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Electrocardiographic Pattern in the Newborn During the First Week of Life

by

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Abstract

One hundred and sixteen babies were given electrocardiogram examination on the 1st day until the 7th day of birth as well as the examination at 3 and 6 months.

There were definite changes in the heart rate, P duration, PR interval, T axis, and T wave of the right precordial leads on the 1st day, especially on the 1st hour of birth. These changes may be caused by physiological adjustment after birth and anatomical changes like the closing of foramen ovale and ductus arteriosus. There were changes on the second day and thereafter caused by increased activities of the left side of the heart. Observations were made on ECG examination on fullterm normal babies on the 1st week of birth. Genetic factors should not be ignored (Sutin and Schrire, 1964) as data gathered in this study have shown some differences from data gathered in other studies.

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Introduction

Starting from the first few seconds of birth until the end of the first week of life there are many physiological changes that take place including anatomical changes in the cardiorespiratory system of the neonate. To the normal neonate, these changes follow a normal pattern. From the cardiological side, these changes can be seen, i.e., changes in ECG that take place in the process of adaptation. Even if the theory regarding the relationship between ECG with physiological data is still limited, however, several investigators have already found some positive relationship between ECG and haemodynamic changes (Comby et al., 1952; Goodwin, 1952).

There have already been several findings by previous graduates regarding ECG changes in neonates during the first week of life (Datey and Barucha, 1960; Hait and Gasul, 1961; Scott and Franklin, 1963; Sutin and Schrire, 1964; Walsh, 1963). To understand the abnormal ECG pattern, we must know the normal pattern first. The aim of this paper is to gather data to determine the ECG pattern of normal babies from birth to the last day of the first week of life.

Material and methods

This investigation involved ECG examination of normal fullterm babies born in the Department of Obstetrics, Dr. Cipto Mangunkusumo Hospital, and R.S. Bersalin Raden Saleh from October to December 1970. The total number of cases were 116 (66 males and 50 females), with birth weight ranging from 2,540 to 4,210 grams. From the first ECG examination, the babies were classified as follows:

* Group I (13 cases): The first ECG examination was obtained at the age of less than 60 minutes; this group is divided between those examined in less than 30 minutes (7 cases) and between 35 to 60 minutes (6 cases).
* Group II (103 cases): The first ECG examination was taken at the age between 65 minutes and 24 hours; this group was divided between those examined between 4½ hours to 24 hours (71 cases) and between 65 minutes to 4 hours (32 cases).

The ECG was examined with a portable Philips Cardiopan 531 which uses direct writers system. The babies were in supine position without administration of sedative. The ECG recording consisted of Standard Leads, Augmented Extremity Leads, and Unipolar Precordial Leads at a speed of 25mm/second, using Chest Electrode with 1.5cm diameter, at least 3 complexes taken from each lead. Before and after the recording of ECG, standardization was done with a sensitivity of 10mm (= 1 mV).

The following ECG examination was carried out from the second day until the 7th day. However, not all babies were fully examined until the 7th day; therefore, the total ECG registration that can be studied included: 0 — 1 day = 116
1 — 3 days = 200
3 — 5 days = 29
5 — 7 days = 10

An ECG follow up at 3 and 6 months was given to only 9 and 7 cases respectively.

Result and discussion

Heart rate — The average of heart rate during the first hour showed the highest at 139 and 137 per minute (Table 1). This average rate decreased by the hour, until the average rate after the 4th hour became 123/minute. This slowing down of the rate as the hours progressed might mean that the babies had adapted themselves to the physiological changes.

TABLE 1 : *The changes of heart rate in the first 24 hours.*

	Heart rate (beats/minute)		
	Average	Minimum	Maximum
< 30′	139	121	160
35′ — 1 hr.	137	106	154
65′ — 4 hrs.	128	99	158
4½ — 24 hrs.	123	91	163

TABLE 2 : *The change of heart rate in the first week*

Age (days)	Heart rate (beats/minute)		
	Average	Minimum	Maximum
0 — 1	126	91	163
1 — 3	122	84	165
3 — 5	128	101	154
5 — 7	134	115	182
3 months (9)	153	110	200
6 „ (7)	152	116	188

From the second day on the babies showed evidences of better adaptation. Table 2 shows that heart rate rise again as age progresses, which is due to the babies' increased activities. The heart rate rose to 122, 128 and then later in the first week 137/minute. This average rate was less than the average reported by Walsh (1963) which showed fluctuation of 150, 152, and 160/minute. ECG at the age of 3 months (9 cases) showed an average heart rate of 153/minute with a range from 110 to 200, and at the age of 6 months (7 cases) the average heart rate was 152/minute with a range from 116 to 188.

