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Night Shift Work: A Risk for Cardiac Arrhythmias?

[1]Abdullah Sokmen [2]Ekrem Aksu [3]Gulizar Sokmen [4]Enes Celik [5]Ayse Soylu [6]Mehmet Kirisci

[1] Assoc.Prof.Dr, MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiology
[2] Dr., MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiology
[3] Prof.Dr. MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiology
[4] Dr., MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiology
[5] Dr., MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Vocational School of Health services
[6] Dr., MD, Kahramanmaras Sutcu Imam University, Faculty of Medicine, Department of Cardiovascular Surgery

Abstract

Background: Shift work has been considered as a risk factor for many health problems including cardiovascular diseases. Although its association with coronary artery disease has been reported, the data about the relationship between shift work and cardiac arrhythmias is limited.

Aim: In this study, we aimed to evaluate whether night shift work is associated with changes in noninvasive electrocardiographic (QT dispersion, P dispersion and fragmented QRS morphology) and echocardiographic (atrial conduction times) predictors of atrial and ventricular arrhythmias.

Material and methods: The study included 32 night and 30 day shift workers. Echocardiographic and electrocardiographic measurements of both groups were compared.

Results: P dispersion, QT dispersion and inter-atrial conduction time was significantly increased and the ratio of presence of fragmented QRS morphology was significantly higher in night shift workers. Other metabolic and echocardiographic parameters were similar between groups.

Conclusion: Night shift work was found to be associated with significant cardiac electrical alterations such as increased P dispersion and QT dispersion, prolonged inter-atrial electromechanical delay and increased frequency of fQRS morphology. All these subclinical abnormalities may indicate an increased risk of atrial and ventricular arrhythmias in night shift workers.

Key words: shift work, electrocardiogram, fragmented QRS, atrial conduction

Corresponding Author: Abdullah Sökmen, ***e-mail:*** abdullahs27@yahoo.com, ***Address:*** Kahramanmaraş Sütçü İmam Üniversitesi, Tıp Fakültesi, Avşar kampüsü, Sağlık Uygulama ve Araştırma Hastanesi, Kardiyoloji AD, 46100, Onikişubat, Kahramanmaraş

Introduction

Cardiovascular diseases (CVD) are the leading cause of death all over the world. Atrial and ventricular arrhythmias constitute a significant portion of these diseases and are associated with increased morbidity and mortality. Early detection and close follow up of individuals carrying high risk for cardiac arrhythmias may improve the prognosis. Many diseases and conditions have been known to be associated with cardiac arrhythmias.

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Shift work has become a common feature in industrialized and rapidly growing societies. In Europe, 16-20% of the workforce are shift workers. Many different work schedules can be described as shift work, including night work, rotating, unpredictable and unscheduled shift work, split shifts, on-call work, variable/flexible working time, prolonged duty periods, and non-standard working hours. The prevalence of shift work-related disorders in the general population may be to 5 %. Shift work has been considered as a risk factor for many health problems including endocrine, metabolic, gastrointestinal, pschyatric and cardiovascular diseases (1-3). Although its association with coronary artery disease has been reported, the data about the relationship between shift work and cardiac arrhythmias is limited. In literature there are few studies reporting prolongation of QT interval, which is a predictor of malign ventricular arrhythmias, in these patients (2,3). But, there is a paucity of data about the effect of night shift work on other electrocardiographic and echocardiographic predictors of arrhythmias. In this study, we aimed to evaluate whether night shift work is associated with changes in noninvasive electrocardiographic (QT dispersion, P dispersion and fragmented QRS morphology) and echocardiographic (atrial conduction times) predictors of atrial and ventricular arrhythmias.

Material and Methods

Patient Selection

This study included 32 health stuff working during night shift for at least 6 months (between 16.00-08.00) and 30 health stuff working during day shift for at least 6 months (between 08.00-16.00). The participants were grouped as night shift workers and day shift workers. The exclusion criteria were age<18 years, hypertension, coronary artery disease, heart failure, collagen tissue diseases, morbid obesity, smoking, alcohol use, valvular heart disease, rhythm disturbances, bundle branch blocks, usage of drugs affecting cardiac conduction and electrolyte disturbances. Blood pressures were measured from left arm on sitting position by a calibrated sphygmomanometer according to recommendations of American Heart Association. Height and weight of the participants were recorded and body mass index (BMI) was calculated.

