

Variations of coronary arteries - cast and angiogram study

Pradeep Singh^{1,*}, Vasundhara Kulshrestha², Brijendra Singh³

¹Lecturer, ²Professor & HOD, SN Medical College, Agra, Uttar Pradesh, ³Additional Professor, Dept. of Anatomy, AIIMS, Jodhpur, Rajasthan

***Corresponding Author:**

Email: psingh2336@gmail.com

Abstract

50 specimens were collected from anatomy and forensic medicine department after postmortem for the present study. In angiographic as well as cast study of coronary vessels, it was observed that there were three types of anastomotic pattern between the coronary arteries right and left (LCA). The conus artery (branch of right coronary artery) was arising separately from anterior aortic sinus as third coronary artery and was present in 20% of specimen studied in present study. 84% of specimen of coronary arteries exhibited interesting variations, like the main trunk of LCA showed either a bifurcation or Trifurcation while in 14% cases showed Quadrifurcation (branching further into four rami) and in 2% cases, even Penta furcation (branching further into five rami) was observed.

Keywords: Right coronary artery, Left coronary artery, Coronary anastomosis, Angiogram, Corrosion-cast

Introduction

Knowledge of normal and variant anatomy as well as anomalies of coronary circulation is an increasingly vital component in management of congenital and acquired heart disease which is vital and is also important to improve the operative outcomes in cardiac ailments.

The recent introduction of selective coronary arteriography provides an accurate localization of anatomical variations and underlying pathology.

The advances made in coronary arterial bypass surgeries and modern methods of myocardial revascularization makes it imperative that a thorough knowledge of the normal and variant anatomy of coronary artery and circulation is required, this idea and thought led to the present study.

Well prepared three dimensional casts provide an unique insight for the study and understanding of the complexity of cardiovascular vascularity, anastomosis and variations if any.

Materials and Method

We took 50 specimens for this study were obtained from the departments of Anatomy and Forensic medicine after postmortem from S.N.Medical College, Agra UP. Specimens of hearts after proper cleaning, to wash away blood and clots were fixed in 10% formalin. The coronary arteries were cannulated through respective ostia and flushed with H₂O₂ Hydrogen peroxide solution so that remaining minor blood clots may be flushed out if any in the smaller arteries.

Butyl Butyrate granules (red and blue color) are dissolved separately in two bottles in the concentration of 14-16% and capped to check evaporation of acetone.

Then 10-15ml of prepared resin is filled into 50ml glass syringe and injected into the ostias of coronary arteries one by one with equal and gentle pressure. The

red colored casting material is injected into right coronary artery and blue colored casting material is injected into left coronary artery, after that the perfused heart is kept in beaker containing tap water and put into oven at 60 degree C for overnight so that complete polymerization takes place.

The perfused heart is taken out of oven on next day and is beaker is replaced gradually by 5% KOH solution and kept into hot air oven at 40 degree C for another eight hours. Soft tissue digestion is performed for 8 hours, and solution becomes dirty and milky so, 5 % KOH solution is changed and maceration is allowed to proceed for another 2 days.

The macerated tissue is then brought out of 5% KOH solution and is washed out carefully and gently in running tap water leaving behind the casts of left and right coronary arteries.

Each cast thus obtained is then dipped in glycerin for 20 minutes and then put into the formalglycerine for 5 to 10 days. This prevents growth of fungus on casts and help to maintain the glare and elasticity.

Now, the casts are ready for observations.

Methodology for preparation of angiogram of coronary arteries: Heart is kept in 1% formal saline and then taken out to wash in running water. The coronary arteries are cannulated through respective ostia and flushed with dilute concentration of H₂O₂ solution to flush out the clots.

10-15 ml of radio-opaque Barium Sulphate solution (BaSo₄) is injected in each coronary artery and X-rays are taken. (Exposure given:- 300 Ma, 40Kv, .04sec., distance-32"). Postero-Anterior and Right & Left Lateral views are taken and X-rays are studied for the branching pattern, anastomotic branches other details.

