CHAPTER V
DISCUSSION
The main purpose of this study was to compare diaphragmatic breathing exercise, flow- and volume-incentive spirometry on pulmonary function and diaphragmatic excursion in patients undergoing laparoscopic abdominal surgery. To the best of our knowledge, this study is the first to compare the effects of diaphragmatic breathing exercise with two different kinds of incentive spirometry and also against a control group. There were 65 patients included in each group and the four groups were homogenous in terms of all demographic parameters. In our study we found that diaphragmatic breathing exercise and volume-incentive spirometry improve lung function and diaphragm excursion in patients undergoing laparoscopic abdominal surgery.

5.1 Comparison of pulmonary function and diaphragm excursion between pre-operative and 1st post-operative day in all four groups

In our study, the diaphragmatic breathing exercise group showed a significant decrease in pulmonary function {Forced Vital Capacity [FVC] (22.4%; p = 0.00), Forced Expiratory Volume in one second [FEV\(_1\)] (24.5%; p = 0.00) and Peak Expiratory Flow Rate [PEFR] (35.8%; p = 0.00)}. Diaphragm excursion also showed a significant decrease (20.6%; p = 0.00) in the 1st postoperative day when compared to the preoperative day.

The flow-incentive spirometry group showed a significant decrease in pulmonary function {Forced Vital Capacity [FVC] (31.0%; p = 0.00), Forced Expiratory Volume in the first second [FEV\(_1\)] (30.9%; p = 0.00), Peak Expiratory Flow Rate [PEFR] (43.2%; p = 0.00)}. Diaphragm excursion also showed a
significant decrease (27.0%; \( p = 0.00 \)) on the 1st postoperative day when compared to the preoperative day.

The Volume-incentive spirometry group showed a significant decrease in pulmonary function \{Forced Vital Capacity [FVC] (25.6%; \( p = 0.00 \)), Forced Expiratory Volume in the first second [FEV\(_1\)] (26.3%; \( p = 0.00 \)) and Peak Expiratory Flow Rate (PEFR) 36.1%; \( p = 0.00 \)}\}. Diaphragm excursion also showed a significant decrease (23.7%; \( p = 0.00 \)) on the 1st postoperative day when compared to the preoperative day.

The control group showed a marked significant decrease in pulmonary function \{Forced Vital Capacity [FVC] (29.2%; \( p = 0.00 \))\}, Forced Expiratory Volume in the first second [FEV\(_1\)] (31.0%; \( p = 0.00 \)) and Peak Expiratory Flow rate [PEFR] (36.6%; \( p = 0.00 \)}\}. Diaphragm excursion also showed a significant decrease (28.4%; \( p = 0.00 \)) on the 1st postoperative day when compared to the preoperative day.

In our study pulmonary function (FVC, FEV\(_1\), and PEFR) and diaphragm excursion showed a decreased on the 1st postoperative day when compared to the preoperative values in all four groups with an average decrease of 27% in Forced Vital Capacity, 28% in Forced Expiratory Volume in one second, 37% in Peak Expiratory Flow Rate and 28% in diaphragm excursion. The present study finding of reduction in pulmonary function during postoperative day is similar to those reported in a previous study.\(^3,21-23\).

Our results are in accordance with Schauer et al. who found 30% to 38% reduction in postoperative pulmonary function (FVC, FEV\(_1\), FEF25%-75%) in
laparoscopic cholecystectomy. Karayiannakis et al. found 22% of FVC and 19% of FEV\textsubscript{1} reduction after laparoscopic cholecystectomy. Ramos et al. found 20% to 30% of reduction in postoperative pulmonary function (FVC, FEV\textsubscript{1}) in laparoscopic cholecystectomy. Ravimohan et al. found 21% to 31% reduction in postoperative day pulmonary function variables (FVC, FEV\textsubscript{1}, FEF25%-75%) in laparoscopic cholecystectomy.

In summary

The results of the present study showed that there is a significant decrease (p<0.05) in pulmonary function (FVC, FEV\textsubscript{1}, and PEFR) and diaphragm excursion in all four groups on the 1\textsuperscript{st} postoperative day when compared with the preoperative day.

