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Left and right ventricular systolic time intervals in the newborn[1]

Usefulness and limitation in distinguishing respiratory disease from transposition of the great arteries

HOWARD P. GUTGESELL, WILLIAM W. PINSKY, DESMOND F. DUFF, JAMES ADAMS, AND DAN G. McNAMARA

From The Lillie Frank Abercrombie Section of Pediatric Cardiology, and Section of Neonatology, Baylor College of Medicine; and Texas Children's Hospital, Houston, Texas, USA

SUMMARY To determine their usefulness in the evaluation of the cyanotic newborn, left and right ventricular systolic time intervals were determined by echocardiography in 67 neonates; 21 were normal, 25 had neonatal respiratory disease, and 21 had dextro-transposition of the great arteries. The time intervals were measured from high-speed recordings of aortic and pulmonary valve motion.

In normal newborns, the right ventricular pre-ejection period tended to be shorter than the left ventricular pre-ejection period while right ventricular ejection time was longer than that of the left ventricle. The ratio of right ventricular pre-ejection period/ejection time was lower than the ratio of these intervals for the left ventricle in 15 of 21 infants (mean 0·33 ± 0·05 SD compared to 0·39 ± 0·06, $P < 0·001$). In patients with respiratory disease, the ratio of right ventricular pre-ejection period/ejection time was increased, primarily because of prolongation of the pre-ejection period. As a result, the ratio of right ventricular pre-ejection period/ejection time was greater than the left ventricular ratio in 15 of 25 patients and the ratios were equal in 8 (mean 0·44 ± 0·11 vs 0·38 ± 0·08, $P < 0·005$). Likewise, in infants with transposition of the great arteries, right ventricular pre-ejection period/ejection time was greater than left ventricular pre-ejection period/ejection time (0·42 ± 0·10 vs 0·26 ± 0·06, $P < 0·001$), and the lowest values of left ventricular pre-ejection period/ejection time were recorded in this group.

The pulmonary valve closed later than the aortic valve in 46 (70%) of the subjects studied; simultaneous semilunar valve closure occurred in 19 (29%), and in 1 subject with respiratory disease the pulmonary valve closed before the aortic valve.

Thus, the ratio of right ventricular pre-ejection period/ejection time was greater than the left ventricular ratio in both neonatal respiratory disease and transposition of the great arteries. A very low left ventricular ratio (less than 0·25) and delayed closure of the posterior semilunar valve suggest the latter diagnosis.

The measurement of systolic time intervals has been widely used as a non-invasive method of studying cardiac function. Most studies have focused on assessment of left ventricular performance, since the left ventricular systolic time intervals can be readily determined from simultaneous recordings of the electrocardiogram, the indirect carotid pulse tracing, and the phonocardiogram (Weissler *et al.*, 1969, 1972). There have been relatively few studies of right ventricular systolic time intervals (Leighton *et al.*, 1971; Curtiss *et al.*, 1976), primarily because of the difficulty in timing right ventricular events by non-invasive techniques. With the development of echocardiography, it has become possible to measure the systolic time intervals of both the left ventricle and the right ventricle (Hirschfeld *et al.*,

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1975a; Mills *et al.*, 1975; Riggs *et al.*, 1977a, b). Alterations of the systolic time intervals have been shown in patients with pulmonary hypertension (Hirschfeld *et al.*, 1975b; Curtiss *et al.*, 1976) and in patients with transposition of the great arteries (Hirschfeld*et al.*, 1975a).

Clinical differentiation of transposition of the great arteries from respiratory disease may be difficult in the newborn, and a non-invasive method of making the distinction is clearly desirable. Neonates with transposition of the great arteries require prompt catheterisation and are often dramatically improved by Rashkind balloon atrial septostomy (Rashkind and Miller, 1966; Mullins *et al.*, 1972; Neches *et al.*, 1972). Catheterisation of the seriously ill newborn entails considerable risk, however, and obviously should be avoided in the infant with primary respiratory disease.

