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The Second Heart Sound in Ventricular Septal Defect

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Ventricular septal defect is one of the most frequently seen congenital heart disease. Although surgical treatment is not necessary for small ventricular septal defect (Group I), moderate (Group II) and severe (Group III) ventricular septal defects should be closed surgically.[1] However, in Eisenmenger's syndrome (Group IV) closure of ventricular septal defect is contraindicated. For this reason, the clinician cannot be satisfied with the diagnosis of ventricular septal defect. He wants to assess the magnitude of hemodynamic overload of the heart, and the relative size of the defect. Because of the fact that the natural history of the disease varies from spontaneus closure of the defect to development of Eisenmenger's syndrome, the patients are evaluated periodically. Although the diagnostic value of the time interval between two components of the second heart sound (A_2–P_2) has been studied by several investigators, there are. discrepancies between their findings. In this study using a particular method we tried to illuminate the subject.

Material and Methods

33 of the cases catheterized with the impression of ventricular septal defect had the definite diagnosis of isolated VSD. The study was done on these 33 patients and 9 control cases. Of the cases with VSD, 9 were female and 24 were male. The range in age was from 1 year old to 13 years old (average 7). Two of the control cases were female and 7 were male (average 7.7 years old).

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On these cases a particular method was applied after rutin cardiac catheterization. The tip of the arterial catheter was located just above the aortic semilunar valve. The tip of the venous catheter was also put just above the pulmonic semilunar valve. Then, simultaneus recordings of the pressures of the both great vessels, and external phonocardiograms were obtained using multi–channel recorder of Electronics for Medicine. In phonocardiography the microphone was located at the pulmonic area. 75 mm/sec and 200 mm/sec paper speeds were used, and at least 2 phases of expiration and inspiration were recorded.

The intervals between the dicrotic notches of the aortic and pulmonic pressure curves were measured (Figure 1 a and 1 b). Similary, A_2–P_2 intervals were measured from external phonocardiograms. These two methods showed the same A_2–P_2 values.

