Electrocardiographic Parameters in Indian Newborns

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Objective: To generate data of electrocardiogram (ECG) parameters according to gestational age in Indian newborns. **Methods**: An observational study was carried out over 7 months in neonatology unit of a tertiary care teaching hospital. Following auscultation, ECG parameters were recorded simultaneously in 12 leads, on third day of life, in hemodynamically stable neonates. Data from 364 babies were analyzed, keeping at least 30 records for each gestational age between 30 to 42 weeks. **Results**: There was no difference in mean heart rate recorded through auscultation and ECG traces. The mean (SD) values recorded were: P wave duration 0.04 (0.01) s, P wave amplitude 1.3 (0.4) mm, T wave duration 0.07 (0.02) s, T wave amplitude 1.1 (0.6) mm, PR interval 0.09 (0.02) s, QRS duration 0.04 (0.01) s, QT interval 0.26 (0.02) s, QTc 0.4 (0.03) s and QRS axis 127 (22) degree. Gestation age-wise percentile charts of different ECG parameters were generated. **Conclusion**: These gestational age-wise percentile charts of different ECG parameters for Indian newborns can be used as reference for neonatal ECG.

Keywords: *Characteristics, Charts, Gestational age, Percentiles.*

Prominent anatomical and physiological changes occur in the cardiovascular system from birth to adolescence [1]. Both term and preterm infants experience cardiorespiratory changes at birth, that coincide with termination of the placental circulation and improved lung compliance. The changes taking place in fetal cardiac physiology during the last part of gestation and perinatal transition are reflected in the evolution of electrocardiographic (ECG) parameters during the neonatal period [1]. In the newborn, ECG recording is necessary for diagnosis of different cardiac ailments, hemodynamic monitoring during intensive care stay and during resuscitation. Survival of even preterm babies has improved because of increasing availability of specialized neonatal care with SpO_2 monitors, cardiac monitors etc. The different ECG parameters reflecting cardiac electrophysiological changes need to be compared with gestational age appropriate data for interpretation. Unfortunately, there is a paucity of data on ECG measurements in term and preterm neonates and such data is nonexistent for Indian babies. We therefore conducted a descriptive observational study to generate gestational age wise data of ECG parameters of the newborn from the Indian perspective.

METHODS

The study was conducted between March and September 2017 in the neonatology unit of a tertiary-care teaching hospital in Kolkata, India. The research protocol was approved by the institutional ethics committee and written informed consent was obtained.

Healthy term or preterm newborns, admitted for establishment of feeding or observation for neonatal jaundice, or babies kept in the maternity ward with mothers requiring postpartum hospital stay were enrolled. Babies with critical illness, birth asphyxia, major congenital anomaly including cardiac abnormality or with maternal antenatal history of serious illness or maternal medication use, were excluded. Gestational age was estimated from the date of last menstrual period, from antenatal ultrasound or new Ballard score [2] as appropriate. If any discrepancy occurred, the gestational age estimated through new Ballard score was accepted.

ECG was recorded on the third day after birth. A twelve lead simultaneous acquisition ECG machine (ClarityMed ECG 100C; CMRR > 90 dB, dynamic range ± 4.25 mV, frequency response 0.05-150Hz (-3dB), time

constant 3.2 sec, input impedance >10 MΩ on each electrode) was used to record ECG. The American Heart Association (AHA) recommendations for pediatric ECG of 150 Hz as minimum bandwidth cut off and 500 Hz as minimum sampling rate were followed [3]. Disposable electrodes were used. Electrode placement and removal were done cautiously in order to avoid injury to the delicate skin, especially in preterm babies. If needed, the electrodes were trimmed to make them smaller in size without damaging the metal panel. Standard electrode sites were carefully identified and placement done according to AHA recommendations [4]. The recording team comprised one ECG technician who operated the ECG machine using a standardized protocol, one junior resident (pediatric postgraduate student) who placed the electrode following guidelines and maintaining asepsis protocol, and one supervising pediatrician. The team was trained beforehand by a pediatric cardiologist and a neonatologist. The same machine and the same team recorded all the ECGs.

