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Assessment of Development of Atria, Ventricles and Great Arteries During Intrauterine Period

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İNTRANTERİN DÖNEMDE ATRİYUM, VENTRİKÜL ve BÜYÜK ARTERLERİN GELİŞMESİNİN DEĞERLENDİRİLMESİ

Fetal ekokardiyografi, 1970 yılından fetüs kalbinin izlenmesinde kullanılan bir yöntemdir. Cross-sectional ekokardiyografik yöntem ise 1980 yılından beri fetüs kalbinin değerlendirilmesinde kullanılmaktadır. Bu çalışma kal boşluklarının ve büyük arterlerin intrauterin dönemde ifetal ekokardiyografik yöntemle incelenmesi amaçlandı. Gestasyon yaşları 16-40 hafta arasında değişen 240 hamile ve fetusları çalışmaya alındı. Hamileler ve fetusları herbiri ardarda gelen iki gestasyon haftasını içeren 12 grupta incelendi. Yalnızca son grup üç gestasyon haftasını kapsıyordu. Herbir grup 20 hamileyi ve fetusu içeriyordu. Kalp boşluklarının uzunlukları, genişlikleri, duvar kalınlıkları, alanları, volümleri, büyük damarların çapları ekokardiyografik olarak değerlendirildi. Sonuç olarak; kalp boşluklarının uzunluk ve genişliklerinin, duvar kalınlıklarının, volüm ve alanlarının gestasyonel period süresince lineer olarak arttığı, bu süre boyunca kalbin sağ yapılarının sol yapılara üstün oldukları belirlendi.

Anahtar kelimeler: *Fetal ekokardiyografi, fetal kalp, büyük arterler, ventrikül.*

Until recently, the only routine assessment about fetal cardiovascular physiology was the heart rate. Although, fetal echocardiography is used since 1970's, the technological insufficiencies lead to the failure in providing details about the anatomy and physiology of fetal heart [1]. The cross-sectional view of fetal heart has been demonstrated in some studies since 1980. And further development of the color and pulsed Doppler methods has increased our understanding [2,3]. Fetal echocardiography, will help us to improve our knowledge about physiology of the fetal heart for not only the diagnostic and therapeutic aim but also the legal and ethical points of view as well [1-3]. In this study, the structures of atrias, ventricles and great arteries were investigated in Turkish fetus.

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PATIENTS and METHODS

The cases were voluntary pregnant women who did not have any problems during the follow-up from September 1993 to March 1994. Those whose husband, children or herself had a congenital heart disease were excluded from the study.

We used gestational age as the standard, rather than parietal diameter of the skull or femur length, for several reason. First, most standard obstetrics programs convert measurement of biparietal skull dimension or femur length to an estimated gestational age. Second all patients who had these studies had accurate estimation of gestational age obtained by their obstetricians or referring radiologists. In our clinical practice of cardiology, patients referred from a prenatal counselling service whose sonographic physicians have always obtained an estimate of gestational age.

The study included 240 pregnants whose fetus between 16 to 40 weeks of their gestastional age. The cases were analysed in 12 groups, each including 20 pregnants. Pregnants in 16th- 17th weeks were studied in the 1st group, 18-19th week pregnants in 2nd group, 20th- 21th week pregnants in the 3rd group, 22nd-23rd week pregnants in the 4th group, 24th- 25th week pregnants in 5th group, 26th-27th week pregnants in 6 group, 28th-29th week pregnants in 7th group, 30th-31st week pregnants in 8th group, 32nd-33rd week pregnants in 9th group, 34th- 35th week pregnants in 10th group, 36th-37th week pregnants in 11th group 38th-39th-40th week pregnants at term in the 12th group.

In the study, a Toshiba Sonolayer SSA-270A colored-Doppler ultrasonography with a 3.75 mHz probe was used. Taking a general look on fetus, the ones with cardiac abnormality were discharged from the study, and in the rest of the cases further evaluation of fetal heart was made. All measurements were obtained using the standard 2- dimensional technique. The ventricular walls and cavity measurements were obtained at a time corresponding to end diastole when the chamber size was at maximum or the wall dimension minimum and to end systole when the chamber size was at minimum or the wall dimension maximum. For the vessels, the aortic and pulmonary annuli were measured in the equivalent of the parasternal short axis at the valve annuli.

