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An impact of comprehensive pulmonary physiotherapy on ABG level and early functional independence in the patient with acute COPD exacerbation with CO_2 narcosis

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ABSTRACT

Chronic obstructive pulmonary disease (COPD) is a chronic illness characterized by an acute exacerbation of respiratory symptoms. Recurrent episodes of acute exacerbation result in acute hypercapnia and acute carbon dioxide narcosis, which are often accompanied byan altered level of consciousness. Acute exacerbations in the elderly have a worse outcome, as evidenced by an increase in comorbid illnesses, length of stay, re-hospitalization rate, and death rate. This article describes the case of an elderly female patient who presented to the emergency unit with complaints of altered conscious state, dyspnea, cough with expectoration, fever, loss of appetite, and abdominal pain. Her ABG tests also revealed a low pH and an abnormal level of blood gases with acute hypercapnia. The patient was admitted to the medical ICU with ventilator assistance as well as medications, but to restore the patient's respiratory capacity and improve the patient's quality of life, a complete physiotherapy management plan was implemented for four weeks. The treatment primarily aimed at stabilizing ABG levels using integrated physiotherapy approaches and thereby improving the patient's medical state. The patient's improvement was measured in the outcomes of ABG levels, COPD assessment test score, Peak expiratory flow rate, FIM scores, dyspnea levels, and walking distance over four weeks, demonstrating the effectiveness of the treatment.

Keywords: Acute CO_2 narcosis, acute exacerbation of COPD, ABG analysis, pulmonary physiotherapy, case report

1. INTRODUCTION

Carbon dioxide (CO_2) narcosis is a condition that occurs when there is an excess of CO_2 in the bloodstream, resulting in a depressed level of consciousness (Drechsler and Morris, 2021). The chronic obstruction during expiration causes CO_2 retention in the lungs, ultimately resulting in hypercapnia and acute carbon dioxide narcosis. Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is a clinical diagnosis determined when a COPD patient experiences a prolonged (e.g., 24–48 h) rise in cough, sputum production, and/or dyspnea (MacIntyre and Huang, 2008). COPD patients have recurring acute exacerbations at a rate ranging from 0.5 to 3.5 exacerbations per year (Torres-Sánchez et al., 2017). These exacerbations and associated hospitalizations have a major effect on ease of life, and their recurrence could affect the natural history of the disease, as evaluated by the rate of pulmonary function deterioration and mortality (Roche et al., 2008). Especially the elderly people with COPD are much more likely to acquire obesity-related comorbid disorders such as cardiovascular disease, diabetes mellitus, and metabolic syndrome (2021 GOLD Reports, 2021). In such patients, obesity has been related to decreased lung function measures, as well as an increased prevalence of various respiratory illnesses and reduced pulmonary function.

In this case, physiotherapy rehabilitation was planned for an elderly female obese patient who was experiencing acute carbon dioxide narcosis along with acute exacerbations of COPDsymptoms that were worsening with each episode due to concomitant illnesses. Female Patients with COPD are more likely to have severe worsening, more hospitalizations, and a longer hospital stay because they have more dyspnea, lower quality of life, and less exercise ability under stable conditions (Kilic et al., 2015). A range of physiotherapy techniques has been proven to enhance functional status in individuals hospitalized for AECOPD when compared to standard care (Torres-Sánchez et al., 2017). In this study, an attempt was made to integrate these individual techniques, construct a protocol, and test whether it is adequately compliant with improving CO_2 narcosis. Our physiotherapy rehabilitation was primarily focused on improving the patient's arterial blood gas (ABG) levels while taking into account the patient's concurrent medical management, comorbidities, and the physiological changes due to aging, thereby improving the patient's morbid condition.

