LAD diameters were measured as 3.64 ± 0.67 , 3.01 ± 0.72 , 2.07 ± 0.34 mm in the proximal, the mid and the distal (Figure 2). Diagonal artery average number was 2.14 ± 0.73 and mean septal number was 2.86 ± 1.25 . Mean diameter of the proximal and distal segment of the CX artery were 2.82 ± 0.66 and 1.88 ± 0.41 mm, and mean obtuse marginalis (OM) number was 1.70 ± 0.78 . When proximal and distal segment diameters of the RCA were compared with LAD and CX diameters, it was determined that RCA was significantly larger ($p < 0.01$). Distal ondulation in LAD and CX artery was observed in 95 patients (95%) (Table 2).

Table 2: Diameter measurements of the coronary arteries in patients with superdominant RCA

	N	Min.	Max.	Mean	SD
LMCA.prox	100	3,11	7,98	4,72	,88
LMCA.mid	100	3,09	7,96	4,70	,89
LMCA.distal	100	3,09	7,90	4,72	,88
LAD.prox	100	2,22	6,00	3,64	,67
LAD.mid	100	1,81	6,72	3,01	,72
LAD.distal	100	1,24	3,10	2,07	,34
Diagonal	100	1,00	3,50	2,09	,47
CX.prox	100	1,80	5,20	2,82	,66
CX.distal	100	1,10	3,60	1,88	,41
OM	100	1,00	2,70	1,92	,40
RCA.prox	100	3,20	9,10	4,45	,93
RCA.mid	100	2,64	7,80	4,20	,99
RCA.distal	100	2,00	6,10	3,50	,80
PDA	100	1,80	4,81	2,79	,52
PLA	100	1,50	3,30	2,31	,39

The correlation among RCA proximal diameter and LMCA proximal diameter and LMCA length was studied. A statistically significant correlation was found between the RCA proximal diameter and the LMCA proximal diameter ($p = 0.03$). It was seen that there had not been a significant correlation between the RCA proximal diameter and the LMCA length ($p = 0.172$) (Table 3).

While an evident decrease in the LAD diameter from proximal to distal has been observed, a reduction in the RCA diameter towards the distal has not been observed, i.e. antegrade tapering is evident for LAD. Tapering indexes were calculated by dividing the difference between the LAD and

the RCA proximal and distal coronary diameters by the proximal diameter. The difference between the LAD TI and the RCA TI is statistically significant ($p < 0,001$) (Table 4).

Table 3: Comparison of the RCA proximal diameter and the LMCA proximal diameter and length

RCA prox. diameter		
	R	P
LMCAprox diameter	0,290*	0,003**
LMCA length	0,138	0,172

* p value $< 0,05$ statistically significant

** Correlation is significant at the 0.01 level (2-tailed).

Table 4: Comparison of the LAD and the RCA tapering indexes

	N	$\bar{x} \pm s$	T	Sig. ^a
LAD.TI	100	0,4320 \pm 0,09	17,176	0,000**
RCA.TI	100	0,1812 \pm 0,11		

^aSignification value for t -test.

Considering anatomical variations of the left main coronary artery, it was classified in four groups. Type 1 (biconcave morphology), type 2 (tapering morphology), type 3 (combined morphology), type 4 (funnel shaped) were detected 25%, 22%, 18%, 35% respectively.

It was observed that SAN artery received its origin from the RCA in 88 patients (88%) and, CX artery in 8 patients (8%) and dual in 4 patients (4%). Also, the conus branch originated from the RCA in 96 patients (96%) and directly from the aorta in 4 patients (4%) with a separate ostium.

Intermediate artery was noted in 41 patients (41%) and its mean proximal diameter was 1.94 \pm 0.54 mm. By evaluating in terms of the myocardial bridge existence, the myocardial bridge in LAD artery has been seen only in 2 patients (2%). There were not any patients having coronary artery anomaly and whose LAD and CX originate from separate ostiums.