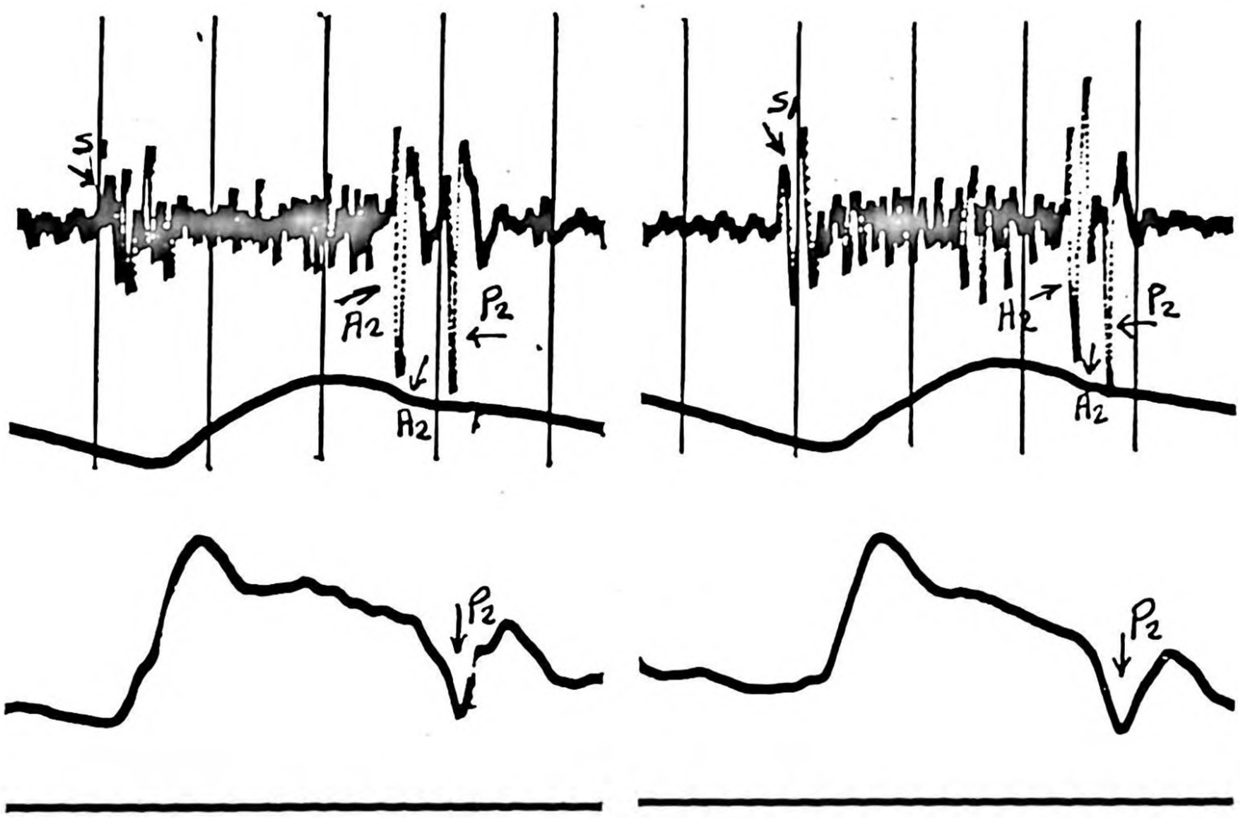

Figure 1 a **Figure 1 b**

The recordings obtained from the 8th patient of Group II. From top to bottom: 1- External phonocardiogram, 2- Aortic pressure curve, 3- Pulmonary artery pressure curve.

A_2 : Closure of the aortic semilunar valve.
P_2 : Closure of the pulmonary semilunar valve.
a : during expiration.
b : during inspiration.

Results

Cases of VSD were classified on the basis of the hemodynamic findings and Gasul's physiological standards.[1]

Group I includes 18 cases in which systolic pressures of the pulmonary artery were less than 35 mm. Hg. Hemodynamic findings are summarized on Table I. 16 of the 18 cases illustrated left–to–right shunt at ventricular level by oxygen saturations. Remaining 2 cases showed positive findings for left–to–right shunt at ventricular level by Hydrogen method. The pulmonary–systemic flow ratio was between 1 to 2. Pulmonary and systemic resistances were within normal limits. Table I also shows the intervals between 2 components of the second heart sound (mean values were obtained from the measurements of A_2–P_2 intervals during consecutive 2 phases of respiration).

Group 2 includes those patients with the pulmonary artery pressure, ranging from 36 mm. Hg. to approximately 75 per cent of the systemic pressures. Hemodynamic findings and A_2–P_2 intervals are shown on Table II. 7 cases had the pulmonary–systemic flow ratio of 2 to 4 and 2 cases less than 2.

Group 3-A includes cases with equilibrated pulmonary and systemic pressures, and only a left-to-right or a bidirectional but predominantly left-to-right shunt. The pulmonary artery pressure ranges from 75 to 100 percent of the systemic pressure. In the cases belonging to this group the pulmonary resistance is normal or elevated to less than half the systemic resistance. The number of the cases is 6. Hemodynamic findings and A_2–P_2 values are shown on Table III. Five of the 6 cases had the pulmonary systemic flow ratio of less than 2. The pulmonary resistances of the 4 patients were higher than normal. However none of the cases showed pulmonary vascular resistance higher than half of the systemic resistance.

Control cases: Hemodynamic findings of these 9 cases were normal. A_2–P_2 values are shown on Table IV.

Discussion

It is advantageous for the pediatrician or cardiologist to be able to predict from clinical examination or simple laboratory tests, what hemodynamic findings are in his patient. Assessing the child with a VSD by means of second heart sound is very helpful. Some investigators found a good correlation between the width of splitting of the second sound and the hemodynamic findings, however some could not.[1, 4] In our study using a different method on a fairly high number of cases we tried to illuminate the subject.

