Original Article
https://doi.org/10.5115/acb.2018.51.3.164
pISSN 2093-3665 eISSN 2093-3673
Anatomy & Cell Biology

Anatomical and radiological angiographic study of the coronary ostia in the adult human hearts and their clinical significance

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Abstract: This study was carried out to investigate the morphometric parameters and variations of coronary ostia in the hearts of adult human cadavers and coronary angiographs. The hearts of 60 adult human cadavers and 400 coronary angiographs were used in this study. The root of the aorta was carefully dissected to clear aortic sinuses, coronary ostia, and sinutubular junction (STJ). Number, locations, internal diameter distance between coronary ostia and their corresponding STJ, sinus bottom, and valve commissures were investigated. The anterior aortic sinus (AAS) revealed a single ostium for right coronary artery (RCA) in 77.5% of male and 80% of female hearts. This ostium gave a common origin for RCA and third coronary artery (TCA) in 15% of male and 20% of female hearts. However, two separate ostia for RCA and TCA origin were seen in 20% of male and 15% of female hearts. Moreover, three ostia were seen in one male and one female hearts within AAS. Meanwhile, the left posterior aortic sinus showed a single ostium for left coronary artery (LCA) in 97.5% of male and 95% of female hearts and two ostia in one male and one female hearts. The ostia were commonly seen below STJ and less commonly were observed above STJ. The distance between the bottom of aortic sinus and LCA ostium was longer than that of RCA. The internal diameter of RCA ostium was significantly ($P<0.05$) narrower than that of LCA but with no significant sex difference. Moreover, anomalous of coronary ostia was observed in seven out 400 angiographs and in two cadaveric hearts. Knowledge the morphometric parameters and anatomical variations of coronary ostia helps the cardiac surgeons to overcome the possible difficulties that could occur during surgical and radiological coronary interventions.

Key words: Coronary ostia, Anatomy, Angiography, Human, Cadaver

Received April 23, 2018; Revised May 10, 2018; Accepted May 18, 2018

Introduction

The aortic valve is present at the beginning of the ascending aorta for one-way passage of the blood from the left ventricle to the aorta. This valve exhibits three main cusps (leaflets), one anterior and two posterior. Just above the cusps, there are three corresponding aortic sinuses of Valsalva [1]. Beyond the upper border of the valve leaflets, the aortic sinuses form the sinutubular ridge (STJ) from the inner aspect of the aorta. These sinuses give the origin of coronary arteries through their coronary ostia, where the right coronary artery (RCA) originates from the anterior aortic sinus (AAS) through its ostium and the left coronary artery (LCA) originates from the left posterior aortic sinus (LPAS) through its ostium [2]. The difference in the diameter of the ostium and its location with reference to STJ may affect the amount of the coronary blood flow [3].

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Anatomical variations in the location of coronary ostia in human hearts can induce myocardial ischemia with subsequent arrhythmia, angina pectoris, infarction, and sudden death [4]. The incidence of such anatomical variations is rare, 0.3% in necropsy series and 1.6% in patients undergoing coronary angiography [5].

In clinical practice, cardiac surgeons and radiologists need more constant and important data about the location and variations of coronary ostia, where the coronary ostia play an important role in coronary angiography, catheterization, and angioplasty [6].

Thus, awareness of the anatomical variations of the coronary ostia is important for cardiologists, interventional radiologists, anatomists, and cardiac surgeons to achieve great advances in the surgery of coronary arteries and good interpretation of the radiological findings.

This study aimed to investigate the incidence and number of the ostia of coronary arteries in the adult human cadaveric hearts, their position with reference to aortic sinus and STJ. Also, the distance from coronary ostium to STJ, sinus bottom, and valve commissures; and the internal diameter of the coronary ostia were measured. The original variations of coronary arteries in cadaveric hearts and angiographs were evaluated as well.

