Trakia Journal of Sciences, Vol. 3, No. 2, pp 44-49, 2005

Available online at:
http://www.uni-sz.bg

ISSN 1312-1723

Original Contribution

VENTRICULAR CORONARY PATTERN IN THE CAT

Diyana Vladova*

Department of Veterinary Anatomy, Histology and Embryology,
Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria

ABSTRACT

The ventricular coronary model was studied on hearts of eleven healthy adult male cats. The arterial network in four of the hearts was studied using injected coloured gelatine. After a polymer inoculation seven hearts were macerated and the vascular prints observed. In all cases studied *A. coronaria sinistra* began as a common trunk. In the coronary furrow we found a division of the artery into *R. interventricularis paraconalis* and *R. circumflexus* with the latter giving off a lot of branches. Variability was observed in *R marginis ventricularis sinistri* and *R. distalis ventricularis sinistri*. *R. marginis ventricularis sinistri* was either well expressed or considerably less expressed. The continuation of *R. circumflexus* along the right interventricular furrow gave rise to *R. interventricularis subsinuosus*. The left coronary artery was found to be involved in the vascularisation of the bigger part of the myocardium, and *A. coronaria dextra* was found to ramify only in the region of *Margo ventricularis dexter.* On the basis of this the ventricular part of the heart could be divided into four regions, namely: 1. *R. interventricularis paraconalis* and *R. distalis ventricularis sinistri;* 2. *R. distalis ventricularis sinistri* and *R. interventricularis subsinuosus*; 3. *R. interventricularis subsinuosus* and *R. marginis ventricularis dextri* and 4. R. *marginis ventricularis dextri* and *R. interventricularis paraconalis*. The separate parts of the ventricular myocardium were found to belong to different haemodynamic framework because the ramification of *A. coronaria dextra* and *A. coronaria sinistra* occurred at a different angle in the separate ventricular segments. We conclude that the ramification peculiarities of *A. coronaria sinistra* and *A. coronaria dextra* determine a left dominant type of ventricular vascularisation in the cat.

Key words: heart, cat, ventricular myocardium, coronary pattern

INTRODUCTION

The contemporary cardiologic techniques allow new experimental and clinical fields which undoubtedly require the understanding of the coronary model in different ventricular segments This fact transforms the anatomical factor into an important diagnostic and therapeutic reference point which focuses research intentions and is subject to a lot of experiments (1-7).

Through coronary circulation the heart receives about 15% of the blood, penetrated into the aorta (8). The coronary arteries (*Aa. coronariae*) begin from the aorta sinuses (*Sinus aortae*) (9-13). Their branches are situated in the coronary and the interventricular furrows. ***A. coronaria sinistra*** begins from the left caudal sinus and supplies the bigger part of the heart. In 72% of cases in the dog the artery begins as a principal trunk which divides in the coronary furrow between *Tr. pulmonalis* and the left auricle into two branches - R. *interventricularis paraconalis* and R. *circumflexus* (8, 14). In 28% of cases these two branches begin independently (14). Regardless of the way of dissociation *R. interventricularis paraconalis* goes along the furrow having the same name and reaching the apex of the heart, and R. *circumflexus* continues along *Sulcus coronarius*, ramifies into 3 - 4 arterial and 6 - 7 ventricular branches and is connected with branches of *A. coronaria dextra*.

A. coronaria dextra dissociates from the cranial sinus of the aorta, passes between the lung trunk and the right auricle and continues subepicardially along the right part of the coronary furrow. It goes down as *R.*

[*]**Correspondence to**: *Diyana Vladova, Department of Veterinary Anatomy, Histology and Embriology, Faculty of Veterinary Medicine, Trakia University, St. agora 6000, E-mail: Diana_vladova@abv.bg*

interventricularis subsinuosus along the interventricular furrow having the same name towards the apex of the heart. The branch dissociates very rarely from *R. circumflexus* (8) or, in 96% of the cases, belongs to *R. circumflexus* (14). In studying the coronary geometry in mice a massive ramification of the left and right coronary arteries has been established. A corrosion specification of the most common ramification model has been carried out in human hearts for the needs of the clinical anatomy (16). In relation to circulation the left ventricular wall is divided into twelve segments, which principally depend on the anterior interventricular artery and *A. circumflexa sinistra* (17). Other data classify the human ventricular myocardium into four regions: antero-septal, postero-septal, left-lateral and right-lateral (3). Arterial vessels in these regions correspond to the territories of the anterior interventricular branch of the left coronary artery (antero-septal region), of the posterior interventricular branch of the right coronary artery (postero-septal region), of A. *circumflexa sinistra* (left laterial region) and of the right coronary artery (right-laterial region). Each of these four regions is additionally subdivided into different segments.

