CHAPTER II
REVIEW OF LITERATURE
2.1 Search Strategies

A comprehensive literature search using electronic databases including PubMed, Med line, Science Direct, Cochrane database of systematic reviews, Cochrane central register of controlled trials, Pro-quest and Blackwell online journals, EBSCO, SCOPUS, academic search premier, CINAHL, Biomed central, clinical trials.gov and web of science databases was undertaken to identify literature. Additional studies were added by manual searching of the reference lists of original investigations and review articles. Keyword search revealed 60 related articles out of which 12 was relevant to the study and included. Most of the excluded articles were those done on cardiac, thoracic and open abdominal surgeries.

The search was conducted using following key words

Incentive spirometry, flow-oriented incentive spirometry, volume-oriented incentive spirometry, diaphragmatic breathing exercise, breathing exercise, laparoscopic abdominal surgery, diaphragm excursion, postoperative complication, laparoscopic cholecystectomy, laparoscopic hernia repair, pulmonary function, lung function, laparoscopic appendectomy, chest physiotherapy.
2.2 Pulmonary function in open versus laparoscopic abdominal surgery

Richard C et al focused on sixteen patients who undergone an open cholecystectomy and twenty patients who undergone laparoscopic cholecystectomy. Pre and post-operatively pulmonary function tests were carried out to determine whether the laparoscopic procedure decreases pulmonary risk. It was found that post-operative FVC measured 52% of the pre-operative function in the case of the open cholecystectomy and 73% of the pre-operative function following laparoscopic cholecystectomy. Further, the post-operative $\text{FEV}_1$ measured 53% of the baseline function in the case of the open cholecystectomy procedure and 72% for laparoscopic cholecystectomy. The researchers therefore concluded that pulmonary function is better and pulmonary risk is lower in the laparoscopic cholecystectomy procedure than in open abdominal surgery.$^8$

Ravimohan SM et al described a prospective comparative study in which pulmonary function and the incidence of pulmonary complications following laparoscopic cholecystectomy were assessed. This was compared to the same parameters following open cholecystectomy. Fifty five patients were involved in the study. The researchers evaluated pulmonary function tests and chest X rays pre and post-operatively. Results showed that following laparoscopic cholecystectomy FVC, $\text{FEV}_1$ and $\text{FEF}_{25-75}$ decreased by 21%, 21% and 30% respectively on postoperative day 1. Following open cholecystectomy, FVC, $\text{FEV}_1$ and $\text{FEF}_{25-75}$ showed a decrease of 44%, 46% and 58% respectively. In the case of patients undergoing laparoscopic cholecystectomy, 15% exhibited atelectasis in the chest X rays; where as 45% of those who had undergone open cholecystectomy exhibited the same. The authors of the research paper arrived at the conclusion that deterioration in pulmonary
function is more evident following open cholecystectomy than laparoscopic cholecystectomy.\(^7\)

Yildirim Osman et al conducted studies to compare pulmonary functions in open versus laparoscopic cholecystectomy. Fifty five patients were involved in the study of whom 27 had undergone open cholecystectomy (Group I), and 28, laparoscopic cholecystectomy (Group II). 24 hour prior to surgery, and again of the 1\(^{st}\) and 6\(^{th}\) day following surgery, pulmonary function tests were performed for patients of both Group I and II. It was observed that on post-operatively day 1, FVC, FEV\(_1\) and FEV\(_1\)/FVC values were statistically lower than the values obtained prior to surgery. Pre-operatively and, again, on the 1\(^{st}\) post-operative day, percentage changes of pulmonary function were measured and showed a notable decrease in FEV\(_1\), FVC, and FEV\(_1\)/FVC values for patients of Group I as compared to those for patients of Group II. Not notable difference was observed in the values of pulmonary function tests carried out on post-surgery day 6. The authors concluded that laparoscopic cholecystectomy patients exhibit better pulmonary function than patients who have undergone the open cholecystectomy procedure.\(^{12}\)