These views both systolic and diastolic measurements of right ventricular wall thickness (RVWT), right ventricular length (RVL), right ventricular width (RVW), left ventric-

Table 1. The average levels of the measurement of the ventricles during systole in different pregnancy week

Gestational week	LVL mm	RVL mm	LVW mm	RVW mm	LVS mm²	RVS mm²	LVV cm³	RVV cm³	LVWT mm	RVWT mm	IVS mm
16-17	6.635+0.92	6.7+1.387	3.5+0.75	3.75+0.92	23.75+7.85	27.17+9.33	0.112+0.60	0.135+0.07	1.3+0.229	1.435+0.28	1.4+0.28
18-19	8.383+2.11	8.392+1.7	4.49+0.67	4.46+0.65	37.35+14.9	41.21+15.7	0.2+0.14	0.225+0.11	1.692+0.28	1.683+0.31	1.692+0.3
20-21	9.224+2.12	8.94+1.57	5.312+1.13	5.75+0.94	49.30+20.1	56.91+20.1	0.306+0.17	0.394+0.33	1.791+0.23	1.994+0.30	2.019+0.3
22-23	9.871+1.98	10.22+1.2	5.871+0.76	6.47+1.04	61.30+14.6	72.47+18.2	0.4+0.130	0.457+0.15	2.071+0.31	2.214+0.31	2.214+0.3
24-25	11.482+2.1	11.77+1.6	6.612+0.99	7.06+1.00	82.11+14.6	95.77+18.7	0.665+0.35	0.718+0.22	2.2+0.37	2.457+0.41	2.376+0.3
26-27	12.329+1.8	13.24+1.8	7.227+0.53	7.56+1.15	95.5+29.4	108.7+35.3	0.8+0314	1.04+0.5	2.427+0.34	2.547+0.39	2.6+0.404
28-29	14.564+2.9	15.05+2.1	7.657+0.74	8.17+1.00	117.2+37.3	144.7+33.7	1.179+0.51	1.457+0.56	2.614+0.41	3.157+0.57	2.97+0.46
30-31	15.621+2.4	16.17+2.3	8.5+1.60	9.38+1.69	147.2+42.6	162.2+40.2	1.536+0.64	1.807+0.60	2.764+0.35	3.157+0.45	3.0+0.35
32-33	15.8+3.062	16.91+3.3	8.728+1.77	9.87+1.90	160.4+58.1	179.9+47.7	1.822+0.89	2.106+0.83	2.927+0.43	3.161+0.49	3.144+0.5
34-35	17.645+3.0	19.40+3.3	9.609+1.26	10.59+1.20	189.4+50.2	224.9+54.7	2.182+1.13	2.750+1.15	3.109+0.33	3.391+0.3	3.236+0.3
36-37	18.459+3.2	19.15+2.9	9.8+1.40	11.04+1.72	216.8+47.2	238.2+65.4	2.395+0.97	3.082+1.33	3.223+0.43	3.548+0.71	3.414+0.5
38-39-40	19.961+3.2	20.43+2.7	10.77+2.15	12.09+1.49	251.1+50.3	274.6+61.7	2.857+0.94	3.8+0.32	3.235+0.32	3.627+0.44	3.504+0.3

ular wall thickness (LVWT), left ventricular length (LVL), left ventricular width (LVWT), interventricular wall thickness (IVMT), right atrium width (RAW), right atrium length (RAL), left atrium width (LAW), left atrium length (LAL) were measured. Then, right atrial (RAS), left atrial (LAS), right ventricular (RVS) and left ventricular sizes (LVS) and volumes (LAV, RVV, LAV, RAV) were separately calculated in both systole and diastole. Volume measurements were made with the single plane elipse method.

Statistical assessment in each of the 12 study groups were made both for systolic and diastolic measurements. Standard deviation analysis for all values measured and regression coefficients were calculated and plotted. Statistical significance between the group averages was determined by the Student-t- test.

