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The Peak of the PQRST and the Trajectory Path of Each Cycle of the ECG 12-Lead Wave

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Abstract

The objective of this present article is to describe the record of the ECG 12-lead examination in order to obtain the peaks of the P, Q, R, S and T from each cycle and also to present the Peak of the PQRST and the trajectory path of each cycle of the ECG 12- lead wave. The duration of the peak R to another is used as the period of each cycle, while the Phytagoras theorem is employed to count the trajectory path of the wave in each step. The Peak PQRST is utilized to diagnose the heart condition, and the trajectory path is the distance taken up by the impulses in the heart muscles. The discrete data from the MIT-BIH and the results of the measurement itself are employed as the data to obtain the values of the peak PQRST and the trajectory path of the wave of each cycle.

Keywords*: trajectory, peak of the PQRST, discrete data, ECG*

1. Introduction

In the field, cardiologists generally merely pay observe the results of examination to the picture of the electrocardiogram and they must count the PQRST by themselves because they usually are not provided with the values of the peak PQRST. And it is very time consuming to count the peak. Therefore, the picture should be complemented with such values. Heart may function as the pump due to the contraction and relaxation of the heart muscles. The heart muscle may contract because they are passé by some impulses spreading from the pacemaker to the Purkinje fibre [1-3]. Some autonomic impulses from the SA node which are periodic cause some periodic cycles too [1-2]. Figure 1 shows the electrical system of the heart.

The recording of some cycles is used to count the frequency, to value the rhythm, to recognize the types of rhytms, to determine the axis an also to know the wave morphology. The choice or the determination of one cycle from the result of the examination is utilized to know heart abnormalities such as hypertrophy, arrhythmia, conduction disturbance (electrical channel disturbance), coronary heart disease (ischemia, injury, infarct), preexistation (NSA conduction is more rapid/is passing other channels) and the like (hypercalemia, hypocalemia, hipercalsemia, hipocalsemia due to metabolic disturbance, effects of medicine, and so on [4-5].

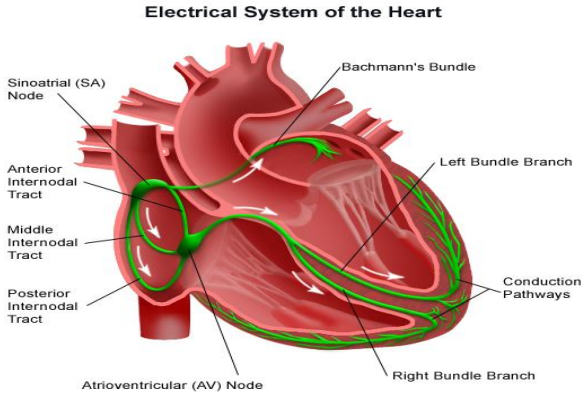

Figure 1. Electrical system of the Heart

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The peak PQRST was studied by [6]. They studied the Heart rate monitoring and PQRST detection based on the graphical user interface with Matlab, using the GUI on matlab, but they did not present the peak value of the PQRST [7]. Studied the Electrocardiogram Feature Extraction and Pattern Recognition Using a Novel Windowing Algorithm but they did not show the peak value of PQRST, merely counted the spesifity and sensitivity of the peak PQRST.

The results of the examination using the Electrocardiogram (ECG) generally are showed in the form of some cycles in the monitor or of some seconds in a piece of paper special for ECG. Figure 2 presents the results in the paper. The range of components in one cycle such as the peak PQRST, intervals and segments may be counted using the background of the boxes in the paper [8]. Figure 2 shows the result of the heart examination using the ECG 12-lead.