2. PATIENT INFORMATION

An 85-year-old femalewith a known history of chronic obstructive pulmonary disease for ten years presented to the medical emergency unit with altered consciousness, complaints of breathlessness that had deteriorated from grade III to grade IV, a worsening of cough with expectoration from the last 15 days, low-grade fever for three days, abdominal pain and giddiness for two days along with she complains of loss of appetite for ten days. She was admitted to the high dependency unit with ventilator assistance.

There was a history of seasonal variance of the symptoms, which used to worsen during the winter months as narrated by the caregiver. She had been exposed to biomass for a long time, which is also thought to be an underlying cause for the condition. She also has a habit of chewing tobacco. She had previously undergone a few episodes with identical symptoms, for which she went to another hospital and was placed on a ventilator in the Intensive Care Unit (ICU) until she was cured. She is also a Type II diabetes mellitus patient who has been on medication for the past 6 years.

3. CLINICAL FINDINGS

The patient was lethargic and afebrile during the clinical examination, with a pulse rate of 77 beats/min, respiratory rate of regular 16 breaths/min with thoracoabdominal character, SPO_2 of 97 percent, and in Synchronized intermittent mandatory ventilation (SIMV) mode with Fraction of inspired oxygen (FiO2) of 60% and BP of 130/70 mmHg. The patient was obese with a BMI of 30.8 kg/m^2. The patient was in a semi-fowler position when observed, and her chest motions were bilaterally reduced. There was pedal edema, and the Juglar venous pressure (JVP) was also elevated. Palpation revealed reduced chest expansion, with bilateral measurements of 1cm, 1cm, and 2cm at the axillary, nipple, and xiphisternum levels, respectively. Anterior and posterior chest excursion was also minimized. Tactile vocal fremitus was reduced on both sides. Percussion produced a hyper resonant sound that was felt bilaterally throughout the lungs. Auscultation revealed bilaterally reduced breath sounds with mild crepitations throughout the lungs.

Timeline of the current episode

Complete timeline of events is shown in table 1 along with the clinical findings and stated management.

Table 1 Timeline of the events and plan of care.

Sr. No.	Date of events	Consultation	Clinical manifestation	Management
1	10 years back	Medical	diagnosed with COPD	Symptomatic medication management
2	5 July 2016	Local hospital	1st episode of acute exacerbation of COPD	Admitted in ICU with ventilator and medication support
3	8th December 2019	Medicine	2nd episode of acute exacerbation of COPD	Admitted in ICU with ventilator and medication support
4	03 November 2021	Medicine department	A recent episode of AECOPD with abnormal ABG findings	Admitted in ICU and on SIMV support along with medical management
5	03 November 2021	Physiotherapy	Reduced respiratory capacity, accumulated secretions, reduced exercise tolerance	Patient's counseling, Aerosol therapy, arousal therapy, flutter, breathing exercise, Postural drainage with FET, mobilization exercises
6	25 November 2021	Discharge	Alleviation of symptoms, stabilization of ABG values, better clinical outcomes, and functional independence	Home exercise program
7	9 November 2021	Follow up	Reassessment of PT management and outcome measures.	Continuation of the Home exercise program

Abbreviations: COPD- Chronic obstructive pulmonary disease, ICU- Intensive care unit, AECOPD: Acute exacerbation of the chronic obstructive pulmonary disease, ABG- Arterial blood gases, FET- Forced expiratory technique, PT- Physiotherapy

Diagnostic assessment

A diagnostic evaluation was carried out on a regular basis. The ABG readings on the day of admission were pH-7.18 (7.35-7.45), pCO2-79.1 mm Hg (36-45), pO2-79.9 mm Hg (80-100), and HCO3- 22.7 mmol/L. (22-28). Because her pH level was less than 7.35 (i.e. 7.18), the patient's hypercapnia was acute, and individuals with acute hypercapnia have changes in consciousness if their PaCO2 level is higher than 75 mmHg (i.e. 79.1 mm Hg). The PEFR was 150 L/min. Radiographic results demonstrated a descent of the diaphragm, a rise in broncho-vascular markings, and an increase in pulmonary hyperinflation, all of which are diagnostic with COPD (figure 1).

