Lean BMIs as markers of malnutrition in chronic obstructive pulmonary disease patients

Suzan S. Salama[a], Aliaë A.R. Mohamed-Hussein[a], Medhat Araby Khalil[b], Safaa Abd El-Gayed Eid[a]

Background Malnutrition is common in chronic obstructive pulmonary disease (COPD) and a relevant concern that may even affect prognosis. A significant number of COPD patients with normal weight also suffer muscle wasting.

Objective The aim of this study was to assess the nutritional status of COPD patients with chronic respiratory failure.

Patients and methods The present prospective analytic case–control study was conducted in the Chest Department, Assiut University Hospital, during the period from January 2013 to February 2014. Sixty-seven COPD patients with chronic respiratory failure and 68 controls were studied according to their nutritional status and body composition using creatinine height and fat-free mass indices.

Results The majority of COPD patients were found to be overweight. As regards body composition, the lean body mass using the fat-free mass index and the creatinine height index was significantly decreased in COPD patients compared with controls.

Conclusion Malnutrition is a common feature among COPD patients. COPD patients have significantly decreased lean body mass. *Egypt J Broncho* 2016 10:33–37
© 2016 Egyptian Journal of Bronchology.

Egyptian Journal of Bronchology 2016 10:33–37

Keywords: body composition, chronic obstructive pulmonary disease, creatinine height index, fat-free mass index, malnutrition

[a]Department of Chest, [b]Department of Public Health, Faculty of Medicine, Assiut University, Assiut, Egypt

Correspondence to Safaa Abd El-Gayed Eid, MSc, Chest Department, Faculty of Medicine, Assiut University, Assiut 71111, Egypt
Tel: 01002569966;
E-mail: safaa_gayed@yahoo.com

Received 31 July 2015 **Accepted** 15 August 2015

Introduction

Malnutrition is common in chronic obstructive pulmonary disease (COPD) and a relevant concern that may even affect prognosis. Low BMI has been shown to be an independent marker of poor prognosis. Nutritional disorders have also been associated with higher morbidity, with involvement of both respiratory and peripheral skeletal muscle, lower exercise tolerance, increased dyspnea, and lower health-related quality of life. Many patients with stable COPD suffer malnutrition. Depletion involves both fat stores and muscle and visceral protein stores, but the greatest effect is seen in muscle wasting. A significant number of COPD patients with normal weight also suffer muscle wasting [1].

Weight loss and depletion of fat-free mass (FFM) is observed in COPD patients independent of the degree of airflow limitation [2].

Weight loss and particularly muscle wasting contribute significantly to morbidity, disability, and handicap in COPD patients. Weight loss and loss in fat mass is primarily the result of a negative balance between dietary intake and energy expenditure, whereas muscle wasting is a consequence of an impaired balance between protein synthesis and protein breakdown. In advanced stages of COPD, both energy balance and protein balance are disturbed. Therefore, nutritional therapy may only be effective if combined with exercise or other anabolic stimuli [3].

The aim of the study was to assess the nutritional status of COPD patients with chronic respiratory failure.

Patients and methods

Study design and ethics

The present prospective analytic case–control study was conducted in the Chest Department and Chest Outpatient Clinic, Faculty of Medicine, Assiut University Hospital, during the period from January 2013 to February 2014. The study design was approved by the Scientific Ethics Committee of Faculty of Medicine of Assiut University. After meeting inclusion criteria, informed consent was obtained from the patient.

Patients

The study included 67 randomly selected COPD patients with chronic respiratory failure diagnosed according to GOLD (2014) guidelines [4], as well as 68 age-matched and sex-matched controls.

Exclusion criteria included chronic hepatic disease, renal failure, malignancy, and diabetes mellitus.

Baseline patient data

All patients underwent the following:

(1) Medical history, examination, spirometry, routine laboratory testing, and investigations.
(2) Nutritional assessment.

Anthropometric variables

(1) Body weight was expressed in kilograms.
(2) Ideal body weight: body weight was expressed as a percentage of ideal weight [5]. Devine formula was used for calculation of ideal body weight [6].
(3) Height was expressed in centimeters.
(4) BMI: BMI was calculated using the following equation [7]:

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

The results of the equation were then classified as follows:

(a) Underweight, if the result was less than 18.5.
(b) Normal weight, if between18.5 and 25.
(c) Overweight, if between 25 and 30.
(d) Grade I obesity, if between 30 and 35.
(e) Grade II obesity, if between 35 and 40.
(f) Grade III obesity, if 40 or greater.