RESULTS

The ages of the pregnant women ranged from 18 to 38 years, the mean age was 25.25 years. The average values of RVW, RVWT, IVS, RV size and RV volume at systole are shown in Table I. All of the values were increasing parallel with the gestational week. RVW, RVL, RV size, RV volume, RVWT and IVS at diastole in relation to the gestational weeks are presented in Table II. All of the values were increasing parallel with the gestational weeks. LVL, LVW, LVWT, LV size and LV volume during systole are shown in relation to the gestational weeks in Table I and diastole in Table II. LAL, LAW, LA area and LA volume, RAW, RAL, RA area and volume are presented during ventricular systole in Table III and during diastole in Table IV. The diameters of aorta and pulmonary artery during the gestational weeks are shown in Table V.

Table 2. The average levels of the measurement of the ventricles during diastole in different pregnancy week

Gestational week	LVL mm	RVL mm	LVW mm	RVW mm	LVS mm²	RVS mm²	LVV cm³	RVV cm³	LVWT mm	RVWT mm	IVS mm
16-17	8.5+1.744	8.912+3.202	5.194+1.125	5.676+1.163	36.253+12.680	39.506+3.683	0.218+0.119	0.237+0.034	1.088+0.169	1.165+0.257	1.1+0.173
18-19	10.350+2.001	10.475+1.949	6.767+1.163	7.192+0.919	56.225+5.601	56.992+0.148	0.367+0.137	0.3392+0.168	1.367+0.192	1.467+0.287	1.342+0.19
20-21	11.537+1.644	11.594+2.357	7.944+1.513	8.550+1.592	76.156+3.901	83.569+3.189	0.6+0.356	0.719+0.459	1.5+0.245	1.675+0.257	1.581+0.055
22-23	13.493+1.322	14.064+1.259	8.714+0.933	9.429+1.140	103.55+7.474	123.371+9.78	0.9+0.263	1.129+0.307	1.693+0.223	1.777+0.267	1.693+0.262
24-25	15.676+2.208	15.453+1.943	9.682+1.198	10.247+1.442	118.006+2.29	143.418+6.40	1.271+0.398	1.559+0.530	1.778+0.377	1.847+0.412	1.859+0.341
26-27	17.387+2.001	17.7+2.42	10.593+1.378	11.327+1.544	158.0+43.793	182.0+53.719	1.78+0.595	2.28+1.033	2.027+0.388	2.153+0.405	2.153+0.366
28-29	18.893+2.824	19.35+2.939	11.65+1.271	12.288+1.215	185.5+47.641	215.714+7.92	2.243+0.731	2.6+0.918	2.386+0.376	2.479+0.387	2.386+0.376
30-31	19.643+3.1	19.607+3.593	12.636+2.007	13.836+2.192	195.794+7.20	246.286+1.33	2.771+1.006	3.229+1.246	2.4+0.408	2.529+0.405	2.450+0.376
32-33	20.261+3.662	21.294+5.504	13.406+2.218	14.428+2.399	225.794+7.20	287.706+4.46	3.094+1.2	3.81+1.435	2.450+0.429	2.639+0.546	2.628+0.529
34-35	22.136+2.503	23.7+2.933	14.591+1.393	16.047+1.135	267.909+1.51	306.99+8.814	4.545+1.39	5.6+1.617	2.6+0.405	2.7+0.344	2.736+0.398
36-37	24.105+3.576	23.905+3.475	14.791+1.544	16.441+1.544	284.5+77.91	335.846+3.52	4.627+1.789	5.514+2.042	2.750+0.375	2.971+0.427	2.791+0.403
38-39-40	25.887+3.927	26.061+5.82	16.422+2.596	17.961+1.671	346.261	408.304+7.5	5.935+2.146	5.935+2.146	2.830+0.323	3.026+0.401	2.839+0.379

Table 3. The average levels of the measurement of the atriums during sysyole in different pregnancy week

