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## Smoking and Hypertension: A Study in Subjects Admitted to Hospital for Cardiovascular Diseases

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### Authors' contributions

*This work was carried out in collaboration between all authors. Authors MB, AM, FGB, EB contributed equally to the ideation of this research and wrote the paper. Authors MB, PS, AN contributed to the data collection and statistical analysis. All authors contributed to the final revision of the paper.*

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### ABSTRACT

**Aims:** There is a general consensus in considering cigarette smoking as a major risk factor for cardiovascular diseases: a direct causal association between smoking and hypertension however is questioned. The present paper reports a study on the effect of cigarette smoking and of other clinical parameters on hypertension in a sample of subjects admitted to Hospital for Cardiovascular Diseases (CVD).

**Study Design:** Observational study.

**Place and Duration of Study:** Department of Cardiology Valmontone Hospital and Department of Biomedicine and Prevention, University of Rome Tor Vergata, between April 2007- December 2013.

**Methodology:** We have studied 335 subjects admitted to the Hospital for Cardiovascular Diseases. Statistical analyses were in the study that was approved by the Ethical Committee. We have considered hypertension in relation to smoking, diabetes, age and sex.

**Results:** Multivariate statistical analyses have shown a high significant effect of age

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( $P < .001$ ) and diabetes ( $P < .01$ ) on hypertension and a border line effect of smoke ( $P = .05$ ). No effect of sex has been detected ( $P = .47$ ). The proportion of subjects with hypertension is positively correlated with the number of risk factors examined.

**Conclusion:** Our data indicate that an independent effect of smoking on blood pressure is relatively small and suggest an additive effect of the variables considered on the risk of hypertension.

*Keywords: Smoking; hypertension; CAD; diabetes; age; epidemiologic studies; LVEF; cardiac hypertrophy.*

## 1. INTRODUCTION

Epidemiologic studies point to an association between cigarette smoking and blood pressure (BP) [1]: a transient increase of BP only is associated with occasional smoking; however, late stable hypertension may occur in habitual smokers. At present there is a general consensus in considering cigarette smoking a major risk factor for cardiovascular diseases but a direct causal association between smoking and hypertension is questioned [2-8]. Animal studies have shown that smoking is associated with hypertension, endothelial dysfunction, leukocyte activation, ROS generation and decreased NO bioavailability [9]. Recent studies in humans have shown that young cigarette smokers display cutaneous vascular dysfunction: reducing nitric oxide-synthase contributes to this dysfunction. Reducing oxidative stress improves cutaneous hyperemia enhancing nitric oxide production [10,11].

The present paper reports a study on the effect of cigarette smoking and other clinical parameters on hypertension in a sample of subjects admitted to Hospital for Cardiovascular diseases (CVD).

## 2. MATERIALS AND METHODS

Three hundred thirty five subjects admitted to the Hospital for Cardiovascular Diseases, already reported in previous studies [12,13] were reconsidered. Relevant clinical parameters of these subjects are reported in these previous studies.

We have defined "high blood pressure" as having a systolic pressure greater than 135mmHg with a diastolic pressure greater than 85mmHg. Left Ventricular Ejection Fraction (LVEF) was determined in all subjects. Left Ventricular Volumes and LVEF were calculated by echocardiography using the modified Simpson's rule, by tracing the endocardial border in 2-chamber view and 4-chamber view. End diastole was defined as the frame in the cardiac cycle in which the cardiac dimension is largest, and end systole was best defined as the time in the cardiac cycle in which the cardiac dimension is smallest.

Chi square test of independence, odds ratio analysis, logistic regression, principal component analysis and correlation analysis were carried out by SPSS programs [14].

Written informed consent was obtained by these patients to participate to the study that was approved by the Ethical Committee of the Hospital.

### 3. RESULTS

Table 1 shows clinical data on the subjects studied.