In the present study, echocardiography was used to measure right and left ventricular systolic time intervals in normal newborns. The results were compared with similar data from neonates with either respiratory disease or transposition of the great arteries to determine the usefulness of this technique in the evaluation of the cyanotic newborn.

Subjects and methods

Echocardiograms were obtained from 67 neonates. The first group consisted of 21 normal newborn infants. They were between 15 and 40 hours of age at the time of study and had no heart disease as judged by physical examination. Informed consent was obtained from the parents and the primary physician before study.

The second group consisted of 25 full-term newborns with respiratory disease. Echocardiograms were performed between 12 and 48 hours after birth. Each patient had cyanosis, clinical evidence of respiratory distress, and arterial blood oxygen concentration below the expected value for the inspired oxygen concentration. The pathogenesis of the respiratory disease frequently was unknown at the time of study and cyanotic congenital heart disease was often an initial diagnostic consideration. However, the final diagnosis was hyaline membrane disease in 5, transient tachypnoea of the newborn (Avery *et al.*, 1966) in 5, persistent fetal circulation (Gersony *et al.*, 1969) in 9, pneumonia in 5, and bilateral choanal atresia in 1.

The third group consisted of 21 patients with dextro-transposition of the great arteries. They ranged in age from 1 day to 6 weeks; 15 were under 1 week of age. The diagnosis was confirmed by cardiac catheterisation and in each patient balloon atrial septostomy was performed. Nine patients had uncomplicated transposition of the great arteries, 7 had an associated ventricular septal defect without pulmonary stenosis, and 3 had ventricular septal defect and pulmonary stenosis. A persistent ductus arteriosus was shown by angiography in 8 of these patients and coarctation of the aorta was present in 2. The incidence of pulmonary stenosis may be underestimated since we avoid repeated attempts to catheterise the pulmonary artery in neonates with transposition of the great arteries (Mullins *et al.*, 1972). The pulmonary artery was entered in only 8 patients, 7 via a ventricular septal defect and 1 via a persistent ductus arteriosus.

Echocardiograms were obtained with a Hoffrel model 101 Ultrasonoscope interfaced to a Honeywell model 1856 strip chart recorder. The left ventricular and right ventricular systolic time

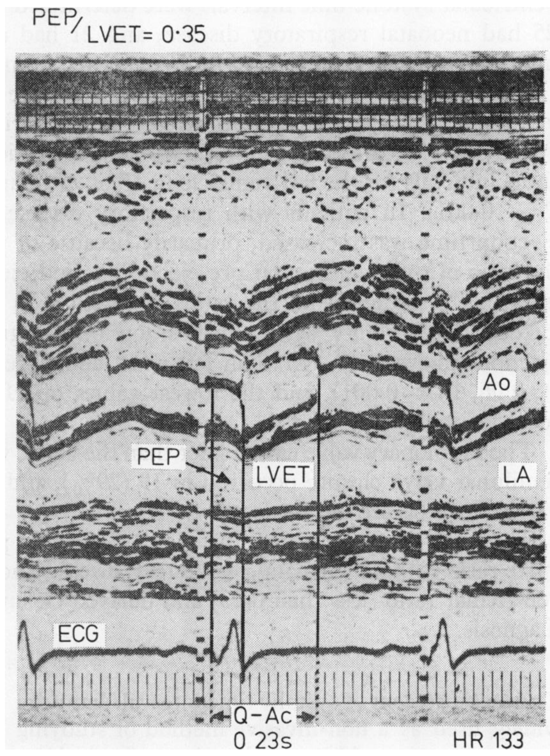

Fig. 1 *Recording of aortic valve motion in a newborn with respiratory disease, illustrating the method for measuring left ventricular systolic time intervals from the echocardiogram. The ratio PEP/LVET was 0·35, and aortic valve closure (Ac) occurred 0·23 s after the onset of the QRS complex of the electrocardiogram (ECG). Time lines are 0·02 s, paper speed 100 mm/s. PEP, pre-ejection period; LVET, left ventricular ejection time; Ao, aorta; LA, left atrium; HR, heart rate.*