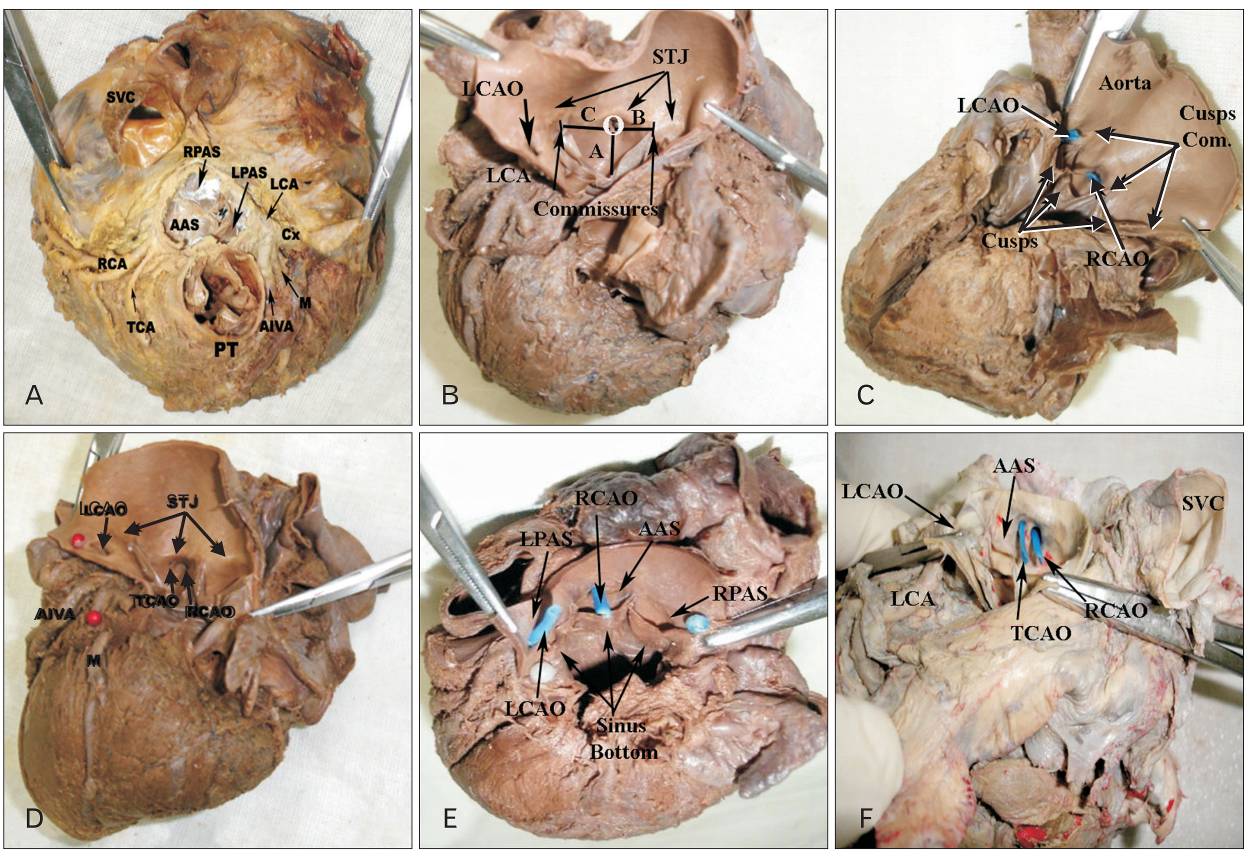

Fig. 1. Light photographs of adult cadaveric human hearts showing the root of the ascending aorta having the aortic sinuses and the ostia of coronary arteries. (A) The ascending aorta lies between the pulmonary trunk (PT) anteriorly and superior vena cava (SVC) posteriorly. It exhibits three aortic sinuses; the anterior aortic sinus (AAS), left posterior aortic sinus (LPAS), and right posterior aortic sinus (RPAS) above their corresponding aortic valve leaflets. The right coronary artery (RCA) and third coronary artery (TCA) originate from AAS through a common ostium, while the left coronary artery (LCA) originates from LPAS through single ostium. AIVA, anterior interventricular. (B) The ostium of the RCA (O) is surrounded by three lines (A–C) that represent the distance between the ostium and the bottom of the sinus vertically and the commissures of valve leaflets at both sides. The ostium of RCA is seen below sinu-tubular junction (STJ) within the AAS. Also, the ostium of LCA is seen below STJ within LPAS. (C) The ostia of both RCA (RCAO) and LCA (LCAO) are seen below the STJ within the corresponding aortic sinus. (D) The AAS shows two ostia below the STJ; one for RCA (RCAO) and the other for the third coronary artery origin (TCAO). (E) The ostia of both RCA (RCAO) and LCA (LCAO) are seen at the level of the STJ. (F) Both RCAO and TCAO are seen within AAS below STJ, while LCAO is present within the LPAS below STJ.

https://doi.org/10.5115/acb.2018.51.3.164

Materials and Methods

The hearts of 60 adult human cadavers (40 males and 20 females) were used in this study. The heart specimens were collected from the Anatomy Department, Faculty of Medicine, King Abdulaziz University, Saudi Arabia after approval the medical ethical committee. The hearts were fixed in 10% formalin solution. Micro-dissection was done for each heart to remove the epicardial layer (visceral pericardium) and the subepicardial fat to expose and clear the coronary arteries. The aortic root was opened and the site of coronary ostia was determined with special reference to the aortic sinus, STJ and valve commissures. Site and number of the coronary ostia were determined in each heart. The internal diameter of coronary ostia and the distance from the ostia to the sinus bottom, STJ, and the commissures of the aortic cusps were measured using 0.01 mm a sensitive digital Verneir's caliper. In addition, 400 coronary angiographs (200 males and 200 female) were retrospectively studied by two cardiologists with the authors to evaluate the origin of coronary arteries and its variations. Any cadaveric heart with previous cardiac surgery or gross pathology was excluded from the study. Also, the unclear coronary angiographic plate was omitted as well. A double check was done to the different measurements by the authors to avoid any bias. The results were tabulated and statistical analysis was conducted using the SPSS version 22.0