Gestational week	LAL (mm)	RAL (mm)	LAW (mm)	RAW (mm)	LAS (mm^2)	RAS (mm^2)	LAV (mm^3)	RAV (mm^3)
16-17	3.5+0.75	4.9+1.10	5.147+1.146	5.524+1.266	18.476+7.98	22.418+10.0	0.065+0.061	0.094+0.06
18-19	4.492+0.671	5.55+1.019	5.392+0.968	6.017+1.304	29.067+2.48	30.517+8.92	0.125+0.062	0.142+0.06
20-21	5.312+1.137	7.019+1.270	6.612+1.063	7.512+1.459	40.069+2.31	46.4+14.93	0.225+0.153	0.231+0.09
22-23	5.871+0.764	8.329+1.040	7.829+1.183	9.014+0.94	57.857+2.28	70.721+17.5	0.379+0.159	0.486+0.21
24-25	6.612+0.991	9.212+1.125	8.841+1.510	9.459+1.73	63.206+3.76	74.775+12.6	0.382+0.139	0.518+0.19
26-27	7.227+0.853	9.920+1.156	9.173+1.322	11.033+1.59	80.587+8.61	101.6+37.02	0.507+0.271	0.707+0.17
28-29	7.657+0.747	10.85+1.381	10.357+1.84	11.3+1.891	85.1+20.886	104.85+22.8	0.6+0.229	0.829+0.29
30-31	8.5+1.1606	11.257+1.79	11.336+2.44	12.129+2.44	109.686+9.0	131.12+35.2	0.929+0.393	1.186+0.55
32-33	8.728+1.778	11.939+2.09	12.122+2.10	13.322+2.84	125.267+43.	146.7+44.13	1.106+0.517	1.465+0.55
34-35	9.609+1.298	13.6+1.487	12.545+2.57	14.491+3.70	150.545+9.3	165.0+17.94	1.509+0.406	1.727+0.50
36-37	9.8+1.401	13.66+2.168	13.664+2.38	15.05+2.886	157.11+0.59	171.89+41.6	1.386+0.555	1.95+0.665
38-39-40	10.778+2.15	15.104+2.39	1[illegible].152+2.35	16.409+2.50	164.783+1.3	205.9+52.29	1.696+0.675	2.404+0.97

The averge values of RVL/LVL, RVW/LVW, RVS/LVS, RVV/LVV, RVWT/LVWT, RAW/LAW, RAL/LAL; RAS/LAS, RAV, LAV an PA/Ao were compared during systole (Table VI). When development of these parameters adjusted to the gestational weeks were investigated, the values for right ventricle were found to be slightly increased than that of left ventricle. The difference between them were statistically not significant ($p>0.45$). However a statistically significant correlation ($p<0.0001$) was found between all cardiac parameters (LVW, RVW, RVL, LVL, RVS, LVS, RVV, LVV, IVS, RVWT, LVWT, RAL, LAL, RAW, LAW, RAS, LAC, LAV, RAV, Aorta, Pulmonary artery) and gestational weeks (Fig. 1-8).

DISCUSSION

In normal human fetus development of parameters such as ventricular diameters, wall thickness, atrial diameters, atrial and ventricular sizes and volumes were investigated by two dimensional M, B mode echocardiography from the 16th gestational week till term. The earliest gestational age of the heart which could be visualized by echocardiography was 16 th gestational week in several studies [4,5], this was 20 weeks. These investigators [4,5] have claimed that the wall thickness of heart could not be measured accurately on a fetus younger than 20 weeks. In our study, however all the parameters of fetal heart could clearly be measured [4,5].

The success in establishing cardiac dimensions was

Table 4. The average levels of the measurement of the atriums during diastole in different pregnancy week