Peculiarities of the coronary morphology determine three basic types of heart vascularisation in man: symmetrical left and right (predominant) type (18). The dissociation of repeating atrioventricular and ventriculoatrial branches forms a superficial and deep network related to the right coronary artery and to *R. circumflexus* of the left one. Such branches have been observed mainly (53.4%) in a symmetrical type of vascularisation and the least significantly (7.5%) in the right type (19). Ilieski (20) has established 81.8% of symmetrical coronary type and 3% of the left one in the pig, and Weaver at al. (21) has found a dominant right coronary artery in the pig in 78% of the cases. In a human heart of the right type the right coronary artery shows typical signs of a “distributing” vessel for the right ventricular wall, but these signs change suddenly when the ramifications reach the small regions of the left ventricular wall which they supply with blood since they do not supply a big part of the posterior left ventricular wall (22).

The lack of data about the whole ventricular model in the cat as a species and an experimental animal has informed this study.

MATERIAL AND METHODS

11 healthy adult male cats (*Felis silvestris f. domestica)*, weighing between 2.9-4.0 kg, were studied. The animals were euthenised with a barbiturate overdose (Thiopental 1g/i.v. BIOCHEMIE GmbH, Kundl-Austria).

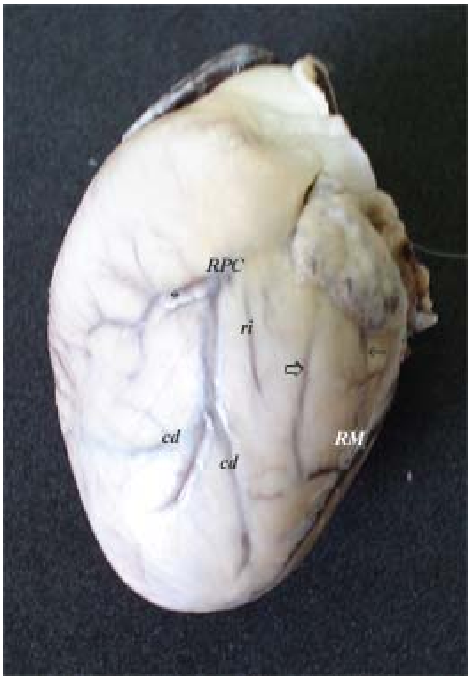
In 4 of the animals studied *Arcus aortae* was cannulated *in situ* and coloured gelatine was injected, and in seven -a polymer inoculation of the vessel network was made with Mercox® Red and Mercox® Clear. Before the polymer inoculation *Arcus aortae* and *V.cava caudalis* were cannulated simultaneously and then 5ml Mercox® Red and 5ml Mercox® Clear were applied respectively. Before the injection of the resin all incoming vessels were tied consecutively. 20 minutes after the polymer inoculation the heart was removed from the body and was put under running water at room temperature (18ºC) for 24 h. Maceration followed in 15% KOH changed every day. Maceration occurred within 3-4 days; after that the corrosion preparations were watched for 48 h in distilled water. Vascular prints were dried at room temperature. The samples were studied in a macro- and stereomicroscope-way by a stereomicroscope (*Hund SL 24AD, Germany*).

Sony® DSC - P43 was used for filming the findings.