DISCUSSION

The right and left coronary artery dominance was first described by Schelinger in 1940 (1). The artery supplying diaphragmatic part of the left ventricular and posterior diaphragmatic side of the interventricular septum was defined as dominant. The condition in which apical supplying is provided by PDA which is a branch of the right coronary

artery has been defined as superdominant RCA and it has been determined that LAD is short and terminates without reaching to the apex. The broadest study on this subject was implemented on 431 patients in 1983, and two anatomical groups were defined in this study; one group reached to the apex and the other shortly terminated before reaching to the apex. It has been determined that blood build up of the apex is provided in LAD at the rate of 77.7%, in PDA at the rate of 10.2%, and dual at the rate of 12.1%. In this study, other characteristics of the group comprising 44 patients (10.2 %) in whom apex is supplied by PDA have not been examined except incidence (2). Later, the term of superdominance has been defined differently in an autopsy study consisting of 200 cases (3). It has been determined that in a group of 178 cases in which the right coronary is considered as dominant, in 19 cases (11%) right coronary artery supplies not only right side of the heart but also posterior wall of the left ventricular, large part of the posterior septum, lateral wall and the apex. This subgroup was called as actual right dominant. It has been stated that RCA is large and long in these cases and continues to be large after the crux and the posterior interventricular artery terminates by moving around the apex at front side of the heart. Superdominant patient rates were found as 10.2% and 11% in previous major studies carried out related to the superdominant RCA (2, 3). This rate in our patient group has been determined as 9%. The patients having superdominant RCA in the coronary angiography and showing normal coronary arteries (32%) were taken into consideration. In an autopsy study consisting of 19 cases carried out thereof and defined as the actual right dominance instead of the superdominant, the RCA proximal diameter, the LAD diameter and the CX artery diameter were measured 3.9 \pm 0.46 mm, 3.3 \pm 0.41 mm, and 2.3 \pm 0.35 mm, respectively. However, in this study, the LMCA diameters and lengths have not been evaluated (3).

In the three studies carried out, the lengths of the LMCA were determined as 11.02 \pm 4.5 mm, 10.4 \pm 5.6 mm and 10.5 \pm 4 mm (4, 6, 7). The correlation between the coronary dominance and the LMCA length was studied and it was shown that the LMCA was shorter in the presence of left dominance (6). Short LMCA was found as correlated with the left branch block in atherosclerosis (5). The conditions that the rate of the normal coronary artery is excessive in

superdominant patients and the mean length of the LMCA is 12.05 ± 3.67 are the findings supporting these data (4, 5). On the other hand, the studies showing that there is not any correlation between the coronary dominance and the LMCA length are available (7,8).

In the study carried out by Fazliogullari and et al., the coronary diameters in Turkish society were evaluated regardless of the dominance. In this autopsy study, the coronary diameters of the 50 cases were examined. Average LMCA, LAD, CX and RCA diameters were measured 4.44 ± 1.79 mm, 3.13 ± 0.64 mm, 2.89 ± 1.08 mm and 3.32 ± 0.79 mm, respectively (9).

In the presence of the superdominant right coronary artery, LMCA shows most frequently type 4 morphology (funnel type) (35%). Subsequently, type 1 biconcave, type 2 tapering and type 3 combined morphology are observed in that order. In a study carried out regardless of the dominance, the most frequent type is observed as type 1 biconcave (54.3%) and this is followed by type 2 (21.4%), type 3 (14.3%) and type 4 (10%), respectively (10). Not only all these findings are the first datum evaluating the morphology of the LMCA in the presence of the superdominant RCA, but also they may be a guide in ever increasing attempts of the LMCA.

The LAD artery is grouped into 3 types. The type which terminates until not reaching to the apex is known as type A; the type which reaches to the apex but feeds inferoapical region of the left ventricular is known as type B; the type which feeds the inferoapical region by moving around the apex is known type C LAD (11). As expected, in our patient group, type A LAD has been observed in all patients. In these cases, the LAD lesions have less clinical importance contrary to the expectations.

