ORIGINAL RESEARCH

IMPACT OF VOLUME-ORIENTED INCENTIVE SPIROMETRY ON INSPIRATORY HOLD VARIABLE OF PATIENTS WHO HAD INVASIVE THORACIC PROCEDURE

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ABSTRACT

Background: Patients who have had invasive thoracic procedures often experience a decrease in respiratory components which includes inspiratory hold capacity (IHC). This can lead to postoperative respiratory complications. Volume-oriented incentive spirometry (VOIS) is a breathing exercise that can improve respiratory function. However, there is limited research on the impact of VOIS on the inspiratory hold capacity of spontaneously breathing patients who have had invasive thoracic procedures.

Aim: To investigate the short-term impact of VOIS on inspiratory hold capacity (IHC) of patients who have had invasive thoracic procedures.

Materials and Methods: 12 patients who had undergone invasive thoracic surgery were purposively recruited for this study. The patients performed VOIS exercises as prescribed by the researchers (3 sets of 5

breaths with 1-minute rest between each set) for every 2 hours of awake period. Rest periods were given to prevent the participants from hyperventilating.

Results: Participants were of mean age 38.83 ± 18.11years, with 9 (75%) of them being male. There was a significant increase in IHC as well as incentive-inspired volume (IIV) following the administration of VOIS for two weeks. There was a significant positive correlation between IHC and IIV.

Conclusion: VOIS is effective in increasing IHC as well as IIV in patients following thoracic surgery. By promoting sustained maximum inspiration, incentive spirometry aids in the recruitment of alveoli, improving lung volumes and overall pulmonary function, and can be effective in reducing postoperative pulmonary complications.

Keywords: Volume-oriented incentive spirometry, Inspiratory hold capacity, Invasive thoracic surgery, Cardiopulmonary, Spirometer.

INTRODUCTION

Physiotherapy plays a critical role in the recovery of patients who have undergone thoracic surgery, particularly in managing airway clearance and the implementation of breathing exercise protocols. These interventions are essential for reducing the incidence of postoperative pulmonary complications (PPCs) such as atelectasis, and in cases where PPCs have already developed, physiotherapy contributes to their resolution[1]. In the physiotherapy management for postoperative patients, deep breathing is a vital practice, emphasizing the use of the diaphragm rather than the accessory muscles for respiration. Patients who actively engage in deep breathing protocols benefit from several physiological improvements. These include the reversal of atelectasis, enhanced oxygenation, increased alveolar ventilation, increased functional residual capacity, and increased diaphragmatic mobility[2,3,4]. Additionally, deep breathing contributes to a higher tidal volume and facilitates the clearance of pulmonary secretions[5,6].

Inspiratory hold is a surrogate measure of plateau pressure or alveolar compliance in patients on ventilators, it permits the pressure to equalize through the respiratory system[7]. During the process of inhalation, an inspiratory hold takes place on the ventilator, in which the flow is deliberately halted. Conversely, in a patient who is spontaneously breathing, the patient voluntarily suspends their breath after the inspiration phase, this action serves to eliminate the pressure impact caused by airway resistance and unveils the pressure within the alveoli[8]. Inspiratory hold capacity (IHC) is a measure of the maximum amount of air a person can hold in their lungs after taking a deep breath[9]. It is an important indicator of respiratory function and can be used to assess the severity of lung disease. Patients who have had invasive thoracic procedures, such as a lobectomy or pneumonectomy, often experience a decrease in IHC[10]. This is due to several factors, including the removal of lung tissue, damage to the nerves and muscles that control breathing, and also due to pain**.** To estimate IHC when using an incentive spirometer, inspiratory hold time (IHT) is utilized, as it is a significant factor of IHC and has been demonstrated to strongly correlate with IHC[11].

Incentive spirometry is frequently used after thoracic surgery to help patients more effectively adhere to deep breathing protocols. This device facilitates sustained, slow deep breaths by replicating the natural

act of sighing[12]. Incentive spirometry is centred on the principle of sustained maximum inspiration (SMI), which is believed to recruit collapsed alveoli and restore preoperative pulmonary function in thoracic surgery patients[13]. The device facilitates SMI by providing visual feedback on inspiratory effort, enabling physiotherapists to coach patients effectively while allowing patients to monitor their performance and progress[13,14]. Volume Oriented Incentive Spirometry (VOIS) is one of the two common types of incentive spirometers. The VOIS enables patients to inhale air through a mouthpiece connected to corrugated tubing, and the volume of inhaled air is indicated on a scale located on the device[15]. While previous studies have demonstrated the efficacy of VOIS in improving post-operative pulmonary function[15,16,17], to the best of the researchers' knowledge, there is a dearth of literature on the effect of VOIS on inspiratory hold capacity post-surgery.