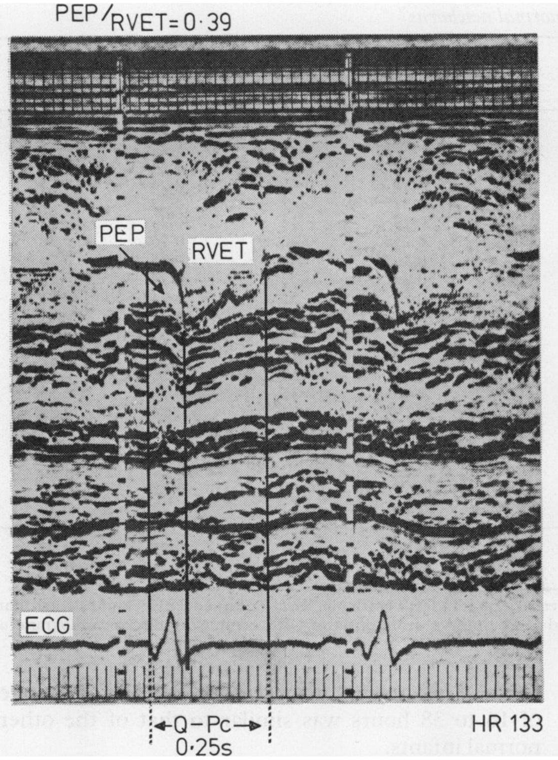

Fig. 2 *Recording of pulmonary valve motion (same patient as Fig. 1) showing method by which right ventricular systolic time intervals were determined. The ratio PEP/RVET is 0·39, and pulmonary valve closure (Pc) occurs 0·25 s after the onset of the QRS complex. PEP, right ventricular pre-ejection period; VET, right ventricular ejection time; HR, heart rate.*

intervals were measured from recordings of aortic and pulmonary valve motion at 100 mm/second paper speed, using the technique described by Hirschfeld *et al.* (1975a) (Fig. 1 and 2). In patients with transposition of the great arteries, left ventricular systolic time intervals were determined from the pulmonary valve recording and right ventricular intervals from the aortic valve recording. For each ventricle the pre-ejection period was measured from the onset of the QRS complex of the electrocardiogram to the point of opening of the corresponding semilunar valve. Left and right ventricular ejection times were measured from semilunar valve opening to closing. The timing of semilunar valve closure was determined by measuring the interval from the onset of the QRS complex of the electrocardiogram to the time of aortic and pulmonary valve closure (Q-Ac and Q-Pc). All measurements were rounded off to the nearest 0·005 second.

Systolic time intervals, particularly those of the right ventricle, are known to be influenced by respiration. Since the phase of the respiratory cycle could not be controlled or recorded during the study, the following method was used to minimise the effects of respiration: (1) systolic time intervals were measured only from records in which each of the semilunar valves was recorded at the same heart rate, and (2) of the cycles recorded at this rate, those with the shortest ejection time were chosen for analysis.

The heart rates of infants with respiratory disease (mean 144 $\pm$ 18 SD) and transposition of the great arteries (149 $\pm$ 20) were significantly higher than those of the normal newborns (130 $\pm$ 12, $P < 0·005$). Previous studies have shown that the ejection time (Weissler *et al.*, 1969; Leighton *et al.*, 1971; Weissler *et al.*, 1972) and, to a lesser extent, the pre-ejection period (Golde and Bursten, 1970; Leighton *et al.*, 1971; Spitaels *et al.*, 1974; Hirschfeld *et al.*, 1975b) are inversely related to heart rate. Therefore, in the subsequent analysis, the absolute values of the right or left ventricular systolic time intervals have been compared only with those of the other ventricle of the same patient. Since the ratio of pre-ejection period/ejection time is relatively independent of heart rate (Spitaels *et al.*, 1974; Hirschfeld *et al.*, 1975b), it has been used for intergroup comparisons.

Student's t test was used to compare the data from the 3 groups of subjects and the paired t test was used for comparison of the 2 ventricles within each group.

