EFFICACY OF CHEST-PHYSIOTHERAPY AND INCENTIVE-SPIROMETRY IN IMPROVING CARDIOVASCULAR AND PULMONARY FUNCTIONAL PERFORMANCES IN INDIVIDUALS POST-THORACO-ABDOMINAL SURGERY: A RANDOMISED CONTROLLED STUDY

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ABSTRACT

Objective: To compare the efficacy of selected chest-physiotherapy and incentive-spirometry in improving cardiovascular and pulmonary functions and preventing complications in individuals who had thoracic and/or abdominal surgery.

Methodology: This study involved 90 individuals (randomized into three groups of thirty), who had thoracic and/or abdominal surgery in a Nigeria tertiary health institution. In addition to early mobilization, the first group was managed with selected chest-physiotherapy; second group with incentive-spirometry and third group using the combination the two procedures. Their cardiovascular (Systolic, Diastolic, Mean Arterial and Pulse pressures and Oxygen-haemoglobin saturation) and pulmonary (Forced Vital Capacity and Expiratory Volume [one-second]) functions were assessed at 24-hour pre-operation, and 24-hour, third-day and seventh-day post-operation. Compliance on the use of incentive-spirometry was assessed using compliance scale. Data was analysis with Analysis of Variance and Kruskal-Wallis test.

Results: Eighty-seven participants completed the study (3 died) with only six had post-operative complications. More were diagnosed of uterine fibroid (38.8%), operated under general anaesthesia (74.5%), and had exploratory laparotomy (35.6%) with midline incision (54.5%). The compliance rate of the participants was 100%. There was significant reduction in cardiovascular and pulmonary functions between 24-hour pre-operation and 24-hour post-operation but there was significant increase in the parameters between 24-hour and third-day and between third-day and seventh-day post-operation in all the groups. Those who received combined therapy performed clinically but not statistically better in all the parameters and with no record of any complication.

Conclusion: Thoracic and/or abdominal surgery has negative impact on the cardiovascular and pulmonary functional performances. Either selected chest-physiotherapy techniques or incentive-spirometry is effective in improving cardiovascular and pulmonary functions and prevent complications in individuals who had had a thoracic and/or abdominal surgery but the combination of both techniques in clinically more efficacious.

Key words: Thoracic Surgery, Abdominal Surgery, Cardiopulmonary Function, Incentive-Spirometry, Chest-Physiotherapy.

INTRODUCTION

Inspite of the advances in surgical techniques and cares, thoracic and abdominal surgeries result in the highest incidence of post-operative respiratory complications as compared to peripheral surgery.1 The complications are sequel to changes in lung volumes that occur in response to respiratory muscle dysfunction and significantly contribute to peri-operative morbidity and mortality as well as increase length of hospital stay and cost of care.1,2

The post-operative complications are often due the effects of anaesthesia and surgery on the cardiopulmonary system. Anaesthetic agents result in significant cardiac depression and haemodynamic instability, impair the contraction of respiratory muscles and depress the respiratory centre in the brain thereby affecting respiratory function.3,4,5 Surgical incisions of the chest or abdominal wall affect the integrity of the respiratory muscles and directly affect their function.3

The effectiveness of best-physiotherapy techniques such as deep breathing exercises and coughing and huffing techniques as well as spirometry in addition to early mobilization have been proved in the prevention and treatment of depressed cardiopulmonary function and post-operative pulmonary complications after thoracic or abdominal surgery.3,4,5,6,7,8,9 However, the use of either of the techniques depend on many factors such as on the cooperation and post operative state of the patient, financial state of the patient and the number of available physiotherapists.8 However, no one can say whether one technique is more effective than the other or the combination of both techniques will yield better treatment outcomes. This study therefore compared the efficacy of selected chest-physiotherapy and incentive-spirometry techniques in improving cardiovascular and pulmonary functional performances and prevent post-operative complication in individuals who had had thoracic and/or abdominal surgery.
METHODS: This randomized control study was approved by the Health Research and Ethics Committee of Lagos University Teaching Hospital, Lagos, Nigeria. Informed consent from the participants were sought and obtained prior to the commencement of the study.

