Original Article

A Cadaveric Study Of The Branching Pattern Of The Right Coronary Artery In The Pakistani Population

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[2,4] Analysis/Interpretation/Discussion
[1] Manuscript Writing
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Abstract

Background: It is very common for coronary arteries to vary in their origin, course, and area of distribution. Knowledge about these variations is unequivocally important for a cardiac surgeon and physician. However, the prevalence of such variations varies among different populations. The already available data on variations in the anatomy of coronary arteries is mostly based on studies conducted on the Western population and quite a few studies report the coronary arterial patterns of the Asian population. Between the two main coronary arteries, i.e., the right coronary artery (RCA) and left coronary arteries (LCA), variation in the branching pattern of RCA is more common than LCA. The present study investigated the branching pattern of RCA in the local population in Pakistan and hence will add to the existing data on inter- and intra-population frequencies of the branching pattern of RCA among non-Europeans.

Methods: It was an observational study of six months duration and conducted on dissection cadavers available in various medical colleges of Rawalpindi and Khyber Pakhtunkhwa. The branching pattern of RCA was studied by the blunt dissection method.

Results: Right marginal, conus, Sinuatrial (SA) nodal, atrioventricular (AV) nodal, and posterior descending arteries (PDA) were arising from RCA in the majority of cases. However, the branching pattern varied from one heart to another as reported in other studies carried out in developed countries. The frequencies of branching patterns of RCA varied from those already reported in the literature.

Conclusion: RCA manifests anatomical variations in branching patterns as reported in international literature and this variation is different in different populations of the world which indicates that postnatal development, along with differences based on geography and ethnicities might contribute to the modification of the anatomical pattern of coronary arteries in humans.

Keywords: Coronary variation, right coronary artery, coronary circulation

Introduction

Variation in the anatomy of coronary arteries is quite common including variation in their origin (Ullah et al., 2015), course, branching pattern, and area of distribution (Bergman et al., 1988; Angelino et al., 2002). However, the prevalence of such variations varies among different populations ranging from 0.3-6% (Abdellah et al., 2009; Kardos et al., 1997; Garg et al., 2000).

PURPOSE OF THE STUDY

Knowledge about coronary variation is unequivocally important for a cardiac surgeon and physician. (Zimmermann et al., 2008). Moreover, these coronary variations form a cornerstone of these procedures to localize areas associated with coronary atherosclerosis, and during coronary artery bypass grafting (CABG). Furthermore, the exploration of varying patterns of coronary arteries will add to the growing body of scientific knowledge (Baptista et al., 1992; Kalpana, 2003).

The already available data on variations in the coronary arterial anatomy is mainly based on studies conducted on the Western population (Kardos et al., 1997; Cieslinski et al., 1993; Frescura et al., 1998; Yamanaka & Hobb, 1990). The number of studies reporting coronary arterial patterns in the Asian population is very limited (Garg et al., 2000; Kaku et al., 1996). Between RCA and LCA, variation regarding the branching pattern is more common in RCA (Topaz et al., 1992; Garg et al., 2000). The present study investigated the branching pattern of RCA using cadaveric hearts of the local Pakistani population and is aimed to contribute to the existing data on the varying anatomy of RCA.

Objective

To find out the branching pattern of RCA in the local Pakistani population.

Materials and Methods

It was an observational study of six months duration carried out in the Anatomy departments of various medical colleges of Rawalpindi and Khyber Pakhtunkhwa. The heart specimens studied were collected from thirty adult male cadavers available in the Anatomy departments of these medical colleges. Blunt dissection was carried out to study the branching pattern of RCA. Research protocol was duly approved by the institutional review board of Army Medical College Rawalpindi, Pakistan.

SAMPLE SELECTION Inclusion criteria:

1. Dissection cadavers of any age group. **Exclusion criteria:**
    1. Any direct heart trauma.
    2. Previous heart surgery. **Method of specimen collection:**

The thoracic cavity was opened as per the guidelines of Cunningham's Manual of Practical Anatomy (Romanes, 1989). An H-shaped incision was applied to the fibrous Pericardium in order to remove the heart from the pericardial cavity. The blunt dissection method was carried out to expose RCA and its branches located at the sub-epicardial level. Various extramural sub-epicardial branches of RCA were noted. Right arterial dominance was noted in cases where the posterior interventricular/descending artery originated from RCA. The observations were recorded with digital photographs.

STATISTICAL ANALYSIS OF THE DATA Analysis of data was carried out by using SPSS (Statistical Package for Social Sciences) Windows version 18. In order to describe the data, descriptive statistics were used. For quantitative variables, the mean (±SD) was calculated. For qualitative variables, frequencies and percentages were calculated.