(5) Triceps skin fold (TSF) and arm muscle area (AMA):
TSF: TSF is measured on the right arm at the midpoint between the acromion process of the scapula and the inferior margin of the olecranon process of the ulna. The arm should be bent at a 90° angle at the elbow to mark the midpoint. The arm hangs by the side with the palm facing anteriorly as a caliper is used to measure a pinch of skin fold. The skin fold is grasped between the thumb and the index finger of the left hand and the caliper is placed ~½ inch from the fingers. When the caliper is perpendicular to the skin fold, the dial can be easily read [8].

AMA: The formula to calculate AMA is as follows:

$$\text{AMA} = \frac{\left[\text{MAC}(\text{cm}) - (\pi \times \text{TSF cm})\right]^2 - 10\,\text{cm}^2\ (\text{males})\ \text{or}\ 6.5\,\text{cm}^2\ (\text{females})}{4\pi},$$

where MAC is midarm circumference.

(6) The fat mass index (FMI) and the fat-free mass index (FFMI) were determined using bioelectrical impedance analysis with an electronic scale, Korona (Korona Haushaltswaren GmbH & Co. KG, Germany).

The FFMI was defined as the FFM (kg) divided by the square of height (m^2), and similarly for the FMI [9].

Laboratory testing

(1) Creatinine height index (CHI): The amount of creatinine excreted in the urine every 24 h reflects skeletal muscle mass because the rate of creatinine formation in skeletal muscles is constant. Predicted values are based on sex and height, with a reference value of ~18 mg/kg body weight/day for women and ~23 mg/kg body weight/day for men. Values of 60–80% of predicted indicate a mild deficit of muscle mass, values of 40–60% of predicted indicate a moderate deficit, and values less than 40% of predicted indicate a server depletion of muscle mass [8].
    (a) Expected creatinine is 23 mg/kg of ideal body weight in men.
    (b) Expected creatinine is 18 mg/kg of ideal body weight in women.
(2) Serum albumin and C-reactive protein.

Statistical analysis of data

Data were analyzed using SPSS software package, version 16. Descriptive statistics were analyzed in the form of frequencies, mean, and SD, and analytic statistics were analyzed using χ^2-test, independent sample *t*-test, correlations, and regression tests. Paired *t*-test was used to compare numerical parametric data before and after intervention. Values were considered significant when *P*-value was 0.05 or less.

Results

In this study, 67 COPD patients with chronic respiratory failure and 68 controls were randomly selected from patients admitted and attended at the Chest Department and Outpatient Clinic, Assiut University Hospital, between January 2013 and February 2014.

Table 1 shows that there is a statistically significant difference in the BMI between COPD patients and controls. COPD patients have significantly higher BMI compared with controls (25.1 ± 5.6 vs. 23.3 ± 2.5). There was a statistically significant difference ($P < 0.01$) in the smoking index between the studied groups, as it was higher in COPD patients compared with controls (61.8 ± 38.2 vs. 42.2 ± 45.5, respectively).

In Table 2, body weight is expressed as a percentage of ideal weight. There was no statistically significant difference between COPD patients and controls as regards their weight percentage of ideal body weight (P = 0.217). The lean body mass using AMA was significantly lower in the COPD group than in the control group (58.4 ± 13.5 and 61.9 ± 4.7, respectively). Moreover, the COPD group had significantly lower lean body mass using the FFMI compared with the control group (31.4 ± 4.8 and 35.8 ± 3.4, respectively). In addition, total body water was significantly lower in the COPD group than in the control group (49.2 ± 6.8 and 55.6 ± 5.8, respectively).

Table 3 shows that COPD patients have significantly lower CHI compared with controls (62.4 ± 24.3 and 91.7 ± 24.2, respectively). Serum albumin was significantly lower in COPD patients than in controls (35.5 ± 4.2 and 41.6 ± 4.2, respectively).