MATERIALS AND METHODS

Participants

The participants of this study were adult patients aged 18 years and above, who have undergone any kind of invasive thoracic procedures (such as thoracotomy, lobectomy or pneumonectomy, mediastinoscopy, thoracocentesis, sternotomy, etc) at the University of Benin Teaching Hospital (UBTH) Benin-city, Edo State, Nigeria. Patients who required mechanical ventilation postoperatively, were sedated, or had a reduced Glasgow Coma Scale (GCS) score and were unable to follow instructions were excluded from the study.

Sample Size & Sampling Technique

A total of 12 participants were recruited via the purposive sampling technique.

Research design

This study was a brief longitudinal study. Participants were monitored over two weeks with inspiratory hold time (IHT) repeated measurements taken at specific intervals (baseline and at 2 weeks).

Research instrument.

Participants used a volume-oriented incentive spirometer (produced by Hudson RCI and Respironics, 2014) as an intervention for deep breathing exercises. A stopwatch was used to measure the time for the inspiratory hold.

Research Procedure

Ethical approval for this study was sought and obtained from the Ethical and Research Committee of the University of Benin Teaching Hospital (ADM/E/22/A/VOL.VII/148301171).
Participants were recruited from the cardiothoracic surgery wards at the University of Benin Teaching Hospital. Before the study commenced, prospective participants were informed about its purpose, and written informed consent was sought and obtained from each participant. The researchers provided participants with instructions on performing volume-oriented incentive spirometer (VOIS) exercises and the inspiratory hold manoeuvre technique. Participants were instructed to perform VOIS exercise with prescription (3 sets of 5 breaths with 1 min rest in between each set) for every 2 hours of awake period, for two weeks. Rest periods were given to prevent the participants from hyperventilating. IHT and incentive-inspired volume were

measured before and after the VOIS intervention.

To measure the dependent variable (IHT) an inspiratory hold manoeuvre technique was carried out at baseline and after two weeks as follows; Patients were positioned in a comfortable and tolerable position. They were then instructed to take a deep breath through their nose hold it for as long as possible, and exhale slowly afterward. A stopwatch was used to measure the time for the inspiratory hold. The procedure was repeated three times and the longest IHT was recorded. Demographic information (age, gender, and type of surgery undergone) was also collected.

Method of Data Analysis

Descriptive statistics was used to summarize the data. Paired t-tests were used to compare the changes in the variables (incentive-inspired volume and IHC) and Pearson's correlation was used to determine the relationships between incentive-inspired volume and inspiratory hold capacity. A p-value of <0.05 was considered statistically significant. Data was analyzed using SPSS software version 27.

RESULTS

A total of 12 patients who had undergone invasive thoracic surgery at UBTH participated in this study. The participants had a mean age of 38.83 ± 18.11 years and 9 (75%) were male. 8 (66.7%) of the participants had closed tube thoracostomy drainage. Other procedures included sternotomy and mediastinal mass excision (8.3% each), thoracocentesis (8.3%), percutaneous drainage (8.3%), and needle decompression (8.3%). This is presented in Table 1.

The mean incentive-inspired volume at baseline score was 983.33 ± 815.57ml and at week two 1704.17 ± 871.90ml. VOIS had a significant effect on the IIV of the participants (p <0.001), with a mean increase of 720.83ml. The mean score for inspiratory hold capacity at baseline was 15.67 ± 7.74 seconds and at week two 20.83 ± 8.45 seconds. VOIS had a significant effect on the IHC of the participants (p = 0.001) with a mean increase of 5.16 seconds. This is shown in Table 2.

There was a significant positive correlation between IIV and IHC both at baseline (p = 0.013) and after two weeks of VOIS intervention (p = 0.008).