Results

Branches of RCA:

i) Right conus artery:

In all hearts, the conus branch arose from the RCA (Fig. 1). ii) Right marginal artery:

The right marginal artery, one of the main branches of RCA, arose from the main stem of RCA in all cases, in which it was present (Fig. 2). The right marginal branch was absent in 1 (3.33 %) case. The right marginal artery gave off one branch in 8 (26.7%), two branches in 5 (16.7%) and no branch in 16 (53.3%) hearts (Fig. 3).

iii) Posterior descending artery (PDA): PDA was branch of RCA in only 22 (73%) hearts (Fig 4); whereas in rest (27%) of these, it either arose from LCA or was formed as a result of anastomosis of both RCA and circumflex branch of left coronary artery (LCX) at crux of the heart. The PDA as a distinct branch was not found in 3 (10 %) hearts however several discrete branches of both RCA and

LCX were supplying myocardium and hence were manifesting a co-dominant pattern of coronary circulation (Fig. 5). iv) SA nodal artery:
SA nodal branch originated from RCA in 27 (90%) cases. In 3 (10 %) cases, SA nodal branch could not be found at least at the sub-epicardial level. v) AV nodal artery:
In 24 (80%) of the heart specimens, the AV nodal branch of RCA was identified at the sub-epicardial level.

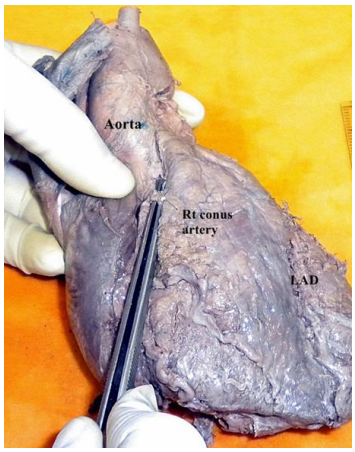

Figure- 1: Photograph of the heart specimen no. 22 showing right conus artery originating from RCA

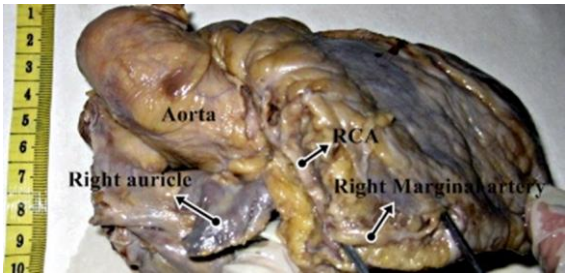

Figure-2: Photograph of heart specimen no. 16 showing right marginal artery arising as a branch of RCA.

vi) Left ventricular branches:
1-2 Left ventricular branches of RCA were noted in 24 (80%) cases.
A pattern of coronary circulation:
Based on the origin of the posterior interventricular artery, the pattern of coronary circulation was right-dominant in 22 (73.3 %) cases (Fig 5).

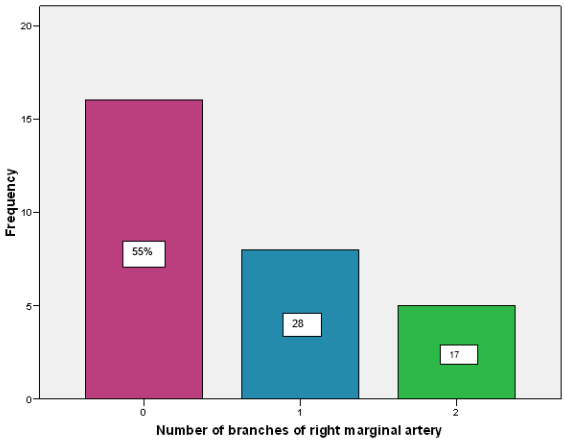

Figure-3: Diagram showing the frequency of different branching pattern of right marginal artery.

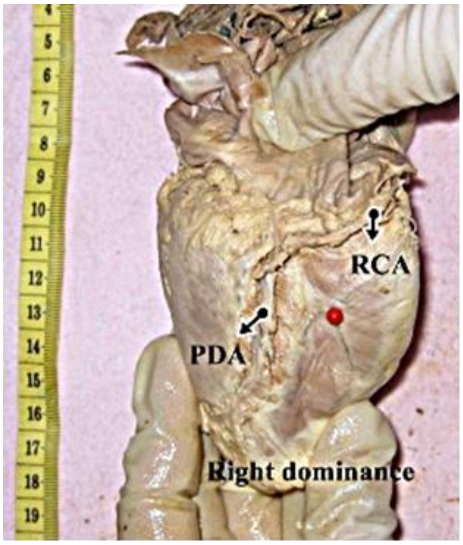

Figure-4: Photograph of the heart specimen no. 17 showing PDA arising as a branch of RCA

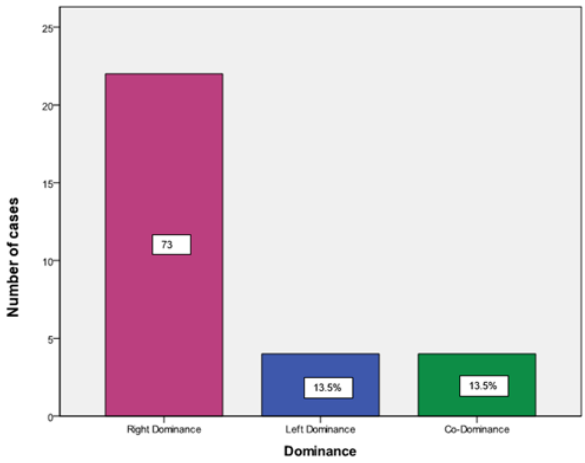

Figure-5: Diagram depicting the frequency of different patterns of coronary.