Therapeutic interventions

The medical management started with the ventilator support, initially on the SIMV for the first four days progressing to the intermittent Bi-level positive airway pressure (BiPAP) along with the oxygen therapy. Other medications prescribed were salbutamol and budesonide through nebulization, enoxaparin, furosemide, hydrocortisone, insulin, pantoprazole, aminophylline, ambroxol, and terbutaline. Table 2 represents the physiotherapy goals with their management approach and rationale. Figure 2 shows the patient using flutter during the physiotherapy treatment.

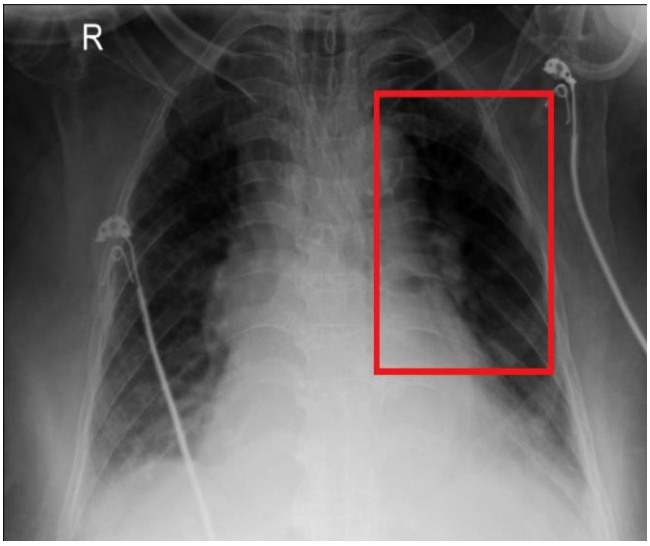


Figure 1 X-ray shows the descend of the diaphragm, increase in the broncho-vascular markings with signs of hyperinflation in the left lung

Table 2 Physiotherapy management regimen

Sr. no.	Goals	PT Interventions	Dosage
1.	To reduce the Anxiety in the ICU and negligence towards health care due to old age	Patient's education Counseling of the patient and the relatives	Counseling about the condition, the protocol, its importance at the beginning of the treatment
2.	To increase the arousal level of the patient	SAT stimulates the person's senses of hearing, touch, and vision individually	At the beginning of the PT treatment once daily, starting from day 1 till day 4
3.	To improve the expiratory flow of the lungs	Breathing exercises: PLB, MIE and diaphragmatic breathing with purse lip expiration	The patient has advised 2-3 sessions per day for 5-10 mins for 3 weeks, once the patient gains full consciousness.
4.	To remove the Accumulated secretions from the airway, obstructing the expiration	Aerosol therapy: Nebulization of budecort or duolin	Daily before each session of physiotherapy
		Airway clearance technique: postural drainage, Suctioning, FET	Twice a day in the modified positions at the beginning followed by suctioning till 4 days and progressing to once a day with FET till the clearing of the secretions from the airway
		Oscillating PEP:Flutter device	On Intermittent BiPAP- 15 minutes of flutter exercise 3 times a day with intermittent breathing control
5.	To maintain the integrity of the joints and prevent the complications of long time recumbency	Passive mobilization techniques and Patient positioning	On SIMV (1^{st}-4^{th} day) – PROM exercises 10reps x 2 sets twice a day until the patient develops full consciousness.