Gestational week	LAL (mm)	RAL (mm)	LAW (mm)	RAW (mm)	LAS (mm^2)	RAS (mm^2)	LAV (mm^3)	RAV (mm^3)
16-17	3.319+0.839	3.629+0.886	4.035+0.812	4.7+1.151	12.129+5.31	14.388+5.98	0.041+0.05	0.047+0.02
18-19	3.775+0.958	4.525+0.968	4.58+0.903	5.283+1.06	17.88+4.075	22.033+6.99	0.092+0.02	0.117+0.03
20-21	5.369+1.148	5.413+1.178	5.644+0.903	6.7+1.281	28.675+11.1	35.4+14.87	0.144+0.07	0.175+0.11
22-23	6.143+0.976	6.307+1.087	6.729+1.015	7.6+1.676	38.59+8.334	45.796+8.14	0.207+0.70	0.279+0.13
24-25	6.541+0.966	7.259+1.204	7.435+1.260	8.518+1.67	44.971+10.2	53.21+14.06	0.265+0.02	0.341+0.12
26-27	7.167+1.083	7.933+1.617	8.743+1.109	9.133+1.60	53.327+12.8	69.38+24.23	0.313+0.11	0.427+0.12
28-29	7.614+1.238	8.621+1.242	8.743+1.109	10.13+2.87	57.707+13.9	79.02+19.42	0.357+0.11	0.514+0.20
30-31	8.329+1.252	9.386+1.32	9.379+1.911	10.62+1.92	79.02+19.42	89.029+20.8	0.493+0.21	0.693+0.26
32-33	8.511+1.611	9.522+1.421	10.022+2.19	11.66+3.04	91.01+27.48	101.96+39.2	0.644+0.28	0.933+0.37
34-35	9.418+0.952	9.736+1.513	10.927+1.90	12.18+2.34	108.93+23.2	112.74+35.1	0.809+0.30	1.2+0.25
36-37	10.195+2.12	10.909+2.39	11.659+2.42	13.6+3.059	109.48+29.5	128.39+41.1	0.964+0.30	1.3+0.09
38-39-40	10.4+1.96	11.874+2.09	12.426+2.59	14.80+2.87	110.80+2.87	143.16+36.0	1.052+0.36	1.52+0.09

Table 5. The diameters of aorta pulmonary artery in different pregnancy weeks

Gestational week	The diameter of aorta (mm)	The diameter of Pul monary artery (mm)
16-17	3.025+0.531	3.206+0.531
18-19	3.325+0.377	3.427+0.476
20-21	4.281+0.241	4.256+0.405
22-23	4.593+0.463	4.807+0.505
24-25	4.953+0.830	5.353+0.989
26-27	5.253+0.473	5.693+0.696
28-29	5.707+0.767	6.371+0.746
30-31	6.136+0.940	6.436+1.093
32-33	6.611+0.820	7.206+0.863
34-35	6.945+0.535	7.436+0.812
36-37	7.127+0.776	7.787+1.055
38-39-40	7.683+1.120	8.496+1.165

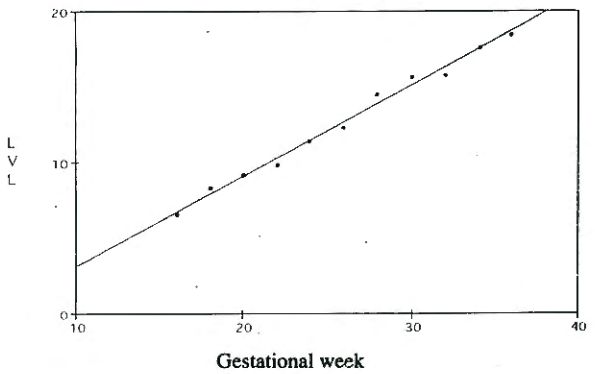
approximately 100 % in this study. This rate was higher than the success rate of 90 % as reported in some studies [5,6]. In autopsy studies, RV volume has been investigated from the 2nd trimester till birth and its dominancy in fetus heart has shown. In echocardiographic studies, contradictory results was given about the right and left ventricular volumes [4,5] Although some different results were given, it was shown that widths of both ventricle increased equally from the 2nd trimester till birth.

We found that the right ventricular width was larger than the left ventricle from the 16th week to term and that the right ventricle /left ventricle ratio was 1.09 during that period. The widths of right ventricle and left ventricle at systole and diastole and their ratios showed parellelism. The results of the study were contrary to the studies of Tan et al. [4] and Martin et al [5], but similar to the study of Sahn et al. [6].

It was shown that the width of right and left ventricles were reaching twice of its size between 18th-

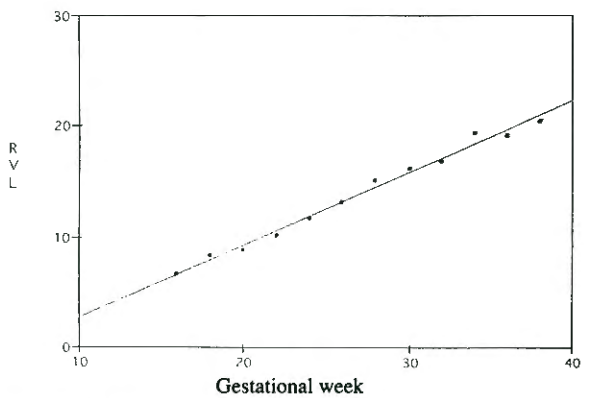
Table VI. The average levels of the right/left values of the heart and t values during systole in different pregnancy weeks