RESULTS AND DISCUSSION

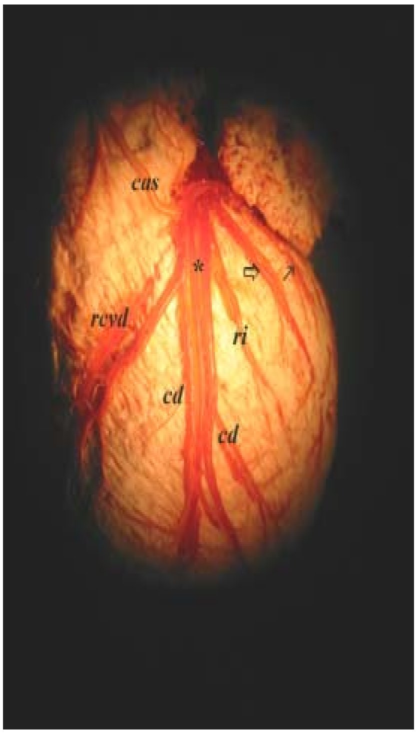
In contrast to Omashi (14), our results show that ***A. coronaria sinistra*** in all the cat hearts studied begins as a common trunk. It divides between the *Truncus pulmonalis* and *Auricula sinistra* into *R. interventricularis paraconalis* and *R. circumflexus*. This confirms some data in the man, dog and some domestic and laboratory animals (10, 11, 23). After its division *R. interventricularis paraconalis* goes down along the furrow having the same name and ramificates into several ventricular branches - *R. coni arteriosi sinister*, *R. collateralis ventricularis dextri*, *R. collateralis proximalis, R. collateralis intermedius, Rr. collaterales distales ventriculares dextri et sinistri* (**Figure 1, Figure 2**). Our results complement those of König et al (13) in the cat and correspond to the findings of Omachi (14) for the dog (except for the common trunk of *A. coronaria sinistra*). There is no unanimous opinion in the literature about the coronary ramification of *R. circumflexus*. *R. circumflexus* continues along *Sulcus coronarius* and ramifies into 6 - 7 ventricular branches (8, 23). Our study has shown that *R.*

circumflexus continues along *Sulcus coronarius* and gives rise to the following: *Rr. proximales ventricularis sinistri*, *R. marginis ventricularis sinistri, R. distalis ventricularis sinistri.* After reaching the right interventricular furrow, *R. circumflexus* goes down alongside it and forms *R. interventricularis subsinuosus* (**Figure 3, Figure 4**). Small branches, participating in the blood supply of a part of the right ventricular myocardium arise from *R. interventricularis subsinuosus.* In the study *R. marginis ventricularis sinistri* and *R. distalis ventricularis sinistri* showed variations, which can be classified into two groups. In 5 of the corrosion hearts studied *R. marginis ventricularis sinistri* was well expressed and dissociates at an angle close to 90° (**Figure 4**). In 2 preparations *R. marginis ventricularis sinistri* was slightly visible and could hardly be differentiated from *Rr. proximales ventriculares sinistrae* (**Fig. 5**). In the cases in which *R. marginis ventricularis sinistri* was slightly expressed, *R. distalis ventricularis sinistri* was established with bigger dimensions and an approximate angle of the branching over 90°. When *R. marginis ventricularis sinistri* was better expressed its associating vessel *R. distalis ventricularis sinistri* was smaller and its angle of ramification was close to 90°.



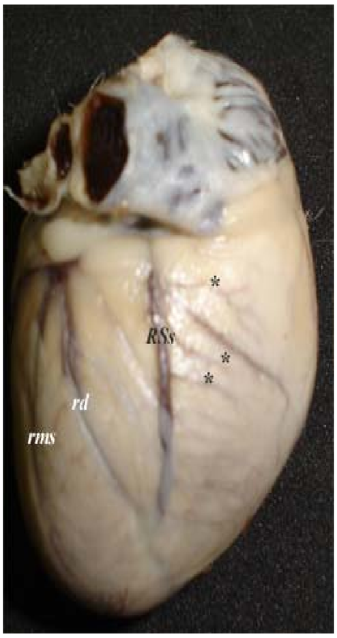
bar = 1 cm

***Figure 1.** Facies auricularis* of heart with coloured gelatine in the arterial network. *RPC,* R. interventricularis paraconalis; **,* R. collateralis ventricularis dextri; *cd,* Rr. collaterales distales ventriculares dextri et sinistri; ⇨, R. collateralis proximalis; →, Rr. proximales ventriculi sinistri; *ri,* R. collateralis intermedius; *RM,* r. marginis ventricularis sinistri.



