Effect of obesity on lung function tests in South Indian population

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Background

Obesity is a modern-day epidemic. Pulmonary function tests are likely to be compromised to varying degrees in these individuals, thus affecting their artificial ventilation under general anesthesia. It is thus important to study the pattern of pulmonary function in these individuals in a group likely to undergo surgery for varying reasons.

Participants and methods

A total of 30 male participants between 45 and 60 years of age attending the surgical outpatient clinic with a BMI of more than 25 kg/m^2 who qualified as obese were included in the study, and a similar number of participants with BMI less than 25 kg/m^2 were randomly selected as controls. Flow-volume loop, forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC were recorded using a computerized spirometer.

Results

FEV_1, FVC, and FEV_1/FVC ratio measured in obese patients were significantly reduced ($P < 0.05$) compared with normal BMI individuals.

Conclusion

The incidence of restrictive tendency is higher in obese individuals compared with controls. As the changes in respiratory mechanics due to obesity are almost completely reversible, early intervention in such patients will ensure lesser chance of complications on the operation table and postoperatively. With the advent of computerized spirometry, analysis of flow-volume loops is indeed of great help to the obese.

Keywords:

FEV_1/FVC, forced expiratory volume in the first second, forced vital capacity, obesity, pulmonary function test, surgical

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Introduction

Obesity is a modern-day epidemic. Obesity must be considered as pathological when the adipose tissue increases to such an extent as to affect health and reduce life expectancy [1]. This study is justified in view of the racial variation of pulmonary function parameters. Pulmonary function tests (PFTs) are likely to be compromised to varying degrees in these individuals, thus affecting their artificial ventilation under general anesthesia. It is thus important to study the pattern of pulmonary function in these individuals in a group likely to undergo surgery for varying reasons.

The WHO estimated that 1.46 billion adults were overweight and 502 million adults (10% men and 14% women) were obese in the year 2008 showing that, since 1980, the global prevalence of obesity had nearly doubled [2]. Furthermore, the WHO predicts that there will be nearly 2.3 billion overweight adults in the world by 2015, with more than 700 million of them being obese. Obesity has reached epidemic proportions in India, with morbid obesity affecting almost 5% of the country's female population [3]. The medical and surgical pathologies associated with obesity show a corresponding upswing in their frequency of occurrence [4].

The negative physiological effects of obesity on lung function have been demonstrated in numerous studies [5–7]. An increase in the abdominal volume preventing full descent of the diaphragm and an increase in the intrathoracic fat reducing the space for complete lung expansion are hypothesized as the causes of restricted total lung capacity (TLC) [8].

In obese individuals, especially on exertion and in supine position — for example, during surgery or when asleep — the changes enumerated above lead to an increased prevalence of respiratory problems [9]. Studies have demonstrated that changes in lung volume can occur at early stages of obesity and are not limited to the morbidly obese individuals [5,6].

Obesity and associated disorders present many difficulties perioperatively during anesthesia and hence require prior planning and awareness of the commonly encountered pitfalls [10].

Participants and methods

A total of 30 male individuals between 45 and 60 years of age attending the surgical outpatient clinic with a BMI of more than 25 kg/m^2 who qualified as obese were included in the study, and a similar number of individuals with BMI less than 25 kg/m^2 served as controls. Flow-volume loop, forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC were recorded using a computerized spirometer.

Informed consent was obtained from all participants.

Ethical approval was obtained from institutional ethics committee.

Following were the inclusion criteria:

(1) Age between 45 and 60 years, and
(2) Blood pressure and blood glucose levels within the normal range.

All participants were free of chronic obstructive pulmonary disease (COPD), asthma, and pleural disease and were nonsmokers.

The exclusion criteria were as follows:

(1) Being known cases of restrictive disease and/or taking treatment for the same;
(2) Having chronic systemic illness such as diabetes, hypertension, and coronary heart disease; and
(3) Being underweight (BMI <18 kg/m^2).

Their BMI was calculated using Quetelet's formula [11]:

$$\text{BMI} = \frac{\text{Weight}(\text{kg})}{\text{Height}^2\ (\text{m})}.$$

Depending on the BMI they were classified as obese individuals or as normal BMI individuals.

Procedure

The test was carried out between 11 a.m. and 1 p.m. in a well-ventilated room. All participants were initially familiarized with the instrument used for testing — a computerized spirometer. SPL-95 computerized spirometer (FIM Company, Villeurbanne cedex, France) was used to measure PFT parameters. The procedure was explained clearly and sufficient demonstration was given. The patient was comfortably seated. Nose clip was applied. The patient was asked to expire air as forcefully and as rapidly as possible into the mouthpiece of the computerized spirometer, followed by a deep inspiration. This procedure was repeated three times with a gap of about 7 min between each maneuver so as to obtain the best of three values as FVC. Flow-volume loop, FEV_1, FVC, and FEV_1/FVC were recorded. Each patient repeated the test three times with a minimum gap of 3 min between any two efforts. The best of the three readings was considered for analysis.

Normal values of FVC and FEV_1 indicated normal PFT. Low values indicated the presence of disease. When the measured value of FEV_1/FVC was 90% or more of the predicted value, in the presence of low FEV_1 and/or low FVC, it indicated the presence of restriction [12]. Predicted values were calculated with the spirometry software spl95.00.91 (Villeurbanne cedex, France). Ethnic correction was carried out as described in a study by Agrawal [3] in North Indian states.

Thus, they were classified into two groups as follows: the control group, which included normal-weight patients (BMI: 18–22.9 kg/m^2), and the study group, which included obese patients (BMI >25 kg/m^2).

Statistical analysis

The unpaired Student *t*-test was used to determine significance. A *P* value less than 0.05 was considered as significant.