Gestational week	RVW/LVW	RVL/LVL	RVS/RVS	RVV/LVV	RVWT/LVWT	RAW/LAW	RAL/LAL	RAS/LAS	RAV/LAV	PUL/AORT
16-17	1.02±0.1 t:2.38	1.07±0.15 t:-0.33	1.17±0.25 t:2.98	0.97±0.31 t:1.0	1.12±0.11 t:4.08	1.15±0.15 t:2.74	1.12±0.21 t:4.57	1.22±0.23 t:3.8	1.14±0.36 t:1.50	1.07±0.36 t:1.04
18-19	1.03±0.9 t:1.37	1.01±0.08 t:0.04	1.12±0.2 t:1.85	1.19±0.41 t:1.39	1±0.16 t:-0.11	0.94±0.30 t:1.88	1.17±0.3 t:0.61	1.14±0.2 t:0.63	1.19±0.44 t:1.48	1.04±0.7 t:1.96
20-21	1.09±0.1 t:3.44	0.98±0.11 t:-1.11	1.23±0.23 t:7.16	1.92±0.55 t:1.75	1.1±0.12 t:3.83	1.13±0.15 t:3.56	1.09±0.14 t:2.87	1.08±0.31 t:4.85	1.23±0.41 t:0.37	1.09±0.08 t:4.77
22-23	1.1±0.12 t:3.12	1.04±0.11 t:1.23	1.19±0.24 t:1.17	1.2±0.32 t:1.47	1.09±0.14 t:1.76	1.07±0.19 t:4.16	1.16±0.16 t:1.37	1.19±0.15 t:4.13	1.28±0.27 t:4.32	1.09±0.04 t:4.28
24-25	1.07±0.13 t:2.25	1.03±0.11 t:1.07	1.22±0.4 t:8.3	1.20±0.31 t:0.66	1.10±0.15 t:2.42	1.02±0.31 t:1.24	1.14±0.15 t:3.07	1.22±0.17 t:5.18	1.32±0.39 t:5.16	1.08±0.8 t:3.26
26-27	0.98±0.28 t:2.08	1.015±0.26 t:2.69	1.19±0.28 t:3.82	1.28±0.65 t:5.60	1.04±0.1 t:1.85	1.21±0.16 t:6.44	1.13±0.17 t:4.07	1.28±0.2 t:5.24	1.43±0.33 t:4.47	1.07±0.08 t:2.85
28-29	1.05±0.8 t:2.58	1.03±0.7 t:1.90	1.28±0.31 t:5.24	1.26±0.28 t:5.19	1.07±0.17 t:1.85	1.14±0.2 t:2.72	1.2±0.2 t:3.39	1.23±0.18 t:5.39	1.38±0.32 t:4.23	1.12±0.13 t:3.63
30-31	1.11±0.8 t:4.98	1.04±0.6 t:2.12	1.1±0.8 t:4.52	1.19±0.26 t:7.66	1.18±0.19 t:4.01	1.07±0.13 t:1.90	1.08±0.13 t:2.12	1.20±0.15 t:5.7	1.24±0.27 t:4.16	1.04±0.06 t:2.83
32-33	1.12±0.12 t:4.06	1.07±0.16 t:1.96	1.20±0.17 t:4.93	1.22±0.25 t:2.46	1.08±0.11 t:2.60	1.09±0.15 t:2.85	1.01±0.11 t:0.165	1.19±0.18 t:5.73	1.44±0.48 t:4.98	1.08±0.04 t:7.08
34-35	1.1±0.7 t:6.2	1.04±0.7 t:2.03	1.20±0.21 t:4.34	1.52±0.34 t:4.95	1.09±0.1 t:3.12	1.15±0.21 t:2.78	1.01±0.34 t:3.03	1.12±0.17 t:2.43	1.29±0.18 t:5.43	1.06±0.05 t:4.38
36-37	1.12±0.7 t:0.15	1.04±0.8 t:1.05	1.28±0.27 t:5.07	1.26±0.28 t:4.14	1.09±0.7 t:5.15	1.11±0.14 t:2.10	1.12±0.15 t:3.60	1.2±0.27 t:1.89	1.46±0.38 t:3.94	1.1±0.09 t:3.04
38-40	1.09±0.29 t:3.01	1.03±0.8 t:1.05	1.24±0.18 t:2.44	1.34±0.21 t:5.67	1.55±2.14 t:5.61	1.15±0.9 t:6.89	1.06±0.11 t:2.54	1.25±0.19 t:3.90	1.40±0.32 t:3.59	1.28±1.11 t:3.75



