Original Research Article

Effects of metabolic syndrome on pulmonary function tests

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ABSTRACT

Background: Metabolic syndrome is defined as at least three of the five following medical conditions: central obesity(mandatory), high blood pressure, high blood sugar, high serum triglycerides, and low serum high-density lipoprotein (HDL). It has been shown that obesity causes physiological impairment in respiratory system.
Methods: In this observational cross sectional study, 60 patients who fulfilled the IDF criteria for metabolic syndrome were included after applying the exclusion criteria and were subjected to spirometry.
Results: Most of the patients had a restrictive pattern (43.3%) (n=26). 33.3% (n=20) of the patients had a mixed pattern while 16.7% (n=10) of the patients had a normal picture. Only 6.7% (n=4) of the patients had an obstructive pattern (p<0.001). Mean value of FEV1 had no correlation with increasing number of components of metabolic syndrome whereas mean value of FVC showed a decreasing trend with increasing number of components of metabolic syndrome. 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).
Conclusions: In conclusion, Patients with metabolic syndrome have significant impairment of the pulmonary function with restrictive pattern being the most common one.

Keywords: Metabolic syndrome, Pulmonary function tests, FEV1, FVC

INTRODUCTION

Metabolic syndrome, also known as "Insulin resistance syndrome", "American syndrome", and "syndrome X", is defined as at least three of the five following medical conditions: central obesity(mandatory), high blood pressure, high blood sugar, high serum triglycerides, and low serum high-density lipoprotein (HDL). There has been an epidemiological transition in the recent past leading to an increase in non – infectious diseases. Among these non-infectious diseases, metabolic syndrome is one of the most important ones. More than one-fifth of the population and roughly 60% of obese individuals are affected.[1]

The key feature of metabolic syndrome is central obesity, which is also known as visceral obesity, apple-shaped adiposity, or male pattern obesity. There is accumulation of adipose tissue predominantly around the waist and trunk. Associated conditions include hyperuricemia; fatty liver (especially in concurrent obesity) progressing to non-alcoholic fatty liver disease; polycystic ovarian syndrome in women, erectile dysfunction in men; and acanthosis nigricans.[2]

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.[3]

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.

METHODS

This study was an observational cross sectional study. The study was conducted in Medicine department and pulmonary department of SGRDIMSR, Amritsar between December 2018-December 2019.

60 patients of metabolic syndrome presenting in the OPD/IPD of SGRDIMSR 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:

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.

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 for metabolic syndrome were selected for the study (Table 1).

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 analysed 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 60 patients fulfilling the IDF criteria for metabolic syndrome were included in the study. Majority of the patients were women (73.3%) (n=44) while men constituted 26.7% (n=16) of the patients.
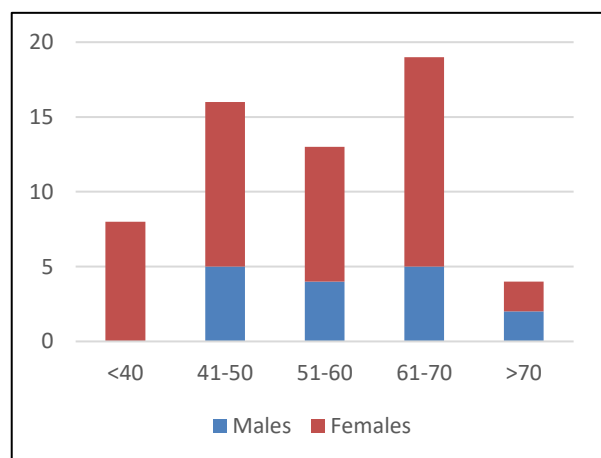

Figure 1: Gender/age distribution of patients.

Most of the patients belonged to the 61-70 years' age group (n=19) followed by 41-50 years' age group (n=16). The mean age of the patients was 57.94 (±10.45) years in men and 54.45 (±11.58) years in women (p 0.296). (Figure 1)
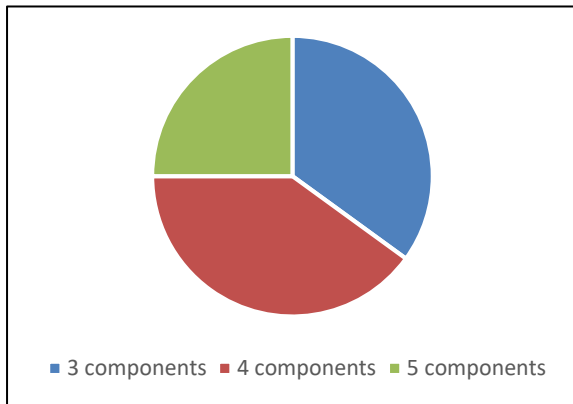

