Effect of Tobacco Use on Arterial Stiffness in Community Dwelling Females

Sandeep Jain¹, Shyam Mathur², Arvind Mathur³, Shuchi Mathur⁴, Harish Agarwal⁵, Tuhin Dubey⁶, Manish Kulshrestha⁶, Jitendra Butolia⁶

Abstract

Aims: The goal of this study was to investigate the changes in arterial stiffness by evaluation of arterial stiffness index and pulse wave velocity in community dwelling tobacco user females and to correlate those changes with duration of tobacco use, amount consumed and severity of addiction.

Methods: This observational cohort study was conducted in Department of Medicine at Dr. S N Medical College, Jodhpur, comprised of 100 females, out of which 55 were community dwelling females using tobacco (cases) and 45 are age-sex matched healthy control group. Out of 55 tobacco user females 21 (38%) were smoker and 34 [62%] were smokeless tobacco user. Pulse wave velocity and arterial stiffness index were evaluated by means of an 8-channel real-time PC-based simultaneous acquisition and analysis system (Periscope).

Results: Average C-F PWV in tobacco user female was 1327±515.2 as compared to 796±157.3 in control and average ASI was 71±20.9 in tobacco user female as compared to 62±13.9 in control that is statistically significant (p=<.05). Both C-F PWV and ASI were significantly higher in tobacco user than control. Average C-F PWV in smoker group is 1683±566.7 as compared to 1108±387.9 in smokeless group. Average ASI is 76±22.9 in smoker group as compared to 66±18.9 in smokeless tobacco user group. Both C-F PWV and ASI were higher in smoker group than smokeless group that is statistically significant (P Value 0.0018).

Conclusions: This study has demonstrated that PWV and ASI are increased in tobacco user females and they are independent predictor of cardiovascular morbidity. Tobacco use either smoking or smokeless causes atherovascular diseases. Smoking is more prone to increase atherosclerosis and cardiovascular morbidity in comparison to smokeless tobacco use.

Abbreviations: C-F PWV (Carotid Femoral Pulse Wave Velocity), PWV (Pulse Wave Velocity), ASI (Arterial Stiffness Index).

Introduction

Tobacco consumption is a major source of cardiovascular mortality and morbidity. Smoking is generally five times more prevalent among males than females.¹ In developed countries smoking rates for men have peaked and have begun to decline, however for women they continue to climb.² India has a huge problem of widespread tobacco use among women, particularly among disadvantaged women.³ Several ingredients of tobacco lead to atherosclerotic disease like stroke, myocardial infarction and peripheral vascular disease. According to a study by an international team of researchers, people under 40 are five times more likely to have a myocardial infarction if they smoke.⁴ In the present study, we have done risk stratification of atherosclerosis in tobacco user females by a newly developed simple non-invasive device (periscope), which measures arterial stiffness in terms of peripheral and central PWV and arterial stiffness index.⁵ We correlated these changes in arterial stiffness with duration of tobacco use, amount consumed, and severity of addiction. Arterial stiffness is independently related to cardiovascular adverse event, indicating that specific assessment of it, may be of greater value in detection of arterial disease, not only clinically overt but also sub clinical asymptomatic. So assessment of arterial stiffness in tobacco user female is a worthwhile screening test for future coronary event.