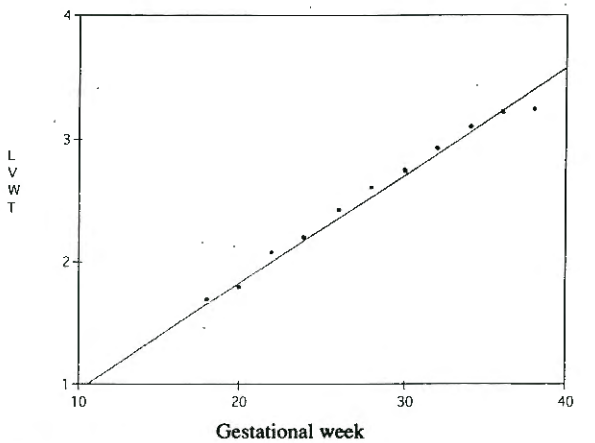
R=0.996 P:0.000

Fig. 1. The correlation between LVL and gestational weeks during systole.



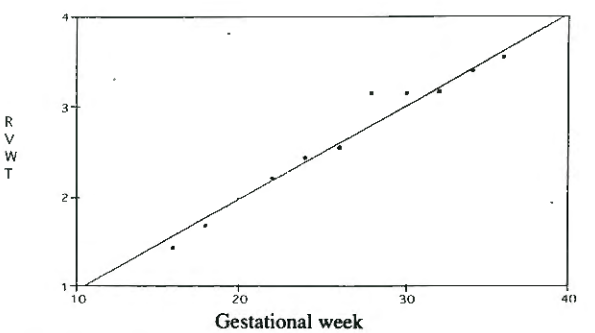
R=0.995 P:0.000

Fig. 2. The correlation between RVL and gestational weeks during systole.



R=0.990 P:0.000

Fig. 3. The correlation between LVWT and gestational weeks during systole.



R=0.981 P:0.000

Fig. 4. The correlation between RVWT and gestational weeks during systole.

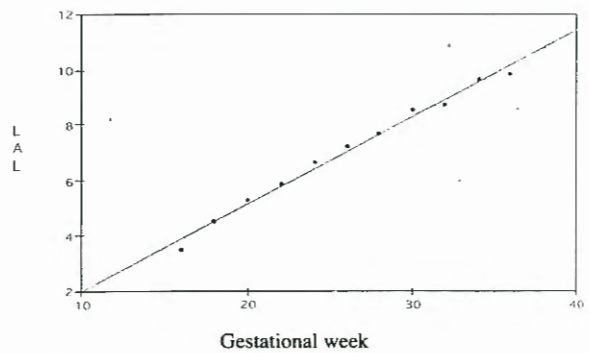
40th gestational weeks, while the fetal heart mass was increasing ten times [7-9], in our study, as our assesment is beginning at the 16th gestational week, it was found to be increasing three times of its size.

We investigated thicknesses of the right and left ventricular walls and of the interventricular septum during systole and diastole from 16th week of gestation till term. During this period, the wall thicknesses of the right ventricle was relatively more than that of the left ventricle. The ratio of wall thicknesses of right to left ventricle was approximately 1.1. The thicknesses of the interventricular septum was similar to that of the left ventricle. Interventricular septum, right and left ventricular wall thickness, left and right ventricular width tended to grow linearly but not exponantially during the gestational period our study was made.

The size and volume of the right ventricle were followed-up from the 16th gestational week till term and were found to be growth proportionally with ventricular width, it was found that the development of both ventricular volume and size was similar and that the right ventricular/left ventricular size and volume were increasing proportionally as 1.1 until term.

