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The relationship between the dimensions of the right coronary artery and the type of coronary vasculature in human foetuses

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Background: *The area of vascular supply of particular coronary arteries is directly linked to the varying typology of the coronary vasculature. This factor may have a significant influence on the coronary vessel diameters. To date there has been no published research that analyses the relationship between the type of coronary vasculature and the dimensions of the epicardial arteries in the human foetus. There are only a few papers that deal with this issue in the postnatal period of human life.*
Material and methods: *The study was carried out on a group of 187 human foetuses aged five to seven months of intrauterine life. Prior to examination all foetuses had been conserved in a 9% formaldehyde solution for a minimum of three months. All foetuses had been aborted naturally. None of them had any external signs of malformations or developmental abnormalities. The number of foetuses in the particular age groups was variable. Adachi/Bianchi classification was used to categorize the particular vasculature types: type I — classic, neither artery is dominating; type II — dominant right coronary artery; type III — dominant left coronary artery.*
Results and conclusions: *The analysis of differences between the artery dimensions in particular types of coronary vasculature revealed that such differences existed between types I and II and also between types II and III.* (Folia Morphol 2011; 70, 1: 13–17)

Key words: coronary artery, development, typology of coronary arteries

INTRODUCTION

Among the factors that affect the coronary artery dimensions are the mass of the heart and the mass of the left ventricle [6, 17, 22, 29]. Varying typology of coronary circulation has an effect on vascular supply areas of particular arteries. It is also related to different coronary artery dimensions [2, 24, 30]. Few papers have analysed the relationship between the type of coronary vasculature and coronary artery dimensions in postnatal life. There is no research evaluating this relationship in the prenatal period. The aim of this study was to evaluate the relationship between the type of coronary vasculature and the coronary artery dimensions in prenatal life. The subject of our investigation was the right coronary artery. Its area of perfusion greatly depends on the domination of particular coronary arteries. The

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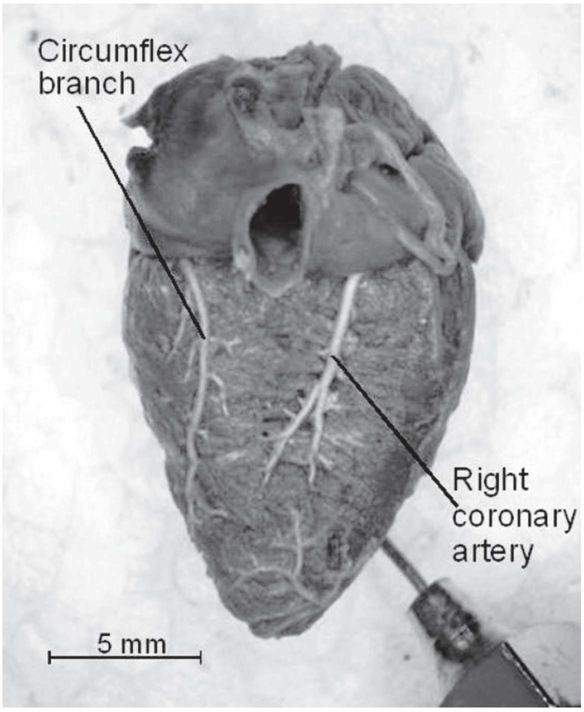


Figure 1. Type I vasculature — classic type, co-dominant right coronary artery and left coronary artery. Diaphragmatic surface. Female fetus aged 22 weeks.

