EVALUATION OF P WAVE DISPERSION IN ECG; QT DISPERSION AND OTHER ECG CHANGES IN PATIENTS ADMITTED TO EMERGENCY DUE TO STROKE

AKUT İNMEYLE BAŞVURAN HASTALARDA: P DALGA DİSPERSİYONU, QT DİSPERSİYON VE DİĞER EKG DEĞİŞİKLİKLERİNİN DEĞERLENDİRİLMESİ

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Geliş tarihi: 24/11/2017

Kabul Tarihi:07/12/2017

ABSTRACT

Aims: In this, a comparison of QT, QT_C, QT_{DIS}, P wave and P_{DIS} values from the first ECG recordings in stroke patients and healthy individuals in emergency department was realized, and it was searched whether these values were predictors of prognosis within gender and age or not.

Materials and Methods: Along with a control group of 90 patients, 76 patients with a diagnosis on ischemic stroke presenting neurological symptoms and brain CT and/or MRI evaluation in the emergency service were included in the study. All patients were analysed with 12-lead electrocardiograms and P_{MAX}, P_{MIN}, P_{DIS}, QT, QTc, QT_{DIS} and QT_{CDIS} intervals were measured.

Results: During the P_{DIS} comparison in control and stroke groups, interval was detected significantly higher in the stroke group [95% CI; 39.55 to 49.40] compared to the control group [95% CI; 26.55 to 33.45]. QT_{DIS} [95% CI; Vs 49.16 to 62.28 39.28 to 46.82] and QT_{CDIS} values [95% CI; 54.22 to 72.83 vs 43,10-51,1739,28-46,82] were also detected statistically meaningful in stroke group compared to control cases.

Conclusion: P_{DIS}, QT_{DIS} and QT_{CDIS} intervals that were determined to be prolonged in stroke groups compared to the control group should be considered as important parameters in prognosis and clinical follow-up.

Key Words: Stroke, Electrocardiogram, P wave dispersion, QT-QTc wave dispersion

ÖZET:

Amaç: Bu çalışmada, acil serviste akut inme hastalarında ve sağlıklı bireylerde ilk EKG kayıtlarından QT, QTc, QT_{DIS}, P dalga ve P_{DIS} değerlerinin karşılaştırılması yapıldı ve bu değerlerin cinsiyet ve yaş açısından prognoz belirleyicileri olup olmadığı araştırıldı.

Gereç ve Yöntem: 90 hastadan oluşan bir kontrol grubu ile birlikte, nörolojik semptomları olan ve iskemik inme tanısı konan 76 hastanın acil serviste beyin BT ve/veya MRI görüntülemesi yapıldı. Tüm hastaların 12 derivasyonlu elektrokardiyografileri analiz edildi ve P_{MAX}, P_{MIN}, P_{DIS}, QT, QTc, QT_{DIS} ve QT_{CDIS} aralıkları ölçüldü.

Bulgular: Kontrol grubu ve inme gruplarındaki P_{DIS} karşılaştırması sırasında, aralık inmeli grupta [% 95 CI; 39.55 ila 49.40] kontrol grubuna [% 95 CI; 26.55 ila 33.45]. QT_{DIS} [% 95 CI; Vs 49.16 ila 62.28 39.28 ila 46.82] ve $QT_{C\ DIS}$ değerleri [% 95 CI; 54.22 ila 72.83'e karşılık 43,10-51,1739,28-46,82] kontrol gruplarına kıyasla inmeli grupta istatistiksel olarak anlamlı bulundu.

Sonuç: Prognoz ve klinik takipte inme grubunda kontrol grubuna göre uzamış olduğu saptanan P_{DIS}, QT_{DIS} ve $QT_{C\ DIS}$ değerleri önemli parametreler olarak düşünülmelidir.

Anahtar Kelimeler: İnme, EKG, P dalga dispersionu, QT-QTc dalga dispersionu.