Results

NORMAL NEWBORNS

In 11 of the 21 normal infants, right ventricular pre-ejection period was shorter than left ventricular pre-ejection period; in 4 infants the right and left ventricular pre-ejection periods were equal, and in 6 the right ventricular pre-ejection period was longer. The mean right ventricular pre-ejection period was 0·06 second, compared with the mean left ventricular pre-ejection period of 0·07 second. Right ventricular ejection time was longer than left ventricular ejection time in 19 of 21 subjects and ejection times of the 2 ventricles were equal in 2 (Table 1a).

The shorter pre-ejection period and longer ejection time of the right ventricle resulted in a mean ratio of right ventricular pre-ejection period/ejection time which was significantly lower than the left ventricular ratio (0·33 $\pm$ 0·05 SD vs 0·39 $\pm$ 0·06, $P < 0·001$) (Fig. 3). However, in 4 infants (cases 4, 6, 13, and 15) a long right ventricular pre-

Table 1a *Left and right ventricular systolic time intervals: normal newborns*

No.	HR	Left ventricle			Right ventricle			Q-Ac	Q-Pc
		LPEP	LVET	LPEP/LVET	RPEP	RVET	RPEP/RVET		
1	125	0·09	0·16	0·56	0·08	0·19	0·42	0·25	0·27
2	100	0·08	0·19	0·42	0·06	0·22	0·27	0·27	0·28
3	140	0·075	0·17	0·44	0·06	0·20	0·30	0·245	0·26
4	133	0·07	0·175	0·40	0·08	0·18	0·44	0·24	0·25
5	110	0·07	0·205	0·34	0·06	0·225	0·27	0·275	0·285
6	133	0·65	0·185	0·35	0·08	0·19	0·42	0·25	0·27
7	118	0·06	0·20	0·30	0·065	0·215	0·30	0·26	0·28
8	133	0·07	0·18	0·39	0·07	0·195	0·36	0·25	0·265
9	136	0·065	0·175	0·37	0·065	0·20	0·32	0·24	0·265
10	133	0·06	0·18	0·33	0·06	0·19	0·32	0·24	0·25
11	133	0·07	0·17	0·40	0·06	0·19	0·31	0·24	0·25
12	110	0·07	0·22	0·32	0·07	0·22	0·32	0·29	0·29
13	150	0·06	0·19	0·32	0·07	0·19	0·37	0·25	0·26
14	130	0·07	0·18	0·39	0·06	0·19	0·32	0·25	0·25
15	136	0·06	0·18	0·33	0·065	0·185	0·35	0·24	0·25
16	120	0·07	0·165	0·42	0·065	0·195	0·34	0·235	0·26
17	125	0·06	0·18	0·33	0·05	0·20	0·25	0·24	0·25
18	140	0·07	0·18	0·39	0·065	0·20	0·32	0·25	0·265
19	133	0·065	0·18	0·36	0·06	0·20	0·30	0·245	0·26
20	130	0·085	0·17	0·50	0·06	0·20	0·30	0·255	0·26
21	120	0·085	0·17	0·45	0·07	0·22	0·32	0·255	0·29
Mean	130	0·07	0·18	0·39	0·06	0·20	0·33	0·25	0·27
SD	12	0·009	0·01	0·06	0·008	0·01	0·05	0·01	0·01

HR, heart rate (beats/minute); LPEP, left ventricular pre-ejection period; LVET, left ventricular ejection time; RPEP, right ventricular pre-ejection period; RVET, right ventricular ejection time; Q-Ac and Q-Pc, interval from onset of QRS complex of electrocardiogram to aortic and pulmonary valve closure, respectively.

ejection period resulted in a mean ratio of pre-ejection period/ejection time greater than that of the left ventricle. The raised right ventricular ratio of these infants was not age-related; their age range of 16 to 38 hours was similar to that of the other normal infants.