TABLE 3 : *Range of heart rate from the 1st day to the 7th day.*

Group	1st day	2nd day	3rd day	4th — 5th day	6th — 7th day
I	121 — 160	111 — 147	97 — 143	126 — 148	122 — 151
II	106 — 154	116 — 129	98 — 151	109 — 138	154

Table 3 shows a wide range of the heart rate. The range of the heart rate does not seem to be influenced by the age of the babies during the first week of life.

• RHYTHM — From the 116 cases studied, regular sinus rhythm was obtained from 101 cases (87.1%). Sinus arrhythmia was obtained from 15 cases (12.8%). Three cases of arrhythmia were identified on the 1st day, 7 cases on the 2nd day, and 5 cases on the 3rd day. This arrhythmia disappeared on the following days. Sinus arrhythmia was noted on the cases with heart rate less than 120/minute. Sutin et al. (1964) did not find arrhythmia from 180 cases. Datey and Barucha (1960) found arrhythmia on 7 out of 44 cases; all of them with heart rate less than 115/minute. Sinus tachycardia (average rate more than 160/minute) was found on 3 cases with the following average rate of 161, 165, and 182/minute, the lowest rate 150 and the highest 188/minute. This tachycardia was identified on the 1st day in 2 cases, and on the 7th day in 1 case (heart rate 182/minute).

TABLE 4 : *The average of "Electrical Axis" P, QRS and T wave.*

Age (days)	P wave			QRS			T wave		
	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
0 — 1	52	0	75	138	90	235	50	-75	150
1 — 3	49	0	90	128	90	225	25	-50	120
3 — 5	46	10	63	141	90	220	25	-30	80
5 — 7	45	30	62	136	90	210	20	-10	30
3 months (9)	48	30	60	59	30	80	36	-10	60
6 „ (7)	53	30	60	47	30	60	19	-30	45

Electrical axis on the frontal plane

* P AXIS — The average of the P axis at birth was + 52 degrees. It appeared that there were no changes of the average of P axis during the first week. This finding is in accordance with the cases of Ziegler (1951), and Datey and Barucha (1960). These findings were also found in the follow-up cases of 3 and 6 months (Table 4).

* QRS AXIS — QRS axis frontal plane varied between + 90 degrees and + 235 degrees on the first day, with an average of + 138 degrees. It seemed that there were no changes in QRS axis during the 1st week. There was only 1 case out of 10 with the ECG on the 7th day which still had QRS axis + 210 degrees (QRS axis at birth of this case was + 235 degrees), while on the other cases QRS axis was not more than + 155 degrees. No further evaluation was made on this case for the possibility of congenital heart disease. Follow-up at the age of 3 months and 6 months showed an average of QRS axis + 59 degrees and + 47 degrees respectively. It was clear that when the axis shifted to the left this was due to the increased activities on the left side of the heart. Sutin and Schrire (1946) investigated the ECG pattern on babies of white people, colored people, and Bantu. They found that the mean of QRS axis within the first 24 hours on white babies lay more to the right side compared with colored or Bantu babies.

* T AXIS — The shift of T axis from + 50 degrees at the age of 0 — 1 day became + 20 degrees on the 7 th day. This shift to the left showed that the positive degree of T wave has been greater on the left precordial leads at the end of the 1st week. Follow-up on the 3rd month and 6th month showed an average of T axis + 36 degrees and + 19 degrees respectively. We identified that there was a definite shift of T axis on the 1st day from + 50 de-

grees to + 25 degrees on the 2nd day, and later on this shift gradually became + 20 degrees on the 7th day (Table 4). This finding is in accordance with the cases of Datey and Barucha (1960), Hait and Gasul (1961), Craige and Harned (1963), and Sutin and Schrire (1964).

TABLE 5 : *Distribution of babies according to "Heant rate" and "P duration" on the 1st and 2nd day of life.*

P Duration (seconds)	Age: 60′ (13) Range of "Heart rate"			Age: 65′ — 24 hrs. (90) Range of "Heart rate"		
	85 — 110	115 — 140	145 — 170	85 — 110	115 — 140	145 — 170
2nd day: < 0.065	1	5	3	19	59	7
> 0.07	0	0	4	0	5	0
1st day: < 0.065	1	9	3	31	53	4
> 0.07	0	0	0	0	2	0

* P DURATION — Table 5 shows that there is no relationship between P duration and heart rate in the 1st week of life. This condition was also stated by Ziegler (1951) and Walsh (1963). P duration on 103 cases showed that 4 out of 13 cases of babies aged less than 60 minutes had P duration of 0.07 seconds or more and on the second day 0.065 seconds or less. Of these aged 60 minutes or more only 5 out of 90 cases had P duration of 0.07 seconds or more. This indicates that for the first 60 minutes of life P duration was more than succeeding hours of life. By the end of 1st week there was no case found with P duration of no more than 0.065 seconds. According to Ziegler (1951) and Walsh (1963) P duration decreases with the age in the first week of life. P duration is prolonged when the clamping process of the umbilical cord is delayed (Walsh, 1963). As it is known, right after birth the pressure in the left atrium increases due to the increased circulation in the lungs. This is probably caused by the prolongation of P duration during the first few minutes of life.

