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Original Research Article

A Hospital Based Observational Cross-Sectional Evaluation of the Effects of Metabolic Syndrome on Pulmonary Function Tests

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Conflict of interest: Nil

Abstract

Aim: To study pulmonary function tests in patients of metabolic syndrome and to record the effects of metabolic syndrome on pulmonary function tests.

Methodology: This study was an observational cross-sectional study. The study was conducted in Department of Medicine, Darbhanga Medical College and Hospital, Darbhanga, Bihar for 12 months. A proper history was taken from the patients and other available sources. The NDD spirometer was used to conduct pulmonary function tests in this study. A thorough general physical and systemic examination was done and final diagnosis was made after doing all the necessary investigations. Data thus obtained were analyzed statistically. The Data was expressed as mean with standard deviation (SD) for quantitative variables. Comparisons between groups were performed using Student's t-test and Anova test for quantitative variables and Chi-square test for nominal/qualitative data. A value of $p< 0.05$ was taken as significant.

Results: A total of 50 patients fulfilling the IDF criteria for metabolic syndrome were included in the study. Majority of the patients were women (70%) (n=35) while men constituted 30% (n=15) of the patients. Most of the patients belonged to the 61-70 years' age group (n=16) followed by 41-50 years' age group (n=13). The mean age of the patients was 55.35 (±12.36) years in men and 52.37 (±13.80) years in women (p=0.324). Patients with 3 components positive had a mean FEV1 of 1.32 (±0.65) L while patients with 4 components positive had a mean FEV1 of 1.49 (±0.72) L. Patients with all 5 components positive had a mean value of FEV1 was 1.35 (±0.60) L. Patients with 3 components positive had a mean FVC of 1.892 (±0.72) L while patients with 4 components positive had a mean FVC of 1.879 (±0.82) L. Patients with all 5 components positive had a mean FVC of 1.822 (±0.76) L. Both FEV1 and FVC correlated negatively with BMI, FBS, waist hip ratio and SBP. Only FEV1 had a negative correlation with Hba1c whereas only FVC had a negative correlation with waist circumference.

Conclusion: Our findings highlight the notion that FVC and FEV1 are inversely associated with the accumulation of metabolic syndrome components and also independently associated with each component of metabolic syndrome.

Keywords: Pulmonary function test, spirometer, metabolic syndrome.

Introduction

Metabolic syndrome is an accumulation of several disorders, which together raise the risk of an individual developing atherosclerotic cardiovascular disease, insulin resistance, and diabetes mellitus, and vascular and neurological complications such as a cerebrovascular accident. Metabolic syndrome has serious implications on an individual's health and healthcare costs. It is necessary to recognize the rising prevalence of metabolic syndrome in America as through intervention the progression of the syndrome can be halted and potentially reversed [1-3].

The underlying etiology of metabolic syndrome is extra weight, obesity, lack of physical activity, and genetic predisposition. The crux of the syndrome is a buildup of adipose tissue and tissue dysfunction that in turn leads to insulin resistance. Proinflammatory cytokines such as tumor necrosis factor, leptin, adiponectin, plasminogen activator inhibitor, and resist in, are released from the enlarged adipose tissue, which alters and impacts insulin handling adversely. Insulin resistance can be acquired or may be due to genetic disposition. Impairment of the signaling pathway, insulin receptor defects, and defective insulin secretion can all contribute towards insulin resistance. Over time, the culmination of this cause development of metabolic syndrome that presents as vascular and autonomic damage [4-6].

In the United States, the prevalence of metabolic syndrome in adults 18 years and older is continuing to be significant. Data shows that the prevalence of this disease process increased from the 1980s to 2012 by 35%. In the 1980s, the incidence was noted to be 25.3% and increased to 34.2% in 2012. However, the most recent data from the National Health and Nutrition Examination Survey (NHANES) shows the prevalence is on a decline with 24% in men and 22% in women [7, 8].