INTRODUCTION

Stroke means a sudden-located and focal neurological syndrome induced by cerebrovascular disease (CVD). Despite advances in medical care, stroke still ranks as the fourth reason of death(1). It's known that cardiac arrhythmias and structural heart diseases have important places in the ethiology of stroke. Atrial fibrillation (AF) is also a frequent cause of stroke. Such that there's the possibility of AF even if it was not detected in the first hospital admission, and it needs further monitoring for diagnosis(2).

It is known that many ECG findings can be observed in stroke patients. It's also known that, since brain regions such as frontal lobe, insular cortex and the amygdala play important roles in the regulation of the heart, via the sympathetic and parasympathetic system, cerebral lesions in these regions are known to cause more cardiac symptoms. Along with AF, QT prolongation, ST segment, T wave changes and AV blocks, life-threatening ventricular arrhythmias can be seen in stroke patients. Therefore, patient monitoring is advised in acute phase(3). With serial ECG monitoring, AF is diagnosed 2.6 times more than as usual. Instead of regular monitoring, rhytm holter is defined as a better method for the identification of paroxysmal AF(3,5).

P wave dispersion (P_{DIS}) is defined as the difference between the maximum and minimum P-wave durations in ECG. It was regarded as the ECG finding that can be used in predicting paroxysmal AF(6). It is stated that the detection of P_{DIS} in ECG taken in the first 24 hours of stroke can be used for detecting paroxysmal AF and the risk of recurrent stroke(7).

QT and QT_C intervals are indicators of ventricular repolarization in ECG. It was reported that QT_C prolongation and QT dispersion (QT_{DIS}) could be seen in stroke patients, and that it can reflect mortality and morbidity(8). QT_{DIS} can change depending on lesion size, type, location and the severity of disease in stroke patients(9). Increased amounts of chatecholamines are held responsible for this increase(10).

Stroke group is vulnerable to the risk of arrhythmias. Monitoring of patients or follow-up with holter is recommended for his situation. P_{DIS} and QT_{DIS} intervals are regarded as important parameters illustrating the recurrence and prognosis, and may reflect patient's potential of arrhythmia easily. Evaluation of these parameters in the early stages will enable earlier detection of the group of patients at risk.

Therefore, in this study a comparison on QT, OT_C, OT_{DIS}, P and P_{DIS} duration in ECG recordings among stroke patients and healthy individuals in emergency room is planned with the aim of determining the correlation of these parameters as well as their probable change with age, gender and prognosis.

MATERIAL AND METHOD

The data in this prospective case-control study was collected in 6 months after receiving ethical approval (between 01.01.2013-31.05.2013). The study included 76 stroke patients who were admitted to Emergency Department of Canakkale State Hospital between the above mentioned dates and who were diagnosed with ischemic stroke with a first ECG findings in sinus rhythm. These patients formed the stroke group (Group S) of the study. Patients with similar age and gender ranges admitted to the emergency were included in the control group (Group C).

With the help of the mean ± SDs obtained from the study by Kocer and friends compairing Pdis and outcomes of stroke patients, the number of patients was determined 61 for each group with 95% confidence interval and 80% power. (11-12) 76 patients and 90 control patients were enrolled in the study within the prescribed time (http://www.openepi.com/SampleSize/SSMean.htm).

Exclusion criteria from the study;

1. Patients with known heart disease (cardiomegaly, valve disease, heart failure, or cardiac arrhythmia),
2. Renal insufficiency (creatinine>1.3 mg.dl-1),
3. Severe anemia (Hb <8 g.dl-1),
4. Diabetes mellitus, hypo / hyperthyroidism, alcohol addiction
5. Patients using drugs that prolong the QT interval,
6. Patients in pregnancy or lactation.

The demographic data of stroke patients and the control group that were diagnosed, their symptoms and signs, laboratory results and ECGs were collected in the emergency department for the study. Stroke was diagnosed by brain CT and/or diffusion MRI of patients

who admitted to the emergency department with neurological symptoms and were diagnosed ischemic stroke.

ECG and ANALYSES

Standard 12-lead ECG (Nihon Kohden Cardiofax M®; Tokyo, Japan) at 25 mm / sec paper speed and 10 mm / mV calibration was recorded from all patients enrolled in the study. All analyses were evaluated by a single specialized cardiologist using a magnifying glass blind to the group for which ECG is included.