Laboratory Analysis

Venous blood samples were taken from all participants after 12 hours of fasting. Complete blood count including hemoglobin level and leukocyte, neutrophil and thrombocyte count was measured from blood samples collected into tubes with EDTA. Biochemical parameters including fasting blood glucose (FBG), aspartate aminotransferase (AST), alanine aminotransferase (ALT), total cholesterol, triglyceride, LDL cholesterol, HDL cholesterol, C-reactive protein (CRP) and thyroid stimulating hormone (TSH) were measured from blood samples after centrifugation and serum separation.

Electrocardiography

Standard 12- lead ECG samples were taken from all participants after work at 25 mm/sec velocity on a standard ECG paper with 0.16-100 Hz filter range and 10 mm/mV voltage. Two cardiologist who were blinded to patient data measured P wave duration and QT interval from ECG

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samples by using a 10-fold magnification lens. P wave duration (ms) was measured from all derivations as the time between the onset and the termination point of P wave. P dispersion (Pd) was calculated as the difference between maximum (Pmax) and minimum (Pmin) P wave durations obtained from 12 derivations. QT interval was measured from the beginning of the QRS complex to the end of the T wave. QT dispersion (QTd) was defined as the difference between the longest (QTmax) and the shortest (QTmin) QT intervals obtained from 12 derivations. Fragmented QRS (fQRS) morphology was defined as the presence of an additional R wave (R'), or notching in the nadir of the R wave or the S wave in the presence of normal QRS interval or the presence of >1 R' (fragmentation) in 2 contiguous leads corresponding to a major coronary artery territory (Figure 1) (4).

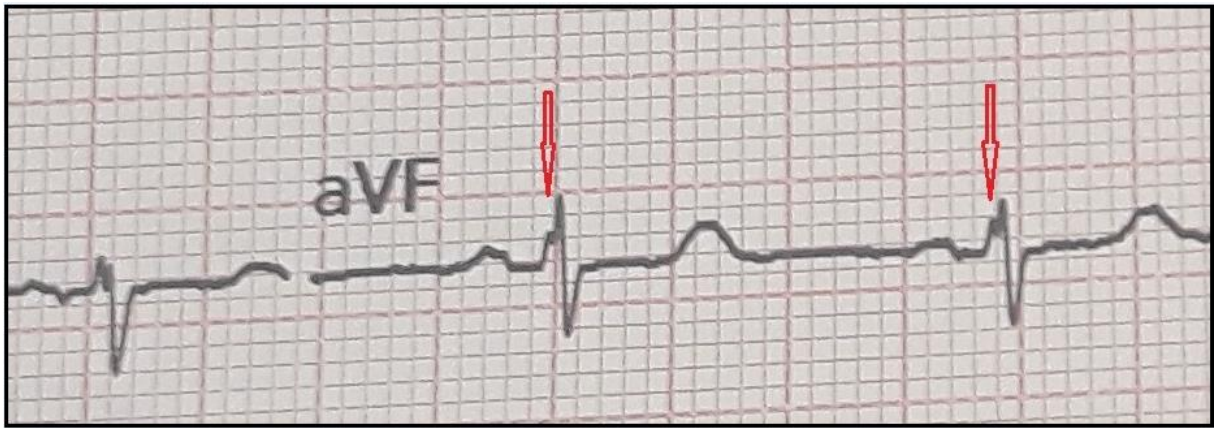

Figure 1: Fragmented QRS morphology on aVF derivation of surface ECG (arrows)

Transthoracic Echocardiography

Echocardiographic examinations were performed from left lateral decubitus position by using Vivid 7 (General Electric, Horten, Norway, 2-4 MHz phased array transducer) echocardiography machine. Echocardiographic measurements were taken together with simultaneous ECG recording by an experienced cardiologist as the average of three cardiac cycles. The measurements of left atrium (LA), aorta, left ventricular end-systolic (LVSD) and end-diastolic (LVDD) diameters, diastolic thickness of interventricular septum (IVSd) and posterior wall (PWd), left ventricular ejection fraction (LVEF) and diameter of right ventricle (RV) were obtained by M-mode echocardiography from parasternal long axis view based on the guidelines of American Society of Echocardiography. The areas of left and right (RA) atriums were obtained from apical four chamber view (5). Mitral early diastolic (E), and late diastolic (A) velocities were measured with

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PW Doppler during diastole by placing sample volume to the tips of mitral leaflets, and E/A ratio was calculated.