6.	To improve the exercise tolerance of the patient	Graded Mobilization exercises Bedside mobility exercises, standing progressing from walking to pedo-cycling (Interval type- training) pedocycle	On intermittent BiPAP (5^{th} -10^{th} day)-Bedside mobility exercises 10reps x 2 sets On oxygen therapy- Standing, interval walking for 5 minutes progressing to 10-15 min to pedo-cycling regularly (from exercising with supplementary oxygen to without supplementary oxygen)
7.	To maintain functional mobility throughout the life	Home exercise program, Energy conservation and pacing technique, the continuation of the above regimen at home	A counseling session for the patient and her relatives at the time of discharge.
Abbreviation: PT- physiotherapy, SAT-Sensory arousal technique, PLB-pursed-lip breathing, FET- forced expiratory technique, PEP-Positive expiratory pressure, BiPAP- Bi-level positive airway pressure, SIMV-Synchronized intermittent mandatory ventilation, PROM- Passive range of motion exercise			

Figure 2 Patient using the flutter in the ICU

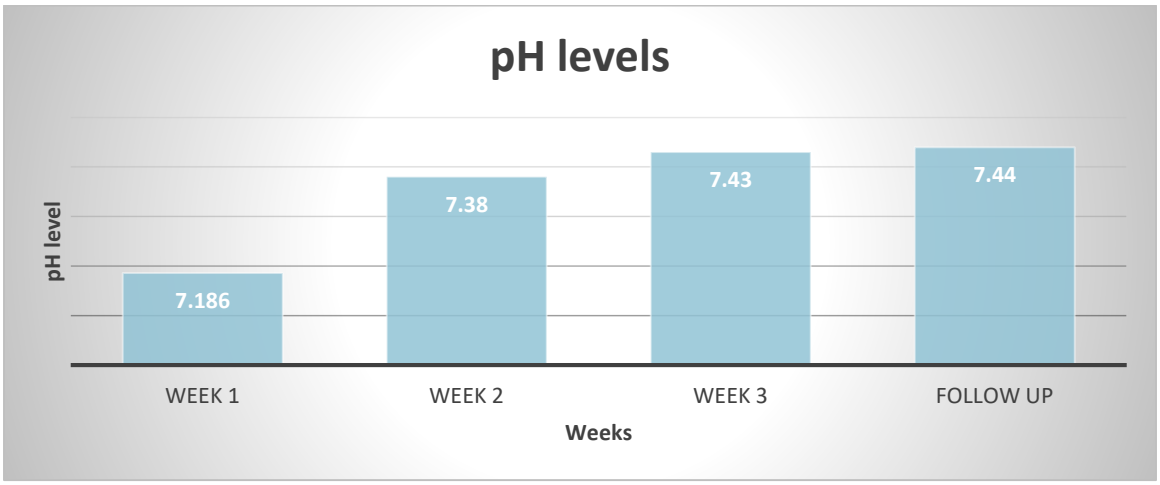
Follow-up and outcome of interventions

The physiotherapy management protocol was followed for 3 weeks along with the 1 week of home exercise program followed by follow-up. The monitoring and examination were done regularly and the outcomes were documented weekly. Table 3 and graph 1 and 2 represent the progress of the patient over 4 weeks. The bars indicate the levels of decreasing pCO_2 and rising pO_2 levels along with the compensating values of HCO_3 in the 4-week treatment.

