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Obesity phenotype influences trend in pulmonary function indices recovery following abdominal surgery: Preliminary report from a Nigerian population

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Abstract
Background: Obesity phenotypes are known to have varying effects on pulmonary function but their effects on trends of pulmonary function indices' recovery among abdominal surgery patients is unclear.
Objective: To investigate the influence of obesity phenotype on pulmonary function trend among abdominal surgery patients.
Methods: An observational study involving 28 female patients aged 20-60 years who were never-smokers. Participants wereclassified into four groups namely: healthy BMI without abdominal obesity; healthy BMI with abdominal obesity; overweight/obese without abdominal obesity; and overweight/obese with abdominal obesity.Pulmonary function indices (FEV1, FVC and PEF) were taken day-1 pre-op; 5th, 6th and 7th day post-surgery.Data were summarized using mean and standard deviation, while Kruskal-Wallis and Jonckheere trend test were used to test for differences and trend across the groups at $p < 0.05$.
Results: Participants were comparable in age and height. Pre-op, group IV had the lowest pulmonary function indices and group I had the highest FEV1, FVC. At 7-day post-op, there was significant difference in pulmonary function indices across the groups, while trend test showed that obesity pattern had significant effect on the trend of FEV1, FVC and PER with group I having the highest values, followed by group III and group II, while group IV had the lowest values.
Conclusion:Obesity phenotype had significant effect on trend of pulmonary function indices among participants. Patients with abdominal obesity, irrespective of BMI, had poor pulmonary function.

Keywords: *Obesity phenotype, Pulmonary function indices, Abdominal surgery*

Résumé
Contexte: Les phénotypes d'obésité sont connus pour avoir des effets variables sur la fonction pulmonaire, mais leurs effets sur les tendances des indices de rétablissement de la fonction pulmonaire chez les patients de chirurgie abdominale n'est pas claire.
Objectif: Pour étudier l'influence du phénotype d'obésité sur la tendance de la fonction pulmonaire chez les patients de chirurgie abdominale.
Méthodes: Une étude observationnelle portant sur 28 patients de sexe féminin âgés de 20-60 ans qui n'étaient jamais des fumeurs. Les participants étaient classifiés en quatre groupes, à savoir : IMC sain sans obésité abdominale ; IMC sain avec obésité abdominale ; surpoids / obèse sans obésité abdominale ; et surpoids / obèse avec obésité abdominale. Les indices de fonction pulmonaire (FEV1, CVF et DEP) ont été prises au jour 1 pré-op ; 5ème, 6ème et 7ème jour post-chirurgie. Les données ont été résumées en utilisant la moyenne et l'écart-type, alors que Kruskal-Wallis et le test de tendance de Jonckheere ont été utilisés pour tester les différences et tendance à travers les groupes à $p <0,05$.
Résultats: Les participants étaient comparables dans l'âge et la hauteur. Pré-op, le groupe IV avait les plus bas indices de la fonction pulmonaire et le groupe I a eu la plus haute FEV1, CVF. A 7 jours post-op, il y avait une différence significative dans les indices de la fonction pulmonaire entre les groupes, tandis que le test de tendance a montré que le modèle d'obésité a eu un effet significatif sur la tendance de FEV1, CVF et PER avec le groupe I ayant les valeurs les plus élevées, suivi par le groupe III et le groupe II, tandis que le groupe IV avait les valeurs les plus faibles.
Conclusion: Le phénotype obésité avait effet significatif sur la tendance des indices de la fonction pulmonaire chez les participants. Les patients présentant avec obésité abdominale, indépendamment de l'IMC, avaient une fonction pulmonaire pauvre.

Mots-clés: *phénotype d'obésité, indices de la fonction pulmonaire, chirurgie abdominale*

Introduction

Effects of obesity on the respiratory system are often underappreciated [1]. The global increasing

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prevalence of obesity, the incidence being higher in women than men [2], poses serious logistics and health challenges to care providers [3].Despite advances in medicine, post-operative pulmonary complications such as pneumonia, atelectasis, respiratory failure, bronchospasm and exacerbation of underlying chronic lung disease occur more frequently in abdominal and thoracic surgery [3]. These complications often prolong hospital stay and contribute significantly to morbidity and mortality in surgical patients [4, 5].

The size and site of excess adiposity influences its effect on respiratory function [6]. Abdominal obesity, coupled with the effects of general anaesthesia, heightens the risk of post-op respiratory complications [7].While general obesity is often assessed during pre-operative assessment of patients, consideration of adiposity pattern is not routinely practiced [8]. It is unclear if obesity pattern affects trend in pulmonary function after surgery though a better understanding of the influence of abdominal obesity, as opposed to general obesity, on trend of post-operative pulmonary function indices may be useful in formulating appropriate strategies to prevent or reduce severity of post-operative respiratory complications. The influence of obesity pattern on the trend of peak expiratory flow, forced expiratory volume in first second and forced vital capacity among female patients undergoing abdominal surgery was investigated in this study.We hypothesized that obesity pattern will have no effect on the trend in pulmonary function following abdominal surgery, hence we compared pulmonary function of patients who had abdominal surgery across four obesity phenotypes.