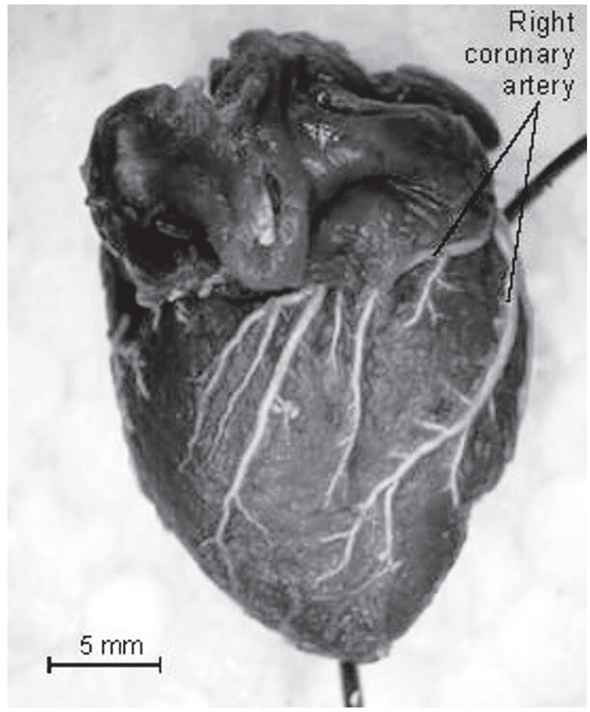


Figure 2. Type II vasculature — dominant right coronary artery. Diaphragmatic surface. Male foetus aged 26 weeks.

right coronary artery may provide for only a small part of the left ventricle. It is the principal source of blood supply, however, to the walls of the right ventricle [19, 30, 31]. This ventricle plays an important role in foetal circulation and is subject to a much greater workload during that period of life [31].

MATERIAL AND METHODS

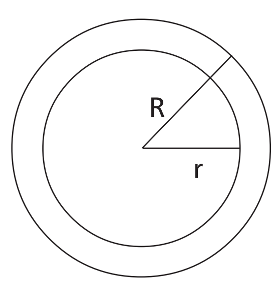
The study was carried out on a group of 187 human foetuses of both sexes, aged four to seven months of intrauterine life. Prior to examination all foetuses had been conserved in a 9% formaldehyde solution for a minimum of three months. All foetuses had been spontaneously aborted. None of them had any external signs of malformations or developmental abnormalities. The morphological age was estimated by analysing the relationship between crown-rump length (v-tub) and the age calculated from the date of last menstruation. All examined material was segregated according to morphological age. The numbers of foetuses in different monthly age classes varied. Consent No. KB/433/2004 was granted by the Bioethics Committee at the CM UMK in Bydgoszcz.

The vessel beds were filled with latex LBS 3060 (approximately 15–30 ml), without distortion of the dimensions of the vessels through a catheter, which was introduced by dorsal access into the thoracic aorta.

In each case the type of vasculature was determined according to the Adachi classification, which distinguishes three types of coronary vasculature [1, 20]:

- type I classic — neither artery is dominating (Fig. 1).
- type II — dominant right coronary artery (Fig. 2).
- type III — dominant left coronary artery (Figs. 3, 4).

For specimen preparation we used a binocular magnifying glass (magnification 0.6–7 × 14, MBS-9, Russia). The measurements were taken using electronic slide callipers (INCO, Poland) with an accuracy range of 0.01 mm. The diameter was measured twice in the proximal part of the vessel, which conforms to segment 1 according to the angiographic classification. All measurements were taken by two independent investigators. The final result recorded was the arithmetical mean of the two measurements. The lumen area of the coronary vessel was calculated using the following formula:



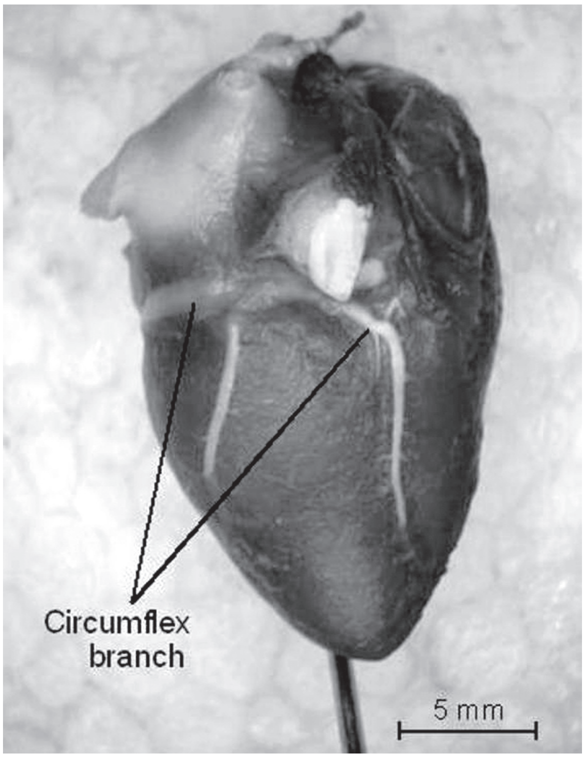


Figure 3. Type IIIA vasculature — dominant left coronary artery. Diaphragmatic surface. Male foetus aged 24 weeks.

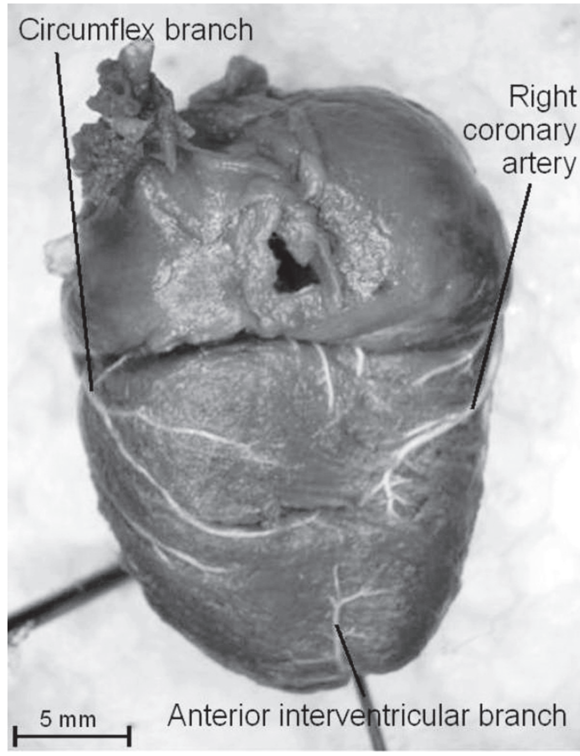


Figure 4. Type IIIB vasculature — dominant left coronary artery. Diaphragmatic surface. Female foetus aged 28 weeks.

D — diameter; R — radius of the vessel; r — radius of the vessel lumen; PP — vessel lumen area; $D = 2R$; $r = R/1.227$; $r = D/2 \times 1.227$; $PP = \pi r^2$; $PP = \pi (D/2.454)^2$; according to Grajek et al. [6] — $R/r = 1.277$; according to MacAlpin [18] — $R/r = 1.2$.

The statistical analysis was carried out using SPSS PC+ programme and software developed by the Department of Histology and Embryology. Analysis of variance was accomplished with Duncan's test. The results were considered to be statistically significant if $p < 0.05$.

RESULTS

The lumen area of the right coronary artery differs in particular types of coronary vasculature and it changes with age — month of foetal life (Table 1). In all of the material the right coronary lumen area increased at a constant rate (in absolute values) in all age groups. When evaluated in relative values, this growth rate tended to slow down with age (Table 2). Visible disproportion existed between the growth rate (both in absolute and relative values) in periods V–VI and VI–VII in the classic type. The artery lumen area grew faster in periods VI–VII. In type II (dominance of the right coronary artery) the increase of the dimension of the right coronary artery was most prominent in months V–VI (the relative growth rate was particularly fast). In months VI–VII this absolute growth rate and the relative rate markedly decreased. A similar pattern was noted for the right coronary artery growth in type III, where the dynamic increase of its dimensions during moths V–VI was followed by stagnation in months VI–VII.

Analysis of variance revealed that the right coronary artery lumen area at the level of its aortic ostium was related to the type of coronary vasculature ($p = 0.002$) (Table 1). In addition, statistically significant differences existed between types I and II, and between types II and III. No such differences with regard to the right coronary artery diameter were found between types I and II (Table 3). Therefore, the sizing of the right coronary artery takes place in the setting of that artery's dominance over its dimensions found in the vasculature types with neither or left coronary artery dominance.