This study involve 90 (41 males and 49 females) patients scheduled for elective thoracic and/or abdominal surgery at Lagos University Teaching Hospital, Lagos, Nigeria. The sample was randomised into three groups of 30 participants each using a computer-generated proxy randomisation. All the participants were mobilized out of hospital bed as early as their conditions permitted. In addition to early mobilization, the first group was managed with selected chest-physiotherapy; second group with incentive-spirometry and third group using the combination the two procedures. Participants were recruited as they became available and were allocated to the pre-determined group depending on their number. The Cardiovascular and pulmonary functions of the participants were assessed at 24-hour pre-operation, and 24-hour, third-day and seventh-day post-operation. Compliance on the use of incentive-spirometer was assessed using compliance scale and it was rated as either complied or not complied. The compliance rating scale was assessed at both third and seventh day. Participant must have full compliance for both days to be rated as complied. Those who were allocated to the second and third groups (groups that used the incentive spirometer) were introduced and made to familiarise with the apparatus 24 hours before their surgery. They were taught how to use it and assured that they understood and mastered the techniques. The presence post-operative complications as confirmed by the consulting physicians and/or surgeons were also recorded.

The cardiovascular variables assessed were the Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and Pulse Pressure (PP) using a mercury sphygmomanometer and a 3M Littmann stethoscope. The assessment was done with the subjects in recumbent position at immediate 24th hours post-operation and in high sitting position subsequently. The pulmonary function variables assessed were the Forced Vital Capacity (FVC) and the Forced Expiratory Volume in one second (FEV1) with the use of a spirometer (Micro Direct Spirometer MS01). A brief description about the assessment procedure including technical steps to obtain pulmonary function data and variables were explained to each subject. After 2–3 tidal breaths, subjects were asked to inhale deeply to total lung capacity and then immediately exhale rapidly (without any pause) through a disposable mouthpiece until as much air as possible has been expelled from the lungs. The test was performed with each subject in dorsal recumbent position at immediate 24 hours post-operative stage but in high sitting position at the 3rd and 7th day post-operative stages. The assessment was repeated 3 times after adequate rest. The average values of the forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) were recorded. The oxygen haemoglobin saturation (SpO2) was assessed using a non-invasive pulse oximeter. A finger, without the presence of nail polish or artificial nail was selected (mostly the index finger). The pulse oximeter was clipped to the finger, over the nail bed and the subject was asked to keep the finger fixed. The device was turned on and the reading on the device monitor was recorded.

Interventions
The Chest-Physiotherapy Group
Participants in this group were managed using selected chest-physiotherapy techniques which include sustained maximal inspiration and coughing and huffing. Each patient was treated 3 times per day for 7 days post-operation. Each treatment time lasted between 45 minutes and 1 hour.

Sustained maximal inspiration
To carry out the sustained maximal inspiration, participants were placed in long sitting position and instructed to take deep breathing to total lung capacity and hold their breath for 2-3 seconds at the completion of inspiration and then exhale. This maneuver was repeated three successive times with a rest for two seconds and then repeated for 5 minutes at every treatment time.

Coughing and Huffing
For the coughing and huffing procedure, participants were placed in long sitting position and were told to place his or her hands on the incision site to support the incision from gapping. They were then instructed to take in a deep breath which was followed by a huff but did not cough on the first and second day post-operation to prevent excessive increase in the intra-abdominal pressure and also to minimise pain. Subjects were then progressed to coughing from the third day post-operation7 to the end of the seventh day.

The Incentive-Spirometry Group
Participants in this group were managed using the incentive spirometer. In long sitting position, they were asked to hold the incentive spirometer in a full upright position, exhale normally, and then place lips tightly around the mouth piece. They were then to inhale slowly to raise piston in the chamber and to continue inhaling in attempt to raise top of the piston as high as possible. They were asked to hold breath for 10 seconds or as long as possible then exhale normally and return the piston to its initial starting position. This was repeated 10 times every hour during the waking hours of the day (12-14 hours).2

The Combine Therapy Group
Participants in this group were managed using the combination of chest-physiotherapy and incentive-spirometry. The procedure for both the incentive spirometer and chest physiotherapy were as described in the two groups above. Chest-physiotherapy was administered 3 times a day while they used the incentive spirometer during the waking hours of the day.

Data analysis
Data were analyzed using SPSS (Statistical Package for Social Sciences) Version 17.0 (SPSS Inc, Chicago, Il). Descriptive
Eighty-seven participants completed this study, 3 died. At 3rd day, there were 88 participants left in the study while 2 subjects had died. At 7th day, 57 subjects completed in the hospital, 30 were assessed on aout-patient basis as they had been discharged from the hospital admission and 1 died. The study therefore recorded mortality rate of 3.3%. The comparison of the demographic characteristics and other pre-operative variables of the participants across the groups are represented in table 1.

