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Impact of Incentive Spirometry in COPD Exacerbations: A Comparative Study

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ABSTRACT

Introduction
Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality in Nepal, with acute exacerbations (AECOPD) leading to severe complications. This study explores the impact of incentive spirometry (IS) on clinical outcomes, arterial blood gases and hospital stay in AECOPD patients.

Methods
This quasi-experimental study was conducted at a tertiary care center in Kathmandu, Nepal and involved 60 AECOPD patients, split into two groups: 30 receiving standard medical treatment (control) without incentive spirometry and 30 using incentive spirometry along with standard medical treatment throughout hospital stay. Demographic and clinical information were recorded and key outcomes - arterial blood gases (ABGs), MMRC score, respiratory rate, oxygen saturation, and hospital stay were measured after initial treatment for acute exacerbation and at discharge. Statistical analysis was done using SPSS 22, with significance set at $p<0.05$.

Results
Both groups showed significant improvement in MMRC and oxygen saturation ($p<0.001$). However, the IS group also demonstrated a significant reduction in respiratory rate (26.73±2.52 to 21.07±2.11, $p<0.001$), unlike the control group (27.3±2.3 to 26.80±2.37, $p=0.12$) and had a shorter hospital stay (5.87±1.36 days vs. 8.56±1.99 days, $p<0.001$). The IS group also demonstrated significant improvements in ABG parameters from admission to discharge: pH (7.35±0.087 to 7.42±0.054, $p<0.001$), pCO_2 (62.76±9.55 to 43.88±6.62, $p<0.001$), and pO_2 (62.76±9.55 to 78.88±6.97, $p<0.001$), while the control group did not.

Conclusion
Incentive spirometry proved superior to medical treatment alone by significantly improving ABGs, respiratory rate and reducing hospital stay in AECOPD patients. These findings support IS as a cost-effective tool in AECOPD management, particularly in resource-limited settings like Nepal.

Keywords
Blood gas analysis; chronic obstructive; length of stay; pulmonary disease, respiratory therapy; spirometry

INTRODUCTION

The 2023 Global Initiative for Chronic Obstructive Lung Disease (GOLD) report defines Chronic Obstructive Pulmonary Disease (COPD) as, "a heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnea, cough, expectoration, exacerbations) due to abnormalities of the airway (bronchitis, bronchiolitis) and/or alveoli (emphysema) that cause persistent, often progressive, airflow obstruction".[1] A comprehensive population-based study conducted between 2016 and 2018, and published in 2021, revealed that the prevalence of COPD in Nepal is 11.7%, while a meta-analysis of studies spanning from 2000 to 2020 found the pooled prevalence of COPD in Nepal to be whooping 22.7%.[2,3]

Acute exacerbation of COPD (AECOPD) is characterized by episodes of symptoms worsening that can culminate in severe outcomes like respiratory failure, high mortality rates and cardiovascular complications.[4] Worsening AECOPD is associated with poorer prognosis and can and substantially stifle patient's quality of life and burden healthcare systems.[4] Incentive Spirometry (IS), also known as Sustained Maximal Inspiration (SMI), is a pulmonary tool for patients undergoing major surgeries that prevent post-operative pulmonary complications and is popular due to its convenience and inexpensiveness.[5]

Exploring the role of incentive spirometry in managing AECOPD patients in a resource-limited setting like Nepal can be pivotal in developing cost-effective strategies to improve patient outcomes. A previous study exploring the role of incentive spirometry in improving outcomes in COPD patients has shown promising results.[7] This study aimed to explore the impact of incentive spirometry in improving clinical outcomes, arterial blood gas levels (ABG) and reducing hospital stay in AECOPD patients compared to AECOPD patients receiving medical treatment alone.

METHODS

This quasi-experimental study was conducted at Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal. A total of 60 participants were selected using purposive sampling, with 30 cases and 30 severity-matched controls. The cases included COPD patients admitted with acute exacerbations, diagnosed as per GOLD criteria. Patients were eligible for inclusion if they were diagnosed with COPD via pulmonary function testing (PFT), had a BMI above 18.3, and consented to participate. Overweight and obese patients were also included in the study. Patients with severe emphysema, a BMI below 18.3, comorbidities, or those who declined to participate were excluded from the study.