Table 1b *Left and right ventricular systolic time intervals: neonatal respiratory disease*

No.	Aetiology	HR	Left ventricle			Right ventricle			Q-Ac	Q-Pc
			LPEP	LVET	LPEP/LVET	RPEP	RVET	RPEP/RVET		
1	HMD	143	0·075	0·16	0·47	0·085	0·16	0·53	0·235	0·245
2	HMD	160	0·07	0·135	0·52	0·09	0·135	0·66	0·205	0·225
3	HMD	156	0·07	0·15	0·47	0·07	0·15	0·47	0·22	0·22
4	HMD	140	0·065	0·16	0·40	0·06	0·18	0·33	0·225	0·24
5	HMD	145	0·07	0·14	0·50	0·07	0·14	0·50	0·21	0·21
6	PFC	127	0·075	0·17	0·44	0·085	0·175	0·48	0·245	0·26
7	PFC	136	0·065	0·175	0·37	0·075	0·175	0·43	0·24	0·25
8	PFC	157	0·06	0·16	0·38	0·08	0·15	0·53	0·22	0·23
9	PFC	86	0·065	0·195	0·33	0·075	0·22	0·33	0·26	0·295
10	PFC	136	0·055	0·15	0·37	0·06	0·16	0·375	0·205	0·22
11	PFC	150	0·065	0·165	0·39	0·75	0·155	0·48	0·23	0·23
12	PFC	157	0·04	0·16	0·25	0·04	0·16	0·29	0·20	0·20
13	PFC	150	0·07	0·19	0·38	0·10	0·17	0·59	0·26	0·27
14	PFC	133	0·07	0·17	0·41	0·07	0·18	0·39	0·24	0·25
15	TTN	144	0·08	0·20	0·40	0·11	0·17	0·65	0·28	0·28
16	TTN	120	0·055	0·20	0·275	0·07	0·205	0·34	0·255	0·275
17	TTN	165	0·045	0·14	0·32	0·065	0·14	0·46	0·185	0·205
18	TTN	145	0·065	0·19	0·34	0·075	0·195	0·38	0·225	0·27
19	TTN	150	0·065	0·20	0·32	0·08	0·17	0·47	0·265	0·25
20	PN	170	0·06	0·14	0·43	0·06	0·14	0·43	0·20	0·20
21	PN	133	0·045	0·18	0·25	0·045	0·18	0·25	0·225	0·22
22	PN	165	0·055	0·16	0·34	0·055	0·16	0·34	0·215	0·215
23	PN	157	0·08	0·17	0·47	0·08	0·17	0·47	0·25	0·25
24	PN	120	0·075	0·19	0·39	0·08	0·19	0·42	0·265	0·27
25	CA	160	0·05	0·17	0·29	0·05	0·17	0·29	0·22	0·22
Mean		144	0·06	0·17	0·38	0·07	0·17	0·44	0·23	0·24
SD		18	0·01	0·02	0·08	0·02	0·02	0·11	0·02	0·02

CA, choanal atresia; HMD, hyaline membrane disease; PFC, persistent fetal circulation; PN, pneumonia; TTN, transient tachypnoea of the newborn.
Other abbreviations as in Table 1a.

Table 1c *Left and right ventricular systolic time intervals: transposition of great arteries*