Materials and Method

Participants

This study was delimited to conscious female patients of ages 20-60 years, who werenever-smokers and no history of respiratory pathology, on admission for abdominal surgery in a teaching hospital in south-western Nigeriaand were able to carry out spirometricmanoeuvre. Participants with previous history of smoking, background of lung diseases, pregnant women and individuals with abdominal tumours were excluded from this study.

Participants were grouped into 4 categories: group I) participants with normal body mass index (BMI) between 18.5 – 24.9kg/m2 and healthy waist circumference (WC < 80cm); group II) participants with normal BMI (18.5 – 24.9kg/m2) and abdominal obesity (WC ≥ 80cm); group III) participants who are overweight/obese (BMI ≥ 25kg/m2) and healthy waist circumference (WC < 80cm); group IV) participants who are overweight/obese (BMI ≥ 25kg/m2) with abdominal obesity (WC ≥ 80cm)

Research design and sampling

This study is an observational study, and participants were recruited through purposive sampling technique.

Procedure for data collection

Ethical approval was sought and obtained from the Health Research Ethics Committee of University of Ibadan/University College Hospital before the commencement of the study. From the pilot study, we observed that most eligible patients became stable from the 2nd day post-operation but could only perform acceptable/useable spirometricmanoeuvre by the 5th–day post-op when pain level, measured by visual analogue scale, was 3 or less. Spirometricmanoeuvre was carried out with the suture site supported with soft pillow in sitting position. The rationale and procedure for this study were explained to each participant and an informed consent to participate in the study was also sought and obtained before commencement of the study. The socio-demographic data of all consenting participants were documented. Anthropometric measurements of %BF, BMI and WC were taken at baseline before spirometry measurements but BMI and WC wereused to categorize participants into four groups based on NIH classification guidelines: group 1) participants with healthy BMI (18.5 – 24.9kg/m2) and healthy waist circumference (WC < 80cm); group 2) participants with healthy BMI (18.5 – 24.9kg/m2) and abdominal obesity (WC ≥ 80cm); group 3) overweight/obese participants with BMI ≥ 25kg/m2 with healthy waist circumference (WC < 80cm); group 4) overweight/obese participants with BMI ≥ 25kg/m2 and abdominal obesity (WC ≥ 80cm) [9]. The selected respiratory function indices (forced vital capacity, forced expiratory volume in first second and peak expiratory flow) of the participants were taken a day before the surgery and on the 5th, 6th and 7th after surgery using ATS/ERS standardization protocol [10].

Table 1: Physical characteristics of participants

Variable	Group I (n=7) mean ± sd	Group II (n=7) mean ± sd	Group III (n=7) mean ± sd	Group IV (n=7) mean ± sd	p- value
Age (yrs)	42.5±8.7	41.9±11.9	41.3±12.7	39.2±13.5	0.42
Wt (kg)	62.8±7.9	67.3±7.1	79.7±3.6	81.2±2.2	0.03
Ht (m)	1.6±0.1	1.7±0.1	1.6±0.3	1.6±0.1	0.97
BMI (kg/m^2)	24.2±5.3	23.2±8.1	31.1±3.4	31.6±4.6	≤ 0.01*
WC (cm)	76.6±4.1	96.8±8.5	78.3±3.7	102.6±4.1	≤ 0.01*
%BF (%)	21.4±2.2	32.4±5.2	25.5±5.3	36.6±4.8	≤ 0.01*

Key
Group I- participants: healthy BMI; without abdominal obesity
Group II- participants: with healthy BMI; with abdominal obesity
Group III- participants: overweight/obese; without abdominal obesity
Group IV: participants: overweight/obese; with abdominal obesity
*: Significant difference at p < 0.05

Data Analysis

Data were summarized using mean and standard deviation and analyzed using Kruskal-Wallis to test differences across the groups, while Jonckheere trend test was used to test for trend across the groups. Alpha level was set at< 0.05.

Results

Physical characteristics of participants

A total of 28 patients (n=7 for each group) who had abdominal surgery and who met the inclusion criteria participated in this study. Table 1 shows the physical characteristics of all participants at baseline. There was no significant difference in age and height (p values > 0.05 respectively) between the groups. Though participants in group 4 were younger, they had the highest indices of obesity (BMI, WC, %BF), while as expected group 1 had the lowest obesity indices. There was significant difference in Wt., BMI, WC and %BF across the groups (p values < 0.05).