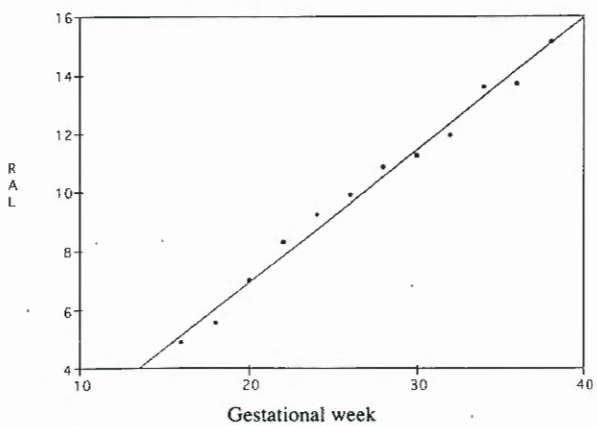
In the study, width, length, area and volume of both atria increased three times from 16th gestational week till to 40th gestational week. Right atrium/left atrium ratio was 1.1 in accordance with the ventricular values. Our results were similar to results of other studies [7,10-12].

Aorta and pulmonary artery width developed parallel with the gestational week. During the development PA/Ao ratio was 1.08 and the pulmonary arterial width was slightly dominant. This dominance was in accordance with the right ventricle/left ventri-



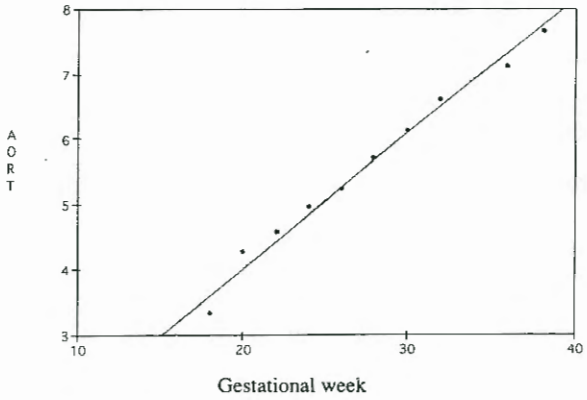
R=0.998 P:0.000

Fig. 5. The correlation between LAL and gestational weeks during systole.



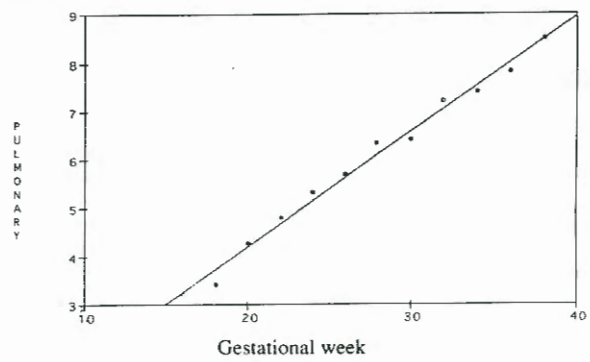
R=0.994 P:0.000

Fig. 6. The correlation between RAL and gestational weeks during systole.



R=0.994 P:0.000

Fig. 7. The correlation between aorta and gestational weeks during systole.



R=0.995 P:0.000

Fig. 8. The correlation between pulmonary artery and gestational weeks during systole

cle ratio. PA/Ao ratio and RV/LV ratios were similar. Published date on this ratio varied equally. Sahn et al. [6] gave 1.2, while Wladimiroff et al [7] 0.96.

Doppler echocardiographic studies are not available, because of claims that Doppler echocardiography with high energy causes potential harm on the fetus [8,9]. We applied this method only in cases with cardiac pathology excluded. PA width was found to be 8 % more than aorta. RV volume was 20 % more than LV volume. This clearly indicates right dominance as in our study.

Conclusion

1. The dimension of the heart chambers, wall thickness, volumes and sizes of the heart chamber and diameters of the aorta and pulmonary artery increase linearly but not exponentially during the gestational period.

2. The parameters of the right ventricle, right atrium and pulmonary artery were shown to be slightly more dominant than those of the left ventricle, left atrium and aorta during the gestational period.

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