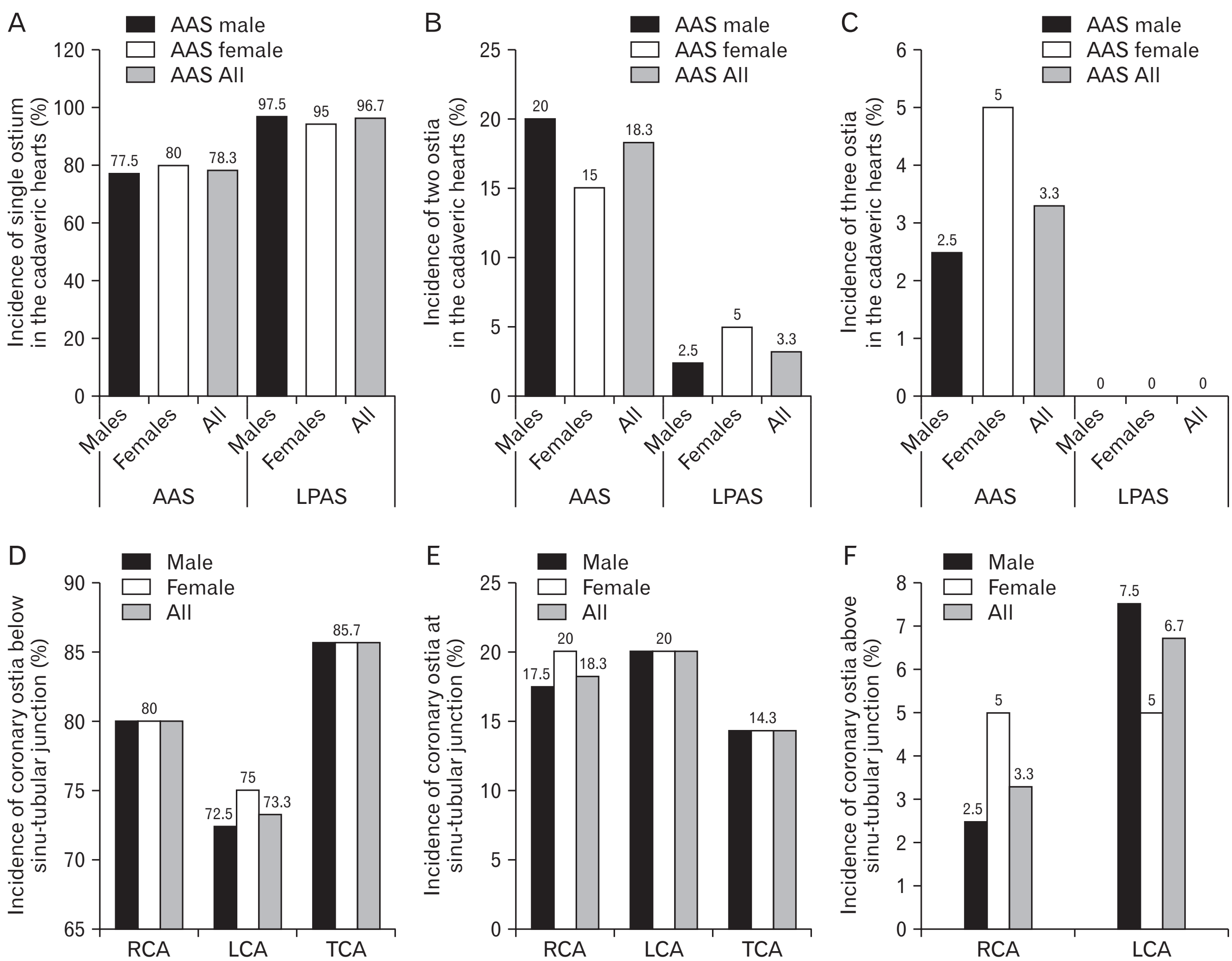

Fig. 2. The numerical and positional incidence of the coronary ostia in the cadaveric hearts (%). (A) The incidence of single ostium in the anterior aortic sinus (AAS) and left posterior aortic sinus (LPAS) is represented in male, female and all cadaveric hearts. (B) The incidence of two coronary ostia in both AAS and LPAS that are observed in male, female and all cadaveric hearts (%). (C) The incidence of three coronary ostia that are recorded within both AAS and LPAS in male, female and all cadaveric hearts (%). (D) The incidence of both right coronary artery (RCA) and left coronary artery (LCA) ostia below the level of the sinutubular junction (STJ) in male, female and all cadaveric hearts (%). TCA, third coronary artery. (E) The incidence of both RCA and LCA ostia at the level of the STJ in male, female and all cadaveric hearts (%). (F) The incidence of both RCA and LCA ostia above the level of the STJ in male, female and all cadaveric hearts (%).

for Windows (IBM Corp., Armonk, NY, USA). The data were reported as the mean±standard deviation (SD). Paired t test and chi-square tests were performed for the different measurements in both male and female hearts. *P*-value of <0.05 was considered significant.

Results

The aortic valve exhibited three main aortic cusps (leaflets), one anterior and two posterior. Above each cusp, there was a corresponding aortic sinus. The LCA originated from the LPAS through its ostium (LCAO), while the ostium of the right coronary artery (RCAO) was seen within the AAS. The cusps of aortic valve were connected with each other at the commissures. Above the level of these commissures, the STJ appeared from its inner side a ridge above the cusps (leaflets) of the aortic valve. Both LCAO and RCAO were observed below the level of STJ. The lines A, B, and C represented the distance between the RCAO and the bottom of the sinus and the commissures at its sides (Fig. 1B–D). The AAS exhibited two ostia for RCA and third coronary artery, while the LPAS showed a single ostium for LCA. These ostia were seen below the level of STJ within their corresponding sinuses (Fig. 1D, F). However, the ostia of RCA and LCA were seen at the level of STJ in few cases (Fig. 1E).