Tissue Doppler Echocardiography (TDE) was performed with transducer frequencies of 3.5-4.0 MHz using a 5 mm pulsed Doppler sample volume. Spectral Doppler signal filters were set to obtain a Nyquist limit of 15 to 20 cm/s with minimal optimal gain settings. The sweep speed was set at 50 to 100 mm/s. A single lead ECG was recorded simultaneously during measurements. In the apical four chamber view, the sample volume was subsequently placed at the level of LV lateral mitral annulus, septal mitral annulus and RV tricuspid annulus. The sampling window was positioned as parallel as possible to the myocardial segment of interest to obtain the optimal angle of imaging. Time intervals from the onset of P wave on the surface ECG to the beginning of the A wave (late diastolic velocity of myocardium), named as PA interval (PA) representing atrial conduction were obtained from lateral mitral annulus, septal mitral annulus, and tricuspid annulus and named PA lateral, PA septum and PA tricuspid respectively. The difference between PA lateral and PA tricuspid (PA lateral-PA tricuspid) was defined as inter-atrial electromechanical delay (EMD), the difference between PA lateral and PA septum was defined as intra-atrial EMD (PA septum-PA tricuspid).

Ethical Approval

Informed consent was obtained from each patient before enrollment. The study was in compliance with the principles outlined in the Declaration of Helsinki and was approved by our institutional ethics committee.

Statistical Analysis

Data were analyzed with SPSS for Windows version 22 (SPSS Inc., Chicago, IL, United States). Shapiro-Wilk test was used to test the normality of distribution for continuous variables. Continuous variables were expressed as means ± standard deviation and median (25% quartile-75% quartile). Categorical data were presented as numbers and percentages. Difference between groups was detected using chi-square test for categorical variables. Mean values of continuous variables were compared between groups using Student's t-test or Mann-Whitney U-test according to whether normally distributed or not. P value of <0.05 was considered statistically significant.

Results

Demographic features of the groups were shown in Table 1. There was no significant difference between groups with regard to age, gender, systolic and diastolic blood pressure, heart rate and BMI.

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Table 1. Demographic features of the groups

	Night shift workers (n:32)	Day shift workers (n:30)	P value
Age (year)	28.34±3.27	29.30±3.78	0.291
Sex, men n (%)	15 (46.9)	12 (40.0)	0.585†
SBP (mmHg)	123.44±7.87	122.50±9.716	0.677
DBP (mmHg)	75.16±8.18	77.00±6.77	0.339
Weight (kg)	78.72±11.42	78.23±8.67	0.852
Height (m)	1.68±0.07	1.66±0.09	0.335
BMI (kg/m^2)	24.17±3.15	25.52±3.56	0.147
Heart rate (beat/m)	78.75±11.42	78.23±8.67	0.852

SBP; Systolic blood pressure, DBP; Diastolic blood pressure, BMI; Body mass index
Independent samples t test, †;Chi-Square test

Laboratory measurements of the groups including hemoglobin, leukocyte count, thrombocyte count, FBG, AST, ALT, triglyceride, LDL-cholesterol, HDL-cholesterol, TSH and CRP levels were similar between groups (Table 2).

Table 2. Laboratory data of the groups

	Night shift workers (n:32)	Day shift workers (n:30)	P value
FBG (mg/dL)	85.25±7.19	86.71±6.33	0.422
Total cholesterol (mg/dL)	165.25±36.27	171.43±36.83	0.512
LDL cholesterol (mg/dL)	109.54±38.32	117.30±33.29	0.402
HDL cholesterol (mg/dL) (Q1-Q3)	37.10 (22.60-44.70)	29.95 (22.60-42.90)	0.471†
Triglyceride (mg/dL), median (Q1-Q3)	106.00 (60.00-145.00)	100.00 (66.00-137.75)	0.868†
AST (UI/L)	22.22±8.10	19.15±4.26	0.070
ALT (UI/L) median (Q1-Q3)	19.00 (13.03-36.05)	18.35 (14.15-27.45)	0.531†
CRP (mg/L) median (Q1-Q3)	3.02 (3.02-3.02)	3.02 (3.02-3.14)	0.636†
TSH (mIU/L) median (Q1-Q3)	2.17 (1.48-2.78)	1.88 (1.23-3.03)	0.709†
Hemoglobin (gr/dL)	14.06±2.71	13.78±1.40	0.601
Leukocyte (/mL)	7.69±2.42	7.52±2.30	0.772
Thrombocyte (/mL)	260.81±50.20	281.46±57.32	0.136