P wave duration was calculated by the measurement of the distance between the intersections at the beginning and the end of P wave deflection on the isoelectric line. After determining P_{MAX}, and P_{MIN}, P_{DIS} interval was calculated by subtracting the value of P_{MIN} from P_{MAX}.

QT interval was calculated by the distance between the intersections at the beginning of QRS wave and the end of T wave on the isoelectric line. Corrected QT (QT_C) was measured with QT interval divided by the square root of RR.

Relations were investigated using Spearman's coefficient and risk factors using binary logistic regression. The results were evaluated in a 95% confidence interval and a significance level of $p < 0.05$.

Biochemical Analyses

Glucose, urea, creatinine, sodium, potassium, chloride, calcium and blood count examinations were made for all the patients included in the study.

Statistical Analysis

IBM SPSS Statistics 22.0 (IBM Corp., Armonk, New York) was used for all data analyses. Arithmetic means, standard deviations, frequency (n) and percentage (%) were used during data analysis.

When the divergencies between groups correlated with normal distribution of data, t test was used, while there was no such correlation Mann-Whitney U was used. Chi-square test was employed for discrete variables. Relationships were searched by the use of Spearman index and the risk factors were searched by the use of dual logistic regression. Results were evaluated at 95% confidence interval and significance level at $p < 0.05$.

RESULTS

76 patients in stroke group and 90 patients as control group were included into this study. 56.7% of stroke patients (n = 51) and 54.4% of patients in the control group (n = 49) were male. When patients' age, sex and laboratory analyses were evaluated, no statistically significant difference was observed (Table 1).

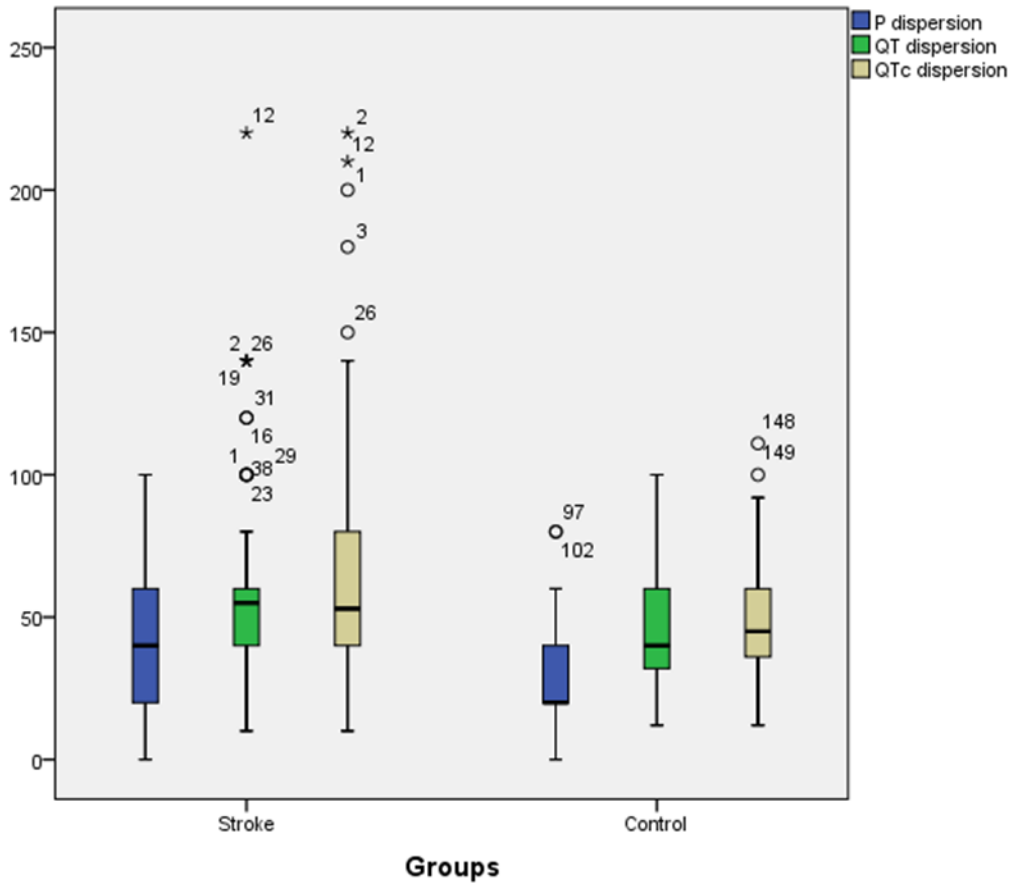
Table 1. Distribution of age, gender and laboratuary results between study groups