* PR INTERVAL — Table 6 indicates that the shortest PR interval is between 0.085-0.11 seconds, and the highest heart rate is between 145-170/minute. On the first day a heart rate of 85-110 was found in 11 (55%) out of 20 cases that had a PR interval of 0.085-0.11 seconds; 46

(66.7%) out of 69 cases with a range of 115-140; and 11 out of 14 cases with a range of 145-170. In other words the findings indicated that the percentage of short PR interval increases with the increase of heart rate. Therefore on the second day, the percentage of those with short PR interval (0.085-0.11 sec.) increased respectively 21 from 32 cases, 49 from 64 cases, and 7 from 7 cases. The conclusion is that from the cases studied, babies on the first or even on the second day showed a negative relationship between heart rate and PR interval; the higher the heart rate the shorter the PR interval (Table 7).

TABLE 6 : *Distribution of babies according to heart rate and relationship between heart rate and PR interval on the 1st and 2nd day of life*

PR interval (seconds)	Age: 60′ (13) Range of heart rate			Age: 65′ — 24 hrs. (90) Range of heart rate		
	85-110	115-140	145-170	85-110	115-140	145-170
1st. day: 0.085-0.11	0	3	5	11	43	6
0.115-0.135	1	2	2	8	20	1
0.14 -0.16	0	0	0	0	1	0
2st day: 0.085-0.11	0	6	3	21	43	4
0.115-0.135	1	3	0	10	12	0

There are differences of opinion regarding the relationship between PR interval and heart rate. Several investigators, i.e. Hafkesbring, Drawe and Ashman (1937), Tudbury and Atkinson (1950), Ziegler (1951), Alimurung and Massell (1956), said that PR interval is influenced by heart rate; but other investigators like Savilahti (1946), Furman and Halloran (1951), doubt this finding. In this study 13 cases aged less than 60 minutes had an average heart rate of 138 and an average PR interval of 0.111 second. On the 2nd day the average heart rate became 122 with an average PR interval of 0.103 second. The prolongation of PR interval at this first hour had a very close relationship with the prolongation of PR interval during the time involved. As P duration is a component of PR interval, so does the prolongation of P duration play a role

in the prolongation of PR interval. The prolongation of PR interval in the first hour had been stated by Michaelson (1959) and Walsh (1963). Except for the enlargement of the left atrium as a cause of the prolongation of the PR interval, the vagal stimulating factor (is supposed to) plays a role as well. In the first hour of birth the baby is still under relative anoxaemia (Smith, 1959). The presence of anoxaemia increases the sentivity of the heart muscle to the vagal stimulation. This vagal stimulation has been regarded as an increasing auriculoventricular conduction (Messe et al., 1949) due to the increased permeability of potassium from conduction tissue (Lepeschkin, 1959). Since vagal stimulation reduces heart rate and no relationship occurs between heart rate with P duration, therefore vagal stimulation which prolonged PR interval is probably caused by a prolonged PR segment.

TABLE 7 : *Percentage of cases with PR interval of 0.085-0.11 and the relationship with the increase of heart rate.*

PR interval (seconds)	Group I & Group II (103) Range of heart rate		
	85-110	116-140	145-170
1st day: 0.85-0.11	11/20 (55%)	46/69 (66.7%	11/14 (78.5%)
1st day: 0.85-0.11	21/32 (65.6%	49/64 (76.5%	7/7 (100%)

* QRS PATTERN —

TABLE 8 : *QRS pattern in precordial leads at birth.*

No. cases	Right side V3R, VI			Transitional zone	Left side V6					
57	R	RS	Rs	Usually VI to V3	r	rS	rs	qrs	and	qrS
	3	46	8		1	41	9	5		1
57	R	RS	Rs	Usually V2 to V5	qR	RS	qRs	qRs	and	Rs
	2	42	13		4	44	3	4		2

From 114 cases studied, all showed prominent R pattern (R, Rs, and RS) with R/S ratio of more than one on the right side (right precordial leads V3R and VI) ; while on the left side 90 out of 114 cases showed prominent S pattern. This shows a dominant right ventricular, so that it

is difficult to differentiate on newborn with pathological right ventricular hypertrophy. There have been many studies made on the dominant R wave of the right precordial leads. Findings have shown that there have been greater variations of pattern on the left side. In this study, of 57 cases with left side pattern r, 41 cases had a pattern rs and transitional zone between V1-V3. Of 57 cases with pattern R, 44 had pattern RS and transitional zone between V2-5; q wave of our cases have been found only on left precordial leads; q wave on the left precordial leads were found in 17 (14.8%) out of 114 cases. Sutin and Schrire (1964) found q wave on the right side in a neonate of less than 2 hours. While left side q wave was found in 10% among the whites and 17% among Bantu's people in the first 24 hours of birth.