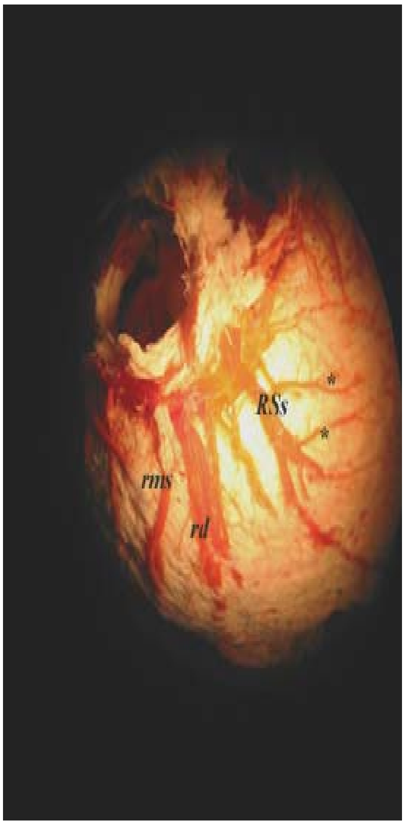
bar = 1 cm

***Figure 2.** Stereopicture of Facies auricularis of corrosion preparation with branches of A. coronaria sinistra. cas, R. coni arteriosi sinister; *, R. interventricularis paraconalis; rcvd, R. collateralis ventricularis dextri; cd, Rr. collaterales distales ventriculares dextri et sinistri; ⇨, R. collateralis proximalis; →, Rr. proximales ventriculares sinistri; ri, R. collateralis intermedius (magnification x 6,5).*



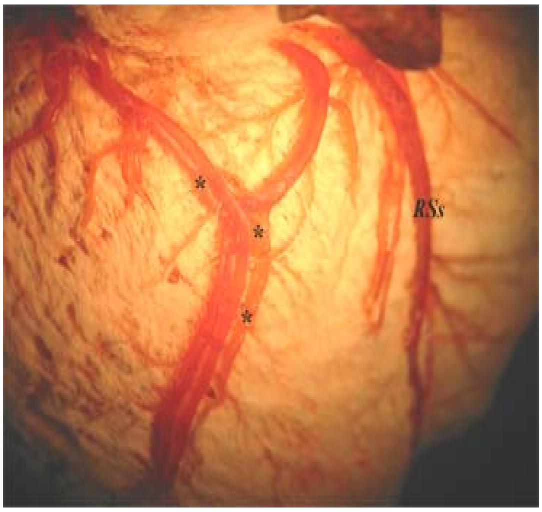
bar = 1 cm

***Figure. 3.** Facies atrialis of a heart with coloured gelatine in the arterial network. RSs, R. interventricularis subsinuosus; rd, R. distalis ventricularis sinistri; rms, R. marginis ventricularis sinistri; *, Rr. ventriculares dextri.*



bar = 1 cm

Figure 4. *Corrosion preparation of Margo ventricularis sinister. RSs, R. interventricularis subsinuosus; rd, R. distalis ventricularis sinistri; rms, R. marginis ventricularis sinistri; *, Rr. ventriculares dextrae (magnification x 6,5).*



bar = 1 cm

Figure 5. *Corrosion preparation of Margo ventricularis sinister. RSs, R. interventricularis subsinuosus; *, R. distalis ventricularis sinistri (magnification x 6,5).*

A. coronaria dextra begins from the cranial sinus of the aorta, enters the coronary furrow between *Truncus pulmonalis* and *Auricula dextra* and in the region of *Margo ventricularis dextra* ramifies into several ventricular branches: *R. marginis ventricularis dextri, R. proximalis ventricularis dextri, R. intermedius ventricularis dextri*, *R. coni arteriosi* (**Figure 5, Figure 6, Figure 7**). Our results did not confirm the existing literature data that *R. interventricularis subsinuosus* in the carnivores could dissociate from the right coronary artery (8, 14).