It has been shown that obesity causes physiologic impairment in respiratory system. Obesity causes airflow limitation with reduction of both FEV1 and FVC, and reduces lung volumes, especially expiratory reserve volume (ERV), and functional residual capacity (FRC), obstructive sleep apnea, a depressed central ventilatory drive, and diminished effects of neurohumoral modulators (example- leptin) due to decreased levels or resistance [9].

In a number of recent studies, it was reported that among the changes in pulmonary function, pulmonary function, deterioration is related to hypertension, type 2 diabetes, low-density lipoprotein cholesterol, overall obesity, abdominal obesity and insulin resistance [9-13]. Among the above listed factors, hypertension, diabetes, and abdominal obesity are included as diagnostic criteria for metabolic syndrome, hence it can be inferred that identifying the relationship between metabolic syndrome and pulmonary function deterioration is meaningful. In a study on the relationship between pulmonary function deterioration and metabolic syndrome, pulmonary function deterioration was detected where there is metabolic syndrome. Even when gender, age, smoking status, alcohol drinking and physical activity factors were reflected, limited pulmonary function deterioration showed independent relevance to increased risk of metabolic syndrome [12]. The objective of the study was to study pulmonary function tests in patients of metabolic syndrome and to record the effects of metabolic syndrome on pulmonary function tests.

Methodology:

This study was an observational cross-sectional study. The study was conducted

in Department of Medicine, Darbhanga Medical College and Hospital, Darbhanga, Bihar for 12 months. 50 patients of metabolic syndrome presenting in the OPD/IPD for related or unrelated problems were selected for the current study and were included in the study group after applying inclusion and the exclusion criteria and after taking written informed consent. The NDD spirometer was used to conduct pulmonary function tests in this study. According to the new IDF definition, for a person to be defined as having the metabolic syndrome, they must have: central obesity (defined as waist circumference* with ethnicity specific values) plus any two of the following four factors:

Obstructive lung impairment was defined as: FEV1 to FVC ratio<70% and FVC> 80% of the predicted value.

Restrictive lung impairment was defined as: FVC<80% of the predicted value and FEV1 to FVC ratio >70%.

Mixed lung impairment was defined as: FEV1 -to-FVC ratio < 70% and FVC< 80% of the predicted value.

Waist was measured in a horizontal plane midway between lowest rib and the iliac crest. Patients fulfilling the IDF criteria (given below) for metabolic syndrome were selected for the study.

Table 1: IDF criteria for metabolic syndrome.

Factors	
Raised triglycerides	≥150 mg/dl (1.7 mmol/l) or on specific treatment for this lipid abnormality
Reduced HDL cholesterol	<40 mg/dl (1.03 mmol/l) in males <50 mg/dl (1.29 mmol/l) in females or on specific treatment for this lipid abnormality
Raised blood pressure	systolic BP ≥130 or diastolic BP ≥85 mm Hg or treatment of previously diagnosed hypertension
Raised fasting plasma glucose	(FPG) ≥100 mg/dl (5.6 mmol/l), or previously diagnosed type 2 diabetes. If above 5.6 mmol/l or 100 mg/dl, OGTT is strongly Recommended but is not necessary to define presence of the syndrome.

The following patients were excluded from the study: Smokers, non-ambulatory patients, thoracic cage abnormalities, diaphragmatic paralysis, occupational exposure to substances like silica, asbestos, coal, beryllium, patients suffering from Asthma/COPD, myopathies.

A proper history was taken from the patients and other available sources. A thorough general physical and systemic examination was done and final diagnosis was made after doing all the necessary investigations. The study was approved by the Ethical Committee of the Institute.

Data thus obtained were analyzed statistically. The Data was expressed as mean with standard deviation (SD) for quantitative variables. Comparisons between groups were performed using Student's t-test and Anova test for quantitative variables and Chi-square test for nominal/qualitative data. A value of p< 0.05 was taken as significant.