Table 4 shows anthropometric parameters in the COPD group as regards severity of airflow limitation based on forced expiratory volume in the first second (FEV_1). There was no statistically significant difference as regards lean body mass using AMA, FFMI, and CHI between COPD patients who had moderate-to-severe obstruction and very severe obstruction. As regards BMI and weight (expressed as percentage of ideal body weight), it was significantly lower in COPD patients who had very severe obstruction than in patients who had moderate-to-severe obstruction (P = 0.041 and 0.001, respectively).

There was no statistically significant difference in BMI, weight (expressed as percentage of ideal body weight), CHI, and albumin between COPD patients with respect to age (Table 5). Despite that, the lean body mass using AMA and FFMI were significantly lower in older COPD patients than in younger patients (55.7 ± 14.6 and 63.9 ± 9.2, respectively; 30.7 ± 4.2 and 32.9 ± 5.6, respectively).

Discussion

Nutrition is a significant issue in managing patients with COPD, because they are at increased risk for malnutrition as the disease progresses [10]. Patients with chronic respiratory failure acutely worsened as patients with COPD show a prevalence of malnutrition ranging from 25 to 40%. A relevant weight loss is seen (of 5% in the previous 3 months or 10% in the previous 6 months) in 25–40% of the patients with a significant pulmonary impairment, which is FEV_1 less than 50%. Mean survival in these patients with cachexia and FEV_1 less than 50% is ~2–4 years, markedly lower than that in those without it [11].

Disadvantages of using body weight in the assessment of nutritional status were demonstrated by Schols *et al.* (1993) [12], who stated that a substantial number of normal-weight COPD patients with abundant fat mass have a depletion of FFM. Moreover, Saudny-Unterberger and colleagues (1997) reported that the changes in body weight as a measure of change in nutritional status in acute exacerbation of COPD is not very useful, as fluid balance is often disturbed; small changes in weight may be the result of either fluid retention or fluid loss complicated by steroid treatment. Therefore, in this study, we used BIA to measure total body water and we assessed nutritional status

Table 1 Demographic data among the studied groups

Parameters	Group 1 (COPD patients)	Group 2 (controls)	P-value
Participants (n)	67	68	
Age (M ± SD) (years)	60.1 ± 10.3	39.0 ± 16.7	<0.01**
Sex [n (%)]			
Male	55 (82.1)	36 (52.9)	<0.01**
Female	12 (17.9)	32 (47.1)	
Weight (kg)	68.2 ± 14.5	64.3 ± 7.2	0.287^{NS}
Height (cm)	165 ± 7.5	166 ± 6.6	0.412^{NS}
BMI (kg/m^2)	25.1 ± 5.6	23.3 ± 2.5	0.017*
Smoking index	61.8 ± 38.2	42.2 ± 45.5	<0.01**

Categorical data are presented in the form of frequency and percentage. Quantitative data are presented in the form of mean ± SD (range), The χ^2-test and t-test were used to test the significance between groups, COPD, chronic obstructive pulmonary disease, NS, not significant (P < 0.05), *Significant (P < 0.05), **Significant (P < 0.01).

Table 2 Anthropometric parameters among the studied groups

Parameters	Group 1 (COPD patients)	Group 2 (controls)	P-value
Participants (n)	67	68	
Ideal body weight	61.4 ± 5.7	59.9 ± 6.1	0.142^{NS}
Wt (% of ideal body weight)	112.6 ± 25	108.3 ± 14	0.217^{NS}
Mid-arm circumference (cm)	28.0 ± 4.2	28.8 ± 2.2	0.167^{NS}
Skin fold thickness (ml)	13.09 ± 7.4	13.4 ± 8.9	0.831^{NS}
Arm muscle area (cm)	58.4 ± 13.5	61.9 ± 4.7	0.040*
Fat mass index	27.7 ± 6.2	23.4 ± 3.7	<0.01**
Fat-free mass index	31.4 ± 4.8	35.8 ± 3.4	<0.01**
Body water	49.2 ± 6.8	55.6 ± 5.8	<0.01**

t-Test was used to test the significance between groups, COPD, chronic obstructive pulmonary disease, NS, not significant (P < 0.05), *Significant (P < 0.05), **Significant (P < 0.01).