Review of literature

“A TV star sued his cardiac surgeon, because in a bypass operation, he negligently removed the healthy coronary artery leaving the defective one behind. The attorney for the surgeon argued in court that the mix-up was a natural result of abnormalities in the patient’s heart”.

The lawyers put the patient’s arteries on trial. Their defense was that the patient had “freakish anatomy” of coronary arteries.

{Information Source, People(weekly),6/12/2000}

Table 1: Coronary artery anomalies in angiographic study

Author	No. of Patients	Variations	Incidence
Baltaxe	1000	09	0.9%
Donaldson	9153	82	0.9%
Hobbs	38,703	601	1.55%
Wilkins	10,661	83	0.78%
Yamanaka	1,26,595	1686	1.3%

According to Vieweg, Alpert and Hagan, the sinuatrial nodal artery arose from right coronary artery in 53%, the left coronary artery in 35% and from both in 11% of 118 patients. The atrioventricular nodal artery arose from right coronary artery in 84%, left coronary artery in 8%, and from both in 8% of 118 patients.

Baptista CA, Didio LJ, Bates JC (1991) studied types of division of left coronary artery. As the investigation was performed in 150 hearts, dissected after injection of colored substance in coronary arteries. Results showed that the left coronary artery presented 3 types of division.

Type-1 Bifurcation in 54.7%

Type-2 Trifurcation in 38.7%

Type-3 Quadrification in 6.7%

Observations

The observations taken include the study by gross dissection, casts preparation and angiograms and perfusion method of the right and left coronary arteries.

The right coronary ostium was present in all specimens in Right anterior aortic sinus. The ostium was below subvalvular Ridge in 78%, at valvular Ridge in 22% and above supra-valvular ridge in none of the specimens.



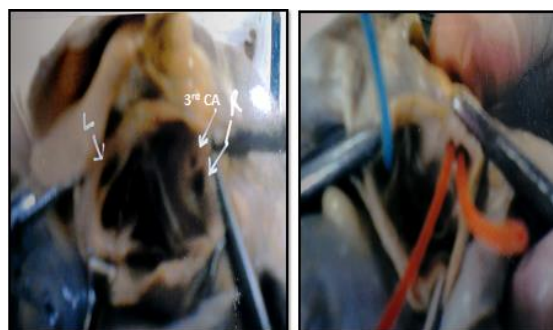
Photograph 1 of cast of RCA showing:

1. Conus artery (CA)
2. Sinuatrial Nodal Artery (SANA)
3. Acute Marginal Artery (AMA)
4. Ventricular Branches (VA)
5. Posterior Interventricular Artery (PIVA)
6. Atrio Ventricular Nodal Artery (AVNA)

The conus artery (branch of right coronary artery) arising separately from anterior aortic sinus as Third coronary artery and was present in 20% of specimens.(Photograph 2).



Photograph 2 is showing the angiogram of Right & Left coronary arteries. The conus artery is seen arising from separate ostium as IIIrd coronary artery indicated by arrow (designated as IIIrd coronary A.)



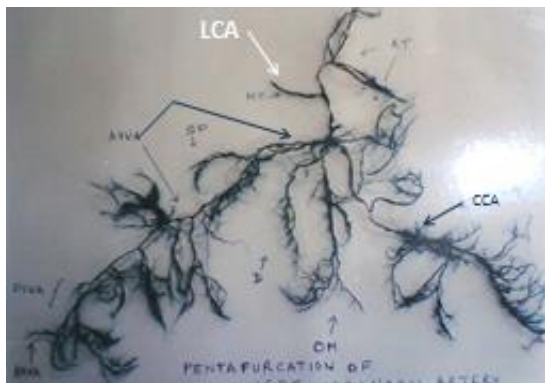
Photograph 3 is cut section of heart showing two ostia in right aortic sinus of Valsalva for Right Coronary Artery (R) and Third Coronary Artery (3rd CA) (Conus Artery arising from separate Ostium). Ostia for Left coronary Artery (L) is also seen.

