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Value of incentive spirometry in routine management of COPD patients and its effect on diaphragmatic function

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Abstract

Background Incentive spirometry (IS) is mostly used postoperatively to avoid pulmonary complications, but its effect on COPD patients and its effect on diaphragmatic functions are still not fully studied. The current study aimed to evaluate the value of IS on arterial blood gases, mMRC dyspnea scale, spirometry, and diaphragmatic functions by ultrasound in patients hospitalized for COPD exacerbation.

Methods and patients Forty patients (37 males, 3 females) were admitted for COPD exacerbations and divided randomly into 2 groups: Group1 (G1) =20 patients (mean age 60.7±5.99) used incentive spirometry (IS) for 2 months with medical treatment. Group 2 as a control group (G2) = 20 patients (mean age 60.3±6.44) were given medical treatment only. ABG, spirometry, mMRC dyspnea scale, and diaphragmatic ultrasound functions were assessed on admission and after 2 months of treatment in the groups.

Results There were statistically significant differences between G1 and G2 after 2 months regarding $PaCO_2$, FEV1/FVC (p=0.001 and 0.042, respectively), and Lt diaphragmatic excursion and diaphragm thickness ratio. There was a statistically significant increase in results of PaO_2, $PaCO_2$, FEV1/FVC, PEFR, and all diaphragmatic findings in group I before and after 2 months of IS but no difference in FVC and mMRC dyspnea scale.

Conclusion Incentive spirometry in COPD patients seems to improve ABG, and spirometry functions together with improving diaphragmatic functions.

Trial registration ClinicalTrials.gov NCT05679609. Retrospectively egistered on 10 January 2023

Keywords Chronic obstructive pulmonary disease, Incentive spirometry, Arterial blood gases, Spirometry, Diaphragmatic ultrasound

Introduction

Chronic obstructive pulmonary disease (COPD) is considered a common cause of mortality and morbidity all over the world [1]. The airflow limitation in COPD promotes air trapping together with a decrease in inspiratory capacity, an increase in end-expiratory lung volume (EELV), and finally leads to lung hyperinflation [2]. This will reduce the diaphragmatic contraction in the inspiration which decreases the generation of inspiratory flow and lead to dyspnea and limitation of exercise [3]. The patients experience dysfunctions of inspiratory muscle from the effect of hyperinflation, malnutrition, increased the work of breathing, impairment of gas exchange, and possible use of corticosteroids [4].

The incentive spirometer (IS) is a device that is used to maximally inflate the lungs and hold on to that

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inflation. It encourages patients with visual feedback. It is a common respiratory therapy postoperative because it prevents and resolves atelectasis by increasing the lung inflation that thoughts to open the collapsed lung alveoli [5, 6].

In COPD patients, it is recommended to use IS postoperative [7]. But still its effect in COPD patients is unknown independently on surgery.

Exercise training lowers ventilatory requirements and reduces dynamic lung hyperinflation that leads to improving oxygen content and so, the systemic oxygen availability in muscles increases [8].

Diaphragm excursion (DE) can be determined by ultrasound which can help to detect diaphragmatic dysfunction [9]. Ultrasound can also detect the thickness of the diaphragm in the zone of apposition [10]. Thickening measuring during deep breathing can reflect the magnitude of the effort of the diaphragm, similar to the ejection fraction of the heart [11]. In cases of air trapping, there was a progressive decrease in both the thickening and thickness of the diaphragm with increasing the severity of this air trapping [12].

Patients and methods

This study was a prospective randomized trial done on 40 patients diagnosed with COPD admitted to the Chest Department in Menoufia University Hospital from the period of March 2021 to May 2022. Written informed consent was taken from the patients; after obtaining ethics committee approval from Menoufia University Hospital (IRB: 6/2022CHES4-1).

This current study aimed to evaluate the effect of IS on ABG, spirometry, and on diaphragmatic function using ultrasound in patients hospitalized for COPD exacerbation and then follow-up 2 months later.

The inclusion criteria were as follows: a confirmed case of COPD according to the criteria of the global initiative for COPD (GOLD) with a post-bronchodilator forced expiratory volume/forced vital capacity (FEV1/FVC) ratio of <70% of patients [13]. The age of all patients was over 40 years.