Data were captured on a structured case report form. Weight, gender and heart rate determined by auscultation, were recorded. Data extracted from the ECG traces were heart rate (bpm), P wave duration (s), P wave amplitude (mm), R wave amplitude in lead V1 (mm), S wave in V1 (mm), R wave in V6 (mm), S wave in V6 (mm), T wave duration (s), T wave amplitude (mm), PR segment interval (s), QRS complex duration (s), QT segment interval (s), QTc (s), and QRS complex axis (degree)

No formal sample size calculation was done beforehand but the target was to recruit at least 30 babies born in each gestational week between weeks 28 to 42. Sampling was purposive and consecutive babies were recruited as far as possible, provided informed consent was available.

Statistical analysis: Descriptive statistics, namely mean, standard deviation (SD), 95% confidence interval (CI), and 10th, 25th, 50th, 75th and 90th percentile values were calculated for the whole cohort and gestational age based weekly subcohorts. Numerical variables were compared between male and female subgroups by Mann-Whitney U test with two-sided $P<0.05$ as the cut-off for statistical significance. Significance of change across gestational age was assessed by Kruskal-Wallis analysis of variance (ANOVA). Correlation between variables was quantified by calculating Spearman's rank correlation coefficient rho, after verifying from scatter plots that an approximately linear relationship exists. Statistica version 6 (Tulsa, Oklahoma: StatSoft Inc., 2001) and MedCalc version 11.6 (Mariakreke, Belgium: MedCalc Software, 2011) software were used for statistical analyses.

RESULTS

Although 511 babies were screened, 364 ECG traces could be analyzed. The exclusions occurred stepwise – 27 babies were excluded at screening (19 failed exclusion criteria; 8 refused consent), 26 were excluded due to difficulties in lead placement, 39 excluded due to poor ECG recording and finally, 55 traces were discarded because the preset criterion of at least 30 records for each gestational week were not met. The babies included were healthy and those born preterm were all ensured to be hemodynamically stable. There were 212 babies (58.2%) in the analyzed cohort who were born before 37 completed weeks. Male babies numbered 191 (52.5%). The mean (SD) birth weight of the whole cohort was 2.11 (0.73 kg) (95% CI 2.03-2.18 kg) and for preterm cohort (*n*=212) was 1.60 (0.13) kg (95% CI 1.55-1.66 kg).

The mean (SD) values were: P duration, 0.04 (0.01) s; P amplitude, 1.3 (0.4) mm; T duration 0.07 (0.02) s; T amplitude, 1.1 (0.6) mm; PR interval, 0.09 (0.02) s, QRS duration, 0.04 (0.01) s; QT interval, 0.26 (0.02) s, QTc interval, 0.4 (0.03) s; and QRS axis, 127 (22) degree. There were no statistically significant gender differences in birthweight, heart rate and ECG parameters.

The gestation age-wise (30 weeks to 41 weeks) summary of the ECG measurements (mean with SD), has been presented in *Table* **I**. Detailed percentile values as per gestation are available in *Web Table* **I**. Among the ECG parameters, heart rate, R and S wave amplitudes and QT interval and QTc showed significant variation with gestational age ($P<0.001$), but the overall range was narrow, as can be seen from the 10th and 90th percentile values, other than for heart rate.

Gestational age showed moderate inverse correlation with heart rate (–0.40) and strong inverse correlation with S wave amplitude in Lead V6 (–0.71). The QT interval showed good inverse correlation with heart rate (–0.55). Birth weight also showed good inverse correlation with S wave amplitude in V6 (–0.68). Correlation was near perfect (0.99) between auscultated heart rate and that derived from ECG.

DISCUSSION

The gestation age-wise (30 to 41 weeks) summary of the ECG measurements, including percentile values were generated. Heart rate, R and S wave amplitudes and QT interval and QTc showed significant variation with gestational age ($P<0.001$).