Patients were assessed following initial standard treatment for AE and at discharge. Informed consent was obtained, and demographic details and clinical profiles were documented for those meeting the inclusion criteria. After stabilization of acute exacerbations, the cases were instructed to perform breathing exercises with an incentive spirometer (IS) along with their medical treatment.

The IS regimen included a minimum of 14 minutes including 7 minutes of inhalation followed by 7 minutes of exhalation, conducted in 6 daily sessions. The study employed a Triflo-type incentive spirometer, priced at Rs 300 NC, which was easily accessible and suitable for post-discharge use. This flow-oriented device had three chambers (600, 900, and 1200 mL/s) and a mouthpiece. IS was initiated at least one hour after initial stabilization with oxygen, bronchodilators, antibiotics, and diuretics as required. Patients were instructed to inhale and exhale slowly, using the rising balls as visual feedback. Initially, drowsy patients only performed exhalation exercises as they could not perform inhalation, gradually advancing to full inhalation-exhalation cycles of 14 minutes with 3 sessions in a day until discharge. Control groups received medical treatment only.

Outcomes measured at discharge included changes in ABGs, MMRC score, respiratory rate, oxygen saturation, and length of hospital stay. Data were entered and tabulated in Excel, and statistical analysis was carried out using SPSS 22. Analytical methods included mean, standard deviation,

Table 1. Baseline patient characteristics

Symptoms	Incentive spirometry group	Non incentive spirometry group	p value
Age	63.9±6.44	64.2±4.25	0.77
Gender (M/F)	(12/18)	(15/15)	0.48
Duration of disease in years	7.33±1.5	7.47±1.78	0.74
No of exacerbation per year	2.2±0.74	1.97±0.72	0.18
GOLD severity	3.37±0.55	3.17±0.70	0.16

Fisher's exact test for chi-square, and independent T-test for group comparisons. A 95% confidence interval was applied, with p-values under 0.05 considered statistically significant.

RESULTS

A total of 60 patients were recruited in the study with 30 patients belonging in each- spirometry and non-spirometry group. The demographic and clinical profiles of the patients in these two groups were comparable, as depicted in Table 1.

Table 2 shows the clinical parameters of the patients (ABGS, MMRC score, respiratory rate and oxygen saturation) after initial stabilization and at discharge and the length of hospital stay across two groups. Notably, there is a significant improvement in these all these parameters in the incentive spirometry group. However, in the control group, though significant improvement in oxygen saturation and MMRC score are obtained following medical treatment, the respiratory rate doesn't show any significant improvement. The duration of hospital-stay, however, is significantly lower in the incentive spirometry group.

DISCUSSION

This study compares the impact of incentive-spirometry in clinical outcomes, arterial blood gas levels length of hospital stay in patients hospitalized for AECOPD compared to medical treatment alone. Significant reduction in hospital stay is a promising finding observed only in patients undertaking incentive spirometry. Among the clinical outcomes, though both MMRC score and SpO2 levels are improved significantly in both arms, the change in MMRC is greater in the non-incentive arm and that in SPO2 levels is greater in patients under incentive spirometry. The respiratory rate however improves significantly only in the incentive group, thus favoring the inclusion of incentive spirometry for management of patients hospitalized for AECOPD. Further, the presence of these improvements despite shorter hospital stay further consolidates our hypothesis favoring the use of incentive spirometry in AECOPD management.

The most severe COPD exacerbations, characterized by inspiratory muscle overload and significant air-trapping can lead to hypercapnic respiratory failure and increased mortality in COPD patients.[8] Arterial blood gas remains the standard approach for measuring gaseous exchange in COPD exacerbations and serves as an important prognostic indicator in AECOPD.[9] Though the patient characteristics were comparable in both groups and length of hospital stay was shorter for patients in the incentive spirometry group, IS showed significant improvement in all three parameters of the arterial blood gases while medical treatment alone failed to show similar results, favoring incentive spirometry in the management of patients with COPD exacerbations.