Photograph 4 is showing two ostia in right aortic sinus of Valsalva (indicated by two red coloured probes. The blue coloured probe is indicating ostia for Left Coronary Artery)

Atrio-ventricular nodal artery (AVNA) arose from RCA in 78% and from LCA in 22% of specimens.

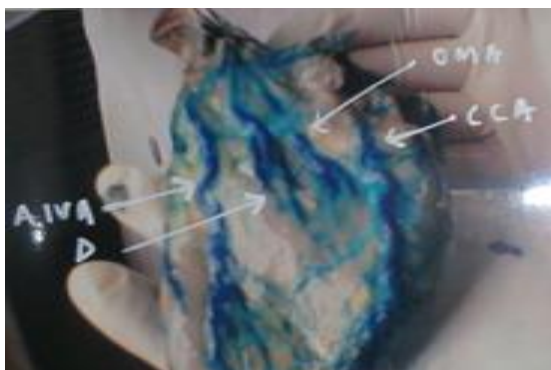
Posterior Interventricular artery (PIVA) arose from RCA in 82% and from LCA in 18% of specimens.

In 2% cases, AIVA is continuous as PIVA and giving rise to AVNA



Photograph 5 is cast of branches of Left Coronary Artery:

1. Main Trunk (MT)
2. Atrial Branches (AT)
3. Pentafurcation of LCA which includes:
 - a. Anterior interventricular artery (AIVA)
 - b. Diagonal Artery (D)
 - c. Obtuse Marginal Artery (OM)
 - d. Circumflex Artery (CCA)
 - e. Atrial Branches
4. Septal Perforators
5. Posterior interventricular artery (PIVA)



Photograph 6 showing Pentafurcation of Left Coronary Artery by dye and cast method:

The Pentafurcation includes:

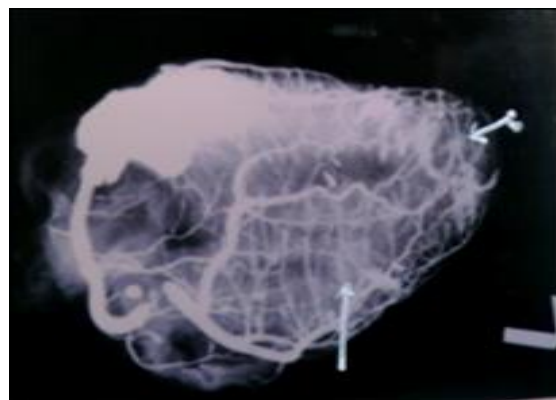
1. Anterior Interventricular Artery (AIVA)
2. Diagonal Artery (D)
3. Obtuse Marginal Artery (OMA)
4. Circumflex Artery (CCA)
5. Atrial branches (can be seen in Photo 5)

In angiographic as well as cast study of right and left coronary arteries, it was found that there were three types of anastomotic pattern between right and left coronary artery;

TYPE-I: minimum anastomosis are seen (Photograph 2) where arteries are not anastomosing to each other and act as end arteries.

TYPE-II; Loop system exist in few branches which are directly anastomosing with RCA and LCA, is evident in radiographic study (Photograph 6).

TYPE-III; In some of the hearts, there was massive network of smaller branches of RCA and LCA and free anastomosis to each other. (photograph 7).



Photograph 7 is angiogram RCA and LCA showing Loop system (indicated by arrow)



Photograph 8 is angiogram of heart showing massive network of smaller branches and anastomosis of RCA & LCA

Discussion

Branches of coronary arteries may vary in origin, distribution, number and size. The name and nature of a branch of coronary artery is defined by that vessel's distal vascularization pattern.

First and highest branch of proximal segment of RCA, arises in 36% of cases from a separate ostium (third coronary artery) in study of Williams et al in 1995, while in present study (Photograph 2, 3 & 4), it was in 20% cases.

The second branch of first segment of RCA, Sinoatrial nodal artery (SANA), according to Caetano & Lopes in 1995 arises from RCA in 58% and from LCA in 42% of specimens while in present study (Photograph 1), it was 60% and 40% from RCA and LCA respectively.