No.	*Associated lesions**	*HR*	*Left ventricle*			*Right ventricle*			*Q-Ac*	*Q-Pc*
			LPEP	*LVET*	*LPEP/LVET*	*RPEP*	*RVET*	*RPEP/RVET*		
1		144	0·05	0·24	0·21	0·07	0·18	0·39	0·25	0·29
2		120	0·06	0·21	0·27	0·10	0·17	0·60	0·27	0·27
3		150	0·045	0·195	0·23	0·06	0·16	0·37	0·22	0·24
4		150	0·05	0·20	0·25	0·065	0·16	0·40	0·225	0·25
5		180	0·04	0·18	0·22	0·07	0·14	0·50	0·21	0·22
6		146	0·03	0·21	0·14	0·06	0·15	0·40	0·21	0·24
7	VSD	135	0·06	0·21	0·21	0·065	0·18	0·35	0·245	0·27
8	VSD	145	0·065	0·18	0·36	0·085	0·14	0·60	0·225	0·26
9	VSD	140	0·04	0·20	0·20					0·24
10	VSD	180	0·05	0·20	0·25	0·065	0·17	0·33	0·235	0·25
11	VSD	120	0·05	0·22	0·23	0·08	0·16	0·50	0·24	0·27
12	VSD	135	0·05	0·20	0·25	0·07	0·18	0·39	0·25	0·25
13	PS	155	0·045	0·24	0·19	0·06	0·16	0·37	0·22	0·28
14	PS	145	0·05	0·20	0·25	0·08	0·17	0·47	0·25	0·25
15	VSD, PS	144	0·04	0·20	0·20	0·06	0·16	0·37	0·24	0·27
16	VSD, PS	145	0·05	0·20	0·25	0·07	0·16	0·43	0·23	0·24
17	VSD, PS	120	0·06	0·20	0·30	0·06	0·18	0·33	0·24	0·26
18	PDA	200	0·035	0·135	0·26	0·05	0·11	0·45	0·16	0·17
19	PDA	170	0·055	0·17	0·32	0·045	0·19	0·23	0·235	0·235
20	PDA, CoA	150	0·045	0·20	0·225	0·065	0·17	0·39	0·235	0·240
21	VSD, PDA, CoA	155	0·07	0·16	0·44	0·08	0·13	0·60	0·21	0·235
Mean		149	0·05	0·05	0·26	0·07	0·16	0·42	0·23	0·25
SD		20	0·01	0·02	0·06	0·01	0·02	0·10	0·02	0·03

CoA, coarctation of aorta; PDA, persistent ductus arteriosus; PS, pulmonary stenosis; VSD, ventricular septal defect.
Other abbreviations as in Table 1a.
*Cases 2, 3, 4, and 14 also had a small, but haemodynamically insignificant PDA shown by angiography.

Aortic valve closure preceded pulmonary valve closure by an average of 0·02 second. In 18 of the 21 normal infants, Q-Ac was at least 0·01 second shorter than Q-Pc at the same heart rate; in 3 infants, these intervals were equal (Table 2).

RESPIRATORY DISEASE

In infants with respiratory disease, the left ventricular pre-ejection period and ejection time were similar to those of the normal subjects (Table 1b and Fig. 3). The right ventricular systolic time intervals were different, however. Though patients with respiratory disease had faster heart rates than the normal infants, right ventricular pre-ejection period was longer (0·07 ± 0·02 vs 0·06 ± 0·01 s, $P < 0·05$). As a result, the mean ratio of pre-ejection period/ejection time for the right ventricle was greater than that for the left ventricle (0·44 ± 0·11 vs 0·38 ± 0·08 s, $P < 0·005$). There was no apparent relation between the systolic time intervals and either the type or severity of the respiratory disease.

Table 2 *Timing of semilunar valve closure in the newborn*

	Q-Pc > Q-Ac	*Q-Pc = Q-Ac*	*Q-Pc < Q-Ac*
Normal	18	3	0
RDS	12	12	1
TGA	16	4	0
	46	19	1

Q-Pc, Q-Ac, time from Q wave of electrocardiogram to pulmonary or aortic valve closure, respectively; RDS, respiratory distress syndrome; TGA, transposition of the great arteries.

In 12 of the 25 patients with respiratory disease, aortic valve closure preceded pulmonary valve closure, as in the normal subjects (Table 2). Simultaneous semilunar valve closure was equally common; in 12 patients with respiratory distress syndrome, Q-Ac and Q-Pc were identical. In one patient, the pulmonary valve closed before the aortic valve.

TRANSPOSITION OF GREAT ARTERIES

The left ventricular systolic time intervals were particularly useful in distinguishing transposition from respiratory disease. In patients with transposition, the left ventricular pre-ejection period was shorter than in normals or in patients with respiratory disease, while the left ventricular ejection time was prolonged (Table 1c). The resultant ratio of left ventricular pre-ejection period/ejection time was significantly ($P < 0·001$) lower in transposition of the great arteries (0·26 ± 0·06) than in the other 2 groups (normals = 0·39 ± 0·06, respiratory disease = 0·38 ± 0·08). In 13 of 21 patients with transposition of the great arteries, the ratio of left ventricular pre-ejection period/ejection time was 0·25 or less; no normal infant and only 4 infants with respiratory disease had a ratio less than 0·30.