In the presence of the superdominant RCA, it has been highlighted that the right coronary artery diameters have increased but, contrary to common belief, there is not a reduction in the system diameters. While a distinct reduction in the LAD diameter towards the distal is observed, expected reduction in the RCA diameter towards the distal is not observed i.e. antegrade tapering is clear in the LAD (12, 13). LAD and RCA tapering indexes have been calculated by proportioning the proximal and distal diameter differences to the proximal diameter and a statistically significant difference between the averages of the LAD TI and the RCA TI has been observed ($p < 0,001$). As far as we

know, there is not a study in the literature that compares dominance related tapering indexes.

As stated in other studies, while the LAD is short and terminates early not until reaching to the apex, the proximal diameter of the LAD is normal but quickly becomes thin towards the distal. In 74% of the cases, developed 2nd or 3rd diagonal and distal diameters terminate together by balancing. This situation gives rise to the existence of the dual LAD. However since the LAD artery terminates early without moving around the apex, it has been observed that Type 1, 2, 3 dual LAD definitions do not have diagnostic feature in the presence of the superdominant right coronary artery. Furthermore, the patients in our study have been evaluated in terms of the accompanying congenital variations. There are studies in which estimated frequencies of the myocardial bridge are 16%, 13.3% and 34.5% (14, 15, 16). In previous studies, the bridge frequency in the right coronary dominant patients has been found lower and the bridge frequency in the left coronary system of the left coronary dominant cases has been found higher (16). We, also, determined the myocardial bridge in only 2 of 100 patients supporting the previous datums. Cases focusing on the absence of left circumflex and anomalous origin of the left anterior descending accompanied by superdominant right coronary artery have been reported in literature. In our study, no coronary artery anomaly was identified (17, 18).

Widow maker infarct is referring to the resulting heart attack when there is a 100% blockage of the LAD proximal. It was shown that the superdominant RCA defined as the actual right dominance had supplied the posterior papillary muscle on its own and it was determined that this artery had perfused more than 50% of the myocardium (3). Therefore, it can be described as widow marker infarct in the presence of superdominant right coronary artery, which is caused by total occlusion of the proximal right coronary artery.

Scoring systems like the SYNTAX score, displaying the extensiveness and severity of a coronary artery disease, are frequently used in identifying treatment protocols and deciding on percutan and surgical treatment. These systems are designed for patients with left, right coronary dominance and balance coronary anatomy, and there is no scoring system with superdominant right coronary artery. This is a major deficiency creating the need for further studies and new scoring systems. Although this study is not com-

parative, yet it will guide prospective studies by revealing the deficiencies of scoring systems identifying the severity of coronary artery diseases. Further, it is important that the presence of superdominant right coronary artery should be analyzed more carefully by cardiology specialists while evaluating coronary artery lesions via coronary angiography and deciding on treatment protocols.

Study limitations

Primarily, a control group has not been established since the study is planned in defining quality. Because this study was based on existing database and data were collected after the catheterization not at the time of initial presentation or catheterization data about some important variables that can influence results such as nitroglycerine usage during the catheterization to prevent vasospasm are lacking.

CONCLUSION

The presence of the superdominant RCA in which the LAD terminates before reaching to the apex, where it is shorter and has small diameter compared to the normal one, and the PDA has bigger diameter and developed is a significant condition. It was shown that the superdominant RCA defined as the actual right dominance had supplied the posterior papillary muscle on its own and it was determined that this artery had perfused more than 50% of the myocardium. As well some lesions of the superdominant RCA may be the reason of the severe ischemia and mitral dysfunction, and recognizing this anatomical variation has an important place in directing the diagnosis and treatment.