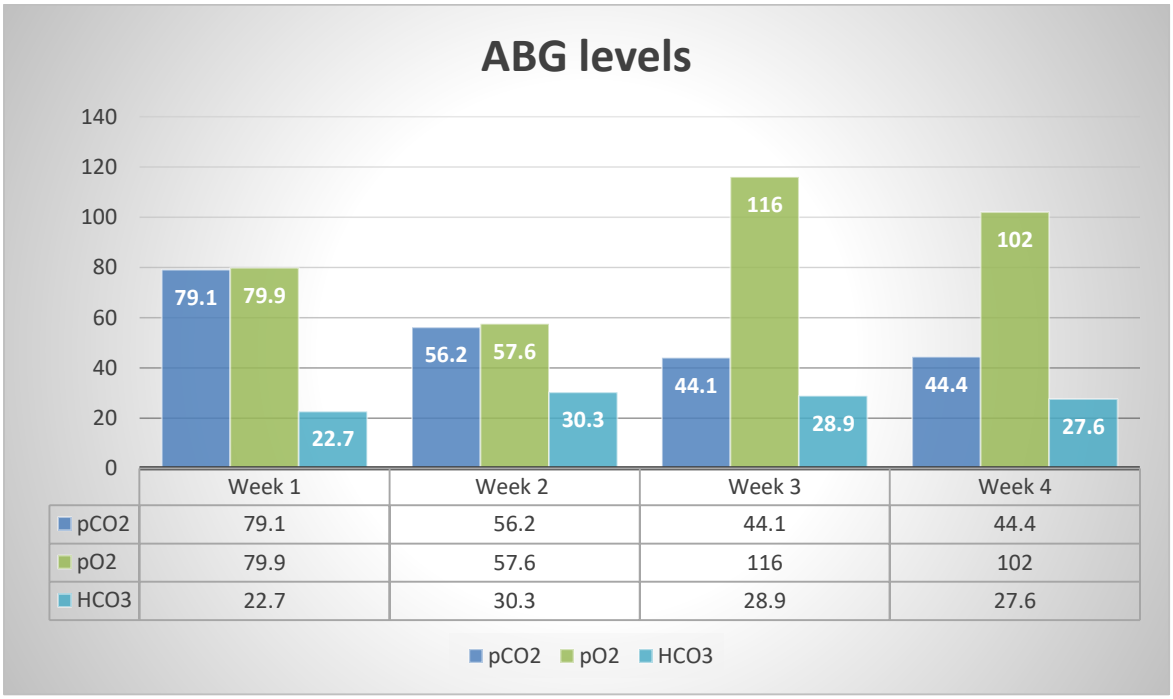
Table 3 The values of outcome measures used to evaluate the progress of the patient

Outcomes	1^{st} week	2^{nd} week	3^{rd} week (At the time of discharge)	Follow up after 2 weeks
Grade of dyspnea (mMRC)	IV	III	II	II
PEFR	150 L/min	180 L/min	220l/min	250 L/min
FiO_2	60%	40%	24%	-
Oxygen therapy	SIMV mode followed by BiPAP	Intermittent BiPAP	0-1L/min	Not required

	mode			
Walking distance in 6 min	-	70m with 3 rest pauses	100m with 3 rest pauses	120m with 2 rest pauses
CAT score (out of 40)	34	30	22	18
FIM (out of 126)	45	58	82	97
Abbreviations: mMRC- modified medical research council, PEFR-peak expiratory flow rate, FiO2- Fraction of inspired oxygen, SIMV-Synchronized intermittent mandatory ventilation, BiPAP-Bi-level positive airway pressure, CAT- COPD assessment test, FIM-Functional independence measure				



Graph 1 The graph represents the evolving values of pH throughout treatment.



Graph 2 The bars in the graph indicate the levels of decreasing pCO2 and rising pO2 levels along with the compensating values of HCO3 in the 4-week treatment.

4. DISCUSSION

CO_2 narcosis, also known as CO_2 poisoning or intoxication, is a condition in which individuals with hypercapnia develop a frank low mental status, including disorientation, somnolence, and lethargy, which can lead to coma and death (Yang et al., 2018). Acute hypercapnia is the driving mechanism of CO_2 narcosis. Hypercapnia can be caused by a variety of conditions, the most prevalent of

which is a chronic obstructive pulmonary disease (COPD). This case study features an 85-year-old female who was experiencing an acute exacerbation of COPD with a low pH and a high concentration of CO_2 in her arterial blood. She had a history of COPD for 10 years, and her obesity had also contributed to her diabetes mellitus. She had a few instances of acute exacerbations before, but with advancing age, each episode became severe and difficult to manage. The treatment began with SIMV mode of ventilation and, was progressed to intermittent BiPAP to oxygen therapy to self-independent respiration along with the medications. In addition to the medical management, comprehensive physiotherapy management was designed accordingly.