FBG; Fasting blood glucose, AST; Aspartate aminotransferase, ALT; Alanin aminotransferase, CRP; C-reactive protein, TSH; Tyroid stimulating hormone.
Independent samples t test; †Mann-Whitney U test

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Standard echocardiographic parameters of the groups were given in Table 3. Cardiac structural parameters including LVDD, LVSD, IVSd, PWd, diameter of aorta, diameter of RA, areas of LA and RA, diameter of RV were similar between groups. The diameter of LA was mildly but significantly increased in night shift workers (p=0.031). There was no significant difference between groups considering cardiac functional parameters including LVEF and E/A ratio.

Table 3. Standard echocardiographic parameters of the groups

	Night shift workers (n:32)	Day shift workers (n:30)	P value
LVDD (mm)	42.81±2.53	42.30±2.61	0.436
LVSD (mm)	29.72±3.21	28.33±3.50	0.110
LVEF (%)	67.03±2.72	66.80±1.86	0.699
IVSd (mm)	9.28±1.25	9.53±1.31	0.441
PWd (mm)	8.47±1.14	8.67±1.24	0.515
LA, diameter (mm)	30.88±2.17	29.10±3.95	**0.031***
RA, diameter (mm)	31.32±2.81	30.00±5.09	0.264
Aorta (mm)	21.63±2.70	21.50±2.37	0.847
LA, area (mm^2)	13.29±1.49	13.54±1.29	0.534
RA, area (mm^2)	12.00±1.19	12.26±1.11	0.423
RV, diameter (mm)	28.19±3.67	27.50±2.36	0.387
E/A ratio	1.46±0.37	1.32±0.25	0.089

LVDD; Left venricular diastolic diameter, LVSD; Left ventricular systolic diameter, IVSd; Diastolic thickness of interventricular septum, PWd; Diastolic thickness of posterior wall, LVEF; Left ventricular ejection fraction, LA; Left atrium, RA; Right atrium, E: Early diastolic velocity, A: Late diastolic velocity.
Independent samples t test; *Difference is statistically significant

Of the predictors of arrhythmia, Pd, QTd and inter-atrial EMD was significantly increased in night shift workers as compared to day shift workers (p<0.001, p=0.015 and p=0.044 respectively). Similarly, the ratio of presence of fQRS morphology on ECG was significantly higher in night shift workers (p=0.02) (Table 4).

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Table 4. Electrocardiographic and echocardiographic predictors of arrhythmia in the groups

	Night shift workers (n:32)	Day shift workers (n:30)	P value
Heart rate (beat/m)	74.11±10.68	72.72±6.97	0.566
Pmax (ms)	99.23±10.26	93.62±8.12	**0.028***
Pmin (ms)	68.65±8.78	72.41±7.27	0.088
Pd (ms)	30.83±9.28	21.29±5.98	**<0.001***
QTmax (ms)	367.69±28.75	373.10±18.54	0.406
QTmin (ms)	328.27±32.71	346.21±19.16	**0.015***
QTd (ms)	38.96±11.79	27.41±7.64	<0.001
fQRS, present n(%)	19(59.4)	9(30)	**0.020†***
PA Lateral (ms)	68.41±4.74	65.93±9.09	0.180
PA Septum (ms)	60.22±4.88	58.87±7.93	0.419
PA Tricuspid (ms)	52.47±5.19	52.07±6.54	0.789
Inter-atrial EMD (ms)	15.94±3.25	13.86±4.61	**0.044***
Intra-atrial EMD (ms) median (Q1-Q3)	7.75±1.78	6.80±2.91	0.123

Pmax; Maximum P wave duration, Pmin; Minimum P wave duration, Pd; P dispersion, QTmax; Maximum QT interval, QTmin; Minimum QT interval, QTd; QT dispersion, fQRS; Fragmented QRS, PA; Time interval from the onset of P wave to the beginning of the A wave, EMD; Electromechanical delay, inter-atrial EMD; PA lateral-PA tricuspid, intra-atrial EMD; PA septum-PA tricuspid,
Independent samples t test; †Chi-Square test * difference is statistically significant;

Discussion

Since the last decades of the last century, the proportion of workers engaged in the typical 7–8 a.m.to 5–6 p.m. Monday to Friday working schedule has been steadily decreasing (3). Shift-work alters the sleep/wake cycle, producing a disruption of the circadian rhythms of biological functions and thus causes an imbalance in homeostasis of the body that leads to internal desynchronization (6,7). A number of chronic diseases including cardiovascular diseases, gastrointestinal disorders, peptic ulcers, diabetes, obesity, sleep disorders, depression, cancers, and other chronic conditions such as immune depression, excessive sleepiness, insomnia, unconscious sleep, reduced alertness and performance capacity during work, and chronic fatigue have been related to shift-work (2,8).