The incidence of coronary ostia within their corresponding aortic sinus was listed (Fig. 2A–C). The AAS revealed a single ostium for RCA in 77.5% of male, 80% of female and 78.3% of all hearts. In six (15%) of male and four (20%) of female hearts, the single ostium gave a common RCA and third coronary artery (TCA) (Fig. 1A). However, the AAS exhibited two separate ostia (Fig. 1D, F) in eight (20%) of male and three (15%) of female hearts. These two ostia provided a separate origin for RCA and TCA. Moreover, in one (2.5%) of male and one (5%) of female hearts, AAS exhibited three ostia for RCA, TCA, and vasa vasorum. Meanwhile, the LPAS showed a single ostium for the origin of LCA (Fig. 1A–E) in 97.5% of male and 95% of female hearts.

Moreover, the positional incidence of the coronary ostia with special reference to corresponding STJ was listed (Fig. 2D–F). The ostium of RCA within the AAS was seen below the level of STJ in 80% of RCA in both male and female hearts. Also, the ostium of LCA within the LPAS was seen below STJ in 72.5% of male, 75% of female and 73.3% of all hearts. The ostium of TCA within the AAS was observed below the level of STJ in 85.7% of their containing hearts. No sex difference (*P*>0.05) was recorded regarding the position of coronary ostia within the coronary sinuses (Fig. 2D). However, the coronary ostia were found at the level of STJ in 17.5% of male RCA, 15% of female RCA, and 16.7% of RCA in all hearts. Also, 20% of LCA ostia in both male and female hearts were seen at the level of STJ in LPAS. In addition, 14.3% of

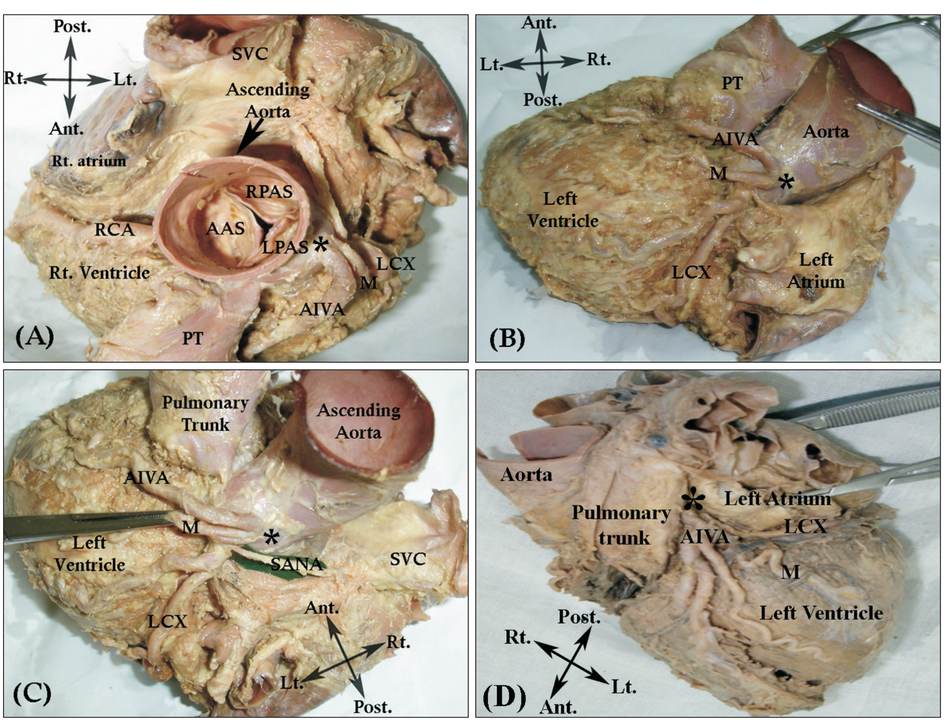

Fig. 3. Light photograph of cadaveric hearts showing original variations of the left coronary artery. (A) The anterior aortic sinus (AAS), left posterior aortic sinus (LPAS), and right posterior aortic sinus (RPAS) above the corresponding aortic cusps at the beginning of ascending aorta. The right coronary artery (RCA) originates from AAS and the branches of left coronary artery (LCA) originate from LPAS. The pulmonary trunk (PT) lies anterior to ascending aorta and superior vena cava (SVC) lies posterior to it. (B, C) The anterior interventricular (AIVA) and left circumflex branches (LCX) originate from LPAS through a common ostium (*) with an absence of LCA. The median branch (M) originates from LCX. (D) The large AIVA and small LCX branches of LCA originate directly from LPAS through a common ostium (*) with an absence of LCA. A median branch (M) is seen originating from AIVA.

https://doi.org/10.5115/acb.2018.51.3.164

TCA ostia within AAS in both male and female hearts were recorded at the level of STJ (Fig. 2E). Meanwhile, the lower incidence of the ostial position was observed above STJ level, where the coronary ostia of RCA in one male and one female hearts were observed above the level of STJ, while the ostium of LCA was seen in three male and one female hearts above the level of STJ in LPAS (Fig. 2F). However, an original anomalous of the coronary arteries was observed in two cadaveric hearts, one male and one female. In these cases, the two main branches of LCA were originated directly from LPAS through a common ostium (Fig. 3).

Meanwhile, in coronary angiographic images, the normal origin of both RCA and LCA from AAS and LPAS respectively was observed in 98% of male and 98.5% of female hearts. However, four out 200 of male (Fig. 4) and three out of 200 of female coronary angiographic cases (Fig. 5) revealed original variations. In these cases, RCA originated from LPAS in one male case, from anterior interventricular branch (AIVA) in one male case, and from left circumflex (LCX) in two female cases. In addition, LCA originated from right posterior aortic sinus in one male case and exhibited only one branch (AIVA) in one female case. However, in one male and two female cases, AIVA and LCX branches of LCA originated from two separate ostia.