Hasukic S et al assessed post-operative pulmonary changes after laparoscopic cholecystectomy. Pulmonary function tests were carried out pre- and post-operatively on thirty patients, arterial blood gas was measured and chest radiographs taken in order to quantify post-operative pulmonary changes taking place after laparoscopic cholecystectomy. Result showed that the preoperative value of Forced expiratory volume in one second (FEV\(_1\)) was 3.12 ± 0.7 and postoperative it was 2.33 ± 0.8, Forced vital capacity’s (FVC) preoperative value was 3.58 ± 0.9 and postoperative value was 2.93 ±1.0. The peak expiratory flow (PEF) preoperatively was 5.59 ± 1.9
and postoperatively it was $4.27 \pm 1.6$. Forced expiratory flow $\text{FEF}_{25-75}$; (preoperative value) was $1.98 \pm 0.9$ and postoperative it was $1.60 \pm 0.7$; were reduced 20-25% on average compared with preoperative values. Nine subjects showed development of micro atelectasis on chest X-ray, though they didn’t show any clinically important change in ABG. The authors concluded that pulmonary function improved and pulmonary complication reduced after laparoscopic cholecystectomy.\textsuperscript{11}

Review article by Richard W.M et al who studied cardiovascular function during and pulmonary function following laparoscopic cholecystectomy; stated that an immediate decrease in cardiac index (CI) and an increase in mean arterial blood pressure (MABP) and systemic vascular resistance (SVR) are characteristic of change in cardiovascular function owing to insufflation. Pulmonary function changes are characterized by reduced compliance without large alterations in $\text{PaO}_2$. A major difficulty in maintaining normocarbia is due to the abdominal distention reducing pulmonary compliance and to $\text{CO}_2$ absorption. The pattern of lung function following Laparoscopic Cholecystectomy is characterized by a transient reduction in lung volumes and capacities with a restrictive breathing pattern and the loss of the abdominal contribution to breathing. These changes are qualitatively similar to but of a lesser level than those following open abdominal surgery.\textsuperscript{3}

Suter M.et al conducted studies in order to assess pulmonary dysfunction in patients following bilateral hernia surgery. At random thirty nine patients were put into two groups: those who had undergone open repair using the stopper technique and those on whom laparoscopic extraperitoneal repair (TEP) had been performed. Pulmonary function tests were carried out prior to and one day following surgery. It was observed that forced vital capacity (FVC), peak Expiratory Flow (PEF) and
Forced Expiratory Volume in one second (FEV₁) all of them measured postoperatively, were significantly altered in both groups. In both groups the PEF dropped by 15 %. Again, the FVC fell by 22 % following the stoppa procedure as against 25 % following laparoscopy. However, the FEV₁ fell by 21 % after stoppa as against 9 % after laparoscopy. The authors arrived at the conclusion that similar pulmonary dysfunction takes place following open bilateral hernia repair and laparoscopic peritoneal repair, except for the significant difference in FEV₁ in the case of the two procedures.²⁵

In summary

Critical review suggests that pulmonary function test is the primary outcome used in both open abdominal surgery and laparoscopic surgeries. Postoperatively there is 50- 60% decrease in pulmonary function (FVC, FEV₁, and PEF) compare to the preoperative period in those undergoing open abdominal surgeries. Whereas preoperative to postoperative reduction in pulmonary function (FVC, FEV₁, and PEF) is approximately 25% in laparoscopic abdominal surgery.
2.3 Diaphragmatic function in laparoscopic abdominal surgery

Filippo Erico M.D et al carried out a study on ten healthy adults undergoing elective laparoscopic cholecystectomy and five undergoing laparoscopic hernia repair in order to determine diaphragmatic function pre and post laparoscopic cholecystectomy. They concluded that in the early postoperative period, the diaphragmatic function is impaired due to reflexic inhibition of phrenic nerve. The internal site of surgical intervention appears to be the critical variable determining diaphragmatic inhibition after laparoscopic abdominal surgery.26