The left ventricular pre-ejection period/ejection time ratio was higher in patients with transposition complicated by large ventricular septal defect than

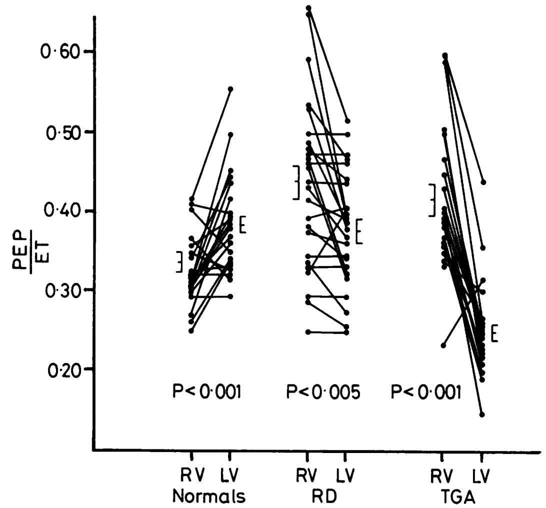

Fig. 3 *Ratio of pre-ejection period (PEP) to ejection time (ET) for the right (RV) and left ventricle (LV) in 3 groups of neonates. In normals, the RV ratio was lower. In infants with respiratory disease (RD) and transposition of the great arteries (TGA), the RV ratio was higher than the LV ratio. Brackets indicate mean ± standard error.*

in those with simple transposition or transposition with pulmonary stenosis (Table 1c). The average ratio for the 7 patients with transposition of the great arteries and ventricular septal defect was 0·28; that for the 5 patients with pulmonary stenosis (3 with and 2 without ventricular septal defect) was 0·24 and that for 6 patients with simple transposition was 0·22.

The right ventricular systolic time intervals in infants with transposition were similar to those of the patients with respiratory disease, and were characterised by a relatively long pre-ejection period and a short ejection time. The ratio of right ventricular pre-ejection period/ejection time was greater than that of the left ventricle in all but 1 patient with transposition of the great arteries, and the mean values for the 2 ventricles provided the most distinct separation of the 3 groups of subjects: right ventricle = 0·42 ± 0·02, left ventricle = 0·26 ± 0·02, $P < 0·001$ (Fig. 3).

The pulmonary valve closed after the aortic valve in 16 of 19 patients with transposition of the great arteries. In the other 3 patients, aortic and pulmonary valve closure was simultaneous (Table 2).

Discussion

In normal subjects, right ventricular ejection begins before and ends after left ventricular ejection (Braunwald *et al.*, 1956). Compared with the left ventricle, the right ventricle is characterised by a short pre-ejection period and a long ejection time (Leighton *et al.*, 1971; Hirschfeld *et al.*, 1975a). In the absence of disorders of myocardial contractility, filling pressure, or conduction, the pressure in the outflow vessel is the major determinant of the systolic time intervals of either ventricle. A rise in the arterial diastolic pressure increases the time required for ventricular pressure to reach arterial pressure and to open the semilunar valve. Though this may, in part, be compensated for by a more rapid rate of rise of ventricular pressure, the net result is usually a prolongation of the pre-ejection period; additionally, arterial hypertension may shorten the ejection time (Curtiss *et al.*, 1976). The result is that the ventricle facing systemic pressure tends to have a higher ratio of pre-ejection period to ejection time than does the ventricle facing pulmonary pressure.

The demonstration that left ventricular and right ventricular systolic time intervals could be measured non-invasively by electrocardiography (Hirschfeld *et al.*, 1975a) suggested that this technique might be of value in the evaluation of the cyanotic newborn. It was unknown whether the rapid heart rates (with shortening of all systolic and diastolic time intervals) and raised pulmonary artery pressure of the newborn would preclude identification of the great arteries by their systolic time intervals.