The morphometric parameters of the coronary ostia revealed that the mean (range/mm) of the internal diameter of RCA, LCA, and TCA ostia was 3.43±0.63 (2.4–5 mm), 4.46±0.68 (3.1–6 mm), and 2.31±0.34 mm (1.8–2.7 mm) in male hearts respectively and 3.34±0.59 mm (2.6–5 mm), 4.38±0.74 mm (3.3–6 mm), and 2.3±0.42 mm (1.8–2.7 mm) for RCA, LCA, and TCA ostia respectively in female hearts. The dimension of the internal diameter of all coronary ostia revealed no significant sex difference (P>0.05), but the internal diameter of RCA ostium recorded a significant difference (P<0.05) compared to that of LCA ostium in the hearts of the same sex (Table 1).

Moreover, the mean (range/mm) of the vertical dimension from the ostium of LCA, RCA, and TCA to their corresponding sinus bottom was 14.2±2.6 (9–18.5 mm), 13.9±2.8 (8.5–20 mm), and 14.1±1.9 mm (11.5–17.1 mm) in male hearts and 13.7±2.8 (9.5–18 mm), 13.4±2.4 (9–18.8 mm), and 13.4±2.1 mm (11.6–16.3 mm) in female hearts respectively, while the mean of the vertical dimension from the coronary ostium of RCA, LCA, TCA to STJ of respective sinus measured 4.1±2.2 (0–7 mm), 3.3±2.02 (0–7 mm), and 4.2±2.7 mm (0–7 mm) in male hearts and 4.1±1.9 (0–7 mm), 3.4±2.1 (0–7 mm), and 4.2±2.9 (0–6.7 mm) in female hearts respectively, with no sex difference (Table 1).

The main horizontal distance from the ostium of LCA to the valve commissure on its left side was 12.3±1.15 mm and that from it to the commissure on its right side measured 11.5±1.3 in male hearts, while in female hearts the distance

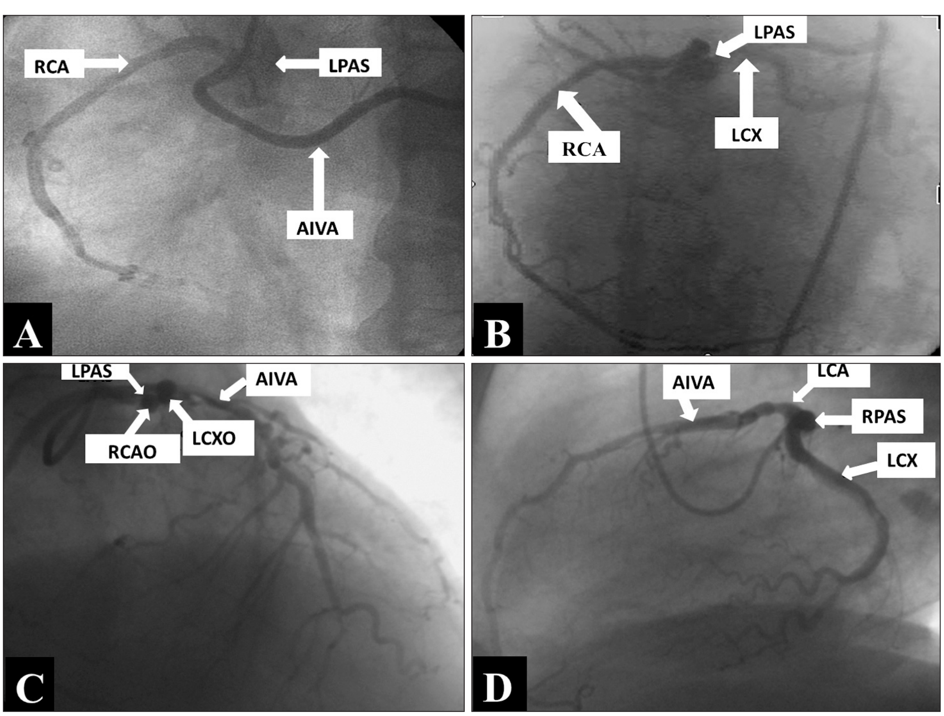

Fig. 4. Coronary angiographs of adult male human hearts showing different original variations of coronary arteries. (A) The right coronary artery (RCA) originates from the anterior interventricular branch (AIVA) of left coronary artery (LCA). (B) The RCA originates from the left posterior aortic sinus (LPAS). (C) The RCA and left circumflex branch (LCX) originate from LPAS. LCX and AIVA originate from two separate aortic sinuses. RCAO, ostium of the right coronary artery. (D) The LCA originates from the right posterior aortic sinus (RPAS).