The physiotherapy techniques used for the regimen were primarily intended at improving the patient's ABG levels by lowering CO_2 levels in the blood and boosting Pao_2 levels, thereby preserving the pH in the normal range. This pH imbalance occurred as a result of hypoventilation in the airways caused by the obstruction, resulting in hypercapnia. As a result, the therapies mostly focused on enhancing lung ventilation. The physiotherapy management began with the patient's and family education and counseling regarding the importance of physiotherapy and the need to stick to it. Breathing techniques, such as pursed-lip and diaphragmatic breathing, were emphasized in the treatment. Pursed lip breathing is beneficial in COPD patients, and deep diaphragmatic breathing has been related to diaphragm muscle activation and improved blood gas levels in those with severe COPD and persistent hypercapnia by aiming to ease the process of exhaling the air that was trapped in the respiratory (Vitacca et al., 1998). MIE was given by maximal inspiration and holding their breath at the end of the maximal inspiration pressure of 1-3 counts (seconds).

The regimen comprised of airway clearance procedures to remove the obstruction from the airways caused by the mucus secreted in the airway tracts. The elimination of blockage improves lung airflow, allowing stored CO_2 to be expelled more easily and allowing more oxygen to enter the lungs, ultimately improving blood pH. In beginning, it started with modified postural drainage with suctioning. Once the patient was shifted to the intermittent BiPAP, the flutter device was brought into use along with forced expiratory techniques (FET). Not all positive expiratory pressure (PEP) devices are thought to be successful in improving the patient's blood gas levels, although oscillating PEP are. The flutter cleanses the airways of the additional thick mucus formed by COPD patients, and all these patients may find it a lot easier to breathe and have far less resistance to air movement in and out of their airways, boosting the gases and pH level in the blood (Imperial College London, 2020).

A gradually progressing walking regimen was implemented alongside. In medically stable patients with acute exacerbation of COPD, with a graded exercise program, there is a substantial rise in pH during exercise, there was a substantial increase in mean differences in PaO_2 and a significant decrease in mean differences in partial pressure of carbon dioxide in arterial blood (Kirsten et al., 1998). The regimen began with In-bed passive mobilization to bedside mobility exercises in the interval period of BiPAP. Once the patient was able to hold the standing position, interval walking and pedo-cycling were initiated along with the supplementary oxygen therapy. As the patient's threshold increased the activities were performed without oxygen therapy.

Other than the mobilization exercises, all other techniques were advised 2-3 times daily for 3 weeks under supervision. The progress seen on the increasing walking distance motivated the patient to improve her respiratory capacity and stick to the protocol. Following three weeks of daily physiotherapy and medical management, the patient was scheduled for discharge based on the resolution of symptoms, stabilization of ABG values, better clinical outcomes, and functional independence and was advised with 2 weeks of a home exercise program with a follow-up date and patient was kept in contact telephonically for protocol adherence.

5. CONCLUSION

This case study presents an integrated and comprehensive physiotherapy program that, when used on time, shows excellent progress in the management of symptom aggravation. It supports medical management in reducing the symptoms. It was found to be beneficial in balancing the values of arterial blood gases as well as improving the respiratory capacity of the lungs. The patient's PEFRvalues, 6MWD, FiO_2 level, CAT score, FIM scores, and ABG levels validate the effectiveness of these physiotherapy sessions in recovery.

Patient's Perspective

The patient readily participated in the physiotherapy treatment, and when she noticed improvement in the outcome measures, her enthusiasm grew and she was satisfied with the treatment.

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Authors' contributions

SSS carried out the assessment, physiotherapy treatment, and follow-up of the patient along with the sequence alignment. MJJ, TML, and SSL contributed to the sequence alignment. VDY and VDV validated the case report. Each author read and agreed to the final manuscript.

Informed Consent

Informed consent was taken from the patient for writing the case report.

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Conflicts of interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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