**Table 1. Clinical data of subjects studied**

| Parameter               | Mean | SD  | % Proportion |
|-------------------------|------|-----|--------------|
| Diabetes                |      |     | 25%          |
| Cardiac hypertrophy     |      |     | 50%          |
| Coronary artery disease |      |     | 59%          |
| Gender (females)        |      |     | 55%          |
| Smoking habit           |      |     | 60%          |
| Body Mass Index (kg/mq) | 27.4 | 0.3 |              |

Table 2 shows the effect of smoking on hypertension: the proportion of subjects with hypertension is higher in smokers than in no smokers. The following Tables 2-5 show a strong positive association of hypertension with diabetes and age, while no significant association is observed between hypertension and sex.

**Table 2. The effect of smoking on the hypertension**

|            | % Proportion of subjects with hypertension | Total n° |
|------------|--|----------|
| Smoking    | 79.2%                                      | 202      |
| No smoking | 65.4%                                      | 133      |

*Chi square test of independence  $X^2$  (2 is an apex) 7.183, df 1, P<.01; OR=2.01 95% C.I.1.195-3.399*

**Table 3. The effect of diabetes on hypertension**

|               | % Proportion of subjects with hypertension | Total n° |
|---------------|--|----------|
| Diabetics     | 90.4%                                      | 84       |
| Non diabetics | 68.1%                                      | 251      |

*Chi square test of independence  $X^2$  (2 is an apex) 15.097, df 1, P<.001; OR=4.44 95% C.I.1.957-10.476*

**Table 4. The effect of age on hypertension**

|           | % Proportion of subjects with hypertension | Total n° |
|-----------|--|----------|
| <65 years | 56.7%                                      | 187      |
| ≥65 years | 87.2%                                      | 148      |

*Chi square test of independence  $X^2$  (2 is an apex) 35.206, df 1, P<<.001; OR (≥65 yrs vs<65 yrs)=5.188; 95% C.I.2.864-9.480*

**Table 5. The effect of sex on hypertension**

|         | % Proportion of subjects with hypertension | Total n° |
|---------|--|----------|
| Females | 71.0%                                      | 183      |
| Males   | 76.9%                                      | 152      |

*Chi square test of independence  $X^2$  (2 is an apex) 1.219, df 1, P .27; OR (males vs females)=0.734; 95% C.I.0.434-1.238*

A logistic regression analysis Table 6 has shown a highly significant effect of age and diabetes on hypertension and a border line effect of smoke. No significant effect of sex has been observed.

**Table 6. Logistic regression analysis. dependent hypertension. Independent sex, diabetes, smoking, age (≥65 yrs vs<65 yrs)**

| Variable | Significance |
|----------|--------------|
| Sex      | P=.47        |
| Diabetes | P<.01        |
| Smoking  | P=.05        |
| Age      | P<.001       |

Table 7 shows a principal component analysis. A coefficient greater than 0.5 has been considered significant and noted in bold. The procedure has extracted two significant components: the first represents hypertension and there is a significant correlation with age and diabetes. The second component represents sex and there is a significant correlation with smoke.

Table 8 shows the correlation between hypertension and smoke: after controlling for diabetes, age and sex a border line association only is observed.

**Table 7. Principal component analysis. Proportion of variance explained by the two components 53.60%**

|              | First component | Second component |
|--------------|-----------------|------------------|
| Sex          | 0.134           | <b>0.785</b>     |
| Hypertension | <b>0.727</b>    | 0.092            |
| Diabetes     | <b>0.613</b>    | 0.237            |
| Smoking      | 0.169           | <b>0.784</b>     |
| Age          | <b>0.650</b>    | 0.113            |

**Table 8. Partial correlation analysis**

|   |                            |
|---|----------------------------|
| Hypertension-smoking<br>(controlled by sex, diabetes and age) | Correlation 0.126<br>P=.06 |
|---|----------------------------|

Fig. 1 shows the relationship between the proportion of subjects with hypertension and the number of factor for which a positive association with hypertension has been observed i.e.: older age, smoking and diabetes. A highly significant correlation is observed with a minimum proportion in subjects with no risk factor and a maximum proportion in subjects carrying all the three factors.