Management of COPD involves a multidisciplinary approach involving pharmacological and non-pharmacological approaches, and pulmonary rehabilitation programs are effective, evidence-based methods used in COPD patients.[10] A prior study conducted in Nepal has shown non-invasive ventilation to be effective in managing respiratory failure, which is a dreaded complication in AECOPD patients.[8,11] In a resource-constrained setting like that of Nepal, where financial and logistic restrictions limit patient's choice of treatment, exploring the role of cost-effective tools like incentive spirometry was much needed in COPD management.

Incentive spirometry has mostly shown promising results in preventing pulmonary complications in post-operative patients, following thoracic surgery.[12] Studies remain inconclusive for its routine post-operative use, nevertheless claiming rehabilitative

Table 2. Comparison of ABGS, MMRC score, respiratory rate and SpO_2 levels after initial stabilization and at discharge and length of hospital stay between patients undertaking incentive spirometry with medical treatment vs medical treatment alone

Parameters	Incentive spirometry group		p value	Non incentive spirometry group		p value
Length of hospital stay (days)	5.87±1.36			8.56±1.99		P<0.001
	After initial stabilization	At discharge	p value	After initial stabilization	At discharge	
MMRC score	3±0.58	2.13±0.34	<0.001	3.17±0.59	2.06±0.52	<0.001
Respiratory rate	26.73±2.52	21.07±2.11	<0.001	27.3±2.3	26.80±2.37	0.12
SpO_2 levels	80.13±6.59	86.9±4.35	<0.001	79±4.86	82.67±4.31	<0.001
pH	7.35±0.087	7.42±0.054	<0.001	7.34±0.043	7.36±0.037	0.02
pCO_2	62.76±9.55	43.88±6.62	<0.001	55.18±5.26	54.08±4.11	0.06
pO_2	62.76±9.55	78.88±6.97	<0.001	62.57±3.86	62.27±3.95	0.07

benefits in high-risk patient subgroups like COPD patients.[13] The American Association for Respiratory Care (AARC) doesn't recommend incentive spirometry for routine use in COPD patients, however favors its use in those with symptomatic secretion retention.[14] A previous study exploring the efficacy of incentive spirometry in patients with COPD has shown significant improvement in arterial blood gas levels after two months of use as compared to medical treatment alone, while no significant benefits have been observed when it comes to patient's symptom control.[7]

This study is unique in exploring the impact of incentive spirometry in clinical parameters used to monitor symptomatic severity in COPD like MMRC grade, respiratory rate and oxygen saturation and length of hospital stay, along with its impact on arterial blood gases. However, the management of COPD is, as stated above, multidisciplinary, and modalities like smoking cessation, domiciliary oxygen therapy, nutrition, exercise training, psychosocial support along with pulmonary rehabilitative measures like incentive spirometry can go a long way in curbing the disease progression.[10]

The study, however, has its limitations. It was conducted in a single center, in a small fraction of patients, without adequate follow-up. A multicenter, randomized controlled trial with adequate quality control, adequate follow-up, and exploring varied outcomes including lung volumes and capacities and overall impact on quality of life is deemed essential to inform guidelines for routine use of incentive spirometry in patients after initial stabilization of AECOPD.

CONCLUSION

Incentive spirometry demonstrates superior effectiveness compared to medical treatment alone in improving arterial blood gases and reducing hospital stay in AECOPD patients. Both groups showed improvements in MMRC score and oxygen saturation; however, the Incentive Spirometry group had additional benefits, including a significant reduction in respiratory rate and a shorter hospital stay. These findings underscore the potential of incentive spirometry as a cost-effective tool in managing AECOPD, particularly in resource-limited settings like Nepal. Multicenter, larger-scale, randomized studies are warranted to consolidate these claims.

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CONFLICT OF INTEREST

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