Groups		**Grup S (n=76)**	**Grup C (n=90)**	**P value**
Initial datas				
Age		68,64±10.02	67.51±9.75	0.707
Gender	Male	44 (%57.9)	49 (%54.4)	0.754
	Female	32 (%42.1)	41 (%45.6)	
Na		137,97±3,56	138,64±3.18	0.202
Cl		102.63±4.94	103.74±3.53	0.103
K		4,24±0,45	4.14±0,49	0.182
Ca		9.30±0,57	9,27±0,50	0.735
ECG measurements				
Heart rate (per minute)		77,53±16,07	71,53±12,50	0.008
$P_{MAX\ (ms)}$		84,74±19,01	75,11±17,04	0.001
$P_{MIN\ (ms)}$		40,53±13,46	45,11±13,26	0.029
$P_{DIS\ (ms)}$		44,47±21,57	30,00±16,49	<0.001
QT (ms)		389,72±31,68	374,51±29,67	0.002
$QT_{C\ (ms)}$		425,39±31,47	417,59±29,25	0.100
$QT_{DIS\ (ms)}$		55,72±28,71	43.06±17.99	0.001
$QT_{CDIS\ (ms)}$		63,53±40,73	47.13±19.26	0.002

(P_{MAX} :P wave maximum duration, P_{MIN}:P wave minimum duration, P_{DIS}:P wave duration dispersion, QT: QT distance, QT_C :QT corrected distance, QT_{DIS} :QT distance dispertion, QT_{CDIS}: QT corrected distance dispersion).

When ECGs of patients in both groups were examined, it was found out that stroke patients had significantly higher heart rates than the control group. Mean P_{MAX} value [95% CI; 80.39 to 89.08] in stroke group (95% CI, 71.54-18.68) was significantly longer statistically compared to the control group. Mean P_{MIN} value in stroke group [95% CI; 37.45 to 43.60] was significantly lower than control group value [95% CI, 42.33 to 47.89]. Mean P_{DIS} interval the stroke group [95% CI, 39.55 to 49.40] was significantly higher compared with the control group [95% CI, 26.55 to 33.45].Mean QT interval was significantly longer in stroke group [95% CI 382.48 to 396, 96] than in the control group [95% CI, 368.29 to 380.72] Mean QT_{DIS} [95% CI; Vs 49.16 to 62.28 39.28 to 46.82] and QT_{CDIS} [95% CI; 54.22 to 72.83 vs 43,10-51,1739,28-46,82] intervals were higher than the control group and this difference was statistically significant (Fig 1). On the other hand, as seen in the same table, QT_C comparisons showed no significant difference (Table 1).

Figure 1: Comparison of groups P_{DIS}, QT_{DIS} and $QT_{CDIS.}$



$P_{DIS:}$ P wave duration dispersion, QT_{DIS} :QT distance dispersion, QT_{CDIS}: QT corrected distance dispersion

Examination of Stroke Group

While 12 (15.8%) stroke patients evaluated as stroke patients at the emergency department were being discharged, 1 (1.3%) patient was hospitalized in intensive care and 63 patients (82.9%) in neurology service. Subsequently, 64 (84.2%) of the hospitalized patients were discharged, and 12 (15.8%) patients died in the follow-up period. The median length of hospitalization was 3 days (range, 1-69). There found no correlation between the duration of hospitalization and heart rate and ECG measurements (for each $p > 0.05$).