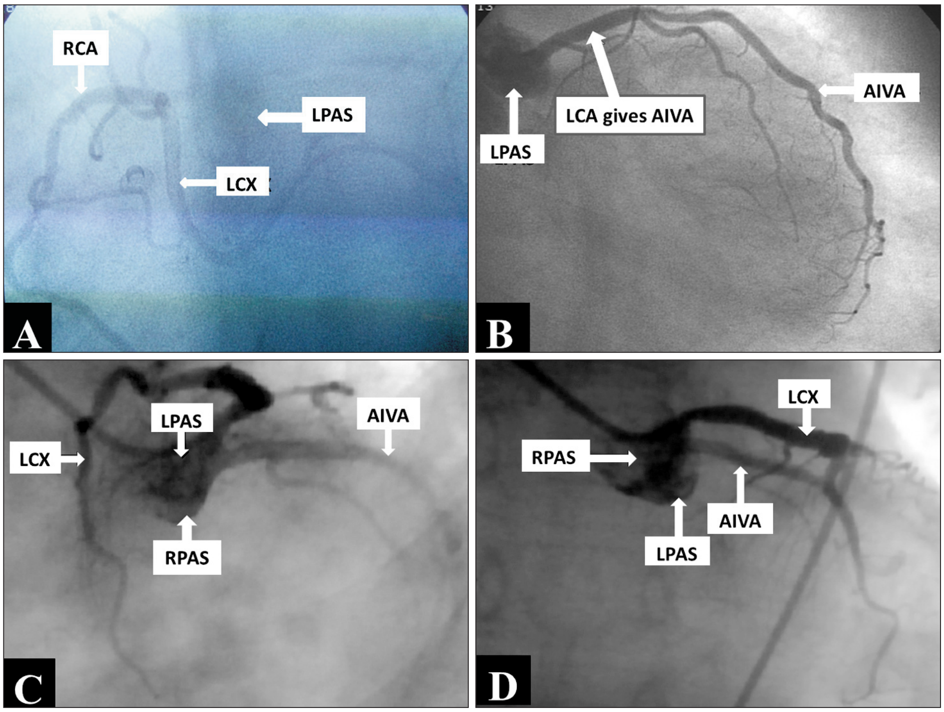

Fig. 5. Coronary angiographs of adult females showing the original anomalous of coronary arteries. (A) The right coronary artery (RCA) originates from the left circumflex branch (LCX). (B) The left coronary artery (LCA) gives only the anterior interventricular branch (AIVA). (C, D) The RCA originates from the LCX. AIVA originates from the right posterior aortic sinus (RPAS) and the LCX originates from the left posterior aortic sinus (LPAS).

Table 1. Morphometric parameters of the coronary ostia in male and female hearts

Parameters of coronary ostia	Male heart			Female heart		
	RCA	LCA	TCA	RCA	LCA	TCA
Ostium–STJ distance						
Mean±SD	4.1±2.2	3.3±2.02	4.2±2.7	4.1±1.9	3.4±2.1	4.2±2.9
Range	0.0–7.0	0.0–7.0	0.0–7.0	0.0–7.0	0.0–7.0	0.0–6.7
Ostium–Sinus bottom distance						
Mean±SD	13.9±2.82	14.2±2.56	14.13±1.9	13.41±2.38	13.65±2.75	13.38±2.1
Range	8.5–20.0	9.0–18.5	11.5–17.1	9.0–18.8	9.5–18.0	11.6–16.3
Internal diameter of coronary ostia						
Mean±SD	3.43±0.63	4.46±0.68*	2.31 ±0.34	3.34±0.59	4.38±0.74	2.3±0.42
Range (mm)	2.43–5	3.1–6	1.8–2.7	2.6–5	3.3–6	1.8–2.7

RCA, right coronary artery; LCA, left coronary artery; TCA, third coronary artery; STJ, sinutubular junction. One-way ANOVA test. *Significance between internal diameter of RCA and that of LCA at $P<0.05$.

between the ostium of LCA and left-side commissure was 11.8±1.1 mm and that between it and right-side commissure was 10.1±1.2 mm. Also, the mean distance from the ostium of RCA and their corresponding commissures was 14.1±1.3 mm on the left side and 11.3±1.1 mm on right side in male hearts, while it measured 14±1.2 mm on the left side and 11.1±1.1 mm on right side in female hearts. No sex difference was reported in the horizontal distance between coronary ostia and their corresponding commissures on both sides, while the distance between the ostia and their left-side commissures recorded a significant difference ($P<0.05$) compared to that on their right-side commissures in both male and female hearts (Table 2).

Table 2. Distance between coronary ostia and cusps' commissures

Ostium	Commissure to	Male heart	Female heart
LCAO	Left	12.3 ±1.15	11.8±1.1
		10.3–15.2	10.3–14.2
	Right	11.5 ±1.3*	10.1±1.2*[,a)]
		9.4–14	9.4–13.5
RCAO	Left	14.1 ±1.3	14±1.2
		10.9–16.1	10.6–15.6
	Right	11.3±1.1*	11.1±1.1*
		9.6–14.2	9.2–13.2

Values are presented as mean±SD or range. LCAO, ostia of both left coronary artery; RCAO, ostia of both right coronary artery. One-way ANOVA test. *Significance with the opposite side of same sex at $P<0.05$. [a)]Significance with opposite sex at $P<0.05$.

