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Digital analysis of the dynamics of the arterial supply to the human foetal kidneys

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Variations in the renal arteries in human individuals and foetuses have already been well studied. Contemporary trends in visualisation techniques focus on the evaluation of the dynamic parameters of blood flow in the vessels (speed, pulsatility, resistance). Most of these data have been obtained by the means of Doppler ultrasound (Fig. 1, 2). The authors have not found any anatomical database containing information about variability in the volume of the foetal renal arteries. The aim of the study is to design a database for variation in foetal renal artery volume in relation to foetal age and sex. The material consisted of digital images of the renal arteries filled with LBS-latex taken from 30 foetuses aged 12–19 Hbd. Digital analysis of the arteries was made with a unique form of software. The program is a 2D vector graphic editor using spliced functions of Bezier. Foetal age is estimated according to the last menstrual period and measurement of manual foot length and femur length (FL) as determined by ultrasound.

key words: renal artery, growth, foetus

INTRODUCTION

The kidneys play a crucial antenatal role in mammals. They create a proper — aqueous environment for a developing foetus. Although the variability of the renal arteries in human foetuses has been already studied [1–3], still very little is known about

Figure 1. Doppler ultrasonography of the left renal artery in a human foetus.

Figure 2. Doppler ultrasonography of the right renal artery in a human foetus.

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their size [6]. The aim of the study was to design a database for both the variability and the size of the renal arteries in human foetuses.

MATERIAL AND METHODS

In the study the arterial supply to the kidneys in 30 foetuses was analysed. The distribution of the sexes was 13 males and 17 females. Foetal age was calculated on the basis of the foot length and femur length, and varied between 13–19 weeks of pregnancy [5]. The arteries of the foetuses were infused with a mixture of 30% suspension of latex "LBS" and detergent. The latex was then polymerised during immersion of the foetuses in 4% formaldehyde solution (Fig. 3). *In situ* and *in tabula* scaled digital images of the retroperitoneal organs and vessels were made for analysis (Olympus Camedia 4040; 2272 × 1704 pix, 24 bit, BMP). Vector graphics software was designed to calculate the volume of the vessels. In the pictures vessels were contoured with Bezier's curves and then volumetry was performed in respect to the scale of the pictures.

Figure 3. LBS latex alloy of the foetal renal artery.

RESULTS

The total volume of the renal arteries rose with age (Table 1, Fig. 4). The left renal artery presented a higher volume then the right (Fig. 5, 6). Sexual differences in the volume were observed. Male foetuses had a greater volume for the left renal artery then females (Fig. 7, 8), whereas in the right renal arteries the tendency was the opposite (Fig. 9, 10).

Table 1. Volume of the renal arteries

Sex	Age [weeks]	Volume of the left renal artery	Volume of the right renal artery	Total volume of renal arteries
M	13.25	3.6446	3.3625	7.0071
F	13.5	2.0562	1.442	3.4982
F	13.7	2.0475	1.5065	3.554
F	14.25	1.8088	2.8423	4.6511
M	14.5	2.7369	2.2695	5.0064
M	14.5	1.6328	4.0168	5.6496
F	14.7	4.1941	1.6695	5.8636
F	14.75	5.8919	3.4475	9.3394
F	15	2.0194	0.8145	2.8339
F	15	2.2806	3.1295	5.4101
M	15.25	3.134	3.7301	6.8641
M	15.5	1.3483	1.6418	2.9901
M	15.5	2.7146	2.2484	4.963
M	15.5	2.4813	6.0048	8.4861
M	15.5	0.8595	6.7993	7.6588
F	15.7	2.5894	5.0859	7.6753
F	15.75	12.6349	4.578	17.2129
F	16	3.177	4.3344	7.5114
M	16	4.3835	4.8004	9.1839
F	16.5	4.2401	0.6101	4.8502
F	16.5	2.4382	4.0646	6.5028
F	16.5	8.9154	4.9591	13.8745
M	16.5	3.8796	7.1029	10.9825
F	17	3.4351	2.6525	6.0876
F	17	8.3438	6.0721	14.4159
M	17	3.0605	3.3876	6.4481
F	17.75	5.3341	6.6691	12.0032
M	18	6.472	6.0565	12.5285
F	18.25	7.8205	19.6924	27.5129
M	19	7.7343	3.4255	11.1598

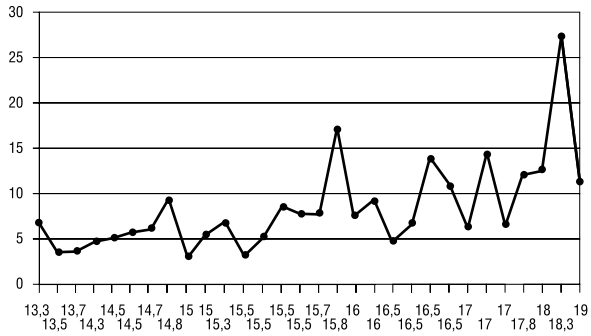

Figure 4. Total volume of the renal arteries.

