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Impact of Incentive Spirometry on Diaphragmatic Excursion in upper abdominal surgeries

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Abstract

Background and Aim of work: It is well known that upper abdominal surgeries resulted in restrictive pattern of breathing. The current study was conducted to investigate the effect of volume-oriented incentive spirometry on diaphragmatic excursion (D.E) during quite breathing (Q.B) and deep breathing (D.B) among patients undergoing elective upper abdominal surgery (UAS) Laparotomy cholecystectomy.

Methods: Thirty male patients with ages ranged from 32 to 50 years with mean of 43.82 ± 5.51 who underwent UAS (Laparotomy cholecystectomies) participated in the study. Initially, all of them trained on deep breathing maneuver with incentive spirometry (IS) device, which provide a measurement of inspired volume. DE was measured during Q.B and D.B by Ultrasound (M mode) preoperatively and on the second postoperative day.

Results: Postoperatively, D.E decreased significantly from 2.41 ± 0.6 mm. (preoperative.) to 1.5 ± 0.48 mm during Q.B, also it decreased from 6.38 ± 1.5 to 4.03 ± 1.4 during D.B. As well, the maximum inspired volume (MIV) reduced significantly postoperatively by 25.58%. D.E during D.B was correlated significantly with MIV (r = .561; R = 31) postoperatively, which does not correlate preoperatively.

Conclusion: I.S maneuver resulted in significant increase in D.E during deep breathing after elective UAS.Also D.E contributed mainly to deep breathing maneuver through I.S post-operatively.

Key words: incentive spirometer (I.S), diaphragmatic excursion (D.E), quite breathing (Q.B), and deep breathing (D.B), upper abdominal surgery (UAS) maximum inspired volume (MIV).

Introduction

Elective upper abdominal surgery (UAS) is planned surgery involving an open incision above or extending above the umbilicus[1].

The postoperative period of abdominal surgery is associated with respiratory muscle dysfunction and impaired physical capacity, which, in turn, are associated with the development of postoperative pulmonary complications[2–3]. Some of the main changes that lead to PPCs are: (a) decreased diaphragm mobility; (b) depressed central nervous system; (c) changes in the ventilation-perfusion ratio; (d) reduced cough efficacy; (e) increased respiratory rate; and (f) reduced pulmonary volumes and capacities[4-5].

Anesthesia, the trauma of surgery, and the conditions inherent to the postoperative period (such as incisions, drains, and catheters) have an impact on the respiratory mechanics and mobility of patients[6-7]. The first postoperative days are associated with limited upright mobilization, fatigue, and restrictive ventilatory defects, among other functional disorders[8].

I.S, also called sustained maximum inspiration, is simply a visual and/or audio feedback device that encourages slow, deep inspiration i.e. the visual input of balls rising in chambers, colored lights, sounds, or dials reflect the degree of inspiratory effort. It provides low-level resistive training while minimizing the potential of fatigue to the diaphragm[9]**.** More over there is controversy about the efficiency of I.S in enhancing diaphragmatic excursion D.E[10].

The diaphragm is the primary inspiratory muscle and it is responsible for 70–80% of pulmonary ventilation. During its contraction, the craniocaudal excursion of the dome of the diaphragm occurs and the thoracic cavity expands, generating enough negative intrapleural pressure to allow air intake into the lungs[11-12-13]. Pathogenesis of postoperative pulmonary dysfunction has been attributed to diaphragmatic function impairment[14].

An interesting method of measuring diaphragm mobility is US. Over the last decades, researchers have used this method to directly measure diaphragm mobility and consider it an accurate tool to determine dysfunctions of this muscle. Compared to fluoroscopy, US has the advantage of being quick, portable and free of ionizing radiation[15-16-17-18-19-20-21-22].

Within available the usefulness of this technique in evaluating the degree of diaphragmatic excursion was investigated after upper abdominal surgeries at Egypt, so it was proposed that the study might provide a new objective method for evaluation of diaphragmatic function in pulmonary rehabilitation.