https://doi.org/10.5115/acb.2018.51.3.164

Discussion

Individuals having multiple ostia should be regular follow-up and carefully looked for any manifestation of ischemic heart diseases [7]. In all specimens of the present study, the LPAS showed a single ostium for LCA in 97.5% of male, 95% of female, and 96.7% of all hearts, while the AAS showed a single ostium in 77.5% of male, 80% of female, and 78.3% of all hearts. In six (15%) male and four (20%) of female hearts, the single ostium of AAS was the common origin of both RCA and third coronary artery (TCA). However, two separate ostia were observed in 20% of male, 15% of female and 18.3% of AAS of all specimens for RCA and TCA. Meanwhile, in one male and one female hearts, AAS exhibited three ostia for RCA, TCA, and vasa vasorum, also LPAS showed two ostia for LCA and vasa vasorum in one male and one female hearts as well. No significant sex variation was recorded in the number of coronary ostia within the aortic sinuses. In consistence with results of this study, Agrawal [8] found 78% of AAS and 96% of LPAS exhibiting a single ostium for RCA and LCA respectively and 16% of AAS and 4% of LPAS having two ostia. Moreover, a single ostium was present in 76.7%, double ostium in 16.7% and triple ostium in 6.6% of the specimens within AAS [9]. In addition, Gajbe et al. [7] stated that out of 30 hearts studied, five hearts (16.7%) revealed more than one ostium in AAS; two of them (6.7%) had two ostia and the other three (10%) showed three separate ostia. However, Bhele et al. [10] found one ostium in 70% of AAS and 84% of LPAS and more than one ostium in the remaining specimens. Meanwhile, a single ostium was observed in 61.9% of AAS and 98.9% in LPAS and two ostia were seen 29.3% of AAS and 1.9% of LPAS [2]. Also, AAS had one to three-minute extra-openings in 36% [1]. The numerical difference of coronary ostia within the aortic sinuses might be related to the number of specimens used or their race and sex.

The presence of multiple ostia within the coronary sinuses with or without original variations of the coronary arteries might be due to the growth of the coronary arteries into the aorta from the peritruncal ring of coronary vasculature, not grow out of the aorta [11]. Moreover, Udaya Sankari et al. [9] added that this process involves apoptotic changes by the molecular mechanism through vasculo-endothelial and fibroblast growth factors, where these factors stimulate the vasculogenesis and angiogenesis. However, the presence of multiple openings within AAS was explained as a result of the absorption of the bulbous cordis into both ventricles during the heart folding [12]. Presence of multiple coronary ostia could induce cardiac abnormalities like hypertrophic cardiomyopathy [7].

Knowledge of the anatomical level of coronary ostia with reference to STJ provides great help in many radiological and surgical cardiovascular procedures [13], where the proximity of coronary ostia to the aortic annulus and valve leaflets could increase the risk of coronary ostial closure during the operation of aortic valve replacement [14]. In this study, the site of the coronary ostia was observed below STJ in 80% of RCA, in 73.3% of LCA and in 85.7% of TCA with no significant sex difference. Similarly, a higher incidence of coronary ostia below STJ was recorded than that at or above STJ levels; in 90% of RCA and 73.3% of LCA ostia [10]; in 65% of RCA and 52.5% of LCA [13]; in 78% of RCA and 68% of LCA ostia [8]; in 63% of RCA and 44% of LCA [15]; in 73.3% for all [9]; in 78% of RCA and 58% of LCA [16]; in 90% of RCA and 80% of LCA ostia [2]; in 75% of RCA and 85% of LCA [17]; in 60% of RCA and 42% of LCA [3]; and below STJ in 89.5% of RCA and 80% of LCA and in 6.7% of RCA and 15.2% of LCA at the level of STJ and in 3.8% of RCA and 4.8% of LCA above STJ [2].

Moreover, results of the present study recorded 16.7% of RCA and 20% of LCA at the level of STJ and 3.3% of RCA and 6.3% of LCA ostia above STJ. Similarly, 10% of RCA and 16% of LCA ostia were seen at the level of STJ [8]. However, a higher incidence of ostia was reported at or above the level of STJ, 56.6% of RCA and 52.2% of LCA ostia at STJ and in 16.6% of RCA and 17.7% of LCA ostia above STJ [18]; 71% and 19% of RCA and 22% and 60% of LCA ostia respectively [19]; 24% of RCA and 39% of LCA at level of STJ and in 11% of RCA and 9% of LCA above STJ [13]; 26% of RCA and 37% of LCA above STJ [15]; 13% of RCA and 29% of LCA above STJ [16]; 10% of RCA and 20% of LCA ostia above STJ [4]; 28% of RCA and 40% of LCA above STJ [3]. Meanwhile, the ostium of RCA was seen below STJ in 16% and above in 2% of the cases. The difference of the original level of coronary ostia in relation to STJ might be due to the geographic or racial difference [20].

Coronary artery origin above STJ was referred to as a high takeoff [21, 22], where the origin of the coronary artery from the proximal one—cm above STJ was considered as a normal variant, while its origin from the next one—cm was considered as takeoff state [22]. Prevalence of a high takeoff was reported as 12% of RCA and 16% of LCA [8]; 6% of coronary arteries [21, 22]; in 3.8% of RCA and 4.8% of LCA [2]. However, the coronary ostia were seen above STJ level in 3.3% of RCA and 6.7% of LCA of the specimens in this study. The difference in the level of coronary ostia might be due to the geographic or racial difference [20]. Awareness of the presence of takeoff abnormalities protects the patient from the problems that could be occurred during the interventional procedures [22], where a higher failure rate in coronary catheterization was recorded in patients having coronary ostium above the level of STJ [21].

The coronary artery originating from coronary ostium below STJ exhibited thinner wall that that had an original level above STJ [1, 2]. The high position of the coronary ostium above STJ and acute initial angle were considered risk factors for acute coronary attack under certain conditions [19].