This study has limitations, including the relatively small sample size and lack of prospective follow-up of ECG and clinical data. Our analysis does not include

TABLE I DESCRIPTIVE STATISTICS OF ECG PARAMETERS IN THE NEWBORN STRATIFIED BY GESTATIONAL AGE IN WEEKS

Gestation	Heart Rate (bpm)	P duration (sec)	P amplitude (mm)	R amplitude in V1 (mm)	S amplitude in V1 (mm)	R amplitude in V6 (mm)	S amplitude in V6 (mm)	T duration (sec)	T amplitude (mm)	PR interval (sec)	QRS duration (sec)	QT interval (sec)	QTc	QRS axis (degree)
30 weeks														
Mean	159	0.04	1.2	7.1	5.1	8.3	9.8	0.05	1.1	0.09	0.04	0.25	0.41	129
(SD)	(17)	(0.01)	(0.3)	(2.8)	(2.3)	(2.7)	(3.8)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(26)
Median	159	0.04	1.0	6.8	4.8	7.8	9.0	0.04	1.0	0.08	0.04	0.25	0.40	130
31 weeks														
Mean	144	0.04	1.2	7.5	5.3	7.5	8.9	0.06	1.2	0.09	0.04	0.26	0.4	127
(SD)	(17)	(0.01)	(0.3)	(3.0)	(2.6)	(3.1)	(3.2)	(0.02)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(24)
Median	147	0.04	1.0	7.0	5.0	7.0	8.8	0.06	1.0	0.08	0.04	0.26	0.40	127
32 weeks														
Mean	137	0.04	1.2	7.6	5.1	7.5	7.8	0.06	1.1	0.09	0.04	0.26	0.4	125
(SD)	(16)	(0.01)	(0.3)	(3.3)	(2.8)	(2.9)	(3.1)	(0.02)	(0.2)	(0.02)	(0.01)	(0.02)	(0.04)	(23)
Median	139	0.04	1.0	7.5	4.5	7.0	8.3	0.06	1.0	0.08	0.04	0.26	0.39	125
33 weeks														
Mean	148	0.04	1.3	7.5	5.9	7.9	9.4	0.06	1.0	0.09	0.04	0.25	0.38	119
(SD)	(20)	(0.01)	(0.4)	(3.3)	(2.5)	(2.5)	(3.5)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(23)
Median	145	0.04	1.0	6.8	5.5	7.0	8.0	0.06	1.0	0.08	0.04	0.24	0.39	120
34 weeks														
Mean	144	0.05	1.3	7.3	5.3	7.6	8.9	0.06	1.1	0.09	0.04	0.26	0.4	123
(SD)	(15)	(0.01)	(0.4)	(3.1)	(1.7)	(2.4)	(3.4)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.02)	(23)
Median	143	0.04	1.0	6.5	5.3	7.0	8.3	0.06	1.0	0.08	0.04	0.26	0.40	125
35 weeks														
Mean	139	0.04	1.4	8.3	5.9	5.5	5.9	0.07	1.2	0.09	0.04	0.27	0.41	125
(SD)	(15)	(0.01)	(0.4)	(3.5)	(1.9)	(1.7)	(2.0)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.03)	(23)
Median	136	0.04	1.5	7.8	6.0	5.5	5.5	0.07	1.0	0.08	0.04	0.27	0.41	125
36 weeks														
Mean	138	0.04	1.23	10.1	7.2	4.4	2.9	0.07	1.2	0.09	0.04	0.26	0.39	127
(SD)	(15)	(0.01)	(0.3)	(3.9)	(2.7)	(1.4)	(1.2)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(19)
Median	137	0.04	1.0	9.3	6.5	4.0	3.0	0.06	1.0	0.08	0.04	0.26	0.39	125