Table-1: Frequency of different branching patterns of RCA and right marginal artery at sub-epicardial level

No. of branches	*RCA*	*Right marginal Artery*
0	_	16 (53.3 %)
1	_	8 (26.7 %)
2	-	5 (16.7 %)
3	2 (6.7 %)	_
4	6 (20 %)	_
5	15 (50 %)	_
6	4 (13 %)	_
7	3 (10 %)	_
Total	30 (100 %)	29 (96.7 %)

Discussion

According to Shakeri et al (2007), anatomical variation is considered as a normal flexibility in the structure. Coronary variations have been vigorously studied to date particularly with effect from 1960s when coronary angiography was introduced in clinical practice. Nevertheless, anatomists and researchers to date have been unable to reach a consensus on what constitutes 'normal' or 'abnormal' coronary arterial anatomy. This might mean that coronary arterial anatomy varies from one individual to another and hence coronary arterial anatomy of two hearts can never be identical
(Schlesinger, 1940). Among the main coronary arteries, RCA has been reported to be more frequently associated with variations as compared to others (Topaz et al.1992 & Garg et al., 2000). The present cadaver-based study was designed to see the anatomical variations in the branching pattern of RCA in the Pakistani population, on carefully chosen specimens.

RCA was noted to arise from the right aortic sinus and thereafter descended in the groove between the right atrium and right ventricle till it reached the right heart border from where it proceeded to the posterior part of the right atrioventricular (AV) groove. The various branches given off by the artery were the conus artery, SA nodal artery, right marginal artery, PDA at the diaphragmatic surface, AV nodal artery, and one or more left ventricular branches. In 4 (13.3 %) hearts, RCA ended near the right heart border or between this border and the crux of the heart in 3 (10 %) cases; in the rest of the cases, it reached the crux or extended even further to anastomose with the terminal part of LCX. This study supports the observations of David et al., (2005) and Sinnatamby (2011) with regard to the course of RCA.

In our study, RCA of 2 (6.7%) hearts had 3 branches, 6 (20%) hearts had 4 branches, 15 (50%) hearts had 5 branches, 4 (13.3%) hearts had 6 branches, 3 (10%) hearts had 7 branches (Table I). Surgical treatment of tetralogy of Fallot necessitates the radiological localization of the origin of the conus branch of RCA in relation to the outflow tract of the right ventricle (Kurjia et al., 1986). The conus branch of RCA is known for its variation in its origin which varies from 7.6% – 51%, and some ethnic differences have been reported by previous studies (Vilallonga, 2003, Schlesinger, 1949; Kurjia et al, 1986). Cademartiri et al. (2007, 2008) based on their two CT angiographic studies reported that the site of origin of this artery is either proximal to the RCA (64.1% and 59%) or aorta and the aortic ostium and aorta (39% and 33.9%, respectively). In our study, the right conus artery originated from the RCA in all cases and thereby contradicts the observations of Cademartiri et al (2007) and Garg et al., (2000). Our study supports the observation of Vilallonga (2003) that ethnic differences might be responsible for this variant pattern of origin of the right conus artery.

According to Gray's Anatomy, the dominance of the coronary arterial system is determined by the artery giving rise to the posterior interventricular/descending branch (Gotzilius, 2008). In our study, the frequency of right dominance was high and present in 73.3% of the population and hence was the most common pattern of circulation, as reported in the international literature (Abdellah et al.,

2009; Gotzilius, 2008). Our observations support the results of Christensen et al., (2010), Abdellah et al., (2009), and Ortale et al., (2004) that the most common pattern of coronary circulation is the right dominant one. However, the available literature shows remarkably different frequencies of the different patterns of coronary circulation which indicates that there is a great variation in the pattern of coronary circulation in different populations of the world. Our observations endorsed Schlesinger (1940)'s findings that no two human hearts can be alike with regard to the coronary arterial tree and so do the branching pattern of RCA.

The underlying basis of this variable pattern of coronary arterial anatomy may be genetic and/or environmental factors. Environmental factors range from variable patterns of maternal nutrition, socioeconomic, healthcare, dietary, psychological factors, exercise patterns and several other factors that have surfaced with gradual modifications over the centuries. One well-known example of the impact of such environmental factors on human health is the reduced occurrence of cases of neural tube defects owing to the peri-conceptual use of folic acid supplements (Giesel, 2003). Increasing migration of world population over the time specially from the less developed to the developed parts of the world in search of better living might have contributed at least in part to the range of variability of anatomical structures in humans (Henneberg, 1992).

Conclusion

It is concluded that the RCA manifest anatomical variations in branching pattern and supports the international literature that the prevalence of this variation in the branching pattern of RCA is different in different populations of the world. This variety in the branching pattern of RCA in different populations lends support to the assertion that postpartum development and changes in wide-ranging environmental factors along with geographic and ethnic differences might modify the anatomical pattern of human coronary arteries.

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