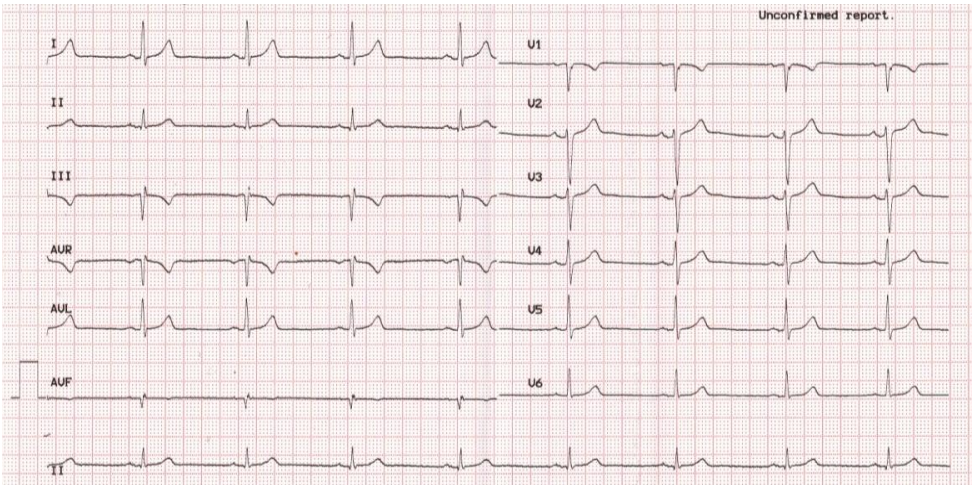


Figure 2. The result of the examination using the ECG 12-Lead

In one cycle, there are some waves, a P and a QRS waves as the depolarization of Atrium and Ventricle, respectively and a T wave as the repolarization of Ventricle [9]. The Peak P or R generally is employed as the guideline to count the duration or the period of one cycle [10]. Figure 3 shows the percentage of one cycle with its components.

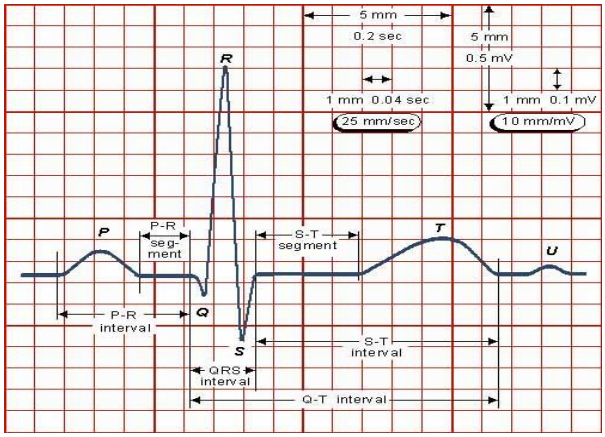


Figure 3. The representation of the Cycle ECG wave

The division of the wave periods consists of wave cycles at the heart for the lateral, inferior, septum and anterior sides [11]. Figure 4 shows leads appropriate with the examined heart sides.

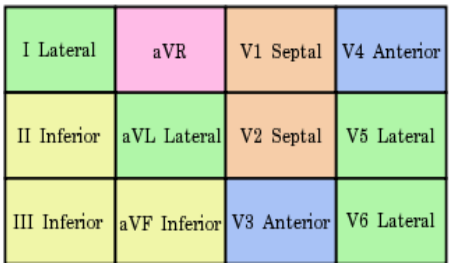


Figure 4. Lead-lead ECG Lead appropriate with the examined heart sides

The trajectory path in one cycle is the distance taken up by impulses at the heart muscles [1]. The peak value and the trajectory path for each cycle will be easily obtained if the examination results are recorded in discrete data. Discrete signals are the sampling result of the analog signal with a certain sampler frequency. If a signal cycle is sampled with the frequency of 250 Hz, it means that in one second there are 250 sampling data, namely the data are taken in each 4 ms (1 up to 250 data). Discrete data are meant as the digitalization process of the time function from the analog signal, while quantizing as the digitalization process of the amplitude from the analog signal [12]. If the two are applied to the analog signal, the signal will become the digital signal.