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From pre-page

Gestation	Heart Rate (bpm)	P duration (sec)	P amplitude (mm)	R amplitude in V1 (mm)	S amplitude in V1 (mm)	R amplitude in V6 (mm)	S amplitude in V6 (mm)	T duration (sec)	T amplitude (mm)	PR interval (sec)	QRS duration (sec)	QT interval (sec)	QTc	QRS axis (degree)
37 weeks														
Mean	135	0.05	1.3	11.5	7.8	4.9	3.3	0.07	1.1	0.09	0.04	0.27	0.41	128
(SD)	(14)	(0.01)	(0.4)	(3.7)	(2.6)	(1.6)	(1.3)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.03)	(19)
Median	136	0.04	1.0	11.3	8.0	5.0	3.0	0.06	1.0	0.08	0.04	0.28	0.40	130
38 weeks														
Mean	132	0.04	1.3	12.2	7.8	4.5	3.1	0.07	1.1	0.09	0.04	0.27	0.4	131
(SD)	(16)	(0.01)	(0.4)	(4.8)	(2.6)	(1.5)	(1.3)	(0.01)	(0.3)	(0.02)	(0.01)	(0.02)	(0.03)	(19)
Median	133	0.04	1.0	12.0	8.3	4.5	3.0	0.08	1.0	0.08	0.04	0.28	0.40	130
39 weeks														
Mean	134	0.05	1.4	12.1	8.4	4.6	3.3	0.08	1.1	0.1	0.04	0.27	0.39	130
(SD)	(18)	(0.01)	(0.4)	(4.8)	(2.4)	(1.8)	(1.5)	(0.02)	(0.3)	(0.02)	(0.01)	(0.02)	(0.03)	(23)
Median	133	0.04	1.5	11.8	8.5	4.8	3.5	0.08	1.0	0.10	0.04	0.27	0.39	130
40 weeks														
Mean	122	0.04	1.2	12	8.5	4.5	3.4	0.07	1.1	0.09	0.04	0.28	0.4	131
(SD)	(15)	(0.01)	(0.5)	(5.1)	(2.6)	(1.9)	(1.3)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.02)	(23)
Median	123	0.04	1.0	12.3	8.3	4.3	3.5	0.07	1.0	0.08	0.04	0.28	0.40	130
41 weeks														
Mean	131	0.05	1.2	12.3	8.8	4.9	3.3	0.07	1.1	0.09	0.04	0.27	0.4	130
(SD)	(14)	(0.01)	(0.4)	(4.5)	(2.4)	(1.8)	(1.4)	(0.01)	(0.2)	(0.02)	(0.01)	(0.02)	(0.03)	(20)
Median	134	0.04	1.0	12.0	9.0	5.0	3.3	0.06	1.0	0.08	0.04	0.26	0.40	130

(Note: n = 32 for gestational age of 40 weeks, 31 for weeks 32 and 33 and 30 for all other weeks)

WHAT THIS STUDY ADDS?

- Gestational age-wise percentile charts of different electrocardiographic parameters have been derived for Indian newborn babies.

ECG data of babies below 30 weeks and over 41 weeks as we did not get sufficient numbers. Logistic limitations prevented us from generating gestation-wise ECG data from babies in the community rather than in hospital. Difficulties were encountered in adhering to chest lead placement following AHA guidelines in babies with small chests and a sizeable number of ECG records had to be discarded owing to lead loosening artefacts caused by movement in the babies.

Most studies on neonatal ECGs done in the 1970s [5,6] do not provide gestation-wise data. Gestational age-specific ECG data is lacking in literature, including from India. Until recently, the most comprehensive study of ECG variability in children was that of Davignon, *et al.* [5] based on measurements made from 2141 White children in Quebec, Canada. Normal limits were presented for few parameters and there were no gestational age-wise stratification attempted. For available parameters, percentile values of ECG parameters in our study are quite comparable to that study [5]. This applies to heart rate, mean QRS axis, QRS duration, R and V amplitude in leads V1 and V6. However, our result differ, to some extent, with respect to P wave duration, QRS duration and QRS axis from figures reported in the study by Rijnbeek, *et al.* [7], where the study population comprised children aged 11 days to 16 years.