Table 3 Laboratory markers among the studied groups

Parameter	Group 1 (COPD patients)	Group 2 (control)	P-value
Participants (n)	67	68	
Creatinine height index %	62.4 ± 24.3	91.7 ± 24.2	<0.01**
C-reactive protein	2.68 ± 2.30	2.86 ± 3.57	0.728^{NS}
Albumin (g/dl)	35.5 ± 4.2	41.6 ± 4.2	<0.01**

t-Test was used to test the significance between groups, COPD, chronic obstructive pulmonary disease, NS, not significant (P < 0.05), **Significant (P < 0.01).

Table 4 Anthropometric parameters in the chronic obstructive pulmonary disease group as regards severity of airflow limitation based on forced expiratory volume in the first second

Parameters	Very severe patients	Moderate-to-severe patients	*P*-value
Participants (*n*)	37	30	
BMI (kg/m^2)	23.6 ± 3.9	28.0 ± 5.4	0.041*
Wt (% of ideal body weight)	104.1 ± 16.2	126.2 ± 25.3	0.001**
Arm muscle area (cm)	58.5 ± 5.2	56.4 ± 23.1	0.680^{NS}
Fat mass index	25.0 ± 5.1	29.4 ± 6.4	0.024*
Fat-free mass index	32.1 ± 3.2	32.2 ± 2.3	0.829^{NS}
Total body water	53.3 ± 6.5	46.9 ± 6.3	<0.01**
Creatinine height index %	68.9 ± 27.8	55.3 ± 25.2	0.131^{NS}
C-reactive protein	3.15 ± 2.4	2.31 ± 1.6	0.243^{NS}
Albumin (g/dl)	34.6 ± 3.4	36.4 ± 4.3	0.167^{NS}

t-Test was used to test the significance between groups, NS, not significant ($P < 0.05$), *Significant ($P < 0.05$), **Significant ($P < 0.01$).

Table 5 Anthropometric parameters as regards age in the chronic obstructive pulmonary disease group

Parameters	≤55	>55	*P*-value
Participants (*n*)	22	45	
BMI (kg/m^2)	26.7 ± 6.8	24.3 ± 4.9	0.106^{NS}
Wt (% of ideal body weight)	117.3 ± 30.2	110.6 ± 23.4	0.342^{NS}
Arm muscle area (cm)	63.9 ± 9.2	55.7 ± 14.6	0.021*
Fat mass index	26.9 ± 6.8	28.0 ± 5.9	0.528^{NS}
Fat-free mass index	32.9 ± 5.6	30.7 ± 4.2	0.048*
Total body water	50.6 ± 7.8	48.5 ± 6.3	0.240^{NS}
Creatinine height index %	62.9 ± 23.4	62.1 ± 25.1	0.909^{NS}
C-reactive protein	2.36 ± 2.08	2.86 ± 2.41	0.420^{NS}
Albumin (g/dl)	35.2 ± 4.3	35.7 ± 4.2	0.643^{NS}

t-Test was used to test the significance between groups, NS, not significant ($P < 0.05$)m, *Significant ($P < 0.05$).

by evaluating body composition using FMI, FFMI, and CHI [13].

In this study, the majority of COPD patients were found to be overweight (112.6 ± 25% of their ideal body weight). According to Odencrants and colleagues (2013), many COPD patients were overweight. Low body weight (BMI≤P25) was found in only 19.1% of the COPD patients. BMI was less than 20 kg/m^2 in 3.9% of the patients. The muscle store was the most frequently affected compartment, although fat and visceral protein depletion was also seen in 20% of the patients. Somewhat more than half of the patients without low body weight had some sort of nutritional disorder [14].