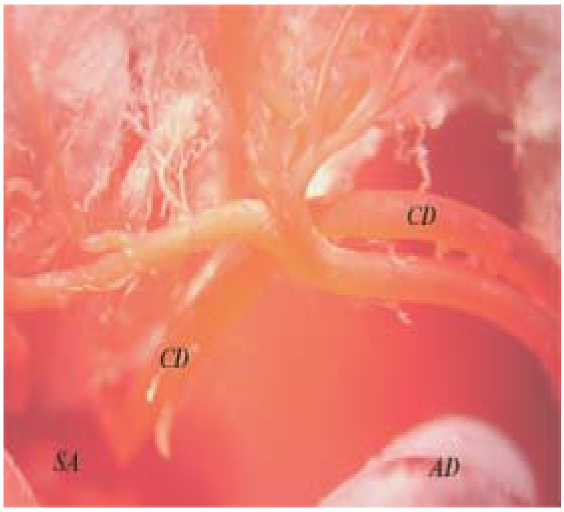
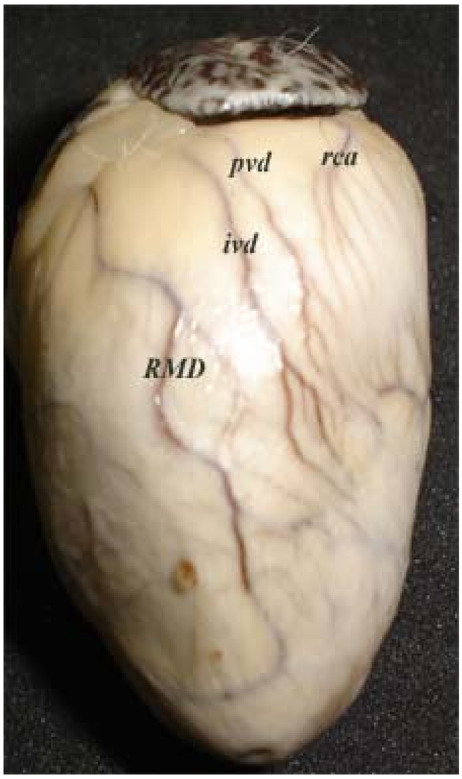


Figure 6. *Dorsal stereopicture of a corrosion preparation at the dissociation of the right coronary artery. SA, Sinus aortae; CD, A. coronaria dextra; AD, Auricula dextra (magnification x 40).*



bar = 1 cm

Figure 7. *Region of Margo ventricularis dexter of a heart with coloured gelatine in the arterial network. RMD, R. marginis ventricularis dextri; ivd, R. intermedius ventricularis dextri; pvd, R. proximalis ventricularis dextri; rca, R. coni arteriosi.*

The myocardium of the human heart is

divided into several functional regions in relation to the coronary vascular model. There are literature data about myocardium division into 4, 6 or 12 segments (3, 17, 23). The cases of slightly visible *R. marginis ventricularis sinistri* established by our study show that this branch could hardly be used as a borderline in determining the myocardial regions. That is why we use *R. distalis ventricularis sinistri*, which, in spite of its variability, is always better expressed. On this basis the ventricular wall of the heart in the cat could be divided into four regions namely: 1) *R. interventricularis paraconalis* and *R. distalis ventricularis sinistri*; 2) *R. distalis ventricularis sinistri* and *R. interventricularis subsinuosus*; 3) *R. interventricularis subsinousus* and *R. marginis ventricularis dextri*; 4) *R. marginis ventricularis dextri* and *R. interventricularis paraconalis*. The separate segments of the ventricular myocardium are probably put under different haemodynamic conditions, which are confirmed by some literature data in the man and the dog (1, 24, 25). The study of the coronary geometry showed that the ramification of *Rr. interventricularis paraconalis et subsinousus* and *A. coronaria dextra* was made at approximately acute angle. However the angle of ramification of *A. coronaria dextra* is approximately bigger than that of *Rr. interventricularis paraconalis et subsinousus.* Exceptions to this ramification peculiarity are *R. coni arteorosi sinister* and the branches of *R. circumflexus*, which branch at an angle close to 90°.

Heart disorders can be discussed in terms of haemodynamic disturbances in the main functional regions. This makes the arterial vascular network important for interpreting the myocardial pathology in the cat.

CONCLUSION

Ramification peculiarities of ***A. coronaria sinistra*** and ***A. coronaria dextra*** show a left dominant type of a ventricular vascularisation in the cat. The superficial coronary geometry divides the ventricular myocardium into four functional regions, related mainly to the dominant ***A. coronaria sinistra.*** The ventricular myocard is put under different haemodynamic conditions, whose disorders are important for interpreting the heart pathology.