At least one abnormal ECG was observed in 64 patients (84.2%). T-wave inversion was observed in 61 patients (80.3%), and ST abnormalities were observed in 57 patients (75%). There observed no significant statistical difference in ECG measurements ofgenders in stroke group. Neither there was observed a correlation among ECG measurements and patients' discharge (Table 2).

Table 2: Comparison of ECG measurements and emergency department and hospital outcomes

	P_{MAX}	P_{MIN}	P_{DIS}	QT	QT_C	QT_{DIS}	QT_{CDIS}
Gender							
Male	84,55±20,17	39,09±12,17	45,45±21,72	386,52±29,01	421,34±27,55	53,86±27,30	62,79±39,85
Female	85,00±17,60	42,50±15,03	43,13±21,62	394,13±35,02	430,97±35,89	58,28±30,79	64,53±42,53
P value	0.919	0.278	0.645	0.305	0.190	0.511	0.859
Outcomes in emergency department							
Hospitalization (n=12	83,43±19,37	39,06±13,06	44,69±22,18	387,28±31,82	422,88±29,83	55,08±28,82	62,34±42,14
Discharge (n=64)	91,67±15,86	48,33±13,37	43,33±18,75	402,75±28,73	438,83±37,71	59,17±29,06	69,83±32,97
P value	0.170	0.028	0.843	0.111	0.107	0.654	0.562
Outcomes in neurology service							
Exitus (n=12=	80,00±17,06	40,00±8,53	40,00±19,07	379,41±32,93	419,08±25,45	52,67±31,53	64,00±52,96
Discharge (n=52)	84,23±19,94	38,85±13,95	45.77±22,87	389,09±31.60	423,75±30,91	55.63±28.46	61.96±39.85
P value	0.500	0.785	0.421	0.346	0.629	0.751	0.881

P_{MAX} : P wave maximum duration, P_{MIN}: P wave minimum duration, P_{DIS}:P wave duration dispersion, QT:QT distance, QT_C :QT corrected distance, QT_{DIS}:QT distance dispersion, QT_{CDIS}: QT corrected distance dispersion

In this study effects of variables on risk factors for each disease were also examined. The rise of P_{MAX}, P_{DIS}, QT, and QT_{DIS} values augment the risk of meaningful illness is about 1-fold (95% CI 1.02-1.98). The decline in P_{MIN} value increases the risk of stroke about 0,950 times. ECG changes, ST segment and T wave changes cause approximately 2-fold increase for the meaningful disease risk.

DISCUSSION

Stroke is the most common cause of death after heart disease and cancer, and 10% of all deaths in the world are brought about by stroke. It is the most common cause for long-term physical disability in adults(13). Arrhythmias caused by cardiovascular dysfunction, ischemic heart damage or complications such as sudden death can frequently occur in the aftermath of acute stroke. In the formation of these complications increased sympathetic activity is known to be accompanied with parasympathetic function. The most precipitating factor for deaths after stroke is of cardiac origin, and it's stated that this is related with the effects of cerebral mechanisms on heart rather than the coronary artery disease(14). Central sympathetic hyperactivity, suppression of cardiac parasympathetic activity, and abnormal baroreceptor function have been shown as causes for this situation(8,15-19). 75% of patients were observed to have ECG changes compared to the past, and cardiac arrhythmias were seen in 28.7% of these patients; arrhythmias were observed frequently if right hemisphere of cerebrum was more affected(20).

In this study, while it was seen in the comparison between the stroke and control groups that higher heart rates were detected in stroke group compared to the control group, there detected no statistically significant difference. In a study conducted by Dogan et al. advent of P_{DIS} of as a predictor of paroxsymal AF was searched in patients with ischemic stroke. In the result of the study, it was confirmed that the the level of P_{DIS} has an independent predictor value for PAF(21).