More (38.8%) participants were diagnosed of uterine fibroid while mesenteric vascular injury, malignant ovarian tumour, lung tumour and endometrosis was diagnosed in 1 participant each. The diagnosis of the participant is presented in table 2. Majority (83.3%) of the participants were operated under general anaesthesia while 15 had either local or epidural anaesthesia. Type of incision used were presented in figure 1. All the participants in groups that used the incentive spirometer complied giving 100% compliance rate. Most of the subjects (89.6%) did not experience any complications while 1, 2 and 3 had pleural effusion, unstable stitches and respiratory failure respectively. Their surgery lasted for 190.38±73.77 minutes while their length of hospital stay was 8.82±5.29 days.

RESULTS

There was significant decrease (p<0.05) in pulmonary variables (FEV1 and FVC) and in SpO2 between the 24-hour pre-operation and 24-hour post-operation in all the groups. During these periods, the mean value of FEV1 reduced from 1.49±0.56 litres to 0.78±0.44 litres while the mean value of FVC reduced from 1.67±0.60 litres to 0.90±0.46 litres. Similarly, the mean value of SpO2 reduced from 98.25±0.97% to 96.77±2.16% (Table 3). There was significant (p<0.05) increase in the pulmonary variables (FEV1 and FVC) and in SpO2 on the 3rd and 7th days post-operation after interventions had being administered (Figures 2 & 3). There was no statistically significant difference among the groups in the selected cardiovascular variables, pulmonary function variables and in the SpO2 at every stage of the study (Tables 3 and 4). There was no statistically significant difference in the presence of post-operative complications among the groups (p=0.460).

Table 1: Pre-operative Variables Showing Homogeneity

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group 1 X± SD</th>
<th>Group 2 X± SD</th>
<th>Group 3 X± SD</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>36.60 ± 11.80</td>
<td>40.48 ± 12.59</td>
<td>38.66 ± 12.25</td>
<td>0.33</td>
<td>0.72</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.61 ± 0.06</td>
<td>1.63 ± 0.04</td>
<td>1.61 ± 0.05</td>
<td>0.70</td>
<td>0.49</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>65.53 ± 16.12</td>
<td>67.83 ± 12.90</td>
<td>63.23 ± 10.89</td>
<td>0.71</td>
<td>0.50</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.00 ± 5.99</td>
<td>25.00 ± 4.10</td>
<td>24.22 ± 4.37</td>
<td>0.28</td>
<td>0.75</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>125.30 ± 18.43</td>
<td>122.37 ± 17.74</td>
<td>124.30 ± 17.99</td>
<td>0.03</td>
<td>0.97</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>79.50 ± 11.58</td>
<td>74.80 ± 13.12</td>
<td>80.23 ± 11.52</td>
<td>0.77</td>
<td>0.47</td>
</tr>
<tr>
<td>HR (b/m)</td>
<td>86.73 ± 18.77</td>
<td>84.30 ± 12.34</td>
<td>90.60 ± 15.36</td>
<td>2.45</td>
<td>0.09</td>
</tr>
<tr>
<td>RR (c/m)</td>
<td>24.57 ± 8.61</td>
<td>23.40 ± 6.99</td>
<td>24.33 ± 6.23</td>
<td>0.17</td>
<td>0.84</td>
</tr>
<tr>
<td>Temp (℃)</td>
<td>36.40 ± 0.63</td>
<td>36.37 ± 0.76</td>
<td>36.53 ± 0.68</td>
<td>0.32</td>
<td>0.73</td>
</tr>
<tr>
<td>SpO2 (%)</td>
<td>98.17 ± 1.11</td>
<td>98.33 ± 0.75</td>
<td>98.13 ± 1.04</td>
<td>0.75</td>
<td>0.72</td>
</tr>
<tr>
<td>PP (mmHg)</td>
<td>43.13 ± 13.74</td>
<td>47.13 ± 16.89</td>
<td>44.13 ± 14.93</td>
<td>0.27</td>
<td>0.77</td>
</tr>
<tr>
<td>MAP</td>
<td>94.54 ± 13.13</td>
<td>90.93 ± 12.80</td>
<td>95.00 ± 12.12</td>
<td>0.39</td>
<td>0.68</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.45 ± 0.43</td>
<td>1.60 ± 0.67</td>
<td>1.43 ± 0.58</td>
<td>0.78</td>
<td>0.18</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>1.65 ± 0.55</td>
<td>1.70 ± 0.65</td>
<td>1.67 ± 0.60</td>
<td>0.84</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Significant at p<0.05