When the diaphragm contracts, it expands the thoracic cavity and tends to displace the abdominal viscera, resulting in lower pleural pressure and higher abdominal pressure. The diaphragm also exerts a force at the site of its attachment to the rib cage, a force directed cranially. The diaphragmatic contraction has two inspiratory effects on the lower rib cage. The first termed the "appositional" component and results from the increase in abdominal pressure acting on the lower rib cage. The second inspiratory effect is termed the "insertional" component; this force is in the direction of its fibers towards the head, causing the ribs to rotate up and out[23].Therefore, abdominal muscle resting tension complements the inspiratory action of the diaphragm by facilitating an increase in pressure in the abdominal compartment rather than outward protrusion of the abdomen during diaphragmatic contraction. In addition, the zone of apposition and dome shape of the diaphragm are maintained during inspiration by abdominal muscle resting tension supporting the abdominal viscera up against this muscle[24].

Because descent of the dome of the diaphragm is opposed by the abdominal contents, contraction of diaphragm fibers inserted into the ribs pulls them upward and outward in what has been described as a bucket-handle motion. If the dome of the diaphragm is flattened, as may be the case in patients with chronic obstructive lung disease or quadriplegia, the diaphragm fibers pull horizontally on the ribs rather than upward and outward. Thus, the diaphragm's ability to increase the dimensions of the thoracic cage is severely limited or lost. Upward and outward rib movement during inspiration is dependent on the cranial orientation of the diaphragm's insertion[24].

During quiet inspiration, the respiratory muscles contract in a coordinated fashion such that the diaphragm descends in a piston like fashion and the ribs move upward and outward in a bucket handle fashion, The increase in the size of the thoracic cavity creates a negative intra thoracic pressure, which draws air into the lungs. The inspiratory muscles then relax, and expiration is accomplished passively, using the elastic recoil of the lungs[24].

Abdominal muscles assist in expiration and facilitate diaphragmatic contraction under all circumstances. All of the abdominal muscles have attachments to the lower ribs. Contraction of these muscles decreases the size of the rib cage to assist expiration. Activity in these muscles increases the intra-abdominal pressure, which not only provides a fulcrum for diaphragm contraction during inspiration but also pushes the abdominal contents cranially, decreasing lung volume and lengthening the diaphragm at end-expiration[25].

M mode U.S is now an accepted qualitative method of assessing diaphragmatic motion in normal and pathological conditions[3].

The main objective of the present study was to evaluate the effectiveness of the implementation of incentive spirometry on diaphragmatic excursion (DE) during quite breathing (QB) and deep breathing (DB) as a guideline for physical therapy assistance for patients undergoing elective open UAS in the early postoperative period.

Material and Methods

Subjects:

Thirty male patients, who had been operated upon for elective upper abdominal surgery were randomly selected from surgery department at October 6 University Hospital. Their ages ranged from 20 to 30 years old with mean age (24.9 ± 3.12 years) and Body Mass Index 27.99 ± 1.79 Kg/m^2. The study was conducted from June, 2015 to December, 2015.

Inclusion Criteria: All Patients**:**

- Had been operated for elective upper abdominal surgery (Laparotomy cholecystectomy).
- Had been undergone Kocher Subcostal incision.
- Who had no radiological findings of lung lobes collapse postoperatively.
- With medically controlled postoperative pain.

Exclusion Criteria:-

Patients who had met one of the following criteria were excluded from the study. Patients:

- With Chronic Obstructive Pulmonary Disease COPD
- Who had developed moderate or severe degree of pleural effusion.
- With mechanical ventilation.
- With radiological finding of lung collapse post operatively.
- With severe or in tolerated incisional pain.

Instrumentation:

1- Incentive Spirometry (I.S.):

Spiro-Ball REF 259- 1300 volumetric exerciser, made in Barcelona (Spain). Used to facilitate deep breathing maneuver.

2- Ultra-Sonography (U.S):

Aloka prosound 4000 (with a 3.8 MHz convex probe), Made in Japan. Used in measurement of diaphragmatic excursion during quiet and deep breathing.

Procedures:

All patients signed a written informed consent and were subjected to all of the following protocol:

1) Preoperative meeting:

The aims of the preoperative meeting were to make patients familiar with the assessment procedure to gain high level of cooperation and to train the patients on I.S for deep breathing maneuver.

The maximum inspiratory volume achieved through I.S maneuver was determined and recorded for each patient.