DISCUSSION

Among the factors affecting the coronary artery lumen area are physiological circumstances such as age [6, 9, 25] and cardiac muscle mass [3, 6, 9, 14, 16]. Others include cardiac pathologies such as left ventricle hypertrophy [4, 22, 23] and diseases af-

Table 1. Right coronary artery lumen area during prenatal life, type I — classic with no dominating arteries, type II — dominating right coronary artery, type III — dominating left coronary artery

Age [m]	Type I		Type II		Type III		All		p
	N	LA ± SD [mm^2]	N	LA ± SD [mm^2]	N	LA ± SD [mm^2]	N	LA ± SD [mm^2]	
V	19	0.47 ± 0.09	24	0.51 ± 0.08	29	0.44 ± 0.09	72	0.46 ± 0.09	0.002**
VI	30	0.58 ± 0.11	22	0.89 ± 0.12	37	0.68 ± 0.08	89	0.69 ± 0.10	
VII	8	1.07 ± 0.13	11	0.95 ± 0.11	7	0.69 ± 0.07	26	0.91 ± 0.11	

N — numbers; LA — artery lumen area; SD — standard deviation; *$p < 0.05$; **$p < 0.01$

Table 2. Relative (R in %) and absolute (A in mm^2) increase in the right coronary artery lumen area in particular periods of foetal life, for particular types of vasculature, and for the whole material

Period Increase	Type I		Type II		Type III		All	
	R (%)	A [mm^2]	R (%)	A [mm^2]	R (%)	A [mm^2]	R (%)	A [mm^2]
V–VI	23	0.11	74	0.38	54	0.22	50	0.23
VI–VII	84	0.49	6.7	0.06	1,5	0.01	32	0.22

Table 3. Duncan's test for the particular types; *$p < 0.05$

Type	Artery lumen area [mm^2]	Particular types	p
I	0.59	I–II	0.021*
II	0.73	I–III	0.95
III	0.58	II–III	0.018*

fecting the arteries directly; aneurysms [8], Kawasaki disease [26], and vascular fistulae [11]. All these factors can lead to either a reduction [7] or an increase in vascular dimensions [5].

These studies were carried out on adults. They led to the conclusion that apart from such factors as atherosclerosis, arterial hypertension, and hypertrophy, the dimensions of particular coronary arteries principally depended on the distribution of vascular supply between these arteries [10, 13, 28]. Dodge et al. [4] analysed the relationship between the coronary vessel typology and the dimensions of the particular arteries and arrived at similar conclusions to ours — derived from foetal observations. They found that differences existed in the right coronary artery dimensions in types I and III with relation to type II. They pointed to the fact that the right coronary artery dimensions were significantly smaller in the type with dominating left coronary artery. On the other hand, in the type with dominating right coronary artery, the dimensions of the circumflex artery were significantly smaller. These results are identical to ours. Similar conclusions were also drawn by Vasheghani-Farahani et al. [27], who examined a huge material of 12,558 subjects. However, the latter did not evaluate the vessel diameters directly, using only the area of vascular supply with regard to the particular types of vasculature. A similar relationship is described by Kaimkhani et al. [12], although the authors pointed out differences that were not statistically significant.

There is only one article, by Lietunow and Pierwyszin [15], with studies of coronary vessels in 74 foetuses and new-borns. But Lietunow and Pierwyszin [15] measured only the dimensions of the coronary artery and types of vasculature. They didn't find any relationship between the dimensions of any vessels or typology. According Lietunow and Pierwyszin [15], the diameter of the right coronary artery corresponded with the lumen area of this artery in our study. There are no other studies to date that confirm these relations in prenatal life. There are few papers that analyse the variability of coronary artery dimensions (other than the right coronary artery) with regard to their vascular supply area and the type of coronary vasculature [19, 21].

CONCLUSIONS

In foetal life, the type of coronary vasculature is related to the right coronary artery lumen area. This is due to different supply areas of particular vessels in different types of cardiac vasculature.

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