Patients with a bad acoustic window by ultrasound (US) that interferes with US measurements, significant reactivity after bronchodilator use, other chronic chest diseases that result in hypoxia, neurological disease, pleural effusion, lung cancer, recent myocardial infarction, medical history of the chest, or abdominal major surgical operation or inability to complete the study procedures were excluded from this study.

The population of the study consisted of 40 patients who were hospitalized with an acute exacerbation of COPD and the patients were randomized and divided into two groups: Group 1: used the incentive spirometer plus medical treatment (G1 group = 20 patients) and group 2: used only medical treatment (G2 group= 20 patients). GOLD staging systems were used to classify all patients from stages I to IV [13].

Methods

All patients underwent a history taking including past medical history, drug history, any comorbidity, and smoking history. After a physical examination, a chest X-ray was obtained. Dyspnea was assessed by The modified Medical Research Council (mMRC) dyspnea scale which is a 5-point (0 to 4) scale depending on dyspnea severity and was explained in Arabic to all patients [14], then arterial blood gases (ABG), spirometry, and US assessment of the diaphragm were done on admission for all patients, and after 2 months of IS use and medical treatment in G1 and after medical treatment in only G2. The patients were hospitalized for about 10 days (6–14 days). The discharge criteria and hospital and home medications were the same for both groups according to GOLD guidelines.

ABG

ABG samples were taken by percutaneous puncture of the radial artery, during breathing room air, and analyzed on the gas analyzer (the Stat Profile pHOx series blood gases analyzers, USA) obtaining data were collected with an emphasis on PaO_2 and $PaCO_2$.

Spirometry

The spirometry was done in the pulmonary function Unit of Menoufia University Hospital (THOR Laboratories Kft Spirometer, Hungary) measuring data were collected with an emphasis on FEV1/FVC, FVC, and peak expiratory flow rate (PEFR).

Diaphragmatic ultrasonography

US was performed using a machine (Philips Affiniti 50 G; Germany), and the patients were asked to sit in a semi-recumbent position.

For the diaphragmatic excursion (DE), we examined by a convex probe (2–5 MHz) using B-mode (Fig. 1), then the M-mode was used to measure the amplitude of DE in quiet breathing and deep breathing [15].

The right hemidiaphragm was obtained by putting the probe subcostal or in the low intercostal area, in between the midclavicular and the mid-axillary lines. In the left hemidiaphragm, it is placed subcostal or more posteriorly than on the Rt side in between the anterior and the posterior axillary lines, and at least three different breathing cycles were recorded and take the average measurement.

Examination of the right hemidiaphragm is made by visualization of the liver window, but on the left side, the

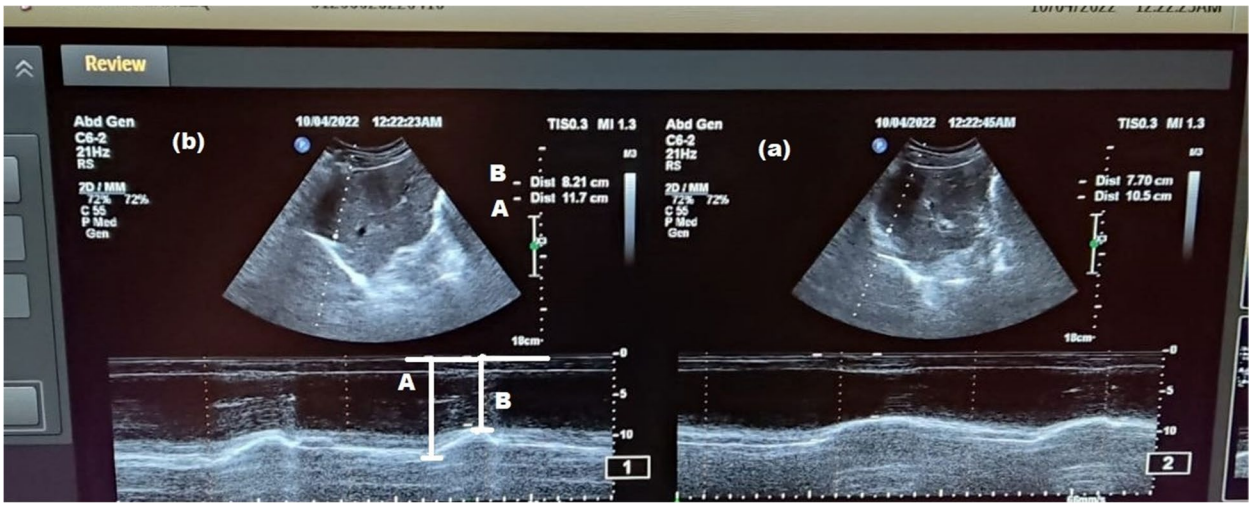

Fig. 1 Diaphragmatic excursion by m-mode (**a**): during quit breathing and (**b**): during deep inspiration. DE = distance A-distance B