The unavailability of the discrete data as the result of the ECG examination will make that the represented ECG parameter values may less dependable since the stated values are taken from the average values of all cycles or from one of the cycles. From the results of the ECG examination completed with the discrete data storage, ECG parameter values for each cycle will be obtained. Any errors in the determination of the parameter values may be checked at the discrete database. The data store in the discrete form enables the ECG data to be printed at the sheet or represented at the screen. On the basis of the explanations above, this article intends to determine the peak of the PQRST for each cycle an also its length in each cycle.

2. Research Method

A quantitative approach was employed in this research. In this paper the data employed are discrete namely the results of the sampling data from the examination stored as the digital file. In this presented research the data are from the Physionet MIT-BIH and the those of researchers' examination results are from the hardware PSL 12-BD. On the basis of the chosen file, the determination of the peak PQRST and the trajectory of one cycle refers to the choice of one of the existing cycles. Lead II serves as the calculation reference.

2.1. Determination of the Peak PQRST

The determination of the Peak PQRST is based on the peak R [5-6], [13-14]. If the peak R is known, the algorithm is as follows:

1. The amplitude minimal value from 150 ms (38n) to before and after the peak R is the peak Q [15]
2. The amplitude minimal value from the peak R and after 80 ms (20n) is the peak S [15].
3. The maximal value from the start cycle (sc) to the peak Q is the peak P.
4. The maximal value from the peak S to the end cycle (ec) is the peak T.
5. If the first cycle does not posses the P wave, the second cycle will be used as the first cycle.

Referring to point 1, for the frequency of 250 Hz, 150/4=37.5 n ≈ 38 n is obtained, meaning 38 n from before to after n peak R. For point 2, 80/4=20 n is gotten, meaning from the n peak R to after 20 n. Figure 5(a) presents the illustration from the algorithm and Figure 5(b) presents the determining one cycle [8].

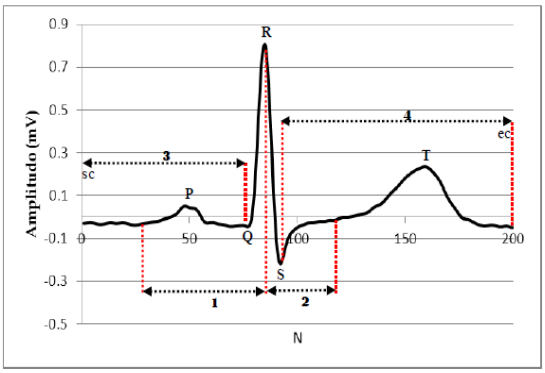


Figure 5(a). Determining the peak PQRST

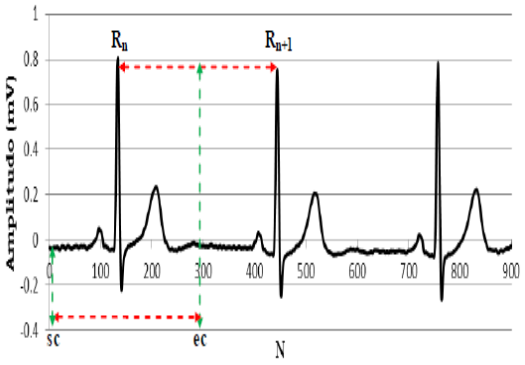


Figure 5(b). Determining one cycle

2.2. Determining the Trajectory of the 1 Cycle

The trajectory of one cycle is determined based on the trajectory in the duration of chosen one cycle. The trajectory of each step in the duration of one cycle is summed up. The trajectory counted depends on the condition whether the trajectory is ascending, level, or descending. The method of counting trajectory of each step follows the following Phytagoras theorem:

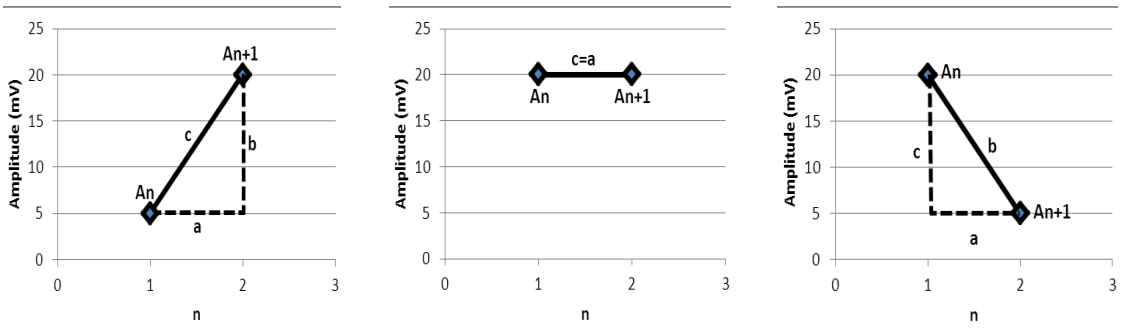
If An<An+1 (ascending), then $c = \sqrt{a^2 + b^2}$.

If An=An+1 (leveling) then c=a.

If An>An+1 (descending), then $b = \sqrt{a^2 + c^2}$.

(An=amplitude at the point /step n^{th} ; An+1=amplitude at the point /step $n+1^{th}$)

The method of counting the trajectory for each step is shown at Figure 6.



a) Ascending trajectory b) Leveling trajectory c) Descending trajectory

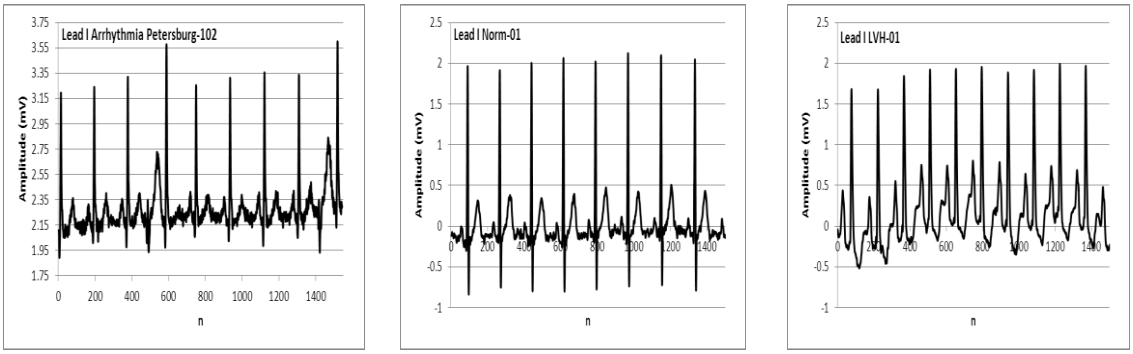
Figure 6. Ascending, Leveling and Descending trajectory

3. Results and Analysis

The findings of this present research are the peak value of the PQRST, the duration and also the length wave for each cycle.

The limited discrete data of the ECG 12-lead caused the writers to take the Physionet data file, namely Arrhythmia 102 Petersburg data, recorded in step 4 ms duration (frequency sampling of 20 Hz). The data files of results of the writers' examination are masda-01 dan Srir-01, with the same duration step (4 ms/frequency sampling of 250 Hz). Step 4 ms for 150 ms duration is equivalent with 38n while for 80 ms equals 20n.

Figure 7 presents the original data of the Arrhythmia Petersburg 102, masda-01 and Srir-01 lead I for 6 second-duration, while Table 1 shows the peak PQRST 3 cycle for 12-lead.