Results

Table 1 shows the significantly higher weight and BMI in the study group compared with the control group. This is expected as obese individuals were included in the study group.

Table 2 shows that the measured FEV_1 and FVC values in the study group were significantly lower compared with controls. Percentage of predicted value of FEV_1

Table 1 Comparison of anthropometric data of nonobese and obese with statistical analysis

Parameters	Nonobese	Obese	*P*-value	Remarks
Age (years)	52.48 ± 2.62	52.45 ± 2.89	<0.05	NS
Height (cm)	168.70 ± 7.50	165.90 ± 7.24	<0.05	NS
Weight (kg)	60.06 ± 5.64	99.43 ± 6.26	<0.001	VHS
BMI (kg/m^2)	22.02 ± 2.47	30.60 ± 1.75	<0.001	VHS

VHS, very highly significant; $P < 0.05$, significant; $P < 0.01$, highly significant; $P < 0.001$, very highly significant.

Table 2 Comparison of forced expiratory volume in the first second values – measured and as percentage of predicted

Parameters	Control group (normal BMI)		Study group (obese)		*P* value
	Mean	SD	Mean	SD	
FEV_1 (l)					
Measured	2.93	0.70	1.72	0.56	<0.001
% of Predicted	91.0	7.15	72.86	16.66	
FVC (l)					
Measured	3.42	0.81	1.93	0.65	<0.001
% of Predicted	97.47	5.83	68.01	15.61	
FEV_1/FVC (%)					
Measured	83.62	4.35	83.42	5.81	<0.05
% of Predicted	96.82	3.1	92.92	7.21	

FEV1, forced expiratory volume in the first second; FVC, forced vital capacity.

and FVC showed a similar pattern. The measured value of FEV_1/FVC *per se* and as percentage of predicted value was significantly reduced in the obese group compared with the control group (Table 2).

Discussion

Adipocyte is no longer considered as a depot for fat storage alone. Studies have proved it to be an endocrine cell releasing many chemical mediators such as leptin (an energy balance regulating hormone), cytokinins such as tumor necrosis factor α and interleukin-6, complement factors such as factor-D, prothrombotic factors such as plasminogen activator inhibitor-1, and angiotensinogen, which is a component of the blood pressure regulating system. Such mediators are involved in lipid homeostasis, insulin sensitivity, blood pressure control, coagulation, vascular health, and contribute to obesity-related pathologies [7,12].

Heredity of body weight is similar to that for height. Obesity is seen to run in families but the inheritance pattern is not Mendelian [8]. Whatever the role of the genes, it is clear that the environment plays a key role in the development of obesity [9].

Indians are genetically susceptible to weight accumulation, especially around the waist. In the male population, abdominal obesity is more common. In such cases, excess adipose tissue is present in the anterior chest wall, anterior abdominal wall, and around visceral organs. This results in the chest wall being less compliant and having reduced respiratory muscle endurance, causing airway resistance and work of breathing to increase correspondingly [7,13]. Diaphragmatic movement is hindered, resulting in diminished basal lung expansion during inspiration and ventilation–perfusion abnormalities with arterial hypoxemia due to closure of peripheral lung units [14]

Vital capacity and TLC are decreased in obesity. It is not certain as to the factors causing this reduction but there are few hypotheses. The increased abdominal volume may lead to decreased descent of diaphragm during inspiration and consequently the thoracic expansion reduces. Abdominal elasticity increases along with an expansion of the ring of insertion of the diaphragm to the lower rib cage [15,16]. Intrathoracic fat is more in obese individuals, which compete with the lungs for space within the intrathoracic cavity. This mechanism would be analogous to that proposed for the restrictive pattern associated with chronic heart failure, which is much improved after cardiac transplantation [8].

Reduced TLC was formerly thought to occur only in massively obese individuals but has now been found in some individuals with less-severe obesity as well [6]. Prospective studies have revealed that weight gain is associated with loss of pulmonary function, whereas weight loss is associated with increase in vital capacity [6,7].

A reduced FVC on spirometry in the absence of a reduced FEV_1-to-FVC ratio suggests a restrictive ventilatory problem. Measuring the TLC and residual volume can confirm the restrictive tendency suggested by spirometry. Restrictive lung diseases exhibit reduced TLC percentage with relative preservation of the residual volume/TLC percentage in fibrosis, a reduced inspiratory capacity and expiratory reserve volume in neuromuscular disease, and severe reduction in the expiratory reserve volume in extreme obesity [17].

Because this class of patients notoriously have a decreased functional residual capacity, they will desaturate quickly [4]; this will be seen before intubation (period of apnea) and after extubation, if oxygen is not maintained.

Although no single test can effectively predict intraoperative and postoperative morbidity and mortality from pulmonary complications, the FEV_1 obtained from good-quality spirometry is a useful tool. When the FEV_1 is greater than 2 l or 50% of the predicted value, major complications are rare. Operative risk is heavily dependent on the surgical site, with chest surgery having the highest risk for postoperative complications, followed by upper and lower abdominal sites. Among the most important modifiable patient-related factors associated with increased operative risk for pulmonary complications is obesity [17]. The deleterious effect of weight gain is, to a large extent, reversible. Improvement in pulmonary mechanics is the great advantage gained by obese patients upon losing weight [18].

Conclusion

The incidence of restrictive tendency is more in obese individuals compared with controls. As the changes in respiratory mechanics due to obesity are almost completely reversible, early intervention in such patients will ensure lesser chance of complications on the operation table and postoperatively. With the advent of computerized spirometry, analysis of flow-volume loops is indeed of great help to obese individuals.

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Conflicts of interest

There are no conflicts of interest.

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