ECG Changes in Young Healthy Smokers: A Simple and Cost-Effective Method to Assess Cardiovascular Risk According to Pack-Years of Smoking

Nirmal Kumar Sharma¹, Kapil Kumar Jaiswal², SR Meena³, Rahul Chandel⁴, Saurabh Chittora⁴, Prem Singh Goga², HB Harish², Rajesh Sagar⁵

Abstract

Objective: To document the prevalence of ECG abnormalities in young healthy smokers and compare ECG changes in smokers, young healthy non-smokers and amongst smokers with different pack years.

Methods: This was a prospective case-control study consisting of 200 young healthy male and female individuals, 150 smokers and 50 non-smokers between ages 25-40 years, further categorized and compared according to age, sex and pack years of smoking. The ECG recordings were analyzed for different ECG parameters like heart rate, P-wave duration, P-wave amplitude, PR interval, QRS duration, RR-interval, ST-segment duration, QT interval and QTc interval. The results were compared using statistical tools.

Results: In present study abnormalities in ECG parameters were significantly more prevalent in smokers as compared to non-smokers (56.66 % Vs 6.00 %) (p<.0001). Heart rate and QTc-interval increased with increase in the number of pack-years. This increase was reflected more in female with a similar number of pack years. P-wave amplitude tended to increase with increase in the number of pack years more so in males. P-wave duration, PR-interval, QRS-duration and RR-interval tended to decrease with increase in the number of pack years more so in females with similar number of pack years. QT-interval and ST-segment duration tended to decrease with increase in the number of pack years more so in males.

Conclusion: ECG abnormalities in this study indicate cardiovascular risk in term of cardiac arrhythmia, pulmonary arterial hypertension, heart blocks etc in such subjects. As this procedure is non-invasive and cost effective it is potentially an effective and yet a simple method for cardiovascular risk evaluation in smokers. Furthermore, such ECG abnormalities may guide the clinician for risk evaluation in smokers and may be used to convince the smokers to quit smoking.

Introduction

In India, Cardiovascular diseases are projected to be the most common cause of death and disability by 2020. 2.6 million Indians are predicted to die due to coronary heart disease, which constitute 54.1% of all cardiovascular disease deaths. Nearly half of these deaths are likely to occur among young and middle-aged individuals (30-69 yrs). More than 80% of tobacco-related deaths will occur in low and middle-income countries by 2030 and expected to increase about 1 billion during this century.

In India, according to a nationwide survey 184 million used tobacco and It kills 8 lakh people every year, according to Indian council of medical research (ICMR) which amounts to 2200 people dying every day from...
tobacco related diseases. Also revealed that each patient suffering from tobacco related disease costs country Rs. 2.5 million through direct medicinal costs, absenteeism, and loss of income due to premature death.4 Nicotine, an alkaloid, increases the vulnerability to various ventricular arrhythmias and causes sudden cardiac death6 and responsible for smoking-related Cardiovascular Diseases (CVD) such as arteriosclerosis and peripheral arterial occlusive disease.7

A 12-lead electrocardiogram (ECG) is a routine, inexpensive tool for assessment of cardiovascular disease in both clinical and research setting and ECG changes powerfully predicts future CVD events.8,9 Hence the present study is carried out to demonstrate the effects of smoking on electrocardiogram and thereby creating awareness and the potential benefits of primordial prevention in such population.

Material and Method

This study was carried out in the Department of Medicine, Government medical college and associated group of hospitals, Kota, Rajasthan from January 2015 to December 2015. 200 young and healthy individuals between ages 25-40 years of both sex, selected from individuals attended the outpatient department.

Details of smoking habit i.e. duration and quantum of smoking, were obtained from smokers. For each subject in the smoker group, number of pack years of smoking was calculated (Number of Pack Years = Average number of packs of cigarette smokes per day x Total number of Years of smoking).10 (One packet =10 cigarette/bidi). Effect of filter in cigarette was considered negligible in this study. 

The subjects were divided into two groups: 
2. Group-B (All Smokers): 150 young and healthy smokers, sub divided as follows
   a. Light smokers- 1-5 pack years,
   b. Moderate smokers- 6-10 pack years
   c. Heavy smokers- 11-15 pack years

Patients with diagnosed hypertension, history of cardiac, respiratory, renal and endocrine disorders, abuse of alcohol and other psychoactive substances, family history of hypertension and cardiac diseases, history of anxiety or depressive disorders, were excluded.

ECG Recording and Evaluation

In all subjects, a 12-lead ECG was recorded by using a standard Multi channel Mortara ELI230 ECG recorder and ECG was evaluated and analyzed for The various ECG parameters namely Heart rate, P wave amplitude, P-wave duration, PR-interval, QRS-duration, RR-interval, QT and QTc interval and ST segment duration were measured. Results were statistically analyzed by using the Student’s ‘t’ test. The probability (p-value) was calculated. p-value of <0.001 was taken as highly significant, a p-value of <0.05 as significant and a p-value of >0.05 as non- significant.