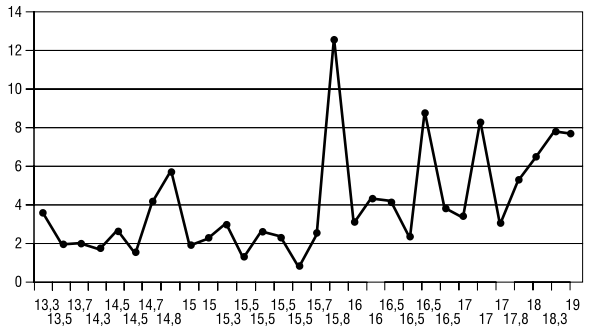

Figure 5. Left renal artery volume.

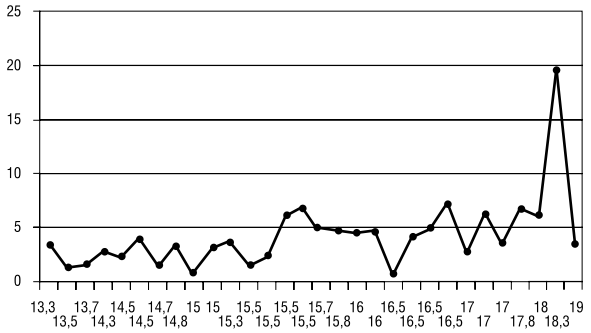

Figure 6. Right renal artery volume.

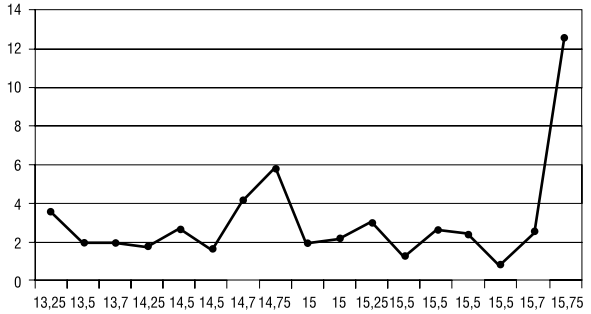

Figure 7. Left renal artery volume in female foetuses.

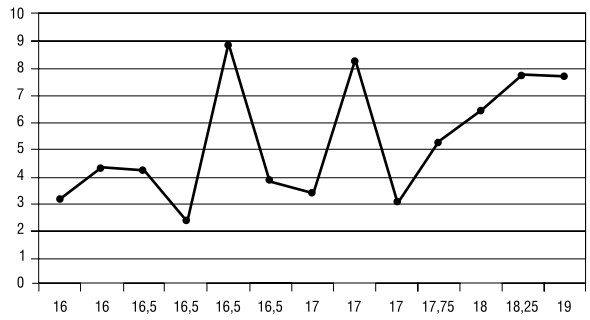

Figure 8. Right renal artery volume in male foetuses.

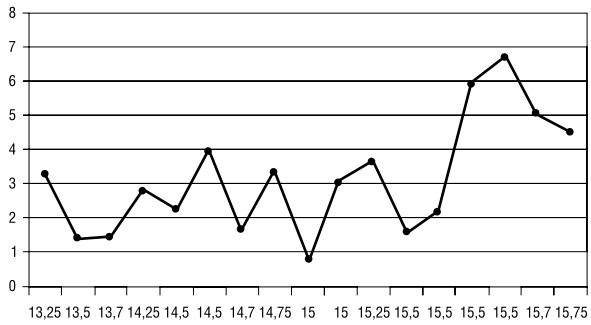

Figure 9. Total volume of the renal arteries in female foetuses.

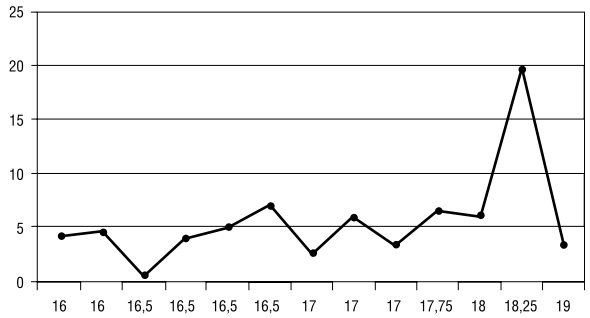

Figure 10. Total volume of the renal arteries in male foetuses.

DISCUSSION

Renal arteries in human foetuses and individuals are of high variability and asymmetry [1, 2]. Our data opened the way to the development of a quantitative analysis of the blood flow in the foetal arteries throughout pregnancy. The asymmetry of the descending aorta position directly influences the volume of the arteries (Fig. 5, 6) [4, 6]. Sexual differences in the variability of the renal arteries have already been studied in adults and in foetuses [3, 4, 6].

The volumetry of the arteries was postulated based on aortographic studies in the adults [3]. The authors did not find comparable data in the references for volumetric study in human foetuses.

CONCLUSIONS

1. Sexual and lateral dimorphism is observable in the volume of the renal arteries in the fetuses studied.
2. Further studies are required to diagnose a linear or non-linear increase in renal artery volume in human foetuses.
3. Vector graphics is useful in vessel volume calculation and may obtain data for quantitative blood flow calculations.

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