Jean Ayoub M.D et al conducted studies to evaluate diaphragm movement before and after cholecystectomy using M-mode sonography techniques which can indicate changes in diaphragmatic mobility in patients who have undergone laparoscopic or open cholecystectomy. Diaphragm inspiration amplitude (DIA) during quiet breathing was found to decrease significantly, from 1.4 cm to 1 cm and from 1.6 cm to 1.2 cm in the case of laparoscopic and open cholecystectomy procedures. Again, DIA was found to decrease noticeably during deep breathing from 6.0 cm to 3.0 cm and from 6.1 cm to 3.1 cm in the case of laparoscopic and open cholecystectomy procedures. The conclusion arrived by the researchers was M-mode sonography techniques are useful in the detection of changes in diaphragmatic mobility following either laparoscopic or open cholecystectomy.27

In summary

Review suggests that the most commonly used technique to assess diaphragmatic function is ultrasonography, which determines the diaphragmatic excursion.
2.4 Diaphragmatic breathing exercise and incentive spirometry on pulmonary function after laparoscopic abdominal surgery

Gastaldi A C et al studied thirty six subjects, twenty women and sixteen men, in order to assess the effect of respiratory kinesiotherapy on respiratory muscle strength and pulmonary function following laparoscopic cholecystectomy. Subjects were randomly sorted into two groups-the exercise and the control. Three breathing exercises were performed by seventeen subjects while other nineteen served as a control group. All the subjects were assessed for Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP), PEF and spirometry (FVC, FEV$_1$ and FEV$_1$/FVC. Both groups registered a decrease in all variables on the first day after surgery. On the second post-operative day, the exercise group showed decreased values for all variables. The values then normalized. However, values of all variables for the control group begin to normalize only on the fifth post-operative day. From this authors concluded that the patients who had undergone laparoscopic cholecystectomy the exercise group showed significantly earlier recovery of pulmonary function and muscle strength than the control group.

Kundra P et al carried out a comparative study on the effect of pre-operative and post-operative incentive spirometry on the pulmonary function of fifty patients who had undergone laparoscopic cholecystectomy (with 25 in the control group and 25 in the study group). The study group had to carry out incentive spirometry fifteen times before surgery, every fourth hourly, for one week. However, the control group underwent incentive spirometry only during the post-operative period. Pulmonary function was recorded before surgery and postoperative 6, 24 and 48 hours and at the time of discharge. Result showed that pulmonary function improvement was seen...
after preoperative incentive Spirometry. The authors concluded that pulmonary function are well-preserved with preoperative than postoperative incentive spirometry.\(^{24}\)

Asharf A E M et al carried out a study on two experimental groups of patients in order to evaluate the effects of aerobic exercise training and incentive spirometry in controlling pulmonary complications following laparoscopic cholecystectomy. One group given aerobic walking raining and incentive spirometry as well as traditional physical therapy (Group A); the other (Group B) was given traditional physical therapy. Results indicated a significant reduction in heart rate, SaO\(_2\) and inspiratory capacity for both groups. The researchers concluded that aerobic exercise and incentive spirometry were beneficial in reducing the post-operative pulmonary complications after laparoscopic cholecystectomy.\(^{23}\)

Olsen M F. reviewed forty four studies in order to evaluate the effects of chest physiotherapy interventions in laparoscopic and open abdominal surgery. Of these studies, fifteen involved on untreated control group the study designs not being comparable to those involving different treatment, results were difficult to interpret. But the results showed that breathing exercises were efficacious in preventing post-operative pulmonary complications in patients undergoing open surgery. The review also showed that laparoscopic procedures impair respiratory function to a considerably lower degree than open surgery. One study in the review showed that routine treatment is not called for in upper gastrointestinal features such as, for instance, fundoplication and vertical banded gastroplasty.\(^{28}\)
In summary

From the review of studies done on laparoscopic cholecystectomy, it can be deduced that those who have been given intervention shows better pulmonary function, inspiratory muscle strength and faster recovery compared to the control group.