Results

Mean age of smokers was 34.15 ± 4.19 years and mean age of non-smokers was 33.44 ± 4.18 years. Both groups were age matched (p=0.3001). In this study, abnormalities in ECG parameters were significantly more likely to be prevalent in smokers as compared to non-smokers (56.66% Vs 6.00%) (p<0.0001) (Table 1).

When various ECG parameters compared between non-smokers and smokers, we observed that mean value of Heart rate, QTc interval (p<0.0001) and P-wave amplitude (p=.0074) were significantly increased in smokers. Mean value of P-wave duration (p=.0044), PR interval (p=.0008), ST segment (p<0.0001) and RR-interval (p<0.0001) were significantly decreased in smokers (Table 2).

As compared to non-smokers, we observed that mean value of heart rate and QTc interval were significantly increased (p<0.0001) in female smokers while mean value of P-wave amplitude was significantly increased (p=.0068) in male smokers. Mean values of P-wave duration (p=.0014), PR interval (p=.0043) and RR-interval (p<0.0001) were significantly decreased in female smokers while

Table 1: Prevalence of ECG abnormalities between young healthy smokers and non-smokers

<table>
<thead>
<tr>
<th>ECG with abnormalities</th>
<th>Non-smokers (n=50)</th>
<th>Smokers (n=150)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG with abnormalities</td>
<td>3 (6%)</td>
<td>85 (56.66%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>ECG without abnormalities</td>
<td>47 (94%)</td>
<td>65 (43.33%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Comparison of ECG parameters between non-smokers and smokers

<table>
<thead>
<tr>
<th>ECG -parameters</th>
<th>Non-smokers (n=50)</th>
<th>Smokers (n=150)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>72.74 ± 5.92</td>
<td>91.55 ± 13.16</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>P-wave duration (ms)</td>
<td>83.60 ± 9.63</td>
<td>79.00 ± 9.81</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>P-wave amplitude (mV)</td>
<td>0.143 ± 0.049</td>
<td>0.165 ± 0.050</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>PR-interval (ms)</td>
<td>141.46 ± 17.83</td>
<td>132.00 ± 16.77</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>QRS-duration (ms)</td>
<td>86.34 ± 11.13</td>
<td>84.87 ± 9.39</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>ST-segment duration (ms)</td>
<td>120.00 ± 9.03</td>
<td>101.87 ± 21.93</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>R-R interval (ms)</td>
<td>823.80 ± 46.01</td>
<td>666.08 ± 94.91</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>QT-interval (ms)</td>
<td>342.86 ± 17.89</td>
<td>336.05 ± 30.17</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>QTc-interval (ms)</td>
<td>377.90 ± 20.88</td>
<td>413.90 ± 34.17</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

All values mean ± SD
Table 3: Comparison of ECG parameters between male, female smokers and non-smokers

<table>
<thead>
<tr>
<th>ECG-parameters</th>
<th>Non-smokers (n=50) (A)</th>
<th>Male smokers (n=120) (B1)</th>
<th>Female smokers (n=30) (B2)</th>
<th>p-value (A-B1)</th>
<th>p-value (A-B2)</th>
<th>p-value (B1-B2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>72.74 ± 3.92</td>
<td>90.98 ± 12.65</td>
<td>93.87 ± 15.07</td>
<td>&lt;p=.0001</td>
<td>&lt;p=.0001</td>
<td>&lt;p=.2836</td>
</tr>
<tr>
<td>P-wave dur. (ms)</td>
<td>83.60 ± 9.63</td>
<td>79.92 ± 8.84</td>
<td>75.33 ± 12.52</td>
<td>p=.0171</td>
<td>p=.0014</td>
<td>p=.0214</td>
</tr>
<tr>
<td>P-wave amp. (mV)</td>
<td>0.143 ± 0.049</td>
<td>0.170 ± 0.062</td>
<td>0.160 ± 0.048</td>
<td>p=.0068</td>
<td>p=.8057</td>
<td>p=.8255</td>
</tr>
<tr>
<td>PR-interval (ms)</td>
<td>141.46 ± 17.83</td>
<td>132.60 ± 16.78</td>
<td>129.60 ± 16.79</td>
<td>&lt;p=.0024</td>
<td>&lt;p=.0043</td>
<td>&lt;p=.3827</td>
</tr>
<tr>
<td>QT-interval (ms)</td>
<td>377.90 ± 20.88</td>
<td>407.91 ± 32.22</td>
<td>437.87 ± 31.59</td>
<td>p=.0014</td>
<td>&lt;p=.0001</td>
<td>&lt;p=.0001</td>
</tr>
</tbody>
</table>

All values mean ± SD

mean values of ST segment duration (p<.0001) and QT interval (p=.0249) were significantly decreased in male smokers. Also, as compared to male smokers, it was observed that mean value of P-wave duration was significantly decreased in female smokers while mean values of QT and QTc-interval were significantly increased in female smokers (Table 3).