With reference to the aortic sinus bottom, results of present study showed slightly higher position of LCA ostia than those of RCA and TCA (P>0.05), where the mean distance between the bottom of coronary sinus and the ostium of LCA was 14.2±2.6 mm in male, 13.7±2.8 mm in female and 14.01±2.6 mm in all hearts with a range 9–18.5 mm while that of RCA was 13.9±2.8 mm in male, 13.4±2.4 mm in female and 13.7±2.7 mm in all hearts with a range 8.5–20 mm. With little difference, the ostial level of TCA was 14.1±1.9 mm in male and 13.4±2.1 mm in female hearts with a range 11.6–17.1 mm. In contrary to the observations of this research, Joshi et al. [2] found the position of RCA ostia at a mean distance 14.08 mm from the bottom of the sinus with a range 9–19 mm and that of LCA was 13.3 mm with a range 8–20 mm. However, lower values were recorded between sinus bottom and coronary ostia, where RCA ostia were found at a mean distance of 13.1±3.2 mm from sinus bottom and that of the LCA was seen at 11.8±3.2 mm [16]. Knowledge of the measurements of ostial height will help radiologists and clinicians during performing angiography and angioplasty [2]. Also, the main distance between the RCA ostia and the bottom was 11.73±2.9 mm and that of LCA was 12.7±2.1 mm [13]. The finding differences in the literature could be due to the arched form of STJ [2].

In consistence with the findings of this study, the location of coronary ostia was commonly shifted to the right commissure, where the horizontal distance from the coronary ostia and their left-side valve commissures was longer than that of the right-side valve commissures, but with no sex difference [3, 16, 23]. However, Joshi et al. [2] found 42% of RCA ostia and 80% of LCA ostia locating centrally between their corresponding valve commissures, while Pejkovic et al. [19] found 85% of LCA ostia in the midline posteriorly and only 15% was seen anteriorly, while the ostia of RCA were observed at the midline posteriorly in 87% and only 13% was seen at an anterior position. The right side location of the ostium of RCA within the aortic sinus could provide a more direct course around the tricuspid valve than other locations within the sinus. Also, the right displacement of LCA ostium could provide better blood supply to the anterior and left parts of the heart by LCA [23].

The dimensions of the internal diameter of coronary arteries have great influence on the results of coronary bypass operations. Also, the interventions like stenting and balloon angioplasty might have complications correlated with smaller calibers that may increase the risk of restenosis [24]. The mean of RCA ostium diameter in the present study was 3.43±0.63 in male, 3.34± 0.59 in female and 3.4±0.61 mm in all cadaveric hearts and that of LCA was 4.46±0.68 in male, 4.38±0.74 in female, and 4.43±0.69 mm in all cadaveric hearts with no sex difference but there was a significant difference (P<0.001) between the ostial diameter of RCA compared to that of LCA. In consistence with the results of this study, the mean of the internal diameter of RCA ostia varied from 3.17 mm to 3.9 mm and that of LCA measured from 4.1 mm to 4.96 mm in different researchers [3, 8, 13, 16, 17, 19]. However, in contrary to the findings of this investigation, the mean of RCA ostia diameter was 2.5±1.0 mm and 2.38±1.33 mm and that of LCA ostia was 2.8±1.0 and 3.17±0.39 mm, respectively [18]. No significant difference was reported in the diameter of RCA and LCA ostia [23]. The knowledge of these data has great importance in clinical and surgical practice, where the change in diameter, site, and the relation of coronary ostia could induce alterations in coronary flow. In different studies, a significant difference, but not sex difference was recorded between the main diameter of RCA ostia compared with that of LCA ostia [8, 13, 16, 17, 19]. These differences might be due to the variation in preparation, measuring method, number of specimens or racial factors.

Congenital anomalies of coronary artery have great importance in clinical cardiology and cardiac surgery especially during open heart surgeries and while performing coronary arteriography. The cardiac anomalies could induce myocardial ischemia and sudden death. The prevalence of the anomalies of the coronary arteries ranged from 0.21% to 5.79% [25]. However, the prevalence of the original variations of coronary arteries varied from 0.45% to 0.95% [26]. In such cases, the coronary arteries may originate from the pulmonary trunk

 https://doi.org/10.5115/acb.2018.51.3.164

or from the right posterior aortic sinus [27]. In this research, the absence of LCA trunk was observed in one male and one female cadaveric hearts (3.3%). In such cases, both LCX and AIVA branches of LCA arose from the LPAS through a common ostium. Also, in angiographic studies, 1.5% of female and 2% of male coronary angiographs revealed the original variation of coronary arteries. In disagreement with results of the present study, no original variations were noticed in the cadaveric hearts specimens [2]. Meanwhile, 1.3% anomalous origin of coronary arteries was reported in 1,879 adult Chinese patients underwent computed tomography coronary angiography [28]. Similarly, the prevalence of coronary artery anomalies in Saudi patients was 1.034% [29], which was close to the prevalence (1.029%) in the literature [30].

In conclusion, knowledge of the morphometric parameters and the detailed anatomy of the coronary ostia provide a clear explanation for the clinical impairments that could occur during the radiological interventional and cardiovascular operations.

Acknowledgements

Great appreciations to all technicians of the Anatomy Department, Faculty of Medicine, King Abdulaziz University for their help in doing this study.

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