Table 1: Sociodemographic characteristics of the participants

	Frequency	**Percentage (%)**
Gender		
Male	9	75
Female	3	25
Type of Surgery		
Closed tube thoracostomy drainage	8	66.7
Sternotomy and mediastinal mass excision	1	8.3
Thoracocentesis	1	8.3
Percutaneous drainage	1	8.3
Needle decompression	1	8.3
	Mean ± SD	
Age (years)	38.83 ± 18.11	

Table 2: Effect of VOIS on incentive-inspired volume and inspiratory hold capacity

	Mean ± SD	**Mean Diff.**	**CI**		**t**	**p**
			Upper	**Lower**		
IIV Baseline	983.33 ± 815.57	720.83	-1002.86	-438.81	-5.63	<0.001
IIV Wk. 2	1704.17 ± 871.90					
IHC Baseline	15.67 ± 7.74	5.17	-7.83	-2.50	-4.27	0.001
IHC Wk. 2	20.83 ± 8.45					

IIV = Incentive inspired volume (ml)

IHC = Inspiratory hold capacity (s)

Table 3: Relationship between incentive-inspired volume and inspiratory hold capacity at baseline and two weeks of VOIS intervention

	R	P
IIV * IHC (Baseline)	0.690	0.013
IIV * IHC (Wk. 2)	0.725	0.008

IIV = Incentive inspired volume (ml)

IHC = Inspiratory hold capacity (s)

DISCUSSION

The study investigated the short-term effect of volume-oriented incentive spirometry (VOIS) on incentive-inspired volume (IIV) and inspiratory hold capacity (IHC) in patients who have undergone an invasive thoracic procedure. From the findings of the present study, VOIS had a significant effect on IIV, with a significant increase observed after 2 weeks of intervention. This finding is in tandem with that reported by Toor *et al*., [13], whose study observed a significant increase in maximum inspiratory volume among patients who used an incentive spirometer daily for 4 weeks. Similar findings were also observed by Ganesh *et al*.,[18] who reported that administration of VOIS for 7 days significantly improved lung volume and peak expiratory flow rate among patients with a tracheostomy tube. Lunardi *et al*.,[19] also reported that VOIS had a greater effect on chest wall volume among healthy adults while requiring lower muscle activity compared to flow incentive spirometer.

This study also observed that VOIS had a significant impact on the IHC of the participants, with a marked increase in inspiratory hold time after two weeks of intervention. To the researchers' knowledge, there is a paucity of studies that have investigated the effect of VOIS on IHC, hence there is a limitation of studies with which the findings of the present study can be directly compared or contrasted. However, similar studies on incentive spirometry have reported positive effects on pulmonary functions like breath-holding time. Vediappan *et al*.,[20] reported that incentive spirometry had a significant effect on breath-holding time among patients with coronary artery bypass graft, albeit the effect is less pronounced compared to when incentive spirometry is combined with the Buteyko breathing technique. The observed significant impact of VOIS on inspiratory hold capacity (IHC) aligns with broader findings on the benefits of incentive spirometry in enhancing pulmonary functions. The increase in inspiratory hold time after two weeks suggests that VOIS effectively promotes deeper, more sustained breaths, which likely strengthens the respiratory muscles and improves lung compliance.

This present study also observed a significant positive correlation between IIV and IHT both at baseline and after two weeks of VOIS administration. This is supported by Aggarwal *et al*.,[21] who reported a significant correlation between breath-holding time and pulmonary functions such as Forced Expiratory Volume in one second,

Forced vital capacity, and Peak expiratory flow rate. The relationship between incentive spirometry and inspiratory hold time may be explained by the way incentive spirometry promotes lung expansion and deep breathing. Incentive spirometers are designed to encourage slow, deep inhalations, which naturally extend the inspiratory phase. By holding the breath after inhalation (inspiratory hold), patients keep the alveoli open longer, allowing for better gas exchange and lung recruitment. This process helps improve lung volumes, increases inspiratory hold time, and enhances overall respiratory function, especially in patients recovering from surgery or with compromised lung function.

CONCLUSION

VOIS is effective in increasing IHC as well as IIV in patients following thoracic surgery. By promoting sustained maximum inspiration, incentive spirometry aids in the recruitment of alveoli, improving lung volumes and overall pulmonary function, and can be effective in reducing postoperative pulmonary complications.

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