Even there are some studies on ECG changes in stroke in the literature, studies about the P wave and P_{DIS} are limited. Kocer et al compared 67 stroke patients and 58 cases in control group and didn't find any differences between P-wave duration and P_{DIS}. Although they concluded that these parameters cannot mean that there is a relation between P wave duration and P_{DIS}, and that they cannot be employed for a predicting factor, they advised further case-study on this issue(11). In our task,76 stroke patients were studied with 90 control cases. In stroke group, P wave duration and P_{DIS} interval were found significantly higher.

In the study of Lazar et al. it was shown that mean QT_{DIS} interval was identified to be significantly higher in dead cases compared to survivors(22). Eckardt et al. showed that QT_{DIS} intervals are prolonged in situations when there is a stroke that includes insular cortex in

stroke patients involving insular cortex lesions with unilateral cerebral ischemia and whose ECG was taken only once in the first 72 hours for the 19 control cases(23). Afsar et al compared 36 acute stroke patients (including intracranial hemorrhagia) with 19 control cases without any cardiovascular diseases or diabetes, and compared serial ECGs in 24 and 72 hours. It was stated that while there was observed a meaningful QT_{DIS} prolongation in first 24 hours, it was observed that the values gradually declined after 72 hours period and came closer to the values of the control group.

In the same study, they showed that QT_{DIS} was significantly higher in acute stroke patients without cardiovascular disease and that this was more dependent on the size of the lesion rather than its localisation(9). In another study, high troponin levels and so probability of myocardial damage was reported in high QT_{DIS} cases(24). In some studies, it was illustrated that QT_{DIS} value was an independent predictor of mortality and functional outcomes in neurological events(8). In our study, in parallel to the literature, QT_{DIS} interval was found statistically and significantly higher in stroke patients compared to the control group. When evaluated with earlier studies, OT_{DIS} prolongation is explicit in stroke patients and influences prognosis.

In this study, ECG assessments were made manually with the help of a magnifying glass. P_{MAX}, P_{MIN}, QT_{DIS}, QT_{MAX} and QT_{MIN} were assessed using a magnifying glass by a single cardiologist. Intra- or inter observer variations can be seen in this type of evaluation. Visual interpretations of the cases may also be different from digital evaluations.

In this study, ECGs were evaluated only during admission to the emergency service. Relations of the complications of the measured evaluation generated in the follow-up period with the mortality of the patients or the detected arrhytmias were not evaluated. The analysis on this study cannot be advised to be employed for the prognosis of stroke patients with the data available.

Stroke increases with age and continues to be a major cause of morbidity and mortality. Though ECG changes in stroke have been studied in recent publications, in this study P_{DIS} was specifically evaluated. As a result, significantly prolonged P_{DIS} in stroke patients was observed. However, similar to previous studies, in stroke patients QT_{DIS} interval was prolonged and cardiac rates increased. ECG evaluations of emergency physcians in stroke

patients are advised to include all these parameters for directing the prognosis and follow-up of of the patient.

REFERENCES

1. Stroke Drops To Fourth Leading Cause Of Death In 2008. Centers For Disease Control National Center For Health Statistics. 2010;301:458-4800.

2. Jauch EC, Saver JL, Adams HP Jr, et al. Guidelines For The Early Management Of Patients With Acute Ischemic Stroke. Stroke. 2013;44:870-947.

3. Lazzaro MA, Krishnan K, Prabhakaran S. Detection Of Atrial Fibrillation With Concurrent Holter Monitoring And Continuous Cardiac Telemetry Following Ischemic Stroke And Transient Ischemic Attack. J Stroke Cerebrovasc Dis. 2012;21:89-93.

4. Douen AG, Pageau N, Medic S. Serial Electrocardiographic Assessments Significantly Improve Detection Of Atrial Fibrillation 2.6-fold In Patients With Acute Stroke. Stroke. 2008;39:480-2.

5. Grond M, Jauss M, Hamann G,et al, Improved Detection Of Silent Atrial Fibrillation Using 72-hour Holter ECG In Patients With Ischemic Stroke:A Prospective Multicenter Cohort Study. Stroke. 2013;44:3357-64.