KEY:
SBP - Systolic Blood Pressure        DBP - Diastolic Blood Pressure
BMI - Body Mass Index               HR - Heart Rate
RR - Respiratory Rate               SpO2 - Oxygen-Haemoglobin Saturation Level
FVC - Forced Vital Capacity         FEV1 - Forced Expiratory Volume in one second
PP - Pulse Pressure                 Temp: Temperature
MAP - Mean Arterial Pressure        X – Mean   SD – Standard deviation

Table 2: Diagnosis and Indication for Surgery of the Participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterine fibroid</td>
<td>35</td>
<td>38.9</td>
</tr>
<tr>
<td>Blunt chest injury</td>
<td>8</td>
<td>8.9</td>
</tr>
<tr>
<td>Abdominal trauma</td>
<td>9</td>
<td>10.0</td>
</tr>
<tr>
<td>Umbilical hernia</td>
<td>4</td>
<td>4.4</td>
</tr>
<tr>
<td>Ruptured appendix</td>
<td>7</td>
<td>7.8</td>
</tr>
<tr>
<td>Overian cyst</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Peritonitis</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Ascitis</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Splenic rupture</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Intestinal obstruction</td>
<td>4</td>
<td>4.4</td>
</tr>
<tr>
<td>Mesenteric vascular injury</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Rupture uterus</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Malignant overian tumour</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Lung tumour</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Colonic tumour</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Perforrated gastric ulcer</td>
<td>4</td>
<td>4.4</td>
</tr>
<tr>
<td>Endometrosis</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>3</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Figure 1: Type of Incision for Surgery had by the Participants

Figure 2: The Changes Observed in the Pulmonary Function (FVC and FEV₁) Across the Stages of Assessment.

**KEY:**
- FVC – Forced Vital Capacity
- FEV₁ – Forced Expiratory Volume in one second
- Pre-Op – Pre-operation Stage
- 24hrs Post-Op – 24 Hours Post-operation Stage
- 3rd Day Post-Op – 3rd Day Post-operation Stage
- 7th Day Post-Op – 7th Day Post-operation Stage

Figure 3: The Changes Observed in the Oxygen Haemoglobin Saturation Levels (SpO₂) Across the Stages of Assessment.

**KEY:**
- Pre-Op – Pre-operation Stage
- 24hrs Post-Op – 24 Hours Post-operation Stage

DISCUSSION

The purpose of this study was to determine the most efficacious therapeutic approach between the use of chest-physiotherapy approach and incentive-spirometry approach in improving cardiovascular and pulmonary functions and preventing complications in individuals who had thoracic and/or abdominal surgery.

It is not uncommon that the pre-operative state of an individual may have a far reaching effect on the outcome of clinical intervention as it often influences the response to treatment as well as prognosis of the individual in a specific condition. However, the fact that the subjects in the groups were homogenous at pre-operative state shows that the results obtained could not have been influenced by the pre-morbid status and other confounding variables of the subjects.

The 3.3% mortality recorded in the participants was due to development of acute respiratory failure. This shows that acute respiratory distress syndrome may be a common cause of mortality post-operatively among individuals who had undergone thoracic and/or abdominal surgeries. This results is lower than that of previous studies but corroborates their findings of 4.4% and 5.4% due to acute respiratory failure.12,13 This shows that acute respiratory failure is a common cause of

mortality in post thoracic and abdominal surgery patients. Therefore, efforts at preventing the occurrence of acute respiratory failure among post thoracic and abdominal surgery patients should be ensured. This can be achieved through the proper integration of physiotherapists into the surgical teams and the adequate use of cardio-pulmonary physiotherapy which had been shown to be effective in preventing acute respiratory failure. Physiotherapy should start form the operative stage so that there can be projection of post-operative complications and adequate measure be taken to prevent it through the peri-operative stage in order to contribute to the surgical discussion and understand the procedures that will be performed to immediate post-operative stage in order to prevent the projected complications and improve cardio-pulmonary function of the post-surgical individual.