2-Incentive Spirometry:

Volume-Oriented Devices: A typical volume-oriented disposable I.S device is a true volume displacement I.S with its volumetric measure is up to 4000 ml. A corrugated large-bore breathing hose and mouthpiece connect the patient to a flexible plastic bellows. During inspiration, as the patient draws air through the breathing hose, the bellows rises, an indicator on the device enclosure indicates the volumetric displacement. Once it reaches its maximum displacement for a given breath, the patient is told to hold the bellows in place for 5 to 10 seconds (the end inspiratory hold). After completion of the maneuver, the patient removes the mouthpiece, allowing gravity to return the bellows to its initial starting position[26].

3-Ultra-Sonography:

The assessment was done by an expert radiologist.

All patients were subjected to ultrasound (U.S) examination to measure quiet and maximal diaphragmatic movement pre-operatively and post-operatively (both pre- & post-assessment) by the same U.S machine and examined by the same skilled U.S radiologist.

- Diaphragmatic movement was imaged trans-subcostal region in Carnio-Caudal (CC) section along the right Mid-Clavicular Line (MCL) across liver window along an imaginary sound beam oriented 45 degrees to the Cranio-Caudal (CC) axis.
- Diaphragmatic excursion (D.E) is measured as the distance difference between the position of the same point on the leading edge of the diaphragm at the end expiration and its position at end inspiration.

Measurement of diaphragmatic excursion was done by 2 methods:

(2-D) measurement:

A point is put on the thoracic surface of the right diaphragmatic cupola (Dome) and the distance difference between the same points during end Expiration and end inspiration is measured on 2-D images in Cm.

(**M-mode) measurement:**

The distance difference between the same leading edge of the diaphragm at end expiration and end inspiration is calculated by M-mode tracing. M-mode measurement was found to be more accurate, precise and reproducible than 2-D measurements (Fig; 1).

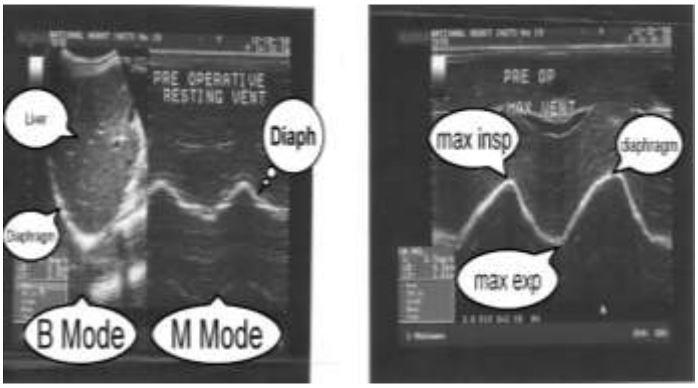

Fig (1): Preoperative (left) & postoperative (right) U/S showing 2-D (B-mode) of the liver and diaphragm in the MCL with subcostal approach, toggled with M-mode of the same scanned media showing diaphragmatic motion (thick white line). Note that during inspiration the diaphragm moves caudal towards the U/S probe and is represented by the upper peak on the M-mode; and during expiration the reverse occurs with the lower peak on M-mode represents the expiration. The difference between the peaks on M-mode is calculated by the machine and it represents the diaphragmatic movement (excursion) in the respiratory cycle.

- D.E were measured using a real-time sonographic system with a 3.8 MHz convex probe (Aloka Prosound 4000, Aloka, Japan ultrasound machine) at a depth of 22-24 Cm. 2-D B-mode was used to obtain the bidirectional cross-section to find the best approach and to select the exploration line. M-mode was then used to display the movement of the anatomical structures found along this line fig. (1A) with a fast horizontal sweep speed of M-mode tracing of 8 frames/sec. In this mode we analyzed the movement of the right cupola of the diaphragm fig. (1B).
- D.E was measured preoperatively after resting in semi-recumbent posture for at least 5 min (to ensure quiet diaphragmatic movement and no dyspnea induced by patient movements or walking). Same procedure was repeated with maximum respiration (end maximum inspiration and end maximum expiration). The same measures were repeated postoperatively (quiet and deep inspiration) both before and after assessment.
- Any related abnormality that may affect free diaphragmatic mobility, like pleural effusion; was looked for and recorded.
- Routine pre & postoperative chest X-rays of the patient were reviewed to ascertain a normally positioned diaphragm on chest X- rays.