Materials and Methods

Present study was conducted in Department of Medicine at Dr. S N Medical College, Jodhpur. Females (age greater than or equal to 15 years.) who were using tobacco in any form were enrolled in the study group while the control group consisted of normal healthy age matched, non tobacco consuming females. Subjects suffering from ischemic heart disease, chronic renal disease and other co-morbid conditions were excluded from our study. A pretested Performa was used to interview the study subjects. The Performa contained questions pertaining to the demographic profile, socioeconomic characteristics, and tobacco consumption habits and Fagerström addiction scale for smokers⁶ and smokeless tobacco⁷ both. Complete clinical examination; Anthropometric measurements including BMI, Routine biochemical analysis including markers of atherosclerosis. Evaluation of ASI and PWV was done by using the instrument Periscope i.e. an 8-channel real-time PC-based simultaneous acquisition and analysis system (M/S Genesis Medical Systems, Hyderabad, India). It has dedicated hardware module connected to 4 ECG electrodes and 4 blood pressure measuring cuffs. The report contains 8-second traces of Lead I and II ECG, all pressure pulse waveforms and all calculated results. PWV was determined by a non-invasive pulse wave analyzing device. Participants were asked to refrain from smoking and drinking caffeine-containing beverages 12h before the test. They were also advised not to take their morning dose of medicine on the day of procedure, before completing the test. Procedure had been performed in the morning hours between 9 and 11 a.m. with subject resting in supine position at least for 10 min before the recording. Electrodes for electrocardiogram were placed on ventral surface of both wrists and medial side of ankles. BP cuffs were wrapped on both upper arm brachial artery and tibial artery above ankles. The cuffs were connected to a plethysmographic sensor, which determines volume pulse...
form and an oscillometric pressure sensor, which measures blood pressure volume waveforms from the brachial and tibial arteries. All the pressure recordings were done for about 10 s and data was stored in the computer for analysis. Software was applied to calculate the following parameters from the waveforms, which are stored in the computer for analysis like - systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), pulse pressure (PP), heart rate (HR), heart pressure (MAP), pulse pressure (PP), heart rate (HR), heart.

Results

The present study comprised of 100 females, out of which 55 were community dwelling females using tobacco (cases) and 45 are age-sex matched healthy control group. Out of 55 tobacco user females 21 (38%) The present study comprised of 100 females, out of which 55 were community dwelling females using tobacco (cases) and 45 are age-sex matched healthy controls. Out of 55 tobacco user females 21 (38%) were smoker and 34(62%) were smokeless tobacco users. Among females smokeless form of tobacco use was more common as compared to smoking. In tobacco user females by occupation 36% were laborers, 28% were farmers, 4% were of white collar, 32% not working (house-wife) while in control group 16% laborer, 15% farmer, 29% housewife, 40% white collar. In the present study we found that tobacco use is more common among laborers and farmers. Family history of tobacco use was present in 70% of cases while 24% in females of control group.

Table 1 shows that average C-F PWV found in tobacco user female was 1327±815.2 as compared to 796±157.3 in control groups that is statistically significant (p<.05). C-F PWV was highest in tobacco user female age group 60+ [1559±641] and lowest in Controls 20-39 age group (754±101). Average ASI was 70.6±14.2 in tobacco user females as compared to 62±13.9 in control group that is statistically significant (p<.05).ASI was highest in tobacco user female age group 60+ [79±11.5] and lowest in controls age group 20-39 [50±11.1] In each group as age increases there was increase in C-F PWV that was statistically significant (p<.05).

Figure 1 shows that Comparison of PWV and ASI was done in smokers and smokeless tobacco users. Average C-F PWV in smokers was 1683±566.7 as compared to 1108±387.9 in smokeless tobacco users. Average ASI was 76±22.9 in smokers as compared to 66±18.9 in smokeless tobacco users. Both C-F PWV and ASI were higher in smokers than smokeless tobacco users.

<table>
<thead>
<tr>
<th>Age Group (in Years)</th>
<th>Case</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20-39</td>
<td>40-59</td>
</tr>
<tr>
<td>N</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>Average C-F PWV (Normal)</td>
<td>851±162.6</td>
<td>971±113.7</td>
</tr>
<tr>
<td>Average C-F PWV (Observed)</td>
<td>1232±271.1</td>
<td>1334±509.9</td>
</tr>
<tr>
<td>Average ASI</td>
<td>55+/−9.65</td>
<td>78+/-20.68</td>
</tr>
</tbody>
</table>

Figure 1 : Distribution of C-F PWV and ASI according to type of tobacco consumed

Figure 2 : Distribution of C-F PWV and ASI according to duration of tobacco use

The relation between amount of tobacco used and CF-PWV and ASI was studied, in both smokers and smokeless tobacco users. Among smokers C-F PWV values increased with the increase in biddies used /day. The highest C-F PWV (1986±873.3) was recorded in smokers who used 20-30 biddies in a day and lowest(1057±324.4) in smokers who used <10 biddies in a day. ASI was highest (94±5.7) in smokers who used 20-30 biddies in a day and lowest (63±19.7) in smokers who used <10 biddies in a day.