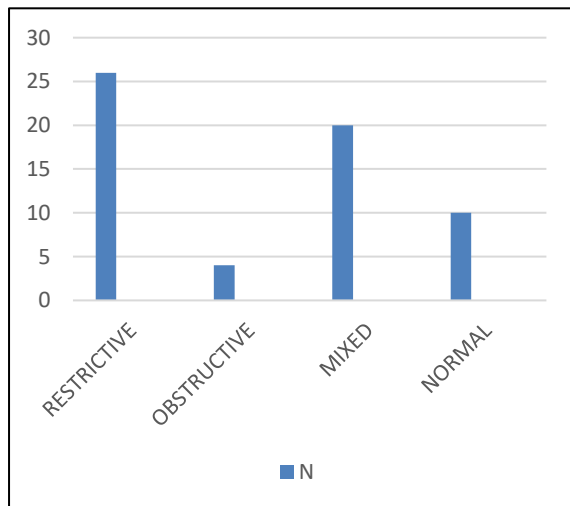**Figure 2: Components of metabolic syndrome.**

Figure 3: Distribution of the patients according to the PFT pattern.

Out of 60 patients, 49 (81.7%) were hypertensives while 11 (18.3%) were normotensives. 73.3% (n=44) of the patients either had diabetes or impaired fasting plasma glucose while 26.7% (n=16) of the patients had normal fasting plasma glucose levels. 58.3% of the patients had impaired triglyceride levels while 78% of the patients had low HDL levels.

90% (n=54) of the patients belonged to the obese category while 5% (n=3) of the patients were overweight and 5% (n=3) had normal BMI. Mean BMI of females (32.02±7.89 kg/m2) was higher than males (31.13±4.73 kg/m2) (p 0.6). Females (124.18±16.82 cm) had a higher mean waist circumference as compared to males (124±17.39 cm) (p 0.971). Similarly, females had a mean waist hip ratio of 1.08 (±0.05) while males had a mean waist hip ratio of 1.06 (±0.04) (p 0.365).

We used the STOP BANG score and Epworth score to evaluate the patients of metabolic syndrome for OSA. Most of the patients (91.7%) (n=55) had a STOP BANG score of ≥3. Males had a significantly higher mean stop bang score of 5.50 (±1.03) as compared to females (4.23±1.46). (p 0.001).

40% (n=24) of the patients had 4 components positive out of 5 while 35%(n=21) of the patients had 3 components positive. 25% (n=15) of the patients had all 5 components positive. (Figure 2)

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 (43.3%) (n=26). 33.3% (n=20) of the patients had a mixed pattern while 16.7% (n=10) of the patients had a normal picture. Only 6.7% (n=4) of the patients had an obstructive pattern (p<0.001). (Figure 3)

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 (p 0.678). Females had a predominantly restrictive pattern while males had a predominantly mixed pattern.

Patients with a restrictive pattern had the highest level of FBS (167.93±68.87 mg/dl). Patients with obstructive pattern had a mean FBS of 146.5 (±33.74) mg/dl. Mean FBS of patients with a mixed pattern was 119.45 (±33.50) mg/dl while patients with a normal PFT pattern had a mean FBS of 104.4 (±15.18) mg/dl (p 0.003). Diabetics and those with impaired FBS levels had predominantly a restrictive pattern (50%) while patients with normal FBS had a predominantly mixed pattern (p 0.147). Similarly, patients with impaired Hba1c predominantly had a restrictive pattern (p 0.611).

Patients with 3 components of metabolic syndrome had a mean FBS level of 127.33 mg/dl while patients with 4 components of metabolic syndrome had a mean FBS level of 160.079 mg/dl. Patients with all 5 components of metabolic syndrome had a mean FBS of 140.76 (p 0.143).

We studied the correlation between components of metabolic syndrome and diastolic blood pressure. Patients with 3 components positive had a mean DBP of 82.8 (±11.28) mm of hg while patients with 4 components positive had a mean DBP of 86.58 (±8.99) mm of hg. Patients with all 5 components positive had a mean DBP of 87.73 (±6.31) mm of hg (p 0.248). We also studied the correlation between components of metabolic syndrome and PFT parameters. Patients with 3 components positive had a mean FEV1 of 1.36 (±0.51) L while patients with 4 components positive had a mean FEV1 of 1.469 (±0.61) L.