6. Dilaveris PE, Gialafos EJ, Sideris SK, et al. Simple Electrocardiographic Markers For The Prediction of Paroxysmal Idiopathic Atrial Fibrillation. Am Heart J. 1998;135:733-8.

7. Dogan U, Dogan EA, Tekinalp M, et al, P-Wave Dispersion For Predicting Paroxysmal Atrial Fibrillation In Acute Ischemic Stroke. Int J Med Sci. 2012;9:108-114.

8. Lazar J, Manzella S, Moonjelly J, Wirkowski E, Cohen TJ, The Prognostic Value Of QT Dispersion In Patients Presenting With Acute Neurological Events. J Invasive Cardiol. 2003;15:31-5.

9. Afsar N, Fak A.S, Metzger JT, Melle GV, Kappenberger L, Bogousslavsky J. Acute Stroke Increases QT Dispersion In Patients Without Known Cardiac Diseases. Arch Neurol. 2003;60:346–350.

10. Lederman YS, Balucani C, Lazar J, et al. Relationship Between QT Interval Dispersion in Acute Stroke and Stroke Prognosis: A Systematic Review. J Stroke Cerebrovasc Dis. 2014;23:2467-2478.

11. Kocer A, Barutcu I, Atakay S, Ozdemirli B, Gul L, Karakaya O, P Wave Duration Changes And Dispersion. A Risk Factor Or Autonomic Dysfunction In Stroke? Neurosciences. 2009;14:14-8.

12. Soe MM, Sullivan KM, Documentation Of Sample Size For Comparing Two Means,2005.http://www.openepi.com/SampleSize/SSMean.htm.

13. Deaths By Cause, Sex And Mortality Stratum In WHO Regions, Estimates For 2002. The World Health Report. 2004:120-122.

14. Oppenheimer SM. Neurogenic Cardiac Effects Of Cerebrovascular Disease. Curr Op Neurol. 1994;7:20-24.

15. Robinson TG, James M, Youde J, Panerai R, Potter J, Cardiac Baroreceptor Is Impaired After Acute Stroke. Stroke. 1997;28:1671-6.

16. Yoshida N, Nozawa T, Igawa A, et al. Modulation Of Ventricular Repolarization And R-R Interval Is Altered In Patients With Globally Impaired Cardiac 123I-MIBG uptake. Ann Noninvasive Electrocardiol. 2001;6:55-63.

17. Nakagawa M, Takahashi N, Iwao T,et al. Evaluation Of Autonomic Influences On QT Dispersion Using The Head-Up Tilt Test In Healthy Subjects. Pacing Clin Electrophysiol. 1999;22:1158-63.

18. Korpelainen JT, Sotaniemi KA, Suominen K, Tolonen U, Myllylä VV. Cardiovascular Autonomic Reflexes In Brain Infarction. Stroke. 1994;24:787-92.

19. Tokgözoglu SL, Batur MK, Topuoglu MA, Saribas O, Kes S, Oto A, Effects Of Stroke Localization On Cardiac Autonomic Balance And Sudden Death. Stroke. 1999;30:1307-11.

20. Daniele O, Caravaglios G, Fierro B, Natalè E, Stroke And Cardiac Arrhythmias. J Stroke Cerebrovasc Dis. 2002;11:28-33.

21. Dogan U,Dogan E, Tekinalp M, et all. P-wave Dispersion for Predicting Paroxysmal Atrial Fibrillation in Acute Ischemic Stroke, Int. J. Med. Sci. 2012;9:108-114.

22. Lazar J, Busch D, Wirkowski E, Clark LT, Salciccioli L, Changes In QT Dispersion After Thrombolysis For Stroke. Int J Cardiol. 2008;125:258-62.

23. Eckardt M, Gerlach L, Welter FL. Prolongation Of The Frequency-Corrected QT Dispersion Following Cerebral Strokes With Involvement Of The Insula Of Reil. Eur Neurol. 1999;42:190-3.

24. Lazar JM, Salciccioli L. Prognostic Value Of QT Dispersion In Acute Stroke. Int J Cardiol. 2008;129:1-2.