In this study, COPD patients had significantly higher BMI compared with controls (25.1 ± 5.6 vs. 23.3 ± 2.5), whereas lean body mass using AMA was significantly lower in COPD patients compared with controls (58.4 ± 13.5 and 61.9 ± 4.7, respectively). COPD patients had significantly lower lean body mass using the FFMI compared with controls (31.4 ± 4.8 and 35.8 ± 3.4, respectively). In addition, COPD patients showed marked decrease in lean body mass using the CHI compared with controls (62.4 ± 24.3 vs. 91.7 ± 24.2, respectively). These findings are in agreement with the study by Baccioglu and colleagues (2014). There was body decomposition (protein or fat depletion) in not only all underweight patients but also some normal/overweight COPD patients, and they suggest that distribution disorders in the body composition occur before being underweight [15]. Moreover, Roca and colleagues (2013) showed that 67% of the patients were normal weight, 10% were underweight, 10% were overweight, and 13% were obese in the COPD group. The results showed that lean body mass ($P < 0.001$), dry lean mass ($P < 0.001$), total body water ($P < 0.001$), and basal metabolic rate ($P < 0.001$) were lower in COPD patients as compared with controls [16].

Loss of lean mass is now recognized as a major comorbidity of COPD and causes functional impairment. COPD individuals with less lean mass have been shown to have more negative outcomes. Skeletal muscle wasting is a powerful predictor of mortality in COPD, independent of the lung function [17]. Clinically, rapid deteriorations in lean body mass have been described following an acute exacerbation of COPD, and particularly in more severe patients ($FEV_1 < 50\%$) [18].

The severity of dyspnea (MRC) and the FFM% explained 43% of the variance of the physical activity, whereas other physiologic and biologic markers did not have additive effects [19]. FFM depletion *per se* plays a part in the reduction of exercise capacity of COPD patients, regardless of dynamic hyperinflation, and is strictly associated with poor cardiovascular response to exercise and to leg fatigue, but not to dyspnea [20]. Gad and colleagues (2006) studied the effect of malnutrition and obesity on St George's Respiratory Questionnaire. They found that St George's Respiratory Questionnaire score is more impaired in COPD patients who are underweight, overweight, and obese, compared with normal body weight patients. Underweight patients have more impaired impact and total score compared with overweight and obese patients [21].

In this study, we found that total body water is significantly lower in the COPD group than in the control group ($P < 0.01$). This finding is in agreement with the study conducted by Roca *et al.* (2013) [16], who reported that total body water ($P < 0.001$) was lower in COPD patients compared with controls.

In this study, there was no statistically significant difference as regards body composition using FFMI, AMA, and CHI between COPD patients who had moderate-to-severe obstruction and those with very severe obstruction, whereas BMI and weight (expressed as percentage of ideal body weight) were significantly lower in COPD patients who had very severe obstruction than in patients who had moderate-to-severe obstruction. These findings are in agreement with the study conducted by Odencrants *et al.* (2013) [14]; they found that there was no significant correlation between pulmonary function and nutritional status. Gologanu and colleagues (2014) found that there were no correlations between parameters of body composition and FEV_1. No significant correlations were found between FFMI and severity of the disease (bronchial obstruction, distance walked, and CAT score) [22]. Mohamed and colleagues (2001) found that malnutrition adversely affects ventilator function in patients with COPD. They found highly significantly lower value of FEV_1 and peak expiratory flow rate among the underweight COPD patients in comparison with overweight patients. They found highly significantly lower values of FEV_1/FVC among the underweight COPD patients in comparison with overweight patients [23].

In this study, we found that there was no statistically significant correlation between anthropometric parameters and age of COPD patients except for AMA, which was significantly lower in older COPD patients than in younger COPD patients. In agreement with our literature, Battaglia and colleagues (2011) found that body composition score did not correlate with age. Age did not differ among BMI groups based on WHO classification ($P = 0.063$) [24].

Conclusion

Malnutrition is a common feature among COPD patients. The majority of COPD patients are normal or overweight, but have lower lean body mass. Loss of lean mass is now recognized as a major comorbidity of COPD, despite that the majority of COPD patients were overweight.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Soler JJ, Sánchez L, Román P, Martínez MA, *et al.* Prevalence of malnutrition in outpatients with stable chronic obstructive pulmonary disease. *Arch Bronconeumol* 2004; **40**:250–258.

2 Lan CC, Su CP, Chou LL, Yang MC, *et al.* Association of body mass index with exercise cardiopulmonary responses in lung function-matched patients with chronic obstructive pulmonary disease. *Heart Lung* 2012; **41**:374–381.

3 Creutzberg EC, Wouters EF, Mostert R, Pluymers RJ, *et al.* A role for anabolic steroids in the rehabilitation of patients with COPD? A double-blind, placebo-controlled, randomized trial. *Chest* 2003; **124**: 1733–1742.