Patients with all 5 components positive had a mean value of 1.34 (±0.58) L (p 0.75). Patients with 3 components positive had a mean FVC of 1.888 (±0.67) L while patients with 4 components positive had a mean FVC of 1.881 (±0.75) L. Patients with all 5 components positive had a mean FVC of 1.812 (±0.71) L. (p 0.944).

Table 2: Correlation of FEV1 and FVC with different variables.

	FEV1		FVC	
	r value	P value	r value	P value
Waist circumference	0.025	0.848	-0.021	0.874
BMI	-0.107	0.415	-0.113	0.392
Waist/Hip ratio	-0.093	0.480	-0.079	0.550
SBP	-0.059	0.653	-0.081	0.540
FBS	-0.070	0.595	-0.117	0.371
Hba1c	-0.003	0.94	0.028	0.871

On studying the correlation between STOP BANG score and PFT pattern, the patients with restrictive pattern had the highest STOP BANG score of 4.73 while patients with a mixed pattern had a STOP BANG score of 4.60 (p 0.774). Patients with a normal pattern had the lowest STOP BANG score of 4.2. Patients with a STOP BANG score of 5-6 had predominantly mixed pattern while all other groups showed a predominantly restrictive pattern (p 0.363).

Both FEV1 and FVC correlated negatively with BMI (-0.107; -0.113) (p 0.415,0.392), FBS (-0.07; -0.117) (p 0.595,0.371), waist hip ratio (-0.093; -0.079) (p 0.48,0.55) and SBP (-0.059; -0.081) (p 0.653,0.540). Only FEV1 had a negative correlation with Hba1c (-0.003) (p 0.94) whereas only FVC had a negative correlation with waist circumference (-0.021) (p 0.874).

DISCUSSION

This was a hospital-based study conducted in the department of Medicine and Chest and TB in SGRD hospital, Amritsar. A total of 60 patients were studied.

The patients who fulfilled the IDF criteria of metabolic syndrome were included in the study. The patients who had a minimum of 3 out of 5 criteria positive were considered to be suffering from metabolic syndrome. This corroborated with the studies done by Chaudhary et al and Mahmud et al which also used the IDF criteria for enrolment of patients in the study.[3,4]

In our study, the age range of the patients was 31-81 with a mean age of 55.38±11.31 years. This was consistent with the study conducted by Kim et al where the mean age was 51.0±5.0 years and Adeyeye et al in which the mean age of the subjects was 59.6±11.30 years.[5,6] However, the mean age varied amongst various studies and no fixed pattern was observed in the studies conducted due to the varying population characteristics.

There were 44 females (73.3%) and 16 males (26.7%) included in the study conducted by us. Similar pattern of sex distribution was seen in the study conducted by Negm et al where 64.4% patients were females and 35.6% patients were males and in the study conducted by Huisstede et al in which majority of the subjects were females.[7,8] However, in the study conducted by Chaudhary et al, majority of the participants were males, constituting 70% of the subjects.[3] The gender distribution of the patients was a chance occurrence and was not prefixed in any of the studies including ours.

The mean BMI of the patients was 31.78 (±7.15) kg/m2 with the mean BMI being higher in females (32.02±7.89 kg/m2) than males (31.13±4.73 kg/m2) (p 0.6). This was in accordance with the study conducted by Adeyeye et al in which females (29.72±8.4 kg/m2) had a higher BMI as compared to males (26.48±5.4 kg/m2).[6] Similarly, the mean waist circumference was higher in females (124.18±16.82 cm) as matched against males (124.00±17.39 cm) (p 0.971). The waist hip ratio was also higher in women (1.08±0.05) as compared to males (1.06±0.04) (p 0.365). This was however contrary to the study done by Lee et al in which the BMI, waist circumference, and waist hip ratio were all higher in males as compared to females.[9] This can be explained by the various ethnic and racial factors contributing to the anthropometric parameters of the two populations.