TABLE I

HEMODYNAMIC FINDINGS AND A_2–P_2 VALUES (GROUP 1)

	Case		Age	Surface area m²	Pulm. flow (L/m²)	Syst. flow (L/m²)	P/S flow ratio	P. A. pressure (mm.Hg)	Aortic pressure (mm.Hg)	Pulm. Resis. (unit)	Syst. Resis. (unit)	A_2–P_2 Values Insp. msec.	Exp. msec.	Mean
1	67/8501	İ.Ö.	4	0.7	5.7	4.3	1.3	30/12	100/75	3	20	59	32	44
2	63/ 23810	Y.Ö.	5	0.7	4.3	3.4	1.3	30/7	80/38	2	17	52	30	40
3	62/16137	İ.E.	7	0.8	3	3	1	17/12	85/60	2	22	60	40	50
4	65/26145	E.A.	6	0.7	7.7	4	1.9	15/3	90/60	1.4	17	78	52	68
5	65/26233	E.A.	11	1	5	3.5	1.4	22/5	105/62	2	22	45	32	39
6	68/40776	H.K.	5	0.7	5.7	4.3	1.3	20/7	98/76	2	18	40	25	32
7	63/42288	S.Ş.	7	0.8	7.5	4.5	1.7	27/7	85/55	2	15	59	32	52
8	62/30856	H.D.	8	0.8	7	5.6	1.3	30/10	90/50	2	14	40	27	35
9	64/33097	E.T.	8	1	4	3.1	1.3	30/15	100/70	3	27	59	32	94
10	62/18513	İ.Y.	8	0.8	6.6	4.5	1.5	32/12	90/50	2	16	50	28	38
11	68/52354	E.K.	12	1	7.5	5	1.5	30/15	100/65	2	16	85	40	69
12	67/48509	S.K.	11	1	5.5	4.4	1.2	25/7	110/80	2	19	20	7	13
13	68/69759	A.A.	13	1.2	5.8	4	1.4	30/10	100/65	2	20	28	2	22
14	65/17159	Y.G.	6	0.8	3	3	1	26/4	117/85	3	32	59	33	48
15	60/10967	B.K.	11	1	8.8	5	1.7	15/6	85/52	1	23	59	32	43
16	68/72731	O.M.	12	1.1	8.1	4	2	20/12	95/60	1.4	16	56	40	48
17	68/41343	K.K.	12	1.5	4.5	3.3	1.8	26/10	120/85	2	28	80	40	67
18	67/15205	A.O.	7	0.9	5	3	1.8	10/4	98/68	1	27	90	65	78

TABLE II

HEMODYNAMIC FINDINGS AND A_2-P_2 VALUES (GROUP 2)

	Case		Age	Surface area m²	Pulm. flow (L/m²)	Syst. flow (L/m²)	P.S flow ratio	P. A. Pressure (mm. Hg)	Aortic pressure (unit)	Pulm. Resis. (unit)	Syts. Resis. (unit)	A_2-P_2 Values Insp. used	Insp. msec.	Mean
1	68/54420	S.G.	6	0.8	4.3	3.7	1.2	40/18	95/70	5	20	78	65	69
2	65/28212	H.A.	3	0.5	9	4	2.3	50/10	80/35	3	20	85	65	74
3	67/37051	Ö.S.	8	0.8	6.6	3	..2	65/25	95/75	5	28	52	32	43
4	68/16849	H.K.	4	0.7	18	4.7	3.8	40/18	80/55	1.5	15	45	35	38
5	68/39451	A.Ö.	7	0.5	6.4	3.4	1.9	52/13	120/78	4	26	85	65	74
6	64/43391	S.Ö.	4	0.7	13	6.5	2	43/17	85/65	2	18	77	55	65
7	68/63270	M.C.	1	0.4	7.5	3.2	2.3	38/15	85/50	2	17	53	43	46
8	68/50336	M.Y.	5	0.6	11.2	5	2.2	60/30	117/78	3	18	65	40	52
9	67/42503	M.B.	4	0.6	11.4	5.3	2.1	40/12	90/60	1.5	13	50	40	45

TABLE III

HEMODYNAMIC FINDINGS AND A_2-P_2 VALUES (GROUP 3-A)

	Case											A_2-P_2 Insp. msec.	Values Exp. msec.	Mean
1	61/18095	A.K.	8	16	4.4	3.7	70/30	80 58	4	19	40	27	30	19
2	68 65575	B.A.	3	0.5	26	4.6	5.6	80/30	80/50	4	14	32	25	28
3	63/41124	S.A.	5	0.6	11	3.4	3.2	65/38	85/65	4	20	35	25	27
4	67/48985	F.S.	1.5	0.4	33	3	11	75/25	85/40	1	20	90	75	81
5	68/62451	Y.T.	2.5	0.5	26	6	4.3	65/33	80/50	2	12	35	25	30
6	68/81342	A.N.	13	0.9	6.6	3.5	1.9	80/33	100/68	8	32	25	15	22