5.2 Possible reasons for decrease in pulmonary function and diaphragm excursion during the postoperative period in laparoscopic abdominal surgery

During the postoperative period, patients exhibit shallow breathing without the intermittent sigh or breaths which are inspired approximately ten times an hour. Patients will breathe shallow leads to a decrease ventilation to dependent lung regions. In the present study, reduced pulmonary function (FVC, FEV\textsubscript{1} and PEFR) and diaphragm excursion in postoperative laparoscopic abdominal surgery subjects might be due to postoperative pain, location of surgical ports, along with anaesthetic, analgesic usage.

The effects of general anaesthesia on distribution of ventilation, and chest wall and lung mechanics leads to ventilation-perfusion mismatch, increased dead space, shunt and hypoxemia. Narcotic/opioid Analgesics and other drugs affect the central regulation of breathing, changing the neural drive of the upper airway and
chest wall muscles; which lead to hypoventilation, a diminished sensitivity of the respiratory center to carbon dioxide stimulation, an increase of obstructive breathlessness, the suppression of the cough reflex and irregular mucus production.\textsuperscript{37}

The location of surgical ports involves trauma near the diaphragm and chest wall/ribs, leading to postoperative incisional pain and reflex inhibition of the phrenic nerve and diaphragmatic reflex paresis resulting in functional disruption of respiratory muscle movement. In addition, when patients remain lying down for long periods during the postoperative period their abdominal content limits diaphragmatic movement.\textsuperscript{26, 38}

Several studies found that diaphragmatic dysfunction is due to gas insufflation in the abdominal cavity which might also be responsible for the increase of resistance and reduced diaphragmatic excursion, leading to reduced lung volume.\textsuperscript{39} All these factors lead to a change in postoperative lung function usually resulting in development of a restrictive pattern and decreased diaphragm excursion in laparoscopic abdominal surgery.

Our results are in accordance with Ford et al., who showed that reduction in inspiratory muscle activity, mainly the diaphragm was the main determinant of impaired pulmonary function. Diaphragm dysfunction may be due to reflex inhibition of efferent phrenic activity.\textsuperscript{40} Several studies suggested that laparoscopic abdominal surgery causes reflex inhibition of the phrenic nerve which might lead to shallow breaths and reduced pulmonary ventilation.\textsuperscript{33} Erice et al. explained reduced pulmonary ventilation mainly due to decreased inspiratory muscle activity.\textsuperscript{41} Adriana
et al. showed a decrease of 27% in the respiratory muscular activity of patients who underwent laparoscopy abdominal surgery.\textsuperscript{42}

5.3 Pulmonary function and diaphragm excursion changes between the 1\textsuperscript{st} post-operative and the 2\textsuperscript{nd} post-operative day in all four groups

In our study, the diaphragmatic breathing exercise group showed a significant improvement in pulmonary function \{Forced Vital Capacity [FVC] (16.2%; $p = 0.00$), Forced Expiratory Volume in one second [FEV\textsubscript{1}] (14.3%; $p = 0.00$), Peak Expiratory Flow Rate [PEFR] (27.8%; $p = 0.00$)\} and diaphragm excursion (22.2%; $p = 0.00$) on the 2\textsuperscript{nd} postoperative day when compared to the 1\textsuperscript{st} postoperative day.

The flow-oriented incentive spirometry exercise group showed a significant improvement in pulmonary function \{Forced Vital Capacity [FVC] (23.6%; $p = 0.00$), Forced Expiratory Volume in one second [FEV\textsubscript{1}] (22.5%; $p = 0.00$), Peak Expiratory Flow Rate [PEFR] 36.6%; $p = 0.00$\} and diaphragm excursion (24.7%; $p = 0.00$) on the 2\textsuperscript{nd} postoperative day when compared to the 1\textsuperscript{st} postoperative day.

The volume-oriented incentive spirometry exercise group showed a significant improvement in pulmonary function \{Forced Vital Capacity [FVC] (19.4%; $p = 0.00$), Forced Expiratory Volume in one second [FEV\textsubscript{1}] (19.1%; $p = 0.00$), Peak Expiratory Flow Rate [PEFR] (27.6%; $p = 0.00$)\} and diaphragm excursion (26.4%; $p = 0.00$) on the 2\textsuperscript{nd} postoperative day when compared to the 1\textsuperscript{st} postoperative day.