The STOP BANG score was significantly higher in males (5.50±1.03) as compared to females (4.23±1.46) (p 0.001). Our results were similar to the results of the study conducted by Farney et al in which the STOP BANG score was higher in males (5.1±1.5) as compared to females (3.3±1.4).[10]

Average FEV1 was higher in males (1.82±0.71 L) as compared to females (1.24±0.42 L) (p 0.007). Average FVC was also higher in males (2.45±0.86 L) as compared to females (1.65±0.49 L). (p 0.002). These findings were supported by the study conducted by Chen et al and Leone et al in which both FEV1 and FVC were higher in males

(FEV1: 3.64 L; 3.4 L) (FVC: 4.61 L; 4.2 L) as compared to females (FEV1: 2.63 L; 2.4 L) (FVC: 3.22 L; 2.9 L).[11,12] On the contrary, the study conducted by Lee et al showed a higher FVC in females (93.3 L) as compared to males (91.8 L) which can possibly be explained on the basis of differences in the ethnicity of the South Asian and the Taiwanese population.[13]

Our study showed that patients with metabolic syndrome primarily had a restrictive pattern (43.3%) (p<0.001) which is in accordance with studies conducted by Chaudhary et al, Rogliani et al and majority of the other studies which also showed a predominantly restrictive pattern in patients of metabolic syndrome.[3,14]

In our study, 26 patients (43.3%) showed a restrictive pattern while obstructive pattern was present in only 4 patients (6.7%). 20 patients (33.3%) had a mixed pattern while 10 patients (16.7%) had a normal study (p<0.001).

In the study conducted by Chaudhary et al, 42 (42%) patients showed a restrictive pattern while 11 (11%) patients showed a mixed pattern.[3]

Age groups of the patients were not significantly associated with any specific PFT pattern. Similar to our study, Negm et al concluded that age was not associated with any specific pulmonary function test abnormality.[7]

Diabetic patients or those with impaired FBS levels predominantly showed a restrictive pattern (n=22) while patients with normal FBS levels predominantly showed a mixed pattern (n=9). (p 0.147)

Similarly, the patients with deranged HbA1c had a predominantly restrictive pattern (p 0.611).

This was substantiated by the study conducted my Leone et al which found blood sugar levels to be independently associated with a restrictive ventilatory pattern.[12]

The mean FBS levels were highest in patients with a restrictive pattern (167.93±68.87 mg/dl) followed by patients with obstructive pattern (146.5±33.74 mg/dl). The patients with mixed pattern had an average FBS of 119.45 (±33.50) mg/dl. FBS levels were lowest in patients with normal PFT pattern i.e. 104 (±15.18) mg/dl. (p 0.003).

Both FEV1 and FVC had a negative correlation with FBS (-0.07; -0.117).

The diastolic blood pressure of the patients was highest in patients who had all 5 components (87.73±6.31 mm of hg) of metabolic syndrome positive as compared to patients who had either three (82.85±11.28 mm of hg) or four (86.58±8.99 mm of hg) components of metabolic syndrome positive (p 0.248). This was comparable to the study conducted by Jung et al in which a worse metabolic profile was associated with a higher diastolic blood pressure.[15]

We compared the mean value of FEV1 with increasing number of components of metabolic syndrome. Patients who had 3 components of metabolic syndrome positive had an FEV1 of 1.36 (±0.51) L while patients with 4 components of metabolic syndrome had an FEV1 of 1.46 (±0.61) L. Patients who had all 5 components of metabolic syndrome had an FEV1 of 1.34 (±0.58) L (p 0.75). 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.[16]

On comparing the FVC of these subjects, a continuous decline in FVC with increase of number of metabolic syndrome components was observed i.e. 3 metabolic syndrome components (1.88±0.67 L), 4 metabolic syndrome components (1.88±0.75 L) and 5 metabolic syndrome components (1.81±0.71 L) (p 0.944). 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.[3,17]

Both FEV1 and FVC correlated negatively with BMI (-0.107; -0.113), FBS (-0.07; -0.117), waist hip ratio (-0.093; -0.079) and SBP (-0.059; -0.081) which was consistent with the study conducted by Chen et al11, Bae et al16 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.[3,6,18] Only FEV1 had a negative correlation with Hba1c (-0.003) whereas only FVC had a negative correlation with waist circumference (-0.021). (Table 2)

However, there were a few limitations of our study. Most of the participants were women and only few men were included which could have led to an unfair comparison between the two genders. We did not assess the post bronchodilator lung function to see any reversibility in lung functions indicative of asthma because obesity is now a recognized risk factor for the occurrence of bronchial asthma. We did not perform DLCO to differentiate between intrathoracic and extrathoracic restriction due to financial constraint of the study. Also, the study measured lung functions and metabolic components at a single time rather than recording long-term repeated observations. The relatively small sample size might prevent us from extrapolating our results to the whole population

CONCLUSION

Our study provides an understanding on how obesity aids to the development of lung function decline and the interplay between metabolic syndrome and lung function. Patients with metabolic syndrome have significant impairment of the pulmonary function with restrictive pattern being the most common one.

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