Results:

A total of 50 patients fulfilling the IDF criteria for metabolic syndrome were included in the study. Majority of the patients were women (70%) (n=35) while men constituted 30% (n=15) of the

patients. Most of the patients belonged to the 61-70 years' age group (n=16) followed by 41-50 years' age group (n=13). The mean age of the patients was 55.35 (±12.36) years in men and 52.37 (±13.80) years in women (p=0.324).

Table 2: Demographic details and comorbidities

Variables		Number	%
Age groups (in years)	<40	6	12
	41-50	13	26
	51-60	10	20
	61-70	16	32
	>70	5	10
Gender	Males	15	30
	Females	25	70
Hypertension	Hypertensives	42	84
	Normotensives	8	16
Diabetes	Present	36	72
	Absent	14	28
BMI	Obese	46	92
	Overweight	2	4
	Normal	2	4

Out of 50 patients, 42 (84%) were hypertensives while 8 (16%) were normotensives. 72% (n=36) of the patients either had diabetes or impaired fasting plasma glucose while 28% (n=14) of the patients had normal fasting plasma glucose levels. 62% of the patients had impaired triglyceride levels while 82% of the patients had low HDL levels.

92% (n=46) of the patients belonged to the obese category while 4% (n=2) of the patients were overweight and 4% (n=2) had normal BMI. Mean BMI of females (32.46±8.22 kg/m2) was higher than males (30.96±4.62 kg/m2). Females had a mean waist hip ratio of 1.10 (±0.06) while males had a mean waist hip ratio of 1.07 (±0.05).

We used the STOP BANG score and Epworth score to evaluate the patients of metabolic syndrome for OSA. Most of the patients (92%) (n=46) had a STOP BANG score of ≥3. Males had a significantly higher mean stop bang score of (5.62±1.20) as compared to females (4.32±1.63). 42% (n=21) of the patients had 4 components positive out of 5 while 34% (n=17) of the patients had 3 components positive. 24% (n=12) of the patients had all 5 components positive.

Table 3: STOP BANG Score and Components of metabolic syndrome.

Variables		Number	%
STOP BANG Score	<3	4	8
	≥3	46	92
Components of Metabolic Syndrome	3 components positive	17	34
	4 components positive	21	42
	5 components positive	12	24
PFT Pattern	Restrictive	21	42
	Obstructive	4	8
	Mixed	15	30
	Normal	10	20

Mean FEV1 of the patients was significantly higher in males (1.82±0.71 L) than females (1.24±0.42 L) (p 0.007). Similarly, the mean FVC was significantly higher in males as compared to females. Mean FVC was 2.45 (±0.86) L in males while females had a mean FVC of 1.65 (±0.49) L (p 0.002).

Most of the patients had a restrictive pattern (42%) (n=21). 30% (n=15) of the patients had a mixed pattern while 20% (n=10) of the patients had a normal picture. Only 8% (n=4) of the patients had an obstructive pattern (p<0.001). Restrictive pattern was dominant in age groups of <40, 41- 50, 51-60 while mixed pattern was dominant in age group of 61-70 and >70. Females had a predominantly restrictive pattern while males had a predominantly mixed pattern.

Patients with a restrictive pattern had the highest level of FBS (168/43±70.24 mg/dl). Patients with obstructive pattern had a mean FBS of 145.4 (±35.34) mg/dl. Mean FBS of patients with a mixed pattern was 120.43 (±35.73) mg/dl while patients with a normal PFT pattern had a mean FBS of 102.57 (±16.32) mg/dl.

We also studied the correlation between components of metabolic syndrome and PFT parameters. Patients with 3 components positive had a mean FEV1 of 1.32 (±0.65) L while patients with 4 components positive had a mean FEV1 of 1.49 (±0.72) L. Patients with all 5 components positive had a mean value of FEV1 was 1.35 (±0.60) L. Patients with 3 components positive had a mean FVC of 1.892 (±0.72) L while patients with 4 components positive had a mean FVC of 1.879 (±0.82) L. Patients with all 5 components positive had a mean FVC of 1.822 (±0.76) L.

Both FEV1 and FVC correlated negatively with BMI, FBS, waist hip ratio and SBP. Only FEV1 had a negative correlation with Hba1c whereas only FVC had a negative correlation with waist circumference.