Among smokeless tobacco user, the highest C-F PWV (1312±193.4) was recorded in females who used >2 sachets in a day and lowest (970±174.2) in females who used <1 sachet in a day. ASI was highest (81±29.4) in females who used >2 sachet in a day and lowest (59±14.2) in females who used ≤1 sachet in a day.

C-F PWV and ASI values increase with the increase with severity of addiction in both smoker and smokeless tobacco users. The highest C-F PWV (2027±525.8) was recorded in smokers who are highly dependent (having addiction score between 7 to 10) and the lowest (C-F PWV 834±180.3) in those who are minimally dependent (addiction score <4). ASI was highest (83±20.9) in group of highly dependent smokers and lowest (53±7.1) in who have minimal dependence. Similar relationship was found in smokeless tobacco user. The highest C-F PWV (1453±543.5) was recorded in smokeless tobacco user females who were highly dependent (having addiction score between 11 to15) and the lowest (C-F PWV 849±96.5) in those who were minimally dependent (addiction score 1-5). ASI was highest (81±20.7) in group of highly dependent smokeless tobacco user and lowest (59±11.7) in those who had minimal dependence.

We also studied correlation of C-F PWV and ASI with the various risk factors of atherosclerosis like age, BMI, hypertension, pulse pressure, ankle brachial index (ABI).

In present study both C-F PWV and ASI increased with age as described in Table 1. In study of BMI with C-F PWV and ASI, we found that both were higher in overweight[C-F PWV =1500±564.1(case)] and normal [C-F PWV =1243±382.5(case)] and underweight[C-F PWV =1243±382.5(case)]
Endothelium, induction of coronary vasoconstriction and by smoking may be due to adverse effects on the vascular endothelial dysfunction. Increased cardiovascular risk caused arterial stiffness at a peripheral.

Binder S et al. 

Increased cardiovascular risk caused arterial stiffness at a peripheral. Both C-F PWV and ASI were higher in tobacco user females than control. Our study was supported by Binder S et al. 

In this study both C-F PWV and ASI were increased with increase in Pulse Pressure. Both were highest in tobacco user females with PP >80 [C-F PWV = 1807±369.3] lower in females with PP <50 [C-F PWV = 977±225.6]. A similar trend was observed in controls also. C-F PWV and ASI were higher when pulse pressure >80 and lowest [C-F PWV = 715±95.3] when pulse pressure < 50, it was statistically significant as p<0.05.

Table 2: Distribution of C-F PWV and ASI in cases and controls according to ABI

<table>
<thead>
<tr>
<th>ABI</th>
<th>Case</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1</td>
<td>&gt;=1</td>
</tr>
<tr>
<td>N</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>Average C-F PWV (N)</td>
<td>96±125.2</td>
<td>940±156.2</td>
</tr>
<tr>
<td>Average C-F PWV (O)</td>
<td>2015±626.2</td>
<td>115±413.4</td>
</tr>
<tr>
<td>Average ASI</td>
<td>75±17.6</td>
<td>68±21.2</td>
</tr>
</tbody>
</table>

Present study shows C-F PWV and ASI were significantly higher in females with systolic blood pressure (SBP) > 140 [C-F PWV =1500±564.1 (case)] ASI=74±22.5 (case)] as compared to females with systolic blood pressure < 120 C-F PWV and ASI were found to increase as SBP increases. In this study both parameter of arterial stiffness were statistically significant (p<0.05) in correlation with SBP.