Comparison of the respiratory function indices at day-1 before surgery between the groups is shown in table 2. Group IV (overweight/obese with abdominal obesity) had the lowest pulmonary function indices (FEV1, FVC and PEF), group I (healthy BMI without abdominal obesity) had the highest FEV1, FVC,

Table 2: Pulmonary function indices day-1 pre operation

Group	I (n=7) mean ± sd	II (n=7) mean ± sd	III (n=7) mean ± sd	IV (n=7) mean ± sd	p- value
FEV$_1$(L)	2.5 ± 0.7	2.1 ± 0.5	2.4 ± 0.8	2.0 ± 0.6	0.13
FVC (L)	3.1 ± 0.4	2.7 ± 0.6	3.0 ± 0.8	2.5 ± 0.7	0.03*
FER (%)	80.6 ± 8.4	77.8 ± 6.9	80.0 ± 7.3	80.6 ± 7.9	0.08
PEF (L/min)	314.5 ± 50.6	252.8 ±18.9	316.8 ± 37.7	227.5 ± 9.6	≤0.01*

(controlling for percent body fat)

Key
Group I- participants: normal BMI; without abdominal obesity
Group II- participants: with normal BMI; with abdominal obesity
Group III- participants: overweight/obese; without abdominal obesity
Group IV: participants: overweight/obese; with abdominal obesity
*: Significant difference at p < 0.05
L: litres
%: Percentage
L/min: Litres per minute

while group III (overweight/obese participants without abdominal obesity) had the highest PEF. After controlling for %BF, there was significant difference in FVC and PEF across the groups, with group I having the highest values and group IV having the least (Table 2). All the groups had normal forced expiratory ration (FER).

Table 3 shows pulmonary function indices of participants on day-7 after surgery and percentage change compared with pre surgery values. There was significant difference in FEV1, FVC and PEF ($p < 0.05$) across the groups with group IV having the lowest FEV1, FVC and PER; and group I having the highest values followed by group III.. Compared with group IV (overweight/obese with abdominal obesity), group I (healthy weight without abdominal obesity) had 65% higher FEV1, 57% higher FVC and 63% higher PER values.

Using the Jonckheere trend test on the data (S=88, n=7), FEV1, was statistically significant (p=0.03). This indicates that obesity pattern has significant effect on the trend of FEV1 with group I having the highest pulmonary function values, followed by group III and group II, while group IV had the lowest values. Similar trends were observed for FVC and PEF (p=0.01).

Table 3: Percentage difference in pulmonary function indices day-7 post operation

Group	I		II		III		IV		
	mean ± sd	%Δ	mean ± sd	%Δ	mean ± sd	%Δ	mean ± sd	%Δ	p
FEV_1	2.8±0.3	+12%	1.9 ±0.4	-10%	2.4 ± 0.9	0%	1.7 ± 0.5	-15%	0.03*
FVC	3.3±0.7	+6.5%	2.3±0.6	-15%	3.1 ± 0.6	+3%	2.1 ± 0.4	-16%	0.01*
PEF	324.2 ±20.4	+3.1%	212.6 ±11.9	-12%	322.8 ± 23.1	+2.5%	198.5 ± 10.6	-13%	≤0.01*
							(controlling for percent body fat)		

Key
Group I- participants: normal BMI; without abdominal obesity
Group II- participants: with normal BMI; with abdominal obesity
Group III- participants: overweight/obese; without abdominal obesity
Group IV: participants: overweight/obese; with abdominal obesity
%Δ: percentage change compared with pre-surgery values
*: Significant difference at $\alpha = 0.05$
FEV_1: measured in litres
FVC: measured in litres
PEF: measured in Litres per minute

Discussion

We found that obesity pattern influenced the recovery of pulmonary function indices of peak expiratory flow, forced expiratory volume in first second and forced vital capacity among female patients who had abdominal surgery. Participants were comparable in age and height across the groups. It was not surprising that there was significant difference in Wt., BMI, WC and %BF, since participants were grouped based on obesity indices. We also noted, in line with previous findings, that %BF increased across the groups as BMI increased [11, 12], though the youngest group (IV) had the highest obesity indices.