We have considered the effects of smoking, age and diabetes on Left Ventricular Ejection Fraction (LVEF) and on cardiac hypertrophy and the effect of smoking and diabetes on the age at onset of Coronary Artery Disease (CAD). Significant effect on LVEF Table 9 has been observed for age (P<.001), diabetes (P=.03) and smoking (P=.05). Significant effect on age at onset of CAD has been observed for diabetes (P< .001) and a border-line effect has been observed for smoking (P=.07). Significant effect on cardiac hypertrophy has been observed for age only (P<.001).

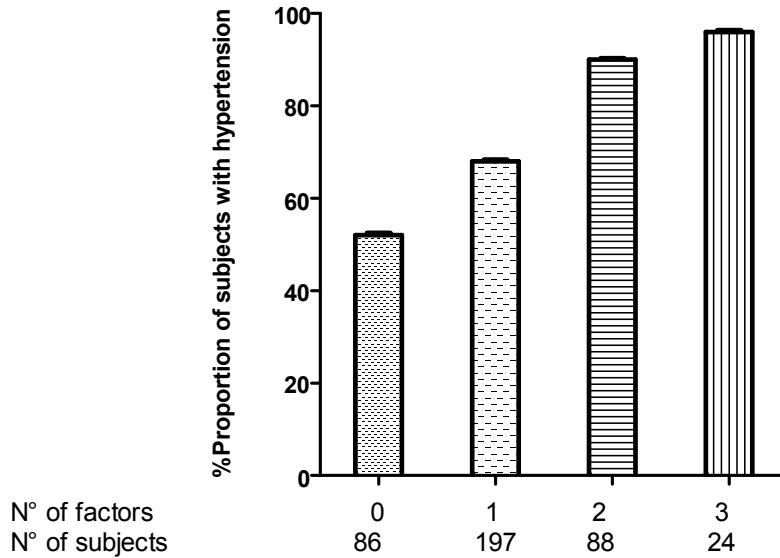


Fig. 1 The relationship between the proportion of subjects with hypertension and the number of factors for which a significant positive association with hypertension has been observed. Factors: diabetes, smoking, age. Linear correlation:  $P < .001$ .

**Table 9. Distribution of LVEF**

|  |       |
|--|-------|
| Subjects within the first quartile (LVEF $\leq$ 45)                    | 23.1% |
| Subjects between the second and third quartile (LVEF $>$ 40 $\leq$ 58) | 55%   |
| Subjects over the fourth quartile (LVEF $>$ 58)                        | 22.0% |

#### 4. DISCUSSION

A preliminary analysis has shown a highly significant association between smoking and hypertension; however, when diabetes and age are included in a multivariate statistical analysis the independent effect of smoking on hypertension tends to become only marginally significant. Partial correlation analysis controlling for sex, diabetes and age gives a correlation of 0.126 between smoking and hypertension ( $P = .06$ ). Thus in accordance with the results of Health Survey for England [15] our data suggest that any independent effect of smoking on BP is relatively small. However, this does not mean that smoking does not increase the risk of hypertension: indeed the data in Fig. 1 suggest an additive interaction among smoking, diabetes and age concerning the risk of hypertension.

In our sample smoking contributes with diabetes and age to the degree of LVEF. No significant contribution is observed for cardiac hypertrophy and only a marginal contribution for age at onset of CAD. At present there is a general consensus in considering cigarette smoking as a major risk factor for cardiovascular diseases and our data suggest that smoking contributes with other important factors to the clinical evolution of cardiovascular diseases.

## 5. CONCLUSION

Our data indicate that although an independent effect of smoking on blood pressure is relatively small, it exerts an additive effect with other variables to the risk of hypertension and to the clinical evolution of cardiovascular diseases.

## CONSENT

All authors declare that 'written informed consent was obtained from the patient for publication of this case report and accompanying images.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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