4 Global Initiative for Chronic Obstructive Lung Disease (GOLD). *Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease*. Bethesda: Global Initiative for Chronic Obstructive Lung Disease; 2014.

5 Schols AM, Mostert R, Soeters PB, Wouters EF. Body composition and exercise performance in patients with chronic obstructive pulmonary disease. *Thorax* 1991; **46**:695–699.

6 Pai MP, Paloucek FP. The origin of the 'Ideal' body weight equations. Ann Pharmacol 2000; **34**:1066–1069.

7 Seidell JC. Obesity: a growing problem. *BMJ* 1999; **10**:428–450.

8 Lee RD, Neiman DC. *Nutritional assessment*. 4th ed. Boston: 2007.

9 Eagan TM, Ueland T, Wagner PD *et al.* Systemic inflammatory markers in chronic obstructive pulmonary disease: results from the Bergen COPD Cohort Study. *Eur Respir J* 2010; **35**:540–548.

10 Evans A. Nutrition screening in patients with COPD. *Nursing Times* 2012; **108**:12–14.

11 Rabe KF, Hurd S, Anzueto A, Barnes PJ, *et al.* Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. *Am J Respir Crit Care Med* 2007; **176**:532–555.

12 Schols AM, Soeters PB, Dingemans AM, Mostert R, *et al.* Prevalence and characteristics of nutritional depletion in patients with stable COPD eligible for pulmonary rehabilitation. *Am Rev Respir Dis* 1993; **147**:1151–1156.

13 Saudny-Unterberger H, Martin JG, Gray-Donald K. Impact of nutritional support on functional status during an acute exacerbation of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1997; **156**:794–799.

14 Odencrants S, Bjuström T, Wiklund N, Blomberg K. Nutritional status, gender and marital status in patients with chronic obstructive pulmonary disease. *J Clin Nurs* 2013; **22**:2822–2829.

15 Baccioglu A, Gulbay BE, Acıcan T. Body composition in patients with stable chronic obstructive pulmonary disease: comparison with malnutrition in healthy smokers. *Eurasian J Med* 2014; **46**:169–175.

16 Roca M, Mitu F, Roca IC, Mihăescu T. Body composition alterations in chronic obstructive pulmonary disease. *Rev Med Chir Soc Med Nat Iasi* 2013; **117**:337–343.

17 Abbatecola AM, Fumagalli A, Spazzafumo L, Betti V, *et al.* Body composition markers in older persons with COPD. *Age Ageing* 2014; **43**:548–553.

18 Walter-Kroker A, Kroker A, Mattiucci-Guehlke M, Glaab T. A practical guide to bioelectrical impedance analysis using the example of chronic obstructive pulmonary disease. *Nutr J* 2011; **10**:35.

19 Costa F, Cusatis GD, Malagrinò L, Antonelli S, Simone CD, Santerini S, *et al.* Dyspnoea and fat free mass are major determinants of reduced physical activity in COPD patients. *ERS* 2011; **38**:3255–3257.

20 Teopompi E, Tzani P, Aiello M, Ramponi S, *et al.* Fat free mass depletion is associated to poor exercise capacity irrespective of dynamic hyperinflation in COPD patients. *Respir Care* 2014; **59**:718–725.

21 Gad SG, Osman AH, El-Sokkary RT, Wafy SM. The effect of nutritional status on the health related quality of life in patients with chronic obstructive pulmonary disease [thesis]. Egypt: Faculty of Medicine, Assiut University; 2006

22 Gologanu D, Ionita D, Gartonea T, Stanescu C *et al.* Body composition in patients with chronic obstructive pulmonary disease. *Maedica (Buchar)* 2014; **9**:25–32.

23 Mohamed SAA, El-shinnawy OM, Sayed SS, Ibraheem MA. Tumour necrosis factor-alpha and weight loss in chronic obstructive pulmonary disease [thesis].Egypt: Faculty of Medicine, Assiut University; 2001

24 Battaglia S, Spatafora M, Paglino G, Pedone C, *et al.* Ageing and COPD affect different domainsof nutritional status: the ECCE study. *Eur Respir J* 2011; **37**:1340–1345.