Arrhythmia Petersburg 102 Masda-01 Srir-01

Figure 7. Original data for 6 second-duration

Table 1. Peak PQRST Data of Arrhythmia Petersburg 102, Masda-01 and Srir-01

		Arrhythmia Petersburg 102					Masda-01					Srir-01				
Lead	Cycle	P (mV)	Q (mV)	R (mV)	S (mV)	T (mV)	P (mV)	Q (mV)	R (mV)	S (mV)	T (mV)	P (mV)	Q (mV)	R (mV)	S (mV)	T (mV)
I	1	2.31	2.01	3.259	2.165	2.399	-0.0085	-0.296	1.9602	-0.0347	0.4162	0.4218	-0.2848	1.6783	-0.4063	0.2648
	2	2.353	1.977	3.314	2.15	2.399	0.0456	-0.2024	1.9074	-0.7494	0.3766	0.3529	-0.1561	1.6745	-0.325	0.0203
	3	2.725	1.974	3.573	2.121	2.304	0.04	-0.2423	1.9982	-0.7954	0.3394	0.5407	-0.1423	1.8368	-0.1617	0.2579
II	1	1.802	1.712	2.542	1.824	2.095	0.0421	-0.3646	1.2169	-0.6731	0.0979	0.4029	-0.3279	1.0215	-0.4793	0.3001
	2	1.938	1.603	2.51	1.761	1.99	-0.0348	-0.315	1.192	-0.7022	0.1717	0.4545	-0.112	1.955	-0.2603	0.1577
	3	2.255	1.729	2.19	1.775	1.843	0.1468	-0.2268	1.2267	-0.6355	0.3626	0.6097	-0.0072	2.1064	-0.1209	0.2941
III	1	-3.036	-2.905	-3.304	-2.889	-2.912	0.0506	-0.0606	-0.7435	0.1616	-0.3103	-0.0209	-0.0431	0.1432	0.007	0.1033
	2	-3.023	-2.902	-3.412	-2.997	-3.016	-0.0004	-0.1126	-0.7154	0.0472	-0.2949	0.1016	0.0441	0.2985	0.0567	0.1374
	3	-3.078	-2.853	-3.993	-2.954	-3.069	0.1046	0.0155	-0.6715	0.1599	0.0252	0.141	0.1361	0.2636	0.0328	0.0562
aVR	1	-3.507	-3.275	-4.301	-3376	-3.657	-0.0168	0.2303	-1.5806	0.7339	-0.2571	-0.4147	0.3063	-1.7499	0.4828	-0.2564
	2	-3.556	-3.242	-4.324	-3.366	-3.685	-0.0054	0.2567	-1.5497	0.7258	-0.2742	-0.4037	0.1341	-1.8147	0.2967	-0.089
	3	-3.902	-3.265	-4.294	-3.359	-3.484	-0.0923	0.2546	-1.6025	0.7155	-0.351	-0.6192	0.0723	-1.9686	0.1453	-0.266
aVL	1	1.384	1.088	1.902	1.127	1.288	-0.0295	-0.1137	1.3518	-0.4982	0.2673	0.2504	-0.1289	0.7676	-0.2467	0.0308
	2	1.317	1.069	1.993	1.203	1.337	0.063	-0.0449	1.3114	-0.3903	0.2908	0.1257	-0.1001	0.697	-0.1909	-0.0585
	3	1.333	1.042	2.415	1.167	1.317	-0.0325	-0.1289	1.3549	-0.4777	0.1501	0.2039	-0.1397	0.7866	-0.0973	0.0909
aVF	1	-0.895	-0.915	-0.699	-0.852	-0.729	0.0463	-0.2166	0.2568	-0.2558	-0.1102	0.107	-0.1855	0.9024	-0.2562	0.2657
	2	-0.863	-0.928	-0.771	-0.938	-0.833	-0.0576	-0.2138	0.2583	-0.2275	-0.0166	0.2701	-0.034	1.1178	-0.1058	0.1476