narrow window of the spleen makes it more difficult. In this case, we can place the probe in a more coronal position and parallel to the ribs [16].

Measurements of the diaphragmatic thickness (DT) were done at the zone of apposition, near the costophrenic angle in between the anterior and mid-axillary lines like the technique of Ueki et al. [17]. The diaphragm appeared as a structure of three layers. A non-echogenic muscle layer in-between 2 echogenic layers (diaphragmatic pleura and peritoneal serosa) [18]. DT was measured at the end of inspiration and the end of expiration bilaterally (Fig. 2). The examination was done by the linear probe (6–12 MHz).

The percentage of DT fraction done by the formula: (DT at end inspiration) - (DT at end-expiration)/(DT at end-expiration) × 100% [11].

Incentive spirometry (IS)

Inspiratory muscle training (IMT) is done by threshold loading or by resistive breathing in most studies. But it was not available for us to do it. The IS is an easy and

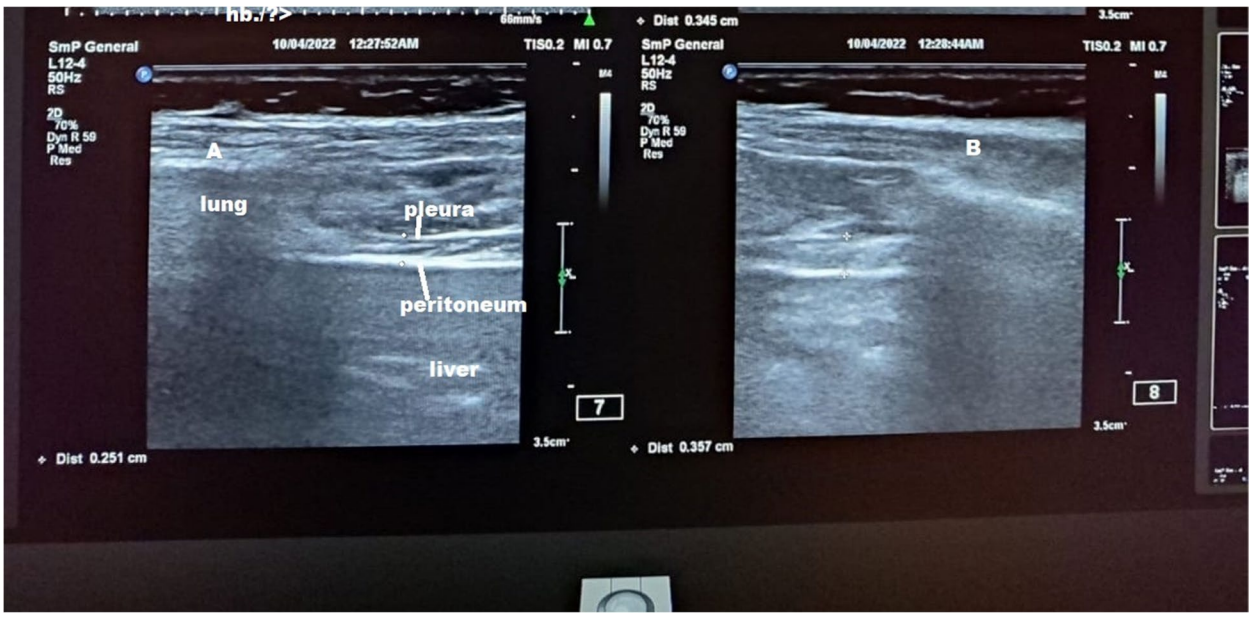

Fig. 2 Measurement of diaphragmatic thickness by the linear probe (**a**): during end expiration, (**b**) during end inspiration

cheap device that can easily be used for inspiratory muscle training at the bedside.