The ratio of right ventricular pre-ejection period/ejection time was raised in both transposition of the great arteries and respiratory disease. Therefore, the low ratio of left ventricular pre-ejection period/ejection time in transposition was the most useful finding for distinguishing the two conditions. Hirschfeld *et al.* (1975a) showed that in older children with transposition, the left ventricular systolic time intervals were those of a ventricle facing the pulmonary circulation (that is, a short pre-ejection period and long ejection time compared to the other ventricle). The present study confirmed these findings; even in the first week of life, most patients with transposition of the great arteries had left ventricular systolic time intervals characteristic of a 'pulmonary' ventricle. The ratio of left ventricular pre-ejection period/ejection time was lower than that of the right ventricle and the pulmonary valve closed later than the aortic valve.

The relation between the left and right ventricular systolic time intervals in normal newborns in this study is qualitatively similar to that reported in older children and adults (Leighton *et al.*, 1971; Hirschfeld *et al.*, 1975b). Riggs *et al.* (1977a) showed a decline in the ratio of right ventricular pre-ejection period/ejection time within the first 48 hours of life. Most of this decline occurred in the first 12 hours of life; the average value of right ventricular pre-ejection period/ejection time for infants 12 to 48 hours old was 0·315, similar to the value of 0·33 for the 15- to 40-hour old normal subjects in our study. Both studies show that by 12 to 24 hours of age, the right ventricle is characterised by a relatively short pre-ejection period. There were some exceptions, however, consistent with the observation that pulmonary artery pressure is often above normal adult levels in the first week of life (Adams and Lind, 1957; Rowe and James, 1957).

In patients with respiratory disease, the right ventricular systolic time intervals were strikingly altered. The ratio of right ventricular pre-ejection period/ejection time was not only higher than that of normal infants, but was often higher than the ratio of left ventricular pre-ejection period/ejection time. This was primarily because of prolongation of right ventricular pre-ejection period. Previous studies (Halliday *et al.*, 1977; Riggs *et al.*, 1977b) have also indicated a raised ratio of right ventricular pre-ejection period/ejection time in newborns with neonatal respiratory disease. Though pulmonary artery pressure was not measured, we assume that it was high in many of our patients; other studies (Rudolph *et al.*, 1961; Fox *et al.*, 1977) have shown raised pulmonary artery pressure (especially in relation to systemic pressure) in newborns with respiratory disease.

Previous descriptions of the echographic features of transposition of the great arteries have emphasised recognition of the altered spatial relation of the great arteries, either by transducer position and angulation (Gramiak *et al.*, 1973) or by the ability simultaneously to record both semilunar valves from a single transducer position (Dillon *et al.*, 1973). While these findings may suggest the diagnosis of transposition, they are very subjective, and more objective criteria for identifying the great arteries have been sought. Solinger *et al.* (1973, 1974) have emphasised that the pulmonary valve, regardless of its location, closes after the aortic valve. Our results support this finding; if one semilunar valve closed after the other, it was, with one exception, the pulmonary valve. However, in 19 of the infants (29%), including 12 of 25 with respiratory disease, we could find no measurable difference between Q-Ac and Q-Pc.

The values of left and right ventricular systolic time intervals obtained in the present study are consistent with current knowledge of the haemodynamics of the 3 groups of subjects. Since the ratio of right ventricular pre-ejection period/ejection time is higher than that of the left ventricle in both transposition of the great arteries and respiratory disease, it does not appear possible to distinguish these conditions on the basis of this finding. However, transposition should be suspected if (1) the ratio of left ventricular pre-ejection period/ejection time is very low (especially if under 0·25) and (2) the posterior semilunar valve closes after the anterior semilunar valve. Used in this manner, measurement of right ventricular and left ventricular systolic time intervals may be a useful supplement to more subjective M-mode echographic techniques, and to cross-sectional echocardiography (Sahn *et al.*, 1974; Maron *et al.*, 1975; Houston *et al.*, 1978) in the evaluation of the cyanotic newborn.

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Requests for reprints to Dr Howard P. Gutgesell, Section of Pediatric Cardiology, Texas Children's Hospital, 6621 Fannin Street, Houston, Texas 77030, USA.