REFERENCES

- 1)Schlesinger MJ. Relation of anatomic pattern to pathologic conditions of coronary arteries. Arch Path. 1940; 30: 403-415.
- 2)Perlmutter LM, Jay ME, Levin DC. Variations in the blood supply of the left ventricular apex. Invest Radiol. 1983; 18: 138-40.
- 3)Nerantzis CE, Papachristos JC, Gribizi JE, Voudris VA. Functional dominance of the right coronary artery : incidence in the human heart Clin. Anat. 1996; 9: 10-3.
- 4)Gazetopoulos N, Ioannidis PJ, Karydis C, Lolas C, Kiriakou K, Tountas C. Short left coronary artery trunk as a risk factor in the development of coronary atherosclerosis. Pathological study. Br Heart J. 1976; 38: 1160-1165.
- 5)Gazetopoulos N, Ioannidis PJ, Marselos A, et al. Length of main left coronary artery in relation to atherosclerosis of its branches. A coronary arteriographic study. Br Heart J. 1976; 38: 180-185.

- 6)Kronzon I, Deutsch P, Glassman E. Length of the left main coronary artery: Its relation to the pattern of coronary arterial distribution American Journal of Cardiology. 1974; 34: 787-789.
- 7)Nowak D, Gielecki J, Zurada A, Góralczyk K. No relationship between the length of the left coronary artery main stem and the type of coronary vasculature in human fetuses from a morphological perspective. Med Sci Monit. 2009; 15: 20-5.
- 8)Virmani R, Chun PK, Robinowitz M, Goldstein RE, McAllister HA Jr. Length of left main coronary artery. Lack of correlation to coronary artery dominance and bicuspid aortic valve: an autopsy study of 54 cases. Arch Pathol Lab Med. 1984; 108: 638-41.
- 9)Zeina AR, Rosenschein U, Barmeir E. Dimensions and anatomic variations of left main coronary artery in normal population: multidetector computed tomography assessment Coronary Artery Disease. 2007; 18: 477-482.
- 10)Zeina AR, Rosenschein U, Barmeir E. Dimensions and anatomic variations of left main coronary artery in normal population: multidetector computed tomography assessment. Coron Artery Dis. 2007; 18: 477-82.
- 11)Ilia R, Rosenshtein G, Weinstein J, Cafri C, Abu-Ful A, Gueron M. Left anterior descending artery length in left and right coronary artery dominance. Coronary artery disease. 2001; 12: 77-78.
- 12)Mancini GB, Ryomoto A, Kamimura C, et al. Redefining the normal angiogram using population-derived ranges for coronary size and shape: validation using intravascular ultrasound and applications in diverse patient cohorts Int J Cardiovasc Imaging. 2007; 23: 441-453.
- 13)Zubaid M, Buller C, Mancini GB. Normal angiographic tapering of the coronary arteries. Can J Cardiol. 2002; 18: 973-80.
- 14)Kim PJ, Hur G, Kim SY, et al. Frequency of myocardial bridges and dynamic compression of epicardial coronary arteries: A comparison between computed tomography and invasive coronary angiography. Circulation. 2009; 119: 1408-1416.
- 15)Rossi L, Dander B, Nidasio GP, et al. Myocardial bridges and ischemic heart disease. Eur Heart J. 1980; 1: 239-245.
- 16)Koşar P, Ergun E, Oztürk C, Koşar U. Anatomic variations and anomalies of the coronary arteries: 64-slice CT angiographic appearance. Diagnostic and interventional radiology Ankara Turkey. 2009; 15: 275-283.
- 17)Oliveira MD, de Fazzio FR, Mariani Junior J, et al. Superdominant Right Coronary Artery with Absence of Left Circumflex and Anomalous Origin of the Left Anterior Descending Coronary from the Right Sinus: An Unheard Coronary Anomaly Circulation. Case Rep Cardiol. 2015; 2015: 721536.
- 18)Sánchez-Zuriaga D, Martínez-Soriano F. Absence of circumflex artery with superdominant right coronary: a classic anatomical dissection study. Surg Radiol Anat. 2015; 37: 211-4.