In this study both C-F PWV and ASI were increased with increase in Pulse Pressure. Both were highest in tobacco user females with PP >80 [C-F PWV = 1807±369.3] lower in females with PP <50 [C-F PWV = 977±225.6]. A similar trend was observed in controls also. C-F PWV and ASI were higher when pulse pressure >80 and lowest [C-F PWV = 715±95.3] when pulse pressure < 50, it was statistically significant as p<0.05.

Discussion

In recent years with the development of readily available noninvasive assessment techniques, investigation of arterial stiffness, especially of the large arteries, has gathered pace. For the measurement of arterial stiffness, several new techniques have been developed. Perhaps the best and most widely used technique to estimate the distensibility and stiffness of the aorta and proximal vessels is Pulse Wave Velocity (PWV).

In our study, we have used a non-invasive device, Periscope, which simultaneously records pressure wave from four limbs to calculate PWVs. The device was validated and found to have good reproducibility in PWV measurement in healthy and CAD patients. We assessed changes in arterial stiffness by evaluation of arterial stiffness index and pulse wave velocity in community dwelling females using tobacco and correlated those changes with duration of tobacco use, amount consumed, and severity of addiction. Our aim is to establish usefulness of these measurements in early detection of subclinical atherosclerosis in tobacco user females and hence, appropriate interventions, if required.

We compared the PWV and ASI in tobacco user females and controls. Both C-F PWV and ASI were higher in tobacco user female group than control. Our study was supported by Binder S et al. who investigated the effect of chronic smoking on arterial stiffness at a peripheral site using pulse wave analysis. They concluded that chronic tobacco smoking is associated with endothelial dysfunction. Increased cardiovascular risk caused by smoking may be due to adverse effects on the vascular endothelium, induction of coronary vasoconstriction and changes in basal nitric oxide (NO) or endothelial nitric oxide synthase (eNOS) protein production. In smokers they found increased values for all assessed parameters of arterial stiffness. Their results suggest that the negative effect of cigarette smoking on the vascular system can be found even in young smokers who have been smoking for less than 10 years. Our study was also supported by the study of K.K. Teo et al. who studied the effect of tobacco use and risk of myocardial infarction. They found that Tobacco use is one of the most important causes of atherosclerosis.

In the present study we did comparison of PWV and ASI in smokers and smokeless tobacco users’ group. Average C-F PWV (1683±566.7) and average ASI (76±22.9) in smokers were higher as compared to smokeless tobacco users. It suggests that smoking was more prone to increase atherosclerosis and cardiovascular morbidity in comparison to Smokeless tobacco use. Cardiovascular and other health hazards associated with the use of smokeless tobacco are poorly documented. Association of smokeless tobacco consumption with occurrence of adverse cardiovascular events like stroke and ischemic heart disease has been studied in detail in western population. Results from these studies paint a mixed picture with some showing increased incidence of these adverse events while others showing no such association.

Kjell Aslund et al. studied to explore whether the use of snuff, a smokeless tobacco product, increases the risk of stroke in men. In a nested case-control study (1 case and 2 matched controls without cardiovascular disease), information on tobacco habits was collected through population risk factor surveys. They concluded that regular smoking doubles the risk of stroke in men, while snuff use (a form of smokeless tobacco use) is not associated with any apparent excess risk. Chemical moieties produced by burning tobacco are probably the most important contributors to smokers’ excess risk of atherothrombotic disease, including stroke.

In our study C-F PWV and ASI values increase with the increase in duration of tobacco use, amount consumed and with severity of addiction for tobacco. The highest C-F PWV and ASI was recorded in cases who used tobacco for duration of >15 years and the lowest in those with duration of ≤5 years. We studied the relation between amount of tobacco use and CF-PWV and ASI, in both smoker and smokeless tobacco user.

Among smokers C-F PWV values increased with the increase in bidis used/day. The highest C-F PWV and ASI were recorded in cases who used >30 bidis in a day and lowest in cases who used <10 bidis in a day. Among smokeless tobacco users the highest C-F PWV and ASI were recorded in cases who used >2 sachets in a day and lowest in cases who used <1 sachet in a day.