The most recent guidelines for interpretation of normal ECG in newborns have been provided by the Task Force for Interpretation of the Neonatal Electrocardiogram of the European Society of Cardiology in 2002 [8]. However, these do not provide gestational age-wise stratification of data. Except the mean P amplitude value, S in V1, R in V6, S in V6, other ECG parameters in our study are comparable with these guidelines. It suggests that Western data may not be appropriate to interpret ECG in Indian babies. Heart rate assessment at birth by ECG may be reasonable according to the 2015 guidelines on neonatal resuscitation from American Heart Association (AHA) [9] and European Resuscitation Council (ERC) [10] since clinical and pulse oximetry assessment are sometimes found to be both inaccurate and unreliable [11-14] in the newborn. Therefore availability of data on heart rate by ECG, stratified by gestational age, will be useful in following the

resuscitation protocol. The influence of gender on some electrocardiographic variables has been noted in some reports [15,16], unlike the results of our study.

Notwithstanding the above limitations, in conclusion, we have provided normative data of ECG parameters according to gestational age in Indian scenario. This data need to be validated at other centers and in the community. These values, validated through additional studies, can serve as reference for interpretation of neonatal ECG, both in term and preterm babies.

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WEB TABLE I DESCRIPTIVE STATISTICS OF ECG PARAMETERS IN THE NEWBORNS STRATIFIED BY GESTATIONAL AGE

Gestational Age	Heart Rate (bpm)	P duration (sec)	P amplitude (mm)	R amplitude in V1 (mm)	S amplitude in V1 (mm)	R amplitude in V6 (mm)	S amplitude in V6 (mm)	T duration (sec)	T amplitude (mm)	PR interval (sec)	QRS duration (sec)	QT interval (sec)	QTc	QRS Axis (degree)
30 weeks														
Mean	159	0.04	1.2	7.1	5.1	8.3	9.8	0.05	1.1	0.09	0.04	0.25	0.41	129
(SD)	(17)	(0.01)	(0.3)	(2.8)	(2.3)	(2.7)	(3.8)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(26)