	3	-0.725	-0.802	-1.222	-0.908	-0.931	0.1266	-0.1857	0.2276	-0.2378	0.1929	0.4154	0.0644	1.102	-0.0401	0.1732
V1	1	0.752	1.141	0.497	0.98	0.81	-0.3063	-0.025	-1.6189	-0.6774	-1.0662	-0.727	0.2039	-0.465	0.1891	-0.269
	2	0.729	1.114	0.48	0.977	0.879	-0.2448	0.0456	-1.5042	-0.5329	-0.2178	-0.6591	0.1518	-0.6213	0.2431	-0.0192
	3	0.353	1.216	0.467	1.065	0.98	-0.1206	-0.0076	-1.4022	-0.4496	-0.1065	-0.8263	0.0467	-0.8066	0.1229	-0.1739
V2	1	-0.513	-0.297	0.343	-0.306	-0.092	-0.2567	-0.1569	-1.2467	-1.6777	-1.7982	-0.5765	0.2068	-0.7391	0.1134	0.0255
	2	-0.477	-0.278	0.421	-0.376	0.02	-0.255	-0.0406	-1.1632	-1.5765	0.5049	-0.6625	-0.0571	-0.8571	0.1328	-0.1108
	3	-0.729	-0.163	0.699	-0.525	-0.248	-0.1355	-0.1998	-0.9938	-1.5735	0.6303	-0.9062	-0.0615	-1.2296	0.0548	-0.218
V3	1	-1.075	-0.958	0.206	-0.964	-0.567	-0.1775	-0.2551	1.113	-1.7378	-0.4777	-0.1047	0.1651	0.3448	-0.1603	0.2534
	2	-1.007	-0.899	0.278	-0.908	-0.366	-0.2077	-0.1423	1.1508	-1.6703	0.446	-0.2574	-0.1557	0.1437	-0.0403	-0.142
	3	-1.052	-0.729	0.306	-0.781	-0.794	-0.0828	-0.2702	1.2994	-1.6572	0.5359	-0.4994	-0.2416	-0.1638	-0.0465	-0.0754
V4	1	0.337	0.366	1.745	0.382	0.092	-0.2251	-0.3406	2.7841	-1.5612	0.3684	0.2969	0.1539	-0.3108	0.6531	0.4133
	2	0.467	0.461	1.814	0.493	0.98	-0.1156	-0.1877	2.9696	-1.3686	0.5336	0.4054	-0.1192	-0.6587	0.2504	0.3499
	3	0.526	0.503	1.676	0.434	0.454	-0.017	-0.2522	2.9972	-1.4569	0.4126	0.2273	-0.0367	-0.7392	-0.006	-0.2008
V5	1	2.569	2.467	3.467	2.592	2.778	-0.1969	-0.3747	2.4591	-1.1185	0.4337	0.2244	-0.0222	-0.7502	-0.1313	0.2154
	2	2.608	2.458	3.408	2.578	2.817	-0.0094	-0.0646	2.828	-0.8272	0.5907	0.0027	-0.4444	-0.9406	-0.1671	0.2456
	3	3.026	2.608	3.255	2.45	2.611	0.0229	-0.2537	2.6768	-1.0673	0.1485	-0.0025	-0.1029	-0.5961	-0.068	0.2717
V6	1	-107.00	-107.00	-107.00	-107.00	-107.00	-0.0625	-0.2526	1.8057	0.6267	0.4667	0.2613	0.0428	-2.9601	0.6128	0.1785
	2	-107.00	-107.00	-107.00	-107.00	-107.00	0.0562	-0.0715	2.05	-0.4998	0.2894	0.0916	-0.2956	-3.3563	-0.0252	0.1733
	3	-107.00	-107.00	-107.00	-107.00	-107.00	0.069	-0.1733	1.9166	-0.6429	0.1328	-0.0257	-0.2961	-3.4789	0.0022	0.2405