Pre-surgery, all groups had good forced expiratory ratio (FER) suggesting absence of obstructive pulmonary disorder. Preservation of FER also indicates that FEV1 and FVC are affected to the same extent with no direct effect on airway patency [11]. Although participants with

Table 4: Jonckheere Trend Test ofPulmonary function indices on day-7 post operation

Group	I	II	III	IV		
	mean ± sd	mean ± sd	mean ± sd	mean ± sd	S-value	p- value
FEV_1(L)	2.8±0.3	1.9 ±0.4	2.4 ± 0.9	1.7 ± 0.5	88	0.03*
FVC (L)	3.3±0.7	2.3±0.6	3.1 ± 0.6	2.1 ± 0.4	115	0.01*
PEF (L/min)	324.2 ±20.4	212.6 ±11.9	322.8 ± 23.1	198.5 ± 10.6	121	≤ 0.01*

Key
Group I- participants: normal BMI; without abdominal obesity
Group II- participants: with normal BMI; with abdominal obesity
Group III- participants: overweight/obese; without abdominal obesity
Group IV: participants: overweight/obese; with abdominal obesity
*: Significant difference at $\alpha = 0.05$

healthy WC (groups I and III) had higher values of FEV1 compared with those with abdominal obesity, (groups II and IV), there was no significant difference in the FEV1 across the groups after controlling for percent body fat. FEV1 is often used to assess airway patency, especially in the diagnosis and monitoring of airway obstruction pathologies such as chronic obstructive pulmonary disease and asthma. This finding indicates that airway patency across the groups is comparable irrespective of obesity pattern. This is supported by data from previous studies suggesting that obesity has a restrictive effect on the chest wall and does not impair airway patency of the lungs [13,14, 5]. The resultsalso showed significant differences in FVC and PEF among the groups, with participants in groups II and IV (with abdominal obesity) having lower FVC and PEF values. Central obesity increases lung compliances thereby limiting the capacity of the lungs to expand [15]. The lower FVC values observed in groups II and IV might be explained by the limitation in the capacity of the lung to expand due to increased workload from excess adipocyte around the thoracic cage. Excess abdominal fat wedges the diaphragm thereby limiting its excursion during inspiration. Reduction in lung capacity has clinical implications, especially in patients undergoing thoracic or abdominal surgery. Individuals with impaired lung capacity pre-surgery are at a high risk of developing pulmonary complications after surgery [7]. Hence, it may be important for healthcare providers to assess for central obesity and take appropriate preventive steps to optimize pulmonary function before surgery and consequently minimize risk of post-op complications.

Sudden decrease in pulmonary function following surgery can be attributed to the combined effects of anaesthesia and post-operative pain which could have depressed respiratory functions, initiated stress responses and interfered with the return to pre-operative baseline of lung function and mobility [7]. Thoracic and abdominal surgeriesare usually more painful than surgeries on the peripheral parts of the body and produce widespread changes in pulmonary function, increase abdominal muscle tone and an associated decrease in diaphragmatic function [8]. As patients gradually recover from the effects of anaesthesia and pain, there is a corresponding gradual improvement in respiratory function [16]. However, these effects could become complicated in patients with abdominal obesity phenotype, as the restrictive effect of the abdominal content may further predispose them to more severe pulmonary function impairment after surgery.

At 7-day post-surgery, group I participants had better pulmonary function values compared with the pre-operative values. The highest increase was noted in FEV1. Group III (though overweight/obese, but with healthy WC) also had regained pre-operative FEV1, and had increases of 3% and 2.5% in FVC and PER respectively. Participants in group III, though overweight/obese but without abdominal obesity, had better pulmonary function indices compared with participants in groups II (healthy weight but with abdominal obesity) and IV (overweight/obese with abdominal obesity). This suggests that abdominal obesity (WC), rather than general obesity (BMI), influences the trend of pulmonary function after abdominal surgery.

Participants in groups II and IV (with abdominal obesity) still had reduced FEV1, FVC and PEF below pre-operation values at the end of the study, with both groups having the highest decrease in FVC. This finding suggests that individuals with abdominal obesity may take a longer period of time to regain pre-surgery pulmonary function. This does not only indicate the need to consider abdominal obesity as an additional risk when conducting preoperative assessment, but also the need to identify such patients and take appropriate measure to optimize their pulmonary function before surgery. Whether the prolonged pulmonary function deficit in these patients will affect the length of hospital stay is however unclear. Findings from this study show that it is not only necessary to assess for general obesity in patients pre-surgery, but also to go an extra mile to identify their obesity phenotype. Patients with poor pre-operative pulmonary function require adequate pre and post-operative interventions to optimize their pulmonary function, as they are more prone to post-operative morbidity and mortality. Though this study did not look at other factors such as cost of care and length of hospital stay between the groups, it is likely that individuals with abdominal obesity might stay longer in the hospital and even require respiratory system support and possible increased cost of care. Further studies are needed to follow up this group of patient to investigate the long term impact of impaired pulmonary function on physical function and performance.

Conclusion

Obesity phenotype influenced trend of pulmonary function recovery following abdominal surgery. At seven days post-surgery, patients with healthy WC had good pulmonary function, while patients with abdominal obesity, irrespective of BMI, had poor pulmonary function. Abdominal obesity should be considered an additional risk when assessing patients for abdominal surgery and may require appropriate preventive measures pre-operatively to minimize its effect [17].

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