10th percentile	134	0.04	1.0	3.8	2.8	5.3	5.5	0.04	1.0	0.08	0.04	0.22	0.36	87
25th percentile	150	0.04	1.0	5.0	3.5	6.0	7.5	0.04	1.0	0.08	0.04	0.24	0.39	120
50th percentile	159	0.04	1.0	6.8	4.8	7.8	9.0	0.04	1.0	0.08	0.04	0.25	0.40	130
75th percentile	174	0.04	1.5	9.0	6.0	10.0	11.5	0.06	1.0	0.10	0.04	0.27	0.43	150
90th percentile	187	0.05	1.5	10.0	8.5	11.0	14.8	0.06	1.5	0.11	0.04	0.28	0.44	157
31 weeks														
Mean	144	0.04	1.2	7.5	5.3	7.5	8.9	0.06	1.2	0.09	0.04	0.26	0.4	127
(SD)	(17)	(0.01)	(0.3)	(3.0)	(2.6)	(3.1)	(3.2)	(0.02)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(24)
10th percentile	121	0.04	1.0	3.5	2.3	4.5	5.5	0.04	1.0	0.08	0.04	0.24	0.36	85
25th percentile	130	0.04	1.0	5.5	3.0	5.0	6.5	0.04	1.0	0.08	0.04	0.24	0.38	115
50th percentile	147	0.04	1.0	7.0	5.0	7.0	8.8	0.06	1.0	0.08	0.04	0.26	0.40	127
75th percentile	157	0.04	1.5	9.0	6.0	9.0	11.0	0.08	1.0	0.08	0.04	0.28	0.42	145
90th percentile	168	0.06	1.5	12	9.3	11.5	13.0	0.08	1.5	0.11	0.04	0.29	0.44	162
32 weeks														
Mean	137	0.04	1.2	7.6	5.1	7.5	7.8	0.06	1.1	0.09	0.04	0.26	0.4	125
(SD)	(16)	(0.01)	(0.3)	(3.3)	(2.8)	(2.9)	(3.1)	(0.02)	(0.2)	(0.02)	(0.01)	(0.02)	(0.04)	(23)
10th percentile	116	0.04	1.0	3.3	2.0	4.3	5.3	0.04	1.0	0.08	0.04	0.24	0.37	95
25th percentile	121	0.04	1.0	5.0	3.5	5.0	6.5	0.04	1.0	0.08	0.04	0.24	0.38	110
50th percentile	139	0.04	1.0	7.5	4.5	7.0	8.3	0.06	1.0	0.08	0.04	0.26	0.39	125
75th percentile	150	0.04	1.5	9.0	6.5	9.0	11.0	0.06	1.0	0.11	0.04	0.28	0.40	140
90th percentile	157	0.06	1.5	13.0	8.5	11.5	13.0	0.08	1.5	0.12	0.06	0.29	0.44	160
33 weeks														
Mean	148	0.04	1.3	7.5	5.9	7.9	9.4	0.06	1	0.09	0.04	0.25	0.38	119
(SD)	(20)	(0.01)	(0.4)	(3.3)	(2.5)	(2.5)	(3.5)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(23)
10th percentile	125	0.04	1.0	3.8	3.0	5.0	6.8	0.04	1.0	0.08	0.04	0.22	0.35	87
25th percentile	136	0.04	1.0	5.5	4.0	6.5	7.0	0.06	1.0	0.08	0.04	0.24	0.36	100
50th percentile	145	0.04	1.0	6.8	5.5	7.0	8.0	0.06	1.0	0.08	0.04	0.24	0.39	120
75th percentile	161	0.04	1.5	9.0	8.0	10.0	11.5	0.08	1.0	0.10	0.04	0.26	0.40	135
90th percentile	180	0.06	2.0	13.0	9.0	12.0	15.0	0.08	1.5	0.11	0.06	0.26	0.43	*150*