The following measurements were recorded:

A- Pre-Operative:

- D.E (the movement of the diaphragm during breathing) had been measured using U.S by an ultrasound expert radiologist preoperatively. It was measured in semi-recumbent position on comfortable bed during quiet and deep breathing (during I.S maneuver).
- The maximal inspiratory volume achieved during I.S maneuver is also determined and recorded preoperatively.

B- Post-Operative:

D.E. had been measured during quiet and deep breathing (during I.S maneuver) at the second postoperative day for the all patients who had been involved in this study by U.S to assess the effect of I.S on D.E after upper abdominal surgery (Laparotomy cholecystectomy).and the maximal inspiratory volume is also determined during I.S. maneuver and recorded postoperatively.

Statistical Analysis :

Descriptive statistics for all variables were done. Paired t-test was used to measure the difference within each variable for the study group. The percentage of improvement was calculated. The level of significance was established at P value < 0, 05 significant.

Results

This study was undertaken to examine the alterations of diaphragmatic excursion (D.E.) during the incentive spirometry (I.S.) maneuver in patients who have underwent elective upper abdominal surgery (Laparotomy cholecystectomy).

Ultrasonography (U.S.) was used to assess D.E. during quiet breathing and deep breathing maneuver in thirty male studied patients before operation and after two days of operation. Patient's demographic data; clinical characteristics and postoperative history were collected from admission record and surgical report.

The collected data for all patients who completed the procedure of the study were presented and discussed under the following heading:

I- Demographic data.
II- Results of the group involved in the study.

I- Demographic Data:

As shown in table (1), the mean value of age for studied patients was 43.82 ± 5.51 years ranged between 32-50 years. The mean value of body weight for studied patients was 79.2 ± 4.80 Kg ranged between 71-89 kg, while their mean values of height was 170.93 ± 3.72 cm ranged between163-177 cm. The mean value of body mass index (BMI) for studied patients was 27.23 ± 1.872 Kg/m^2 ranged between 23-31.54 Kg/m^2.

Table (1): Mean ± SD of demographic characteristics of studied patients.

Variables	Mean ± SD	Range
Age (yrs.)	43.82 ± 5.51	32 - 50
Weight (Kg)	79.2 ±4.80	71 - 89
Height (cm)	170.93 ± 3.72	163 - 177
BMI (Kg/m^2)	27.23 ± 1.87	23 - 31.54

II- Results of studied patients:

As observed in table (2), and (Fig; 2) the mean values of ultrasound measured diaphragmatic excursion (cm) during quiet breathing for studied patients (Pre) was (2.41± 0.6 cm) while it decreased after two days of operation (Post) to (1.5±0.48 cm), this revealed statistical significant ($P<0.05$) reduction in the mean values of ultrasound measured diaphragmatic excursion (cm) during quiet breathing for studied patients.

As revealed from table (2) and (Fig; 3) of the mean values of ultrasound measured diaphragmatic excursion (cm) during deep breathing before surgery was (6.38±1.5 cm) while it decreased after two days of operation to (4.03±1.4 cm), this revealed statistical significant ($P<0.05$) reduction in the mean values of ultrasound measured diaphragmatic excursion (cm) during deep breathing for studied patients.

As Shown in table (2) and illustrated in (Fig; 4), the mean values of maximum inspiratory volume in milliliter (ml) Preoperative was (2490± 436 ml) while it decreased after two days of operation postoperative to (1853± 345 ml), this revealed statistical significant ($P<0.05$) reduction in the mean values of maximum inspiratory volume in milliliter (ml) Pre and Post-operative for studied patients.

Table (2): Comparison of mean ± SD of measured variables pre and post-operative.

Variable	Pre-operative	Post-operative	T-value	P-value
Diaphragmatic excursion (cm) during quiet breathing	2.41 ± 0.6	1.5 ± 0.48	8.6	0.01*
Diaphragmatic excursion (cm) during deep breathing	6.38 ± 1.5	4.03 ± 1.4	8.6	0.01*
maximum inspiratory volume in milliliter (ml)	2490 ± 436	1853 ± 345	19.22	0.00*

Level of significance at $P < 0.05$. * = significant.