The rapid drop in the cardio-pulmonary functions and the oxygen haemoglobin saturation levels (\(\text{SpO}_2\)) at immediate 24 hours post-operation may have been due to the various detrimental effects of thoracic and abdominal surgeries on the cardiopulmonary system. It may have also been due to the effects of anaesthetic and surgical procedures as both anesthesia and surgical trauma have been shown to be major contributors to the decrease in pulmonary function.\(^1\),\(^14\) They cause changes in pulmonary mechanics, decrease in functional residual capacity, changes in the production of surfactant and result in patients adopting a monotonous breathing pattern at post-operative stage. In addition to that, damage to cough reflex and bronchial hygiene which are common complications of anaesthesia contribute to the development of atelectasis, causing ventilation-perfusion mis-match and reduction in the oxygen haemoglobin saturation levels.\(^1\)

A 56% reduction in forced vital capacity (FVC) and 83% reduction in forced expiratory volume in one second (FEV\(_1\)) observed in this study at 24 hours post-operation corroborates the findings of previous studies,\(^1,6,12,15,16\) who reported about 60% reduction in FVC with a prolonged recovery period after thoracoabdominal surgery. This shows that surgery has negative effect on the oxygen available to the lung and the amount that is utilized in the lung.

The fact that there was a reduction in the \(\text{SpO}_2\) at 24 hours post-operation corroborates the findings of previous studies where there was a significant reduction in the \(\text{SpO}_2\) immediately post-operation.\(^1,6,17\) However, this result is contrary to the result of the study of Renault et al.,\(^8\) who reported that there was no significant drop in the \(\text{SpO}_2\) at the first day post-operation. The difference in the results of this study and those of some of the previous studies may be due to the fact that in the study of Renault et al.,\(^8\) majority of the patients were on oxygen supplement and they were assessed while on the supplementary oxygen therapy. But at 48 hours post-operation, after most of them had been weaned off oxygen therapy, there was statistically significant decrease in their \(\text{SpO}_2\).

In this study, 6.6% of the subjects had post-operative complications (pleural effusion, unstable stitches and respiratory failure) which was relatively lower compared to those of Gosselink et al.,\(^1,12\) and Mackay & Ellis,\(^18\) where the overall incidence of postoperative pulmonary complication was 12% and 16% respectively. The reason for lower percentage in the incidence of complications in this study may have been due to the supervision and close monitoring of the subjects in this study to ensure a proper usage and adherence to the intervention. This is evident in the fact that all the participants showed good compliance on the compliance scale.

Comparison among the three groups showed that none of the groups has statistically significant superiority over the other one in improving cardiovascular and pulmonary functions and in post-operative complication in individual who had had thoracic and/or abdominal surgery. However, the combination of the two approaches is more clinically benefical to the patients in improving cardio-pulmonary function and preventing post-operative complications. This corroborates the findings of Crowe and Bradley\(^17\) who reported that there were no significant differences between groups in relation to FVC and FEV\(_1\) when comparing respiratory physiotherapy (DBE, early mobilization and bronchial hygiene techniques) with respiratory physiotherapy associated with incentive spirometry. However, our finding disagrees with those of them as they concluded that incentive spirometry combined with physical therapy is not more effective than post-operative physiotherapy alone in improving pulmonary function (FVC and FEV\(_1\)). The difference in our result and those of the previous studies may be due to the fact that in our study, we closely monitored the use of the incentive spirometers while in their studies they however added that the use of the spirometers were not monitored, therefore, the effectiveness of the spirometer in their study could not be fully evaluated.

Furthermore, the results of this study agree with the findings of the study conducted by Renault et al.,\(^8\) where they compared the effectiveness of incentive spirometer and deep breathing exercise. They found no statistically significant difference between the groups in improving the pulmonary function and oxygen haemoglobin saturation levels post operation. Another similar study conducted by Agostini et al.,\(^16\) on the effectiveness of incentive spirometer in preventing pulmonary complications post thoracic surgery revealed that there was no statistically significant difference in the occurrence of complication between the control group who received early mobilization only and the intervention group who received early mobilization with addition of deep breathing and coughing exercise. He concluded that the addition of deep breathing and coughing exercises to physiotherapists directed early mobilization does not significantly reduce the incidence of post operative complications.
The results of the study also corroborate those of previous studies who concluded that cardiovascular and pulmonary functions and post-operative complications can be well treated and prevented using incentive spirometry and other chest physiotherapy techniques independently and can also be combined depending on the judgment of the managing physiotherapist. Emphasis must however be placed on monitoring of the patient especially patients on incentive spirometry to ensure adherence to the interventions and adequate outcome of intervention.

CONCLUSION: Thoracic and/or abdominal surgery has negative impact on the cardiovascular and pulmonary functional performances. Either selected chest-physiotherapy techniques or incentive-spirometry is effective in improving cardiovascular and pulmonary functions and prevents complications in individual who had had a thoracic and/or abdominal surgery but the combination of both techniques is clinically more efficacious.

REFERENCES


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