Transitional zone of babies with pattern r on the left side was between V1-V3 as compared with the cases found by Datey and Barucha (1960) where the transitional zone was between V3-V6. This difference showed a large number of RS pattern on the left side in our cases, while none was found in Datey's.

TABLE 9 : *T wave on precordial leads.*

		V3R	V1	V6
At birth (116 cases)	Positive	60%	58.6%	54.3%
	Diphasic	20%	26.7%	10.3%
	Negative	15.6%	11.2%	15.5%
	Flat	4.4%	3.5%	19.9%
2nd day (110 cases)	Positive	31.8%	42.7%	60.9%
	Diphasic	37.2%	33.6%	8.2%
	Negative	29.2%	23.7%	6.4%
	Flat	1.8%	0.0%	24.5%
5th — 7th day (39 cases)	Positive	2.6%	2.6%	79.6%
	Diphasic	30.8%	33.7%	5.1%
	Negative	61.5%	58.6%	5.1%
	Flat	5.1%	5.1%	10.2%
3 months (9 cases)	Positive	0.0%	0.0%	100%
	Diphasic	0.0%	0.0%	100%
	Negative	100%	100%	0.0%
	Flat	0.0%	0.0%	0.0%
6 months (7 cases)	Positive	0.0%	0.0%	100%
	Diphasic	0.0%	0.0%	0.0%
	Negative	100%	100%	0.0%
	Flat	0.0%	0.0%	0.0%

• T WAVE — On table 9, T wave at birth on both right and left precordial leads shows positive in V3R = 60%, V1 = 58.6%, and V6 = 54.3% from 116 cases.

Right precordial leads : V3R and V1 at birth show a positive T wave as much as 60% and 58.6% respectively from 116 cases observed. On the 2nd day there was a tendency for T wave to shift to diphasic and negative. Ziegler (1956) stated that positive T wave in the right precordial leads after the first 24 hours strongly suggested the presence of pathological Right Ventricular Hypertrophy. With our cases it was not so, for on the 2nd day positive T wave was found to be 31.8% and 42.7% on V3R and V1 respectively, until on the 5th — 7th day where 2.6% were found both on V3R and VI which were similar to the findings of Walsh (1964). ECG examination at 3 months (9 cases) and 6 months (7 cases) showed T wave on V3R and VI to be negative. The different movement of T wave as shown before was found among 5 cases, when the T wave exmanination on the 2nd day became positive. The first examination in these 5 cases of neonates made before 60 minutes after birth showed that 3 cases registered flat T wave which turned positive on the 2nd day; one case of diphasic T wave on the 2nd day registered —/++, and one negative T wave became positive on the 2nd day. Datey and Barucha (1960) also found this exceptional movement as mentioned above in 3 out of 44 cases. This abnormality may be due to electrolyte changes or due to increased O_2 saturation which is caused by an impaired respiration.

Left precordial leads: Positive T wave in V6 at birth was found in the majority of cases (54.3%). T wave changes in the left precordial leads increased with age. T wave became positive on the 2nd day (60%) and on the 5th — 7th day (79.6%); examination on the 3rd and 6th month showed that 100% of T wave became positive on V6. At the age of 3 and 6 months negative T wave on V5 and V6 was no longer observed, while most of the cases were on V4 positive, flat, or diphasic; only 1 case was negative at the age of 6 months. Negative T wave on V6 is often found at birth (Bettro and Mendy, 1946; Richman and Master, 1951; Datey and Barucha, 1960; Sutin and Schrire, 1964). In the cases presently studied negative T wave on V6 at birth was 15.5%; diphasic 10.3%; and flat 19.9%. Schaffer et al. (1950), Alimurung et al. (1951), and Ziegler (1951) did not find negative T wave on V6 in newborn babies. Sutin and Schrire (1964) stated that negative T wave on V6 is found more in colored and Bantu newborns than in whites. Changes in T wave in the 1st week

have been found in several cases studied earlier. Significant changes of T wave in the first week of life were detected in the right precordial leads (Scott and Franklin, 1963) which is in accordance with the cases in this study. At the end of the first week the majority showed negative T wave in the right precordial leads and positve in the left precordial leads, the same cases as observed by Datey and Barucha (1960), Scott and Franklin (1963), and Walsh (1964).

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