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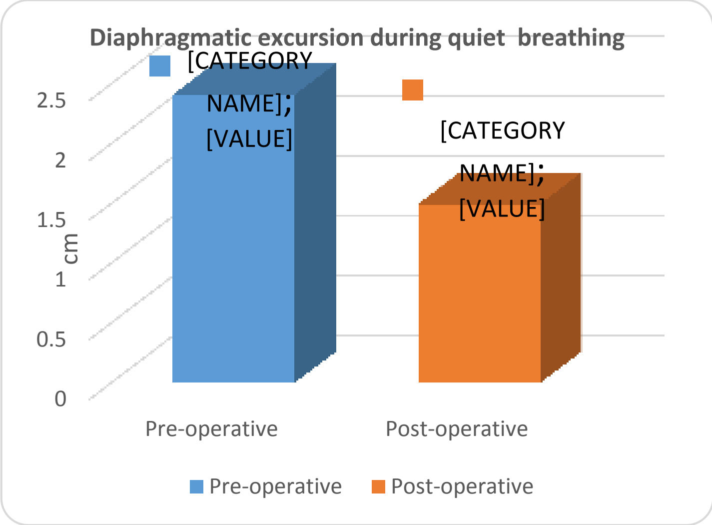

Fig (2): Shows the mean values of ultrasound measured diaphragmatic excursion (cm) during quiet breathing before surgery and after surgery

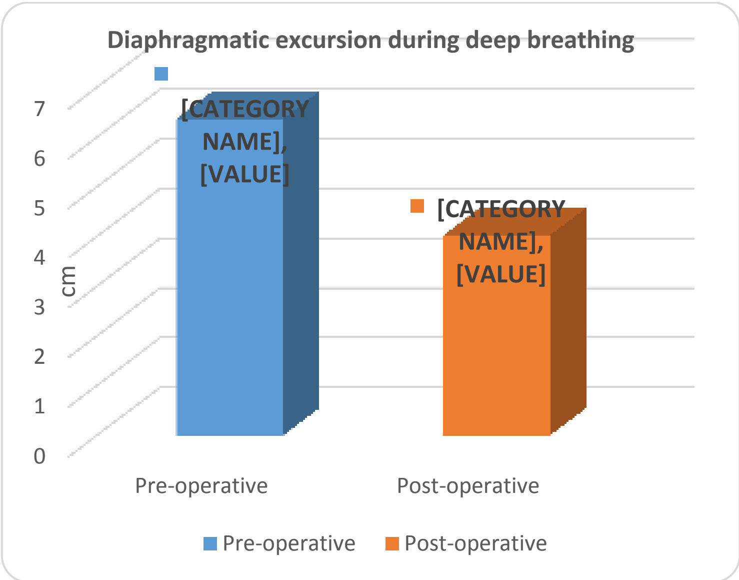

Fig (3): Shows the mean values of ultrasound measured diaphragmatic excursion (cm) during deep breathing Pre-operative and Post-operative for studied patients.

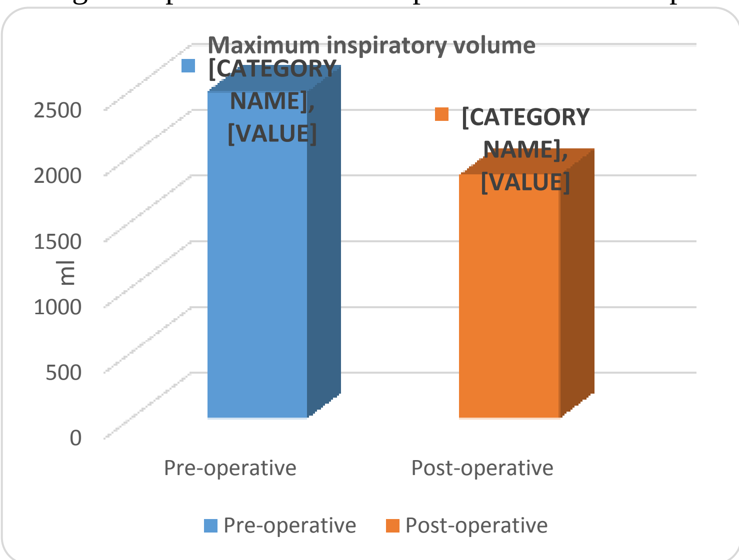

Fig (4): *Shows the mean values of maximum inspiratory volume in (ml) Pre and Post-operative for studied patients.*

As illustrated in table (3) and in (Fig; 5), there was a significant (P<0.01) increase in measured diaphragmatic excursion (in cm) during deep breathing (during I.S. maneuver) post-operative that correlated with maximal inspiratory volume (in ml) by 0.561 cm.., while there was a non-significant correlation -0.026 between deep breathing maneuver and maximal inspiratory volume pre-operative.