C-F PWV and ASI values increase with severity of addiction in both smoker and smokeless tobacco users. Our study was favored by Hee Sun Koo et al. who studied Effects of Smoking on the Pulse Wave Velocity and Ankle Brachial Index in Adolescents. Among the smoking group, they investigated the association between the duration of smoking, the age at which smoking started and the total number of cigarettes smoked with the PWV and ABI. The brachial-ankle PWV (baPWV) in the smoking group was higher than that of the non-smoking group. Among
the smokers, the heart-brachial PWV (hbPWV) was significantly associated with the duration of smoking and the total number of cigarettes smoked.

We also studied the various risk factors of atherosclerosis like age, BMI, hypertension, pulse pressure, ankle brachial index. In present study both C-F PWV and ASI increased with age. C-F PWV and ASI was highest in tobacco user female age group 60+ and lowest in Control 20-39 age group. Age related arterial changes are responsible for increase in PWV and ASI. This is supported by study of Danxia Zheng, et al who assessed Arterial stiffness by carotid-femoral pulse wave velocity and divided Patients into a high PWV group and a low PWV group based on the median of PWV. Age was significantly higher in the high PWV group than in the low PWV group. In the correlation analysis, PWV was positively associated with age (p < 0.01). Multiple regression analysis showed that PWV was independently related to PP (p < 0.01).

In study of BMI with C-F PWV and ASI, we found that both were higher in overweight than normal and underweight. Our study hold up by Ewa Pedeleka who in Poland found that overweight and obesity correlate with stiffness of the arterial wall and correlation between parameters of large artery wall elasticity and BMI as revealed (r = –0.1303, P = 0.0060).

Present study shows C-F PWV and ASI were significantly higher in females with SBP>140 as compared to females with normal SBP, C-F PWV and ASI were found to increase as Systolic Blood Pressure increases.

In this study C-F PWV and ASI were higher in females with increased pulse pressure in both cases and controls. C-F PWV and ASI increased as pulse pressure increased.

Our study favored by Scona-Mi Park et al who have shown that Arterial stiffness increases both with the systolic blood pressure and pulse pressures, which is known to be a major contributor to atherosclerosis and the most important cause of cardiovascular disease.

In our study ABI was inversely related to both marker of arterial stiffness and C-F PWV and ASI were maximum when ABI was <1in tobacco user females It is supported by Koji Y et al who compared the applicability of ABI and PWV as marker for predicting the prevalence of CAD in subject with a high risk of atherosclerotic cardiovascular disease. ABI and brachial-ankle PWV were measured in 472 subjects who subsequently underwent coronary angiography for diagnosis or exclusion of CAD.A multivariate logistic regression analysis demonstrated that a low ABI is an independent marker of additive risk of CAD, whereas a low brachial-ankle PWD may be used as an independent marker for excluding the risk of CAD among subjects with a high risk of atherosclerotic cardiovascular disease.

In present study pulse pressure, blood pressure, C-F PWV, ASI were significantly higher in tobacco user females than healthy controls and they were increased with duration of tobacco use, consumed amount of tobacco use, and with severity of addiction.

**Conclusion**

This study has demonstrated that pulse wave velocity (PWV) and arterial stiffness index (ASI) are increased in tobacco user females and they are independent predictor of cardiovascular morbidity. Tobacco use either smoking or smokeless tobacco use causes atherosclerotic diseases. Smoking is more prone to increase atherosclerosis and cardiovascular morbidity in comparison to smokeless tobacco use. Arterial stiffness may act either as a marker for the development of future atherosclerotic disease, or may be more directly involved in the process of atherosclerosis. Increased stiffness may precede the onset of clinically overt atheromatous disease. Early identification of individuals at risk, by improved detection of changes in stiffness may help in providing beneficial intervention at an early stage. Therefore, detection of arterial disease (not only clinically overt but also sub clinical asymptomatic) by evaluation of arterial stiffness, is a worthwhile screening test for future coronary event in tobacco users.

**References**