The distribution of SA Nodal arteries allows to understand the possible of Sinusal nodal syndrome and permits the surgeon, a safe approach to cardiac diseases.

In 84% of specimens in our study, the main trunk of LCA showed either a bifurcation or trifurcation. Table-2 compares the divisions of main trunk of LCA with the studies of Baptista (1991) and Cavalcanti (1995).

In 2% cases, even Penta furcation was noticed (Photograph 5 & 6) in present study.

Table 2: Divisions of main trunk of left coronary artery (in %)

Branches	Baptista (1991)	Cavalcanti (1995)	Present Study
One Branch	-	-	None
Bifurcation	54.7	60	50
Trifurcation	38.7	38.18	34
Quadrifurcation	6.7	-	14
Pentafurcation	-	-	02
Total	100	100	100

References

- Aharinejad, S, W. Schreines, F. Neumann (1998): Morphometry of human coronary arterial trees: The Anatomical Record 251:50-59.
- Baptista, CAC, DiDio, LJA, Davis, J.T.,(1998): The cardiac apex and its superficial blood supply. Surg. Radol. Anat; 10:151-60.
- Baptista, C.A.(1991): Types of division of left coronary artery and the ramus diagonalis of the human heart. Japanese Heart Journal. 32(3):323-335.
- Baroldi, G. and Scomazzoni, G.(1956) : The collaterals of the coronary arteries in normal and pathological hearts. Circulation Research 4:223-229.
- Blunk, J.N., Didio, LJA, (1971): Types of coronary circulation in human hearts. Ohio state med J. 67:596-607.
- Cavalcanti, J.S. et al.(1995) : Anatomic Variations of the coronary arteries. Arq. Bras Cardiology 65(6):489-492.
- Davidson CJ, Laskey WK, Hermiller JB, et al.(2000) Randomised trial of contrast media utilisation in high-risk PTCA : The Court trial, circulation 101:2172.
- Engel, H.J. and Torres, C.(1975): Major variations in anatomical origin of the coronary arteries – angiographic observations in 4250 patients without associated congenital heart disease. Cathet. cardiovascular Diagnosis 116(5):157-169.
- Gray's Anatomy (1995): Circulatory system 38th Edn. Churchill Livingstone. U.S.A. pp 1505-1510.
- Hadziselinovic, H, Scre rov, D.(1979): Superficial anastomosis of blood vessels in the human heart. Acta Anat; 104:268-78.
- Hood, J.H.(1973): Anatomy of the coronary arteries. Seminars Roentgen;8:3-17.
- Jose Roberto Ortale et al (2003): The posterior ventricular branches of the coronary arteries in the human heart, Brazil.
- Kumar K.: Acta Anat (Basel). 1989;136(4):315-8.
- Lie JT(1979) Heart and vascular systems: Ludwig J.ed. Current Methods of Autopsy Practice. 2nd ed. Philadelphia, Pa: WB Saunders Co.,p.21-50.
- Smith G.T.(1962): The anatomy of coronary circulation. Am J. Cariol: 9:327-342.
- Takushi Kohmoto, Noriyoshi Yamamoto, (1997): Assessment of transmucosal perfusion in alligator hearts. American Heart Association, Circulation 95: pp (1585-1591) db59@columbia.edu.
- Tomsett DH.(1970): Anatomical techniques living stone, Edinburgh.
- Weaver ME, Pantely GA, Bristow JD, Ladley HD: Cardiovasc Res.1986, Dec.;20(12) : 907-17.
- Williams P.L. Bannister, L.H., Berry M.M.; Collins. P; Dyson. M. Dusse J.E. Ferguson M.W.J.(1995): Gray's Anatomy In: Circulatory system 38th Edn. Churchill living stone, U.S.A. pp 1505-1510.
- Zamir M.(1996): The Structure and branching characteristics of the right coronary artery in a right dominant human heart. Can.J.Cardiol.;6:p 593-599.