Discussion

Metabolic syndrome is a complex disorder featuring chronic inflammation characterized by the constellation of abdominal obesity, hyperglycemia, hypertension, and dyslipidemia. Its definition varies by organization and expert group. The definition of the revised NCEP: ATP III is one of the most widely used. Although previous studies examined the association between individual components of metabolic syndrome and pulmonary function, the contribution of each component of metabolic syndrome to complications and comorbidity seems to differ between each race group. For instance, insulin resistance is related to blood pressure in white but not in black Americans [14]. Therefore, each component of metabolic syndrome may have a different influence on pulmonary function across racial groups.

Impaired pulmonary function, which includes measurements of forced expiratory volume in one second (FEV1) and forced vital capacity (FVC), is mainly present in individuals with chronic obstructive pulmonary disease (COPD) and asthma [15]. Previous studies have shown that reduced FEV1 is a strong predictor of coronary heart disease, COPD-related mortality, and cardiovascular mortality [16-18]. Reduced FVC is also a marker for increased mortality in asymptomatic adults [19] or individuals with metabolic syndrome [20]. Recent years have seen an increased focus on metabolic syndrome in the prediction of lung function impairment. Previous data from Asian [21, 22] and European [23, 24] patients demonstrated a substantial association between impaired pulmonary function and metabolic syndrome. However, the diagnostic criteria and clinical features of metabolic syndrome varied by race. Few studies have focused on the U.S. general population to investigate the association between lung capacity and metabolic syndrome. In

addition, important risk factors [25, 26], such as gender, smoking status, biomarkers of inflammation, and C-reactive protein (CRP), were not fully taken into account in previous studies.

We compared the mean value of FEV1 with increasing number of components of metabolic syndrome. Patients with 3 components positive had a mean FEV1 of 1.32 (±0.65) L while patients with 4 components positive had a mean FEV1 of 1.49 (±0.72) L. Patients with all 5 components positive had a mean value of FEV1 was 1.35 (±0.60) L (p=0.84). Hence, no correlation was found between the increasing number of components of metabolic syndrome and FEV1. This was in concordance with the study conducted by Bae et al which did not find a correlation of FEV1 and increasing number of components of metabolic syndrome [27].

On comparing the FVC of these subjects, a continuous decline in FVC with increase of number of metabolic syndrome components was observed i.e. . Patients with 3 components positive had a mean FVC of 1.892 (±0.72) L while patients with 4 components positive had a mean FVC of 1.879 (±0.82) L. Patients with all 5 components positive had a mean FVC of 1.822 (±0.76) L. These findings were similar to those obtained by the studies conducted by Chaudhary et al (3 metabolic syndrome components (2.86±0.06 L), 4 metabolic syndrome components (2.80±0.08 L) and 5 metabolic syndrome components (2.78±0.09 L) and Ford et al (3 metabolic syndrome components 4217.2 L, 4 metabolic syndrome components 4044.6 L, 5 metabolic syndrome components 3974.2 L) which showed a decreasing trend in FVC with increasing number of components of metabolic syndrome [28, 29].

Both FEV1 and FVC correlated negatively with BMI, FBS, waist hip ratio and SBP which was consistent with the study conducted by Chen et al [30] , Bae et al [27] and majority of the other studies, the strongest correlation of FEV1 being with BMI as was shown in the study conducted by Chaudhary et al and Yeh et al which found obesity to be the strongest predictor of deterioration in pulmonary function tests and that of FVC being with plasma glucose levels as was shown in the study done by Adeyeye et al [28, 31, 32]. Only FEV1 had a negative correlation with Hba1c only FVC had a negative correlation with waist circumference. [33]

Conclusion:

Our findings highlight the notion that FVC and FEV1 are inversely associated with the accumulation of metabolic syndrome components and also independently associated with each component of metabolic syndrome. Patients with metabolic syndrome have significant impairment of the pulmonary function with restrictive pattern being the most common one.

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