The control group showed a significant improvement in pulmonary function \{Forced Vital Capacity [FVC] (13.7% $p = 0.00$), Forced Expiratory Volume in one
second $[\text{FEV}_{1}]$ (14.3%; $p = 0.00$) Peak Expiratory Flow Rate (PEFR) (19.2%; $p = 0.00$)) and diaphragm excursion (19.0%; $p = 0.00$) on the 2nd postoperative day when compared to the 1st postoperative day.

**In summary**

In our study pulmonary function (FVC, FEV$_1$, and PEFR) and diaphragm excursion in all experimental groups showed a greater improvement from the 1st postoperative to the 2nd postoperative day than was observed in the control group.

**5.4 Comparison of difference in pulmonary function and diaphragm excursion between pre-operative and 2nd post-operative day in all four groups**

The difference in Forced Vital Capacity (FVC) between the preoperative and 2nd post-operative day of patients in the diaphragmatic breathing exercise group (9.8%; $p = 0.00$) and the volume-incentive spirometry group (11.1%; $p = 0.00$) was found to be significantly less than those in the flow-incentive spirometry group (14.7%; $p = 0.00$) and the control group (19.5%; $p = 0.00$).

Difference in the Forced Expiratory Volume in one second (FEV$_1$) between the preoperative and the 2nd post-operative day of patients in the diaphragmatic breathing exercise group (13.7%, $p = 0.00$) and the volume-incentive spirometry group (12.2%; $p = 0.00$) was found to be significantly less than those in the flow-incentive spirometry group (15.3%; $p = 0.00$) and the control group (21.1%; $p = 0.00$).

The difference in Peak Expiratory Flow Rate (PEFR) between the preoperative and the 2nd post-operative day of patients in the diaphragmatic breathing exercise group (17.9%; $p = 0.00$) and the volume-incentive spirometry group (18.5%; $p = 0.00$)
was found to be significantly less than those in the flow-incentive spirometry group (22.4%; p = 0.00) and the control group (24.4%; p = 0.00).

The difference in diaphragm excursion between the preoperative and the 2\textsuperscript{nd} post-operative day of patients in the diaphragmatic breathing exercise group (2.9%, p = 0.20) and volume-incentive spirometry group (3.5%; p = 0.39) was found to be significantly less than those in the flow-incentive spirometry group (8.9%; p = 0.00) and the control group (14.8%; p = 0.00).

In our study pulmonary function (FVC, FEV\textsubscript{1}, and PEFR) and diaphragm excursion in the intervention groups (diaphragmatic breathing exercise and volume incentive spirometry group) was nearly equivalent to those of the preoperative values when compared to the control group. Several studies have shown that pulmonary function after laparoscopic abdominal surgery returns to normal values in around 5 days.\textsuperscript{3} Our findings are similar to those reported in a study carried out on pulmonary function following in patients who had undergone laparoscopic cholecystectomy where exercise was compared to the pulmonary function of a control group and found to be significantly better.\textsuperscript{21-23}

\textbf{In summary}

In our study systematically compared the effects of three different breathing techniques on diaphragm excursion and pulmonary function in subjects undergone laparoscopic surgery and it was found that pulmonary function and diaphragm excursion was found to be better preserved in the diaphragmatic breathing exercise group and volume incentive spirometry group when compared to the pulmonary
function and diaphragm excursion of the flow-incentive spirometry group and the control group.

5.5 Comparison of recovery of pulmonary function and diaphragm excursion between the groups postoperatively

Comparison of the preoperative and the 2nd post-operative day difference in pulmonary function and diaphragm excursion between the experimental groups and the control group showed that there is significant improvement in pulmonary function \{Forced Vital Capacity (FVC); \( p = 0.03 \)} and diaphragm excursion; \([p = 0.00]\) in the diaphragmatic breathing exercise group and volume- incentive spirometry group when compared to the same for the control group.