Table (3): Correlations between deep breathing and maximum inspiratory volume pre and post-operative.

Variable	R	P-value
Deep breathing. VS maximum inspiratory volume pre-operative	-0.026	0.893
Deep breathing. VS maximum inspiratory volume post-operative	0.561*	0.001

*: Correlation is significant at the 0.01 level

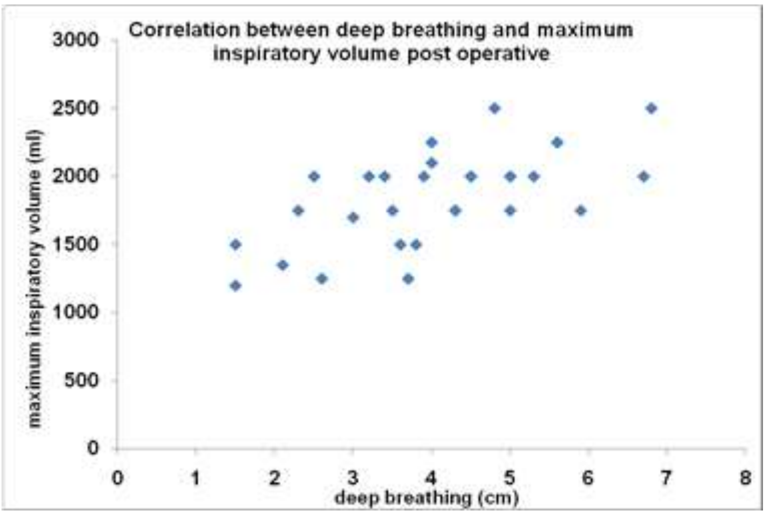

Fig (5): Show the Correlation between diaphragmatic excursion during deep breathing and maximum inspiratory volume postoperative.

Discussion

The aim of this study was to investigate the effect of UAS (Laparotomy cholecystectomy) on normal breathing pattern and diaphragmatic excursion (D.E) and to determine the cause of increased lung volume during incentive Spirometry (I.S) maneuver, if it was attributed to chest wall expansion or to the diaphragmatic excursion (D.E). This will guide physiotherapists in their interventions for patients following UAS.

The measurement in this study was the excursion of the diaphragm preoperatively and on the second postoperative day, also maximal inspiratory volume during I.S maneuver was recorded for all patients.

The measure was done for the group for comparison between pre and postoperative measurements. It was done from semi recumbent position (Semi Fowler's position) during both quiet and deep breathing (during I.S maneuver). It was done from the right anterior copula of the diaphragm using the M- mode Ultrasonography (U.S).

The results of the this study revealed a significant reduction in diaphragmatic excursion during quiet and deep breathing on the second postoperative day when compared to the preoperative values for studied patients following UAS (Laparotomy cholecystectomy).

Also revealed a significant reduction in the maximum inspiratory volume on the second postoperative day when compared to the preoperative values for studied patients following UAS (Laparotomy cholecystectomy).

The results showed that I.S maneuver resulted in significant increase in D.E during quiet and deep breathing. Pre-operatively, D.E was correlated non significantly with the increased inspired volume created by deep breathing. While it was correlated significantly after the operation. Also there were statistical changes in maximal inspiratory volume during I.S maneuver between preoperative and postoperative records.

Available studies investigate similar issue of the current study **Chuter et al., 1989** conducted a study to determine whether I.S maneuver produces a voluntary activation of diaphragmatic movement in patients with postoperative diaphragmatic dysfunction. Respiratory Inductance plethysmography (RIP) was used to measure the tidal volumes of the abdomen and chest in eight women before cholecystectomy and on the first and third postoperative days. In resting patients the relative contribution of the abdominal compartment lowered on first postoperative day than preoperative measurements, reflecting the effect of surgery on diaphragmatic function. preoperatively, I.S increased the tidal volume (Vt.) of the abdominal compartment as a result of increased diaphragmatic movement but this effect was not seen post operatively, instead , postoperative patients responded to I.S. by increasing the tidal excursion of the chest compartment without any increase in abdominal tidal volume. Thus, I.S failed to increase diaphragmatic movement in postoperative patients[27].