The trajectory of 1 cycle wave for all leads is based on the lead I (the chosen lead) cycle and the duration/ the trajectory may be counted on the basis of the printer speed to print the waves at the ECG sheet (25mm/ second). Based on the calculation of L (ms)/40 ms, the trajectory of L(ms) for the data of Arrhythmia 102, Masda-01 and of Srir-01, the results are as show in Table 2 respectively.

Table 2. the trajectory of L(ms) for the data of Arrhythmia 102, Masda-01 and of Srir-01

Arrhytmia 102					Masda-01				Srir-01			
Lead	Cycle	Σ n	Duration RR (ms)/L (ms)	L (mm)		Σ n	Duration RR (ms)/L (ms)	L (mm)		Σ n	Duration RR (ms)/L (ms)	L (mm)
I	1	183	732/732.087	18.302		179	716/724.413	18.110		146	584/584.126	14.603
	2	210	840/840.085	21.002		176	704/708.367	17.709		143	572/572.127	14.303
	3	161	644/644.114	16.103		173	692/700.360	17.509		144	576/576.133	14.403
II	1	183	732/732.074	18.302		179	716/724.206	18.105		146	584/584.154	14.604
	2	210	840/840.103	21.003		176	704/708.213	17.705		143	572/572.153	14.304
	3	161	644/644.069	16.102		173	692/700.174	17.504		144	576/576.157	14.404
III	1	183	732/732.060	18.302		179	716/724.050	18.101		146	584/584.002	14.600
	2	210	840/840.098	21.002		176	704/708.044	17.701		143	572/572.002	14.300
	3	161	644/644.104	16.103		173	692/700.046	17.501		144	576/572.002	14.300
aVR	1	183	732/732.065	18.302		179	716/724.298	18.107		146	584/584.139	14.603
	2	210	840/840.070	21.002		176	704/708.279	17.707		143	572/572.140	14.304
	3	161	644/644.065	16.102		173	692/700.256	17.506		144	576/572.145	14.304
aVL	1	183	732/732.055	18.301		179	716/724.101	18.105		146	584/548.026	13.701
	2	210	840/840.066	21.002		176	704/708.153	17.704		143	572/572.026	14.301
	3	161	644/644.092	16.102		173	692/700.160	17.504		144	576/572.028	14.301
aVF	1	183	732/732.045	18.301		179	716/724.024	18.101		146	584/584.047	14.601
	2	210	840/840.080	21.002		176	704/708.037	17.701		143	572/572.046	14.301
	3	161	644/644.058	16.101		173	692/700.019	17.500		144	576/572.046	14.301
V1	1	183	732/732.036	18.301		179	716/724.134	18.103		146	584/584.054	14.601
	2	210	840/840.043	21.001		176	704/708.189	17.705		143	572/572.054	14.301
	3	161	644/644.038	16.101		173	692/700.136	17.503		144	576/572.054	14.301
V2	1	183	732/732.046	18.301		179	716/724.103	18.105		146	584/584.073	14.602
	2	210	840/840.075	21.002		176	704/708.360	17.709		143	572/572.078	14.302
	3	161	644/644.070	16.102		173	692/700.202	17.505		144	576/572.086	14.302
V3	1	183	732/732.078	18.302		179	716/724.425	18.111		146	584/584.103	14.603
	2	210	840/840.115	21.003		176	704/708.491	17.712		143	572/572.105	14.303
	3	161	644/644.103	16.103		173	692/700.314	17.508		144	576/572.097	14.302
V4	1	183	732/732.105	18.303		179	716/724.966	18.124		146	584/584.227	14.606
	2	210	840/840.148	21.004		176	704/708.839	17.721		143	572/572.255	14.306
	3	161	644/644.117	16.103		173	692/700.734	17.518		144	576/572.299	14.307
V5	1	183	732/732.065	18.302		179	716/724.703	18.118		146	584/584.393	14.610
	2	210	840/840.095	21.002		176	704/708.592	17.715		143	572/572.355	14.309
	3	161	644/644.060	16.102		173	692/700.534	17.513		144	576/572.346	14.309
V6	1	183	732/732.000	18.300		179	716/724.350	18.109		146	584/584.842	14.621
	2	210	840/840.000	21.000		176	704/914.604	22.865		143	572/572.855	14.321
	3	161	644/644.000	16.100		173	692/700.265	17.507		144	576/572.983	14.325
Avg. duration (ms)			738.66		Avg. duration (ms)		704.00		Avg. duration (ms)		577.33	

Heart rate is the number of beats per minute. The heart beat is caused by the ventricle depolarization (peak R) in 1 minute.

4. Conclusion

The following conclusions may be made in this research:

1. Peak PQRST and the trajectory for each cycle may be counted based on the peak R to peak R
2. If the first cycle does not posses P wave, the second cycle may be chosen as the first cycle
3. Peak PQRST and the trajectory at each cycle have different values due to different cycle duration

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