Heart rate, P-wave amplitude and QTc interval increased as the age increases and were significantly higher in 36-40 years age group smokers when compared with non-smokers and other age group smokers (p<0.05). Mean value of RR-interval and QT interval decreased as the age increases and were significantly decreased in 36-40 years age group smokers when compared with non-smokers and other age group smokers (p<0.05). Also, mean value of PR interval and ST segment duration were significantly decreased in 31-35 year age group when compared with non-smokers (p<.001) and not significant when compared with other age group smokers (p>.05) (Table 4).

Amongst non-smokers and smokers (divided into 1-5, 6-10 and 11-15 pack year groups) for various ECG parameters, we observed that mean value of heart rate (72.74 ± 3.92 Vs 79.62 ± 8.32 Vs 89.04 ± 5.76 Vs 106.00 ± 7.73 beats/ min.), P-wave amplitude (0.143 ± 0.049 Vs 0.150 ± 0.054 Vs 0.160 ± 0.053 Vs 0.170 ± 0.062 mV) and QTc interval (377.90 ± 20.88 Vs 400.32 ± 25.92 Vs 416.93 ± 34.06 Vs 424.47 ± 37.15 msec) respectively, increased as the pack years of smoking increases. This rise was significantly high (p<0.001) in 11-15 pack year group smokers when compared with non-smokers and other pack year group smokers. Similarly, mean value of ST segment duration (120.00 ± 9.03 Vs 114.60 ± 21.30 Vs 101.80 ± 17.80 Vs 89.20 ± 19.04 msec), RR-interval (823.80 ± 46.01 Vs 757.60 ± 71.75 Vs 673.82 ± 44.66 Vs 568.90 ± 36.47 msec) and QT interval (342.86 ± 17.89 Vs 347.74 ± 24.83 Vs 341.96 ± 26.19 Vs 318.44 ± 31.21 msec) decreased as the number of pack years increases and were significantly (p<0.001) decreased in 11-15 pack year group smokers when compared with non-smokers and other pack year groups smokers. Also, P-wave duration and PR interval decreased as the number of pack years increase and were significantly (p<0.001) decreased in 11-15 pack year group smokers when compared with non-smokers, however it was not significant when compared with other pack year group smokers (p>.05) (Table 5).

Discussion

In this case-control study, it was found that abnormalities in ECG parameters were more likely to be prevalent in smokers as compared to non-smokers. We found that the resting Heart rate...
Heart rate (beats/min) 72.74 ± 3.92 79.62 ± 8.32 89.04 ± 5.76 106.00 ± 7.73

Increase in resting heart rate is an indicator of high sympathetic tone. Increase in QTc-interval may because of ventricular repolarization altered in young smokers. The difference in the heterogeneity of ventricular repolarization between smokers and non-smokers are mainly due to heart rate difference between two groups.

In our study, we have tried to establish a newer cardiovascular risk stratification method for coronary artery disease in smokers in term of ECG changes depending upon number of pack years and factors like age and sex of the patients. Different ECG parameters were statistically compared between different groups of patients taking into account age, sex, quantity and duration of smoking in terms of pack years.

So, interestingly majority of ECG abnormalities as mentioned here tended to be more prevalent in females as compared to males with a similar number of pack years and more the number of pack years greater the prevalence of ECG abnormalities. Thus, this study establishes that smoker females were more prone to have cardiac morbidity as compared to males with a similar number of pack years. In the general population, major and minor ECG changes predict increased mortality. Individuals who smoke are more likely to have ECG findings consistent with ischemic heart disease, structural heart disease, and cardiac rhythm disorders. Such changes have been found even in young individuals with lesser number of pack years.

The relevance of this study lies in the fact that such ECG abnormalities in smokers identify the patients of different sex and age groups noninvasively who would be at risk to have cardiac morbidity and mortality in the future. So, the present study provides a cost effective, non-invasive cardiovascular disease risk stratification in smokers.

**Conclusion**

This study clearly showed the importance of ECG evaluation in young healthy smokers. These ECG abnormalities indicate cardiovascular risk in term of cardiac arrhythmia, pulmonary arterial hypertension, heart blocks etc in such subjects. Also, in past studies have noted similar ECG abnormalities in young smokers. As this procedure is non-invasive, cost effective, easily available and simple to evaluate so it is potentially an effective and yet a simple method for cardiovascular risk evaluation in smokers. Further large scale studies may be required to see whether these ECG abnormalities reverse after quitting smoking, if so after how much time? Furthermore, such ECG abnormalities may guide the clinician for risk evaluation in smokers and may be used to...
convince the smokers to quit smoking.

Abbreviations

AMP: Amplitude; AV: Atrio-ventricular; CVD: Cardiovascular disease; DUR: Duration; ECG: Electrocardiography; ICMR: Indian Council of Medical Research; ms: milliseconds; mV: millivolt; PY: Pack Year; QTc: Corrected Qt Interval; SD: Standard deviation; WHO: World Health Organization

Acknowledgement

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References