5.6 Possible reasons for improved pulmonary function and diaphragm excursion in the diaphragmatic breathing exercise group

The present study showed that the Diaphragmatic breathing exercise group was able to improve pulmonary mechanics thus leading to a beneficial effect on pulmonary function (FVC) and diaphragm excursion. Diaphragmatic breathing exercise improves diaphragmatic descent and diaphragmatic ascent during inspiration and expiration respectively. Slower deep inspiration ensures more even distribution of air throughout the lung, particularly to the dependent lung.\(^{16}\) The physiological effects of diaphragmatic breathing exercise is that breathing through full vital capacity and holding for 3-5 seconds, ensures full inflation of the lungs thus opening up alveoli which have low volume and stimulating the production of surfactant. It will also decrease activity of accessory muscles, ensure that breathing patterns are as close to normal as possible and also reduce the work of breathing.\(^{16,31}\)
Our results are in accordance with the findings of Tahir et al. who showed that diaphragmatic breathing exercise will improve basal ventilation.\textsuperscript{43} Webber and Menkes et al. found that diaphragmatic breathing exercise will improve tidal volume and also facilitate secretion removal.\textsuperscript{44,45} Blaney et al. observed that tactile stimulation over the subject’s lower costal margin as well as verbal instruction served to significantly increase diaphragmatic movement during diaphragmatic breathing exercises.\textsuperscript{46} Manzano et al. found that diaphragmatic breathing exercise was able to improve pulmonary mechanics and lead to beneficial effect on Forced Vital Capacity (FVC).\textsuperscript{47} Grams et al. evaluated the efficacy of diaphragmatic breathing exercise for the prevention of postoperative pulmonary complications and for the recovery of pulmonary mechanics and found that diaphragmatic breathing exercise appeared to be more effective.\textsuperscript{17}

\textbf{5.7 Possible reasons for improved pulmonary function and diaphragmatic excursion in the volume-incentive spirometry group}

The present study showed that the volume-incentive spirometry group also had improved pulmonary mechanics that led to a beneficial effect on pulmonary function (FVC) and diaphragm excursion. After laparoscopic abdominal surgery, it may be hard to take a deep breath and if patients do not breathe deeply it may lead to postoperative pulmonary complications. The Volume-Incentive spirometer is a mechanical device used to take slow, deep long breaths that encourage patients to breathe to total lung capacity, to sustain that inflation and open up collapsed alveoli.\textsuperscript{18}
The volume-incentive spirometer will be more ‘physiological’ because the training volume is constant until it reaches the maximum inspiratory capacity (level pre-set by physiotherapist). It provides a low level of resistance training while minimizing the potential fatigue to the diaphragm. Our study results are in accordance with Denise et al. who showed that when volume-incentive spirometry was performed with low inspiratory flow it promoted diaphragmatic excursion and improved the expansion of the basal area of chest wall. Minschaert et al. observed that patients treated with incentive spirometry would have early recovery of the pulmonary volume. Kundra et al. found that the use of incentive spirometry in the preoperative period leads to greater improvement in the lung functions than if given in the postoperative period. Souse of the Volume-incentive spirometer will result in active recruitment of the diaphragm and other inspiration muscles which may lead to improved pulmonary function and diaphragm excursion.

5.8 Limitation of the Study

- There was no blinding in the study procedure, the same investigator who randomized the patients into the experimental groups and the control group measured the outcome variables (pulmonary function test) and the same investigator taught the exercises to all experimental groups.
- Diaphragm excursion measurement was not done by the same radiologist throughout the study and the finding would have been confounded by the expertise of professional.
- Type of anaesthesia, analgesia and postoperative pain was not recorded which could affect the findings.
There was no follow up in the study as all patients were discharged on the 2nd postoperative day. As a result we are unaware which group values returned to normal.

Patient adherence to the intervention programs was recorded by providing a log book to each subject, in which they had to make an entry every time they did the prescribed technique but there is no way to verify the authenticity of these entries.

5.9 Suggestions for the Future Research

- Future research could be directed at long-term follow-up to see which group sustains improvement for a long duration and the functional aspect of recovery.
- Future studies can be carried out to compare the effect of the techniques on patients who have undergone upper and lower abdominal laparoscopic surgeries, using a larger sample size.
- Effect of combining therapy like incentive spirometer and diaphragmatic breathing exercise can be studied on laparoscopic abdominal surgery patients
- Future research can be done by assessing and using respiratory muscle strength and patient comfort with different technique as an outcome in laparoscopic abdominal surgery.
- Similar studies can be conducted on patients following open abdominal surgeries, cardiac and thoracic surgeries.
5.10 Clinical Implication

Based on the results of the study we strongly recommend the following:

- Volume-incentive spirometry and diaphragmatic breathing exercise can be recommended for all patients preoperative and postoperatively over flow-oriented incentive spirometry as an intervention for the generation and sustenance of pulmonary function and diaphragm excursion in the management of laparoscopic abdominal surgery.