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From pre-page

Gestational Age	Heart Rate (bpm)	P duration (sec)	P amplitude (mm)	R amplitude in V1 (mm)	S amplitude in V1 (mm)	R amplitude in V6 (mm)	S amplitude in V6 (mm)	T duration (sec)	T amplitude (mm)	PR interval (sec)	QRS duration (sec)	QT interval (sec)	QTc	QRS Axis (degree)
34 Weeks														
Mean	144	0.05	1.3	7.3	5.3	7.6	8.9	0.06	1.1	0.09	0.04	0.26	0.4	123
(SD)	(15)	(0.01)	(0.4)	(3.1)	(1.7)	(2.4)	(3.4)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.02)	(23)
10th percentile	125	0.04	1.0	4.0	3.0	5.0	4.5	0.05	1.0	0.08	0.04	0.24	0.37	90
25th percentile	130	0.04	1.0	5.0	4.0	6.0	7.0	0.06	1.0	0.08	0.04	0.24	0.38	100
50th percentile	143	0.04	1.0	6.5	5.3	7.0	8.3	0.06	1.0	0.08	0.04	0.26	0.40	125
75th percentile	157	0.04	1.5	8.5	6.5	9.0	10.5	0.08	1.0	0.10	0.04	0.28	0.42	135
90th percentile	166	0.06	2.0	12.5	7.8	11.5	14.0	0.08	1.5	0.11	0.06	0.28	0.45	157
35 weeks														
Mean	139	0.04	1.4	8.3	5.9	5.5	5.9	0.07	1.2	0.09	0.04	0.27	0.41	125
(SD)	(15)	(0.01)	(0.4)	(3.5)	(1.9)	(1.7)	(2.0)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.03)	(23)
10th percentile	122	0.04	1.5	4.0	3.3	3.5	3.3	0.05	1.0	0.08	0.04	0.24	0.38	92
25th percentile	130	0.04	1.5	6.0	5.0	4.0	5.0	0.06	1.0	0.08	0.04	0.26	0.39	115
50th percentile	136	0.04	1.5	7.8	6.0	5.5	5.5	0.07	1.0	0.08	0.04	0.27	0.41	125
75th percentile	150	0.04	1.5	10.5	7.0	7.0	7.0	0.08	1.5	0.10	0.04	0.28	0.42	135
90th percentile	161	0.06	2.0	13.8	8.0	7.0	8.3	0.08	1.5	0.11	0.06	0.29	0.44	157
36 weeks														
Mean	138	0.04	1.23	10.1	7.2	4.4	2.9	0.07	1.2	0.09	0.04	0.26	0.39	127
(SD)	(15)	(0.01)	(0.3)	(3.9)	(2.7)	(1.4)	(1.2)	(0.01)	(0.2)	(0.01)	(0.01)	(0.02)	(0.03)	(19)
10th percentile	118	0.04	1.0	5.8	4.5	2.8	1.0	0.06	1.0	0.08	0.04	0.22	0.35	100
25th percentile	125	0.04	1.0	7.0	5.5	3.5	2.0	0.06	1.0	0.08	0.04	0.24	0.37	120
50th percentile	137	0.04	1.0	9.3	6.5	4.0	3.0	0.06	1.0	0.08	0.04	0.26	0.39	125
75th percentile	150	0.04	1.5	12.5	9.0	5.5	4.0	0.08	1.0	0.10	0.04	0.28	0.40	140
90th percentile	157	0.06	1.5	16.3	11.0	6.0	4.5	0.08	1.5	0.12	0.05	0.28	0.44	152
37 weeks														
Mean	135	0.05	1.3	11.5	7.8	4.9	3.3	0.07	1.1	0.09	0.04	0.27	0.41	128
(SD)	(14)	(0.01)	(0.4)	(3.7)	(2.6)	(1.6)	(1.3)	(0.01)	(0.3)	(0.01)	(0.01)	(0.02)	(0.03)	(19)
10th percentile	120	0.04	1.0	6.8	4.3	3.0	2.0	0.06	1.0	0.08	0.04	0.24	0.36	100
25th percentile	125	0.04	1.0	8.0	6.0	4.0	2.5	0.06	1.0	0.08	0.04	0.26	0.38	120
50th percentile	136	0.04	1.0	11.3	8.0	5.0	3.0	0.06	1.0	0.08	0.04	0.28	0.40	130
75th percentile	142	0.06	1.5	13.5	9.5	5.5	4.0	0.08	1.0	0.10	0.04	0.28	0.43	140
90th percentile	153	0.06	2.0	17.0	10.8	7.3	5.3	0.08	1.5	0.11	0.06	0.30	0.44	152
38 weeks														
Mean	132	0.04	1.3	12.2	7.8	4.5	3.1	0.07	1.1	0.09	0.04	0.27	0.4	131
(SD)	(16)	(0.01)	(0.4)	(4.8)	(2.6)	(1.5)	(1.3)	(0.01)	(0.3)	(0.02)	(0.01)	(0.02)	(0.03)	(19)
10th percentile	113	0.04	1.0	6.8	4.0	2.0	1.5	0.06	1.0	0.08	0.04	0.24	0.36	105