The IS used was a flow-oriented incentive spirometer (UNICARE, model UNA01, China), which had three chambers, 600, 900, and 1200 cc/s, with a ball in each chamber and a mouthpiece (Fig. 3). The patients were first trained to use it by one of the chest physicians. After a quiet exhalation, they were instructed to take slow full inspirations and to keep it for as long as they can (at least for 5 s) and then expire slowly. The balls were raised and suspended up by the sustained inspiration that corresponded to the inspiratory flow. The device is used during wake time every hour at least 5–10 times in the session [7]. IS was used for 2 months from the 1st day of admission. Every 2 weeks, telephone contact with the patients was done to ensure compliance, and also one of the patient's relatives who is the main health caregiver has been instructed for the maneuver to follow up with the patient.

Statistical analysis

Data were collected, tabulated, and statistically analyzed using an IBM personal computer with Statistical Package of Social Science (SPSS) version 20 (SPSS, Inc., Chicago, Illinois, USA). Quantitative data were presented as mean, standard deviation (SD), range, and qualitative data were presented as numbers and percentages.

Chi-square test (χ^2) is used to study the association between two qualitative variables; when the expected cell count of more than 25% of cases was less than 5, Fischer's exact test for 2 × 2 tables were used, *t* test was used for comparison between two groups having quantitative variables, and Mann-Whitney test (nonparametric test) was used for comparison between two groups not normally distributed having quantitative variables. Paired *t* test was used for comparison between two related groups having quantitative variables, and Wilcoxon signed-rank test (nonparametric test) was used for comparison between two related groups not normally distributed having quantitative variables. The significance level was set at a *P* value of <0.05.

Fig. 3 Incentive spirometer used in the study (UNICARE, China)

Results

Forty patients diagnosed with COPD were admitted to the Chest Department in Menoufia University Hospital by exacerbation. The patients were randomly divided into 2 groups: group 1 (20 patients, 19 males and 1 female, age 60.7±5.99 years) and group 2 (20 patients with 18 males and 2 females, age 60.3±6.44 years). There were no statistically significant differences between both groups regarding socio-demographics, comorbidities, and clinical data (Table 1) and between both groups on admission regarding ABG, spirometry (Table 2), and diaphragmatic ultrasound finding (Table 3).

After 2 months of the study, there were statistically significant differences between both groups regarding FEV1/FVC and Lt DE in deep inspiration (*P* value 0.04 and 0.048, respectively) and highly statistically significant differences regarding $PaCO_2$ and Rt and Lt DT ratio (*P* value 0.001, 0.007 and 0.001, respectively) (Tables 4 and 5).

G1 showed high statistically significant differences before and after the IS used with medical treatment regarding PaO_2, $PaCO_2$ (*P* value 0.002 and 0.003, respectively), FEV1/FVC, and PEFR (*P* value 0.001) together with all diaphragmatic findings by US (*P* value 0.001) but no statistically significant differences regarding FVC. The dyspnea scale improved but did not reach a significant level (*P*=0.235) (Tables 6 and 7).

G2 showed statistically significant differences regarding PaO_2 (*P* value 0.011) and highly statistically significant differences regarding Rt DE in quit breathing (*P* value 0.008), but no statistically significant differences regarding other parameters.

Discussion

This study aimed to evaluate the effect of IS use for 2 months on ABG, spirometry functions, and diaphragmatic excursion and thickness ratio in COPD patients hospitalized by acute exacerbation. The results showed that in COPD patients, incentive spirometry for a short duration can improve some respiratory functions, and blood gases and can improve diaphragmatic functions, so it can be a supplemental therapy in a COPD management program.

Table 1 Socio-demographic and comorbidities of the studied groups (*N*=40)