Shift work can increase the risk of CVD by several interrelated psychosocial and physiological mechanisms. The psychosocial mechanisms relate to difficulties in controlling working hours, decreased work–life balance, and poor recovery following work. The most probable physiological and biological mechanisms are related to the activation of the autonomic nervous system, inflammation, changed lipid and glucose metabolism, and related changes in the risk

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for atherosclerosis, metabolic syndrome, and type II diabetes (9).

It has been known that people subject to circadian desynchrony exhibit several metabolic disturbances such as increased cortisol, decreased TSH, decreased insulin sensitivity, increased glucose level and tendency to dyslipidemia (9). In our study, metabolic parameters including FBG, TSH and cholesterol levels were found to be similar between groups. Since night shift workers were young (mean age 29 years) in our study, negative effects of circadian desynchrony on metabolic parameters may not be manifest yet.

In addition to metabolic disturbances, shift work may also be a risk factor for the development of cardiac arrhythmias as a consequence of the related lifestyle changes, jobstrain and stress, social stres and circadian desynchrony. In this study, we evaluated noninvasive predictors of atrial and ventricular arrhythmias including Pd, atrial EMD, QTd and fQRS morphologyby using ECG and echocardiography in night shift workers.

Among cardiac arrhythmias, atrial fibrillation (AF) is the most common arrhythmia encountered in clinical practice, and associated with significant mortality and morbidity due to hemodynamic impairment and thromboembolic events. Impaired atrial conduction is an important step in the pathophysiology of AF. Atrial conduction times can be evaluated by both invasive (electrophysiological study) and noninvasive (Pd on ECG and atrial EMD on echocardiography) methods. It has been shown that prolongation of Pd and inter- or intra-atrial EMD is an independent predictor for development of AF (10-13). In our study, both inter-atrial EMD and Pd was found to be prolonged significantly in night shift workers meaning the risk of atrial arrhythmias may be increased in these individuals.

QTd and fQRS morphology, cheap and easily available electrocardiographic parameters, indicates heterogeneous depolarization of ventricular myocardium caused by ischemia, fibrosis or chronic inflammation and has been found to be related to incrased risk of ventricular arrhythmias (14,15). In our study, we found that QTd was significantly increased and the ratio of presence of fQRS morphology was significantly higher in night shift workers. These findings may be related with increased risk of ventricular arrhythmias and resultant increase in cardiovascular mortality and morbidity in night shift workers.

To the best of our knowledge, this is the first study evaluating atrial EMD and fQRS morphology in night shift workers. In literature, few studies exploring the relationship between shift work and repolarization abnormalities (QT interval) reported conflicting results. In their study Melony et. al reported that QT was prolonged in night shift workers. Our study revealed that Pd and QTd increased, interatrial EMD was prolonged and ratio of fQRS increased in night shift workers. These cardiac electrical changes may be caused by circadian desynchrony leading to increased sympathetic activity and subclinical inflammation. Additionally, night shift-related lifestyle changes, jobstrain and stress, social stres, difficulties in controlling working hours, decreased work–life balance, and poor recovery following work may contribute to development of cardiac electrical abnormalities (2,3,8,9).

Study limitations

First limitation of the study was relatively small number of participants. Another significant limitation of the study is the lack of Holter ECG monitoring to document the relationship between electrical abnormalities and arrhythmias. Larger studies with longer follow-up periods are needed to detect the prognostic value of these electrical alterations, to assess their persistency and to document their relationship with long term cardiovascular complications in night shift workers.

Conclusion

In conclusion, night shift work was found to be associated with significant cardiac electrical alterations such as increased Pd and QTd, prolonged inter-atrial EMD and increased frequency of fQRS morphology. All these subclinical abnormalities may indicate an increased risk of atrial and ventricular arrhythmias in night shift workers.

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