REFERENCES

1. Madzharova, M., Vascularisation of the pericardium and the heart wall in the man and the dog. Thesis, MA, Varna, 1974.
2. Hyde, D. and Buss, D., Morphometry of the coronary microvasculature of the canine left ventricle. *Am J An*, 177(3): 415-425, 1986.
3. Grande, N., Travel, D., Silva, A., Pereira, A., Aguas, A., Anatomical basis for the separation of four cardiac zones in the walls of human heart ventricles. *Surg Radiol Anat*, 16(4): 355-361, 1994.
4. Crick, S., Sheppard, M., Ho, S., Gebstein, L., Anderson, R., Anatomy of the pig heart: comparisons with normal human cardiac structure. *J Anat*, 193(1): 105-119, 1998.
5. Coussement, P. and de Geest, H., Multiple coronary artery – left ventricular communications: an unusual prominent Thebesian system. A report of four cases and review of the literature. *Acta Cardiol*, 49(2): 165-173, 1994.
6. Kassab, G., The coronary vasculature and its reconstruction. *Ann Biomed Eng*, 28(8): 903-915, 2000.
7. Koizumi, M., Kawai, K., Honma, S., Kodama, K., Anatomical study of a left single coronary artery with special reference to the various distribution patterns of bilateral coronary arteries. *Ann Anat*, 182(6): 549-557, 2000.
8. Gadzhev, S., Anatomy of domestic animals.Vol. II, Stara Zagora, pp 5-32, 1999.
9. Habermehl, K.-H., Morphologie und Funktion der Herzeigengefëße. Zürich. 111-135, 1965.
10. De Lahunta, A. and Habel, R., Applied Veterinary Anatomy. W. B. Saunders Company: West Washington Square, Philadelphia, PA, pp 19-105, 1986.
11. Anderson, W. and Anderson, B., Atlas of canine anatomy. Lea & Febiger, USA, pp 417-583, 1994.
12. Nomina Anatomica Veterinaria. 4th ed., Zürich and Ithaca, New York, International Committee on Veterinary Gross Anatomical Nomenclature and autorized by the Eighteenth General Assembly of the World Association of Veterinary Anatomists, pp 63-106, 1994.
13. König, H., Ruberte, J., Liebich, H.-G., Organs of the cardiovascular system (systema cardiovasculare). In: Veterinary Anatomy of Domestic Mammals. König H. and Liebich H.-G. (*eds*), Schattauer GmbH, Germany, pp 415-464, 2004.

14. Omachi, N., Variationen der Arteriae coronariae und Venae cordis baim Hund, unter besonderer Berücksichtigung der Versorgung des Sinuatrialknotens, der Subepikardialen Anastomosen sowie der intramuralen Verlaufsstrekcen. *Inaugural-Dissertation*, Hannover, pp. 117, 2000.
15. Icardo, J., Colvee, E., Origin and course of the coronary arteries in normal mice and iv/iv mice. *J Anat*, 199(4): 473-482, 2001.
16. Von Ludinghausen, M., The clinical anatomy of coronary arteries. *Anat Embryol Cell Biol*, 167 (III–VIII): 1-111, 2003.
17. Reig, J., Jornet, A., Petit, M., Segmentary analysis of the coronary artery distribution in the left ventricle. *Surg Radiol Anat*, 15(2): 91-97, 1993.
18. Hadziselimovic, H., Vascularization of the conducting system in the human heart. *Acta Anat*, 102: 105-110, 1978.
19. Krupa, U., The atriovantricular and ventriculoatrial branches of the human coronary arteries in relation to the type of arterial vascularization. *Folia Morphol* (*Warsz*), 53(4): 295-302, 1994.
20. Ilieski, V., Topography of intercoronary anastomosis in diferent coronary patern in swine heart. *Macedonian Veterinary Review*, 28(1-2): 95-98, 1999.
21. Weaver, M., Pantely, G., Bristow, J., Ladley, H., A quantitative study of the anatomy and distribution of coronary arteries in swine in comparison with other animals and man. *Cardiovasc Res*, 20(12): 907-917, 1986.
22. Zamir, M., Tree structure and branching characteristics of the right coronary artery in a right-dominant human heart. *Can J Cardiol*, 12(6): 593-599, 1996.
23. Pejković, B. and Krajnc, I., The anatomic variability of the coronary vasculature of the human heart – Part I: Functional vascular zones – A morphological view. *Wien Klin Wochenschr*, 116(11-12): 391 – 393, 2004.
24. The Cardiovascular Simulations Laboratory, Influence of the Geometry of the Left Main Coronary Artery Bifurcation on the Distribution of Sudanophilia in the Daughter Vessels. *Arterioscler Thromb Vasc Biol*, 17: 1356-1360, 1997.
25. Smith, N., Pullman, A., Hunter, P., Generation of an anatomically based geometric coronary model. *Ann Biomed Eng*, 28(1): 14-25, 2000.