Recently **Tyson et al., 2015** investigate the effect of IS on pulmonary function of 150 adult patients following exploratory laparotomy. All patients received the standard postoperative pain control and instructions for deep breathing, coughing, and early ambulation. Patients in the intervention group received additionally incentive spirometers and instructed to fully inflate the incentive spirometer every hour. Mean initial FVC did not differ significantly between the intervention and control groups. Although patients in the intervention group tended to have higher final FVC measurements, the change between the first and last measured FVC was not statistically significant. They found that education and provision of incentive spirometry for unmonitored patient use does not result in statistically significant improvement in pulmonary dynamics following laparotomy. Thus, the use of IS following laparotomy was not recommended[28].

The contradiction with finding of the current study may be attributed to the method of D.E. evaluation. As Sonographic assessment was more reliable[4-29-21-3-30-31-32]. Also the type of IS used and the methodological inadequacy of comparing between deep breathing and IS device that encourages slow, deep inspiration[10]. Physiologically, there may be a difference in the effect of various devices.

M-mode sonography offers several advantages over other available techniques: It offers direct visualization of diaphragmatic movement, providing a time motion curve describing quantitatively diaphragm movements. Most currently used techniques, like trans-diaphragmatic pressure, ratio of abdominal to thoracic circumference changes and electromyography; allow only indirect assessment of diaphragm motility.

. Fluoroscopy provides direct visualization of diaphragm movements, but cannot be used for long lasting or repeated studies, because it requires radiographs. M-mode sonography can be easily coupled with other techniques, such as pressure and airflow measurement, for phase relationship assessment and comparative studies. M-mode sonography offers high axial, spatial, and time resolution, thus allowing accurate measurement of absolute distance. This technique is totally noninvasive and non-constraining for the patient and is therefore easily accepted. Besides, M-mode sonography is relatively simple and widely available. Portable machines allow this procedure to be performed at the patient's bed side[4].

Kantarci et al., 2004 used M- Mode U.S to evaluate the quantitative measurement of diaphragmatic motion in 164 healthy subjects and they supported that U.S. is widely addressed in the functional evaluation of the diaphragm[29].

Confirming the evaluation by U.S **Boussuges et al., 2009** stated that Ultrasonography has many advantages over fluoroscopy, including the lack of ionizing radiation and the possibility of use at the bedside of the patient.

Two hundred ten healthy adult subjects (150 men, 60 women) were investigated. M-mode was used to display the movement of the anatomical structures. Examinations were performed during quiet breathing, voluntary sniffing and deep breathing. Diaphragmatic excursions were measured from the M-mode sonographic images and has been shown to be reproducible[21].

Kim et al., 2010 approved that M-mode U.S is now an accepted qualitative method of assessing diaphragmatic motion in normal and pathological conditions[3].

Noh et al., 2014 conducted a study on 14 asymptomatic adults (9 males, 5 females) to validate the accuracy of ultrasound imaging measurements of diaphragm movements by concurrently comparing these measurements to the gold standard of radiographic imaging measurements. Results showed strong correlations between ultrasound and radiographic imaging measurements of the diaphragm during inhalation, exhalation, and excursion. These findings suggest that ultrasound imaging measurement is useful to accurately evaluate diaphragm movements during tidal breathing. Clinically, ultrasound imaging measurements can be used to diagnose and treat diaphragm movement impairments in individuals with neuromuscular disorders including spinal cord injuries, stroke, and multiple sclerosis[30].

Mariani et al., 2016 stated that US of the diaphragm is a promising technique that offers information about diaphragm morphology and function. In ICU patients, it may already be of clinical value for instance to demonstrate severe diaphragm weakness[31].

Haaksma et al 2017 stated that ultrasound is a valuable tool to screen for diaphragm dysfunction in intensive care unit (ICU) patients[32].

Study investigated the effect of position on compartmental tidal volume (Vt.) of abdominal compartment was done by **Chuter et al., 1990** IRP used to measure compartmental Vt. of the abdomen and the chest in eight women before and after cholecystectomy. Their results explained that change in posture from supine to semi-recumbent position in some patients is associated with reduction of Vt. of abdominal compartment and less efficient length- tension relationships but generally they preferred the semi recumbent position for resting patients as it is associated with improved arterial oxygenation[33].