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Gestational Age	Heart Rate (bpm)	P duration (sec)	P amplitude (mm)	R amplitude in V1 (mm)	S amplitude in V1 (mm)	R amplitude in V6 (mm)	S amplitude in V6 (mm)	T duration (sec)	T amplitude (mm)	PR interval (sec)	QRS duration (sec)	QT interval (sec)	QTc	QRS Axis (degree)
25th percentile	120	0.04	1.0	8.0	6.0	4.0	2.5	0.06	1.0	0.08	0.04	0.24	0.39	120
50th percentile	133	0.04	1.0	12.0	8.3	4.5	3.0	0.08	1.0	0.08	0.04	0.28	0.40	130
75th percentile	142	0.04	1.5	15.0	10.0	5.0	3.5	0.08	1.0	0.10	0.04	0.28	0.40	140
90th percentile	157	0.06	1.8	18.5	11.0	6.0	4.3	0.08	1.5	0.12	0.06	0.30	0.44	152
39 weeks														
Mean (SD)	134 (18)	0.05 (0.01)	1.4 (0.4)	12.1 (4.8)	8.4 (2.4)	4.6 (1.8)	3.3 (1.5)	0.08 (0.02)	1.1 (0.3)	0.1 (0.02)	0.04 (0.01)	0.27 (0.02)	0.39 (0.03)	130 (23)
10th percentile	113	0.04	1.0	6.5	5.3	2.3	1.5	0.06	1.0	0.08	0.04	0.24	0.36	97
25th percentile	115	0.04	1.0	7.5	6.0	3.0	2.0	0.06	1.0	0.08	0.04	0.24	0.38	110
50th percentile	133	0.04	1.5	11.8	8.5	4.8	3.5	0.08	1.0	0.10	0.04	0.27	0.39	130
75th percentile	150	0.06	1.5	15.5	10.0	6.0	4.0	0.08	1.0	0.12	0.04	0.28	0.41	145
90th percentile	161	0.06	2.0	18.8	11.8	7.0	5.3	0.11	1.5	0.12	0.06	0.30	0.42	162
40 weeks														
Mean (SD)	122 (15)	0.04 (0.01)	1.2 (0.5)	12 (5.1)	8.5 (2.6)	4.5 (1.9)	3.4 (1.3)	0.07 (0.01)	1.1 (0.2)	0.09 (0.01)	0.04 (0.01)	0.28 (0.02)	0.4 (0.02)	131 (23)
10th percentile	100	0.04	1.0	6.0	5.5	2.0	1.8	0.06	1.0	0.08	0.04	0.26	0.38	100
25th percentile	111	0.04	1.0	7.5	6.0	3.0	3.0	0.06	1.0	0.08	0.04	0.28	0.39	115
50th percentile	123	0.04	1.0	12.3	8.3	4.3	3.5	0.07	1.0	0.08	0.04	0.28	0.40	130
75th percentile	136	0.04	1.0	15.5	11.0	6.0	4.0	0.08	1.0	0.10	0.04	0.30	0.41	150
90th percentile	145	0.06	2.0	19.3	12.0	7.0	4.5	0.08	1.5	0.12	0.04	0.30	0.44	162
41 weeks														
Mean (SD)	131 (14)	0.05 (0.01)	1.2 (0.4)	12.3 (4.5)	8.8 (2.4)	4.9 (1.8)	3.3 (1.4)	0.07 (0.01)	1.1 (0.2)	0.09 (0.02)	0.04 (0.01)	0.27 (0.02)	0.4 (0.03)	130 (20)
10th percentile	109	0.04	1.0	6.8	5.8	2.3	1.8	0.06	1.0	0.08	0.04	0.24	0.36	100
25th percentile	120	0.04	1.0	8.5	7.0	4.0	2.5	0.06	1.0	0.08	0.04	0.26	0.37	120
50th percentile	134	0.04	1.0	12.0	9.0	5.0	3.3	0.06	1.0	0.08	0.04	0.26	0.40	130
75th percentile	142	0.04	1.5	14.5	10.0	6.0	4.0	0.08	1.0	0.10	0.04	0.28	0.41	140
90th percentile	150	0.06	1.8	19.8	12.3	7.3	5.3	0.08	1.5	0.12	0.05	0.29	0.42	155

n=32 for gestational age of 40 weeks, 31 for weeks 32 and 33 and 30 for all other weeks.