TABLE IV

A_2–P_2 VALUES (CONTROL GROUP)

	Case		Insp. msec.	Exp. msec.	Mean
1	68/66479	M.T.	30	15	23
2	68/71667	N.P.	40	25	30
3	68/70133	R.K.	45	27	37
4	68/66482	Y.Ş.	50	27	37
5	68/76251	Y.A.	50	40	43
6	68/73800	H.Ç.	53	37	48
7	68/77300	F.K.	35	15	25
8	67/55223	M.Y.	45	30	38
9	68/71665	M.A.	45	30	35

In order to study the second heart sound in different cardiovascular anomalies, some investigators used external pulse pressure curves of the carotid artery and phonocardiograms.[5 8] The dicrotic notches of the curves were used to determine the closure of the aortic valve. Corrections were made for the delay of the vibrations from aortic valve to carotid artery. We preferred our method, mentioned above, in order to have more reliable results.

1. Average A_2-P_2 of Group I during expiration was 33.72 mesc., and of control group was 27.33 msec. In normal cases this was 10.6 msec. in Aygen and Braunwald's[9] study, and 27 msec. in Craige and Hill's[10] study. Blazek and Bliss's[11] values were 33 msec. for small VSD, and 22 msec. for normals. Statistical analysis of our values revealed that separation of group 1 from normal cases was not possible using A_2-P_2 intervals (Table V).

TABLE V

STATISTICAL DATA OF A_2–P_2 VALUES MEASURED DURING EXPIRATION

Groups	$\bar{x}$	D	LSD
Group I	33.72	6.39	9.37
Control	27.33		
Group I	33.72	15.39	10.65
Group II	49.11		
Group II	49.11	17.11	19.49
Group III	32.00		

$\bar{x}$: Mean value of A_2–P_2 measured during expiration.

D : Difference between means.

LSD: Least significant difference.

2. Average A_2-P_2 of Group 2, measured during expiration, was 49.11 msec. Statistically, there was a significant difference between the values of Grup 1 and Group 2. In other words two groups can be differentiated with the A_2-P_2 values measured during expiration.

Similarly, Kardalinos found good correlation between the magnitude of the shunt and the width of the second sound provided that the pulmonary vascular resistance was normal.[2]

3. Average A_2-P_2 during expiration in group 3-A was 32 msec. As mentioned above this value for Group 2 was 49.11 msec. Statistically, no significant difference was found between them. In other words, A_2-P_2 values are not useful to differentiate these two groups. To our knowledge there is no satisfactory study in the literature comprising these groups.

Pure tones at different frequencies with an interval more than 20 msec. are audible seperately.[12] Considering that the heart sounds are complex from the standpoint of frequency, they need wider intervals to be heard separately. For this reason heart sounds with more than 40 msec. interval are split during auseultation.[13] We grouped the cases, in that, whether the second sound was widely split.

Two of the 9 controls showed widely split second sound. In Group 1, 6 of the 18 cases had widely split second sound. In Group 2, 7 of the cases showed A_2-P_2 intervals, heard split in the expiration. In Group 3-A, 1 patient had widely split second sound.

Statistical analyses were done on Group 1 and 2, in that, they had widely split second sound. p number was 0.0375. In other words Group 1 and 2 can be differentiated using this method. Practically, this finding is very important, because of the fact that, Group I does not need operation, although Group 2 does need.

Summary

In order to investigate the diagnostic value of the second heart sound in patients with VSD, classified in groups, in regard to the hemodynamic findings and Gasul's physiological standards a particular method was used, and with this method 42 cases were studied.

The intervals between the closure of the aortic and pulmonic semilunar valves were measured. The conclusions obtained are as follows.

1. The average of A_2-P_2 in the first group and the control group in the expiration could not be used for differentiation between these groups.

2. On the other hand the A_2-P_2 values in the expiration were found to be very useful in differentiation between the first and second groups.

3. The second sound in the second group showed wide splitting in comparison with other groups.

4. The average of A_2-P_2 in the second and Group 3-A in the expiration could not be used for differentiation between these groups.

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