The semi-recumbent position of the patients during U.S assessment was supported by other investigators[34-35]. The improvement of gas exchange and increased in functional residual capacity is associated with semi recumbent position was approved by **Timothy et al., 1991** in a study included 14 healthy women prior to cholecystectomy and on the first and third postoperative days. Preoperatively, the relative contribution of the chest wall compartment to tidal volume was increased by moving from the supine to the semi-recumbent posture, in contrast to what happened in the preoperative period, there was no change in the relative contribution of both rib cage and abdomen when the patients moved from the supine to semi-recumbent position in first postoperative day but on the third postoperative day, there was an increase in abdominal motion in the semi-recumbent position[34].

Melendez et al., 1992 showed that there is a progressive increase in abdominal contribution in relation to increase in Vt. as a subject goes from sitting to supine position. This is thought to result from an improved diaphragmatic length tension relationship. This supported that I.S performed at low angle of inclination may be of greater benefit than the standard upright maneuver[35].

The decrease in D.E and lung volume (during I.S) postoperative compared to preoperative measurements is attributed to different causes, including anesthesia[36]**,** location of surgical incision[37-38]**,** and local abdominal pain[39].

Karcz and Papadakos 2013 stated that pulmonary function is markedly altered both by general anesthesia and by surgery. Significant atelectasis is found in most anesthetized adults and there is a marked increase in alveolar hypoventilation, V/Q mismatch and pulmonary shunt as early as with induction of anesthesia[40].

Smetana et al., 2006 stated that the closer the incision is to the diaphragm, the greater the risk for postoperative respiratory dysfunction. Considering the different types of procedures, thoracic, abdominal and aortic surgeries carry the highest risk. Furthermore, upper abdominal surgery carries a greater risk than lower abdominal surgery among abdominal procedures[41]. **Weller and Rosati 2008** showed that the rate of postoperative pulmonary complications was nearly double if patients underwent open surgery as opposed to laparoscopic surgery in an analysis of 19,156 patients who underwent bariatric surgery[42].

Anesthetic causes include the use of opioids, neuromuscular blocking drugs and general anesthesia[43]. Depressed central respiratory drive secondary to drug overdose or the residual effects of opioids, sedative hypnotics and inhaled anesthetics and, possibly, due to metabolic derangements such as metabolic alkalosis and severe hypothyroidism; ventilatory muscle dysfunction and generalized weakness secondary to residual neuromuscular blockade[44].

Ford et al., 2003 Showed that a reduction in diaphragmatic movement was the main determinant of impaired respiratory function[45].

Previous studies have suggested that inhibition of diaphragmatic contraction after thoracotomy is secondary to reflxogenic inhibition of phrenic neural activation due to general anesthesia rather than due to pain alone[36].

Dureuil et al., 2005 suggested that diaphragmatic dysfunction results from reflex inhibition of efferent phrenic nerve activity secondary to irritation of splanchnic afferents than from contractile failure of the diaphragm or surgical trauma to abdominal wall[46].

The I.S. was used in the current study as a deep breathing maneuver. The increased abdominal contribution in relation to the increase in tidal volume trough I.S. is consistent with that of **Melendez et al., 1992** who Studied 16 patients post thoracotomy. Patients were studied before surgery and on postoperative days 1 and 3, their results showed that preoperative I.S. resulted in a large increase in Vt.; this increase is attributed to both rib cage and abdominal contributions to ventilation during quiet breathing but abdominal contributions was greater[35].

Ayoub et al., (2001) suggest that diaphragmatic dysfunction is secondary not only to surgically caused irritation of the visceral afferents, but also to a mechanical reflex to counter incisional pain by reducing respiratory mobility in the surgical zone[7].

Although I.S resulted in patients taking deeper breaths, the postoperative incentive Vt. was considerably reduced. The cause may be contributed to pain reflexes arising from the subcostal incision site along with decreased compliance and altered chest wall mechanics.

On the other hand they attributed the increase in Vt., postoperative to rib cage recruitment not to diaphragmatic recruitment.

Bhat et al ., (2007