Studied variables	Group I (cases) (*N*=20)	Group II (controls) (*N*=20)	Test of significance	*P* value
Age/years				
Mean±SD	60.7±5.99	60.3±6.44		
Median	60.0	61.5	*t* test	0.840
Range	45.0–72.0	48.0–70.0	0.203	
Sex				
Male	19 (95.0)	18 (90.0)	FE	1.00
Female	1 (5.00)	2 (10.0)	0.360	
Smoking				
Yes	19 (95.0)	18 (90.0)	FE	1.00
No	1 (5.00)	2 (10.0)	0.360	
DM				
Yes	6 (30.0)	3 (15.0)	FE	0.451
No	14 (70.0)	17 (85.0)	1.29	
Hypertension				
Yes	6 (30.0)	5 (25.0)	X^2	0.723
No	14 (70.0)	15 (75.0)	0.125	
mMRC dyspnea scale				
Scale 2	2 (10.0)	3 (15.0)	X^2	0.890
Scale 3	16 (80.0)	15 (75.0)	0.232	
Scale 4	2 (10.0)	2 (10.0)		
GOLD staging				
Stage II	8 (4.0)	6 (30.0)	X^2	0.603
Stage III	10 (50.0)	13 (65.0)	1.010	
Stage IV	2 (10.0)	1 (5.00)		

FE Fisher's exact test, X^2 chi-squared

There were statistically significant differences between both groups after 2 months regarding $PaCO_2$ and FEV1/FVC (*P*=0.001 and 0.042, respectively). There was a statistically significant improvement in the results of PaO_2, $PaCO_2$, FEV1/FVC, and PEFR in group I before and after 2 months of IS but the mMRC dyspnea scale did not reach a significant level although its value improved.

Igarashi et al. studied the effects of IS on pulmonary functions and ABG (that were measured at the start of the program, and 2 and 4 weeks after the start) in normal advanced age and COPD groups, they found that there were significant increases in vital capacity, FEV_1, PEFR, the flow at 75 % VC (V_{75}), maximal voluntary ventilation MVV and PaO_2, and a significant decline in alveolar-arterial oxygen gradient D(A-a) O_2 at both 2 and 4 weeks after the start in both groups. In addition, V_{25} increased significantly in the COPD group [19].

In another study that evaluated the effect of incentive breathing exercise that was given for half an hour every day for 6 weeks on patients of COPD in a controlled study, there was a significant increase in vital capacity and a decrease in air trapping in the exercise group. Also, there was a remarkable improvement in the feeling of well-being and breathlessness [20].

Scherer et al. studied the effects of inspiratory muscle training by using a portable device in COPD patients for an 8-week duration, and the control group used the IS to perform breathing exercises. The study showed that the breathing exercises improved dyspnea and the maximum inspiratory pressure (P_{Imax}) in the IS group because of an improvement in their inspiratory muscle performance [21].

Ahmad et al. found that there were significant changes from baseline after a 4-week intervention of a combination of inspiratory muscle training (IMT) and chest physiotherapy treatments in pulmonary function, exercise tolerance, the strength of inspiratory muscle, and quality of life among hospitalized patients with mild to moderate COPD [22]. Also, it is reported by Cortopassi et al. and Barakat et al. with changes of 2.6% and 16.2%, respectively in FEV1/FVC [23, 24].

The study of Tout et al. showed a significant increase in FEV1 and PEFR in COPD patients who underwent a

Table 2 Comparison between the studied groups regarding ABG finding and spirometry finding (*N*=40)

Studied variables	Group I (*N*=20)	Group II (*N*=20)	Test of sig.	*P* value
PaO_2 (mmHg)				
Mean±SD	61.8±3.36	62.1±5.07	*t* test	0.789
Median	61.5	62.5	0.257	
Range	55.0–67.0	53.0–71.0		
$PaCO_2$(mmHg)				
Mean±SD	46.5±6.07	48.3±4.18	*t* test	0.141
Median	48.0	48.0	1.51	
Range	32.0–57.0	39.0–57.0		
FVC (%)				
Mean±SD	79.6±11.4	80.0±4.51	*t* test	
Median	80.0	79.5	0.027	0.885
Range	52.0–107.0	72.0–90.0		
FEV1/FVC				
Mean±SD	56.6±10.7	57.2±7.03	U	
Median	59.0	57.0	0.515	0.606
Range	23.0–66.0	45.0–60.0		
PEFR (%)				
Mean±SD	27.2±7.56	28.9±7.65	U	
Median	25.5	26.5	0.558	0.577
Range	17.0–51.0	20.0–42.0		

FEV1 forced expiratory volume in the 1st second, *FVC* forced vital capacity, *PEFR* peak expiratory flow rate

Table 3 Comparison between the studied groups regarding diaphragm finding by ultrasound (*N*=40)

Rt DE (cm) (quit inspiration)				
Mean±SD	2.93±0.79	2.96±0.84		
Median	3.10	3.10	*t* test	0.915
Range	1.20–4.00	1.20–4.00	0.107	
Lt DE (cm) (quit inspiration)				
Mean±SD	3.54±0.85	3.56±0.87	*t* test	
Median	3.65	3.90	0.084	0.934
Range	2.00–4.60	2.00–4.60		
Rt DE (cm) (deep inspiration)				
Mean±SD	4.11±0.75	4.12±0.79	*t* test	
Median	4.20	4.20	0.044	0.965
Range	2.20–5.20	2.20–5.20		
Lt DE (cm) (deep inspiration)				
Mean±SD	4.67±0.80	4.68±0.83	*t* test	
Median	4.90	4.90	0.035	0.972
Range	2.60–5.90	2.60–5.90		
RT DT ratio (%)				
Mean±SD	49.5±14.2	49.4±8.03	U	
Median	48.5	49.0	0.268	0.789
Range	25.0–94.0	30.0–65.0		
Lt DT ratio (%)				
Mean±SD	57.2±11.9	55.5±8.63	U	
Median	56.0	55.0	0.199	0.842
Range	35.0–94.0	35.0–70.0		

DE, diaphragmatic excursion, *DT* diaphragmatic thickness, *U* Mann–Whitney *U* test

protocol of rehabilitation utilizing Threshold® inspiratory muscle training (IMT) [25].

Smart et al. studied COPD patients and the study showed that besides increasing respiratory muscle strength, IMT improved the functional capacity, exercise capacity, dyspnea, and quality of life [26].

These effects may be explained by the fact that IS can assist the subject to inspire lung capacity through sustained maximal inhalation, helped by visual feedback. This will increase transpulmonary pressure and lung volume together with diaphragmatic mobility. The collapsed areas in the lungs will expand that preventing alveolar collapse together with inducing greater lower inspiratory muscle activity that improves breathing capacity [7, 27–30].

In comparison with the study of Basoglu et al. who studied the efficacy of IS in COPD patients, there were no significant differences in pulmonary functions between the IS group and the post-treatment group but the use of IS for 2 months with medical treatment improved the arterial blood gases and health-related quality of life [31].

In this study, there was a statistically significant difference between the studied groups after 2 months regarding left DE in deep inspiration, and Rt & Lt diaphragm thickness ratio.

There was a statistically significant improvement in all diaphragmatic findings by the US before and after 2 months among group I

The contractile force of all respiratory muscles is proportional to the increase in the intra-alveolar pressure which explains the fact that to obtain the total lung capacity, intense muscle activity should occur [32].

To make breathing exercises with the IS, the person mobilizes a large tidal volume (TV) with a low respiratory rate, which increases the muscle strength by increasing the inspiration/expiration ratio [33].

There are limited studies that study the value of IS on both diaphragmatic excursion and thickness in COPD patients.

Various research studied the effects of IS on a diaphragmatic excursion in different studying groups that came following our study, e.g., Udayamala et al. found that IS exercise promotes a greater DE assessed by ultrasonography in healthy participants during both rest and breathing exercises [34]. Also, Darnley et al. reported that IMT may improve exercise capacity, diaphragmatic function, and feelings of dyspnea in individuals with chronic coronary artery disease [35].

Table 4 Comparison between the studied groups regarding ABG finding and spirometry finding after 2 months (*N*=40)

Studied variables	After 2 months		Test of sig.	*P* value
	Group I (*N*=20)	Group II (*N*=20)		
PaO_2 (mmHg)				
Mean±SD	65.5±7.63	63.9±4.05	U	0.092
Median	66.0	64.5	1.68	
Range	37.0–79.0	55.0–71.0		
$PaCO_2$ (mmHg)				
Mean±SD	43.6±7.03	50.7±4.72	U	**0.001****
Median	44.0	50.0	4.08	
Range	31.0–67.0	40.0–58.0		
FVC (%)				
Mean±SD	77.2±15.0	80.5±4.93	U	
Median	81.5	80.0	0.163	0.871
Range	32.0–107.0	72.0–90.0		
FEV1/FVC				
Mean±SD	60.2±10.9	57.6±7.72	U	
Median	63.5	57.0	2.03	**0.042***
Range	30.0–69.0	45.0–77.0		
PEFR (%)				
Mean±SD	31.9±8.11	28.9±7.65	U	
Median	32.0	26.5	01.35	0.174
Range	20.0–52.0	20.0–42.0		
mMRC dyspnea scale				
Scale 2	6 (30.0)	7 (35.0)	X^2	0.942
Scale 3	12 (60.0)	11 (55.0)	0.1204	
Scale 4	2 (10.0)	2 (10.0)		

**High significant, *Significant

Table 5 Comparison between the studied groups regarding diaphragm by ultrasound finding after 2 months (*N*=40)

Studied variables	After 2 months		Test of sig.	*P* value
	Group I (*N*=20)	Group II (*N*=20)		
Rt DE (cm) (quit inspiration)				
Mean±SD	3.35±0.73	3.03±0.83		
Median	3.40	3.20	*t* test	0.207
Range	2.20–4.50	1.30–4.10	1.28	
Lt DE (cm) (quit inspiration)				
Mean±SD	4.06±0.82	3.61±0.88	*t* test	
Median	4.30	4.00	1.64	0.109
Range	2.50–5.00	2.10–4.60		
Rt DE (cm) (deep inspiration)				
Mean±SD	4.51±0.76	4.06±0.72	*t* test	
Median	4.65	4.20	1.86	0.071
Range	3.10–5.80	2.30–5.00		
Lt DE (cm) (deep inspiration)				
Mean±SD	5.14±0.78	4.63±0.78	*t* test	
Median	5.25	4.80	2.04	**0.048***
Range	3.30–6.40	2.50–5.80		
RT DT ratio (%)				
Mean±SD	58.5±13.3	49.7±8.03	U	
Median	58.0	50.0	2.70	**0.007****
Range	27.0–100	33.0–65.0		
Lt DT ratio (%)				
Mean±SD	67.3±12.5	54.9±8.27	U	
Median	66.5	56.0	3.51	**0.001****
Range	27.0–99.0	34.0–66.0		

**High significant, *Significant

Hala et al. studied chronic kidney disease (CKD) patients; their results showed that IS training for 8 weeks had significant good effects on DE and quality of life in CKD patients on regular hemodialysis [36].

The effect of IS on DE may be due to the improvement of diaphragm power and mechanics together with the strength of inspiratory muscles.

On the other hand, the results of this study conflict with the results of the study of Barbalho-Moulim et al. who stated that there was a non-significant change in DE with the IMT program for 4 weeks, but the difference could be explained by the short study duration and different in studying group [37].

The study of Ramírez-Sarmiento et al. studied the effect of pressure threshold IMT on the structural changes in the respiratory muscles of patients with COPD. The muscle fibers from the external intercostal muscle before and after 5 weeks showed significant increases in the proportion of type I fibers (by 38%) and the size of type II fibers (by 21%). This structural remodeling leads to functional improvement [38].

Many studies observed that breathing exercises against load increase maximum inspiratory pressure (MIP) together with the endurance capacity of inspiratory muscles as it leads to significant hypertrophy of type I and type II fibers of the diaphragm [39, 40].

Cheng et al stated that after respiratory muscle training, COPD patients exhibited a significant increase in FEV1, MIP, maximum expiratory pressure (MEP), SpO_2 at rest, DT fraction, and DE (all $P < 0.01$) [41].

We considered US measurements obtained from the right and left sides, although some studies studied only the right side of the patients, as the left side has a poor acoustic window [42].

We tried to assess the left diaphragmatic function and found that the left diaphragmatic excursion improved better than the right side in G1 before and after IS use and between both groups after 2 months. This needs to be evaluated in future studies.

Table 6 ABG and spirometry before and after 2 months of IS use and medical treatment among group I (*N*=20)

Studied variables	Group I		Test of significance	*P* value
	Before	After 2 months		
PaO_2 (mmHg)				
Mean±SD	61.8±3.36	65.5±7.63	*Z*	**0.002****
Median	61.5	66.0	3.13	
Range	55.0–67.0	37.0–79.0		
$PaCO_2$(mmHg)				
Mean±SD	46.5±6.07	43.6±7.03	*Z*	**0.003****
Median	48.0	44.0	3.01	
Range	32.0–57.0	31.0–67.0		
FVC (%)				
Mean±SD	79.6±11.4	77.2±15.0	*Z*	0.220
Median	80.0	81.5	1.22	
Range	52.0–107.0	32.0–107.0		
FEV1/FVC				
Mean±SD	56.6±10.7	60.2±10.9	*Z*	**0.001****
Median	59.0	63.5	3.92	
Range	23.0–66.0	30.0–69.0		
PEFR (%)				
Mean±SD	27.2±7.56	31.9±8.11	*Z*	**0.001****
Median	25.5	32.0	3.73	
Range	17.0–51.0	20.0–52.0		
mMRC dyspnea scale				
Scale 2	2 (10.0)	6 (30.0)	X^2	0.276
Scale 3	16 (80.0)	12 (60.0)	2.571	
Scale 4	2 (10.0)	2 (10.0)		

**High significant, *Z* Wilcoxon signed-rank test

Table 7 Comparison between diaphragm finding by ultrasound before and after 2 months among group I

Studied variables	Group I (*N*=20)		Test of sig.	*P* value
	Before	After 2 months		
Rt DE (cm) (quit inspiration)				
Mean±SD	2.93±0.79	3.35±0.73	Paired *t*	
Median	3.10	3.40	test	**0.001****
Range	1.20–4.00	2.20–4.50	5.36	
Lt DE (cm) (quit inspiration)				
Mean±SD	3.54±0.85	4.06±0.82	Paired *t*	
Median	3.65	4.30	test	**0.001****
Range	2.00–4.60	2.50–5.00	9.12	
Rt DE (cm) (deep inspiration)				
Mean±SD	4.11±0.75	4.51±0.76	Paired *t*	
Median	4.20	4.65	test	**0.001****
Range	2.20–5.20	3.10–5.80	7.40	
Lt DE (cm) (deep inspiration)				
Mean±SD	4.67±0.80	5.14±0.78	Paired *t*	
Median	4.90	5.25	test	**0.001****
Range	2.60–5.90	3.30–6.40	8.49	
Rt DT ratio (%)				
Mean±SD	49.5±14.2	58.5±13.3	*Z*	
Median	48.5	58.0	3.92	**0.001****
Range	25.0–94.0	27.0–100		
Lt DT ratio (%)				
Mean±SD	57.2±11.9	67.3±12.5	*Z*	
Median	56.0	66.5	3.93	**0.001****
Range	35.0–94.0	27.0–99.0		

**High significant

There was a statistically significant increase in the results of PaO_2 and Rt DE in quit inspiration in group II before and after 2 months of medical treatment. This can be explained by the improvement of oxygenation after treatment in the exacerbation. The $PaCO_2$ improved more in G1 this may be explained by more effect on respiratory muscle function by IS.

The pulmonary function parameters did not show significant differences although improvements in lung function were stated in studies on long-acting B agonists as maintenance therapy; this may be due to the short duration of the study and the unknown actual start of medications in each patient [43–45].

Conclusion

It was concluded that the IS improves ABG, some parameters in pulmonary functions, and diaphragmatic functions in COPD patients who are hospitalized by acute exacerbations. Further studies are needed to assess the value of IS in COPD patients and to compare it with other respiratory therapy modalities for a longer period and its correlation with GOLD classifications. Also, evaluation of diaphragmatic function after IS in COPD patients with more facilities, e.g., pressure-derived parameters and electromyography.

Limitation of the study

There were some limitations to this study. The number of patients needs to be increased. The study did not include stable COPD patients or the effect of IS on the quality of life, and these are recommended in future studies. Not all parameters of pulmonary functions had been studied.

Abbreviations

ABG	Arterial blood gases
COPD	Chronic obstructive pulmonary disease
DE	Diaphragmatic excursion
DT	Diaphragmatic thickness
EELV	End-expiratory lung volume
FEV	Forced expiratory volume
FVC	Forced vital capacity
IMT	Inspiratory muscle training
IS	Incentive spirometry
mMRC	Modified Medical Research Council

PEFR Peak expiratory flow rate
US Ultrasound

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Not applicable.

Authors' contributions
Study design: M.E. Data collection: A.E, H.E, and M.E . Data analysis: S.A and M.E. Interpretation of results: A.E, S.A and M.E. Initial draft: A.E and H.E. final review of the manuscript content: all authors. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethics Committee of Menoufia University Hospital. Written informed consent was obtained from all participants.

Consent for publication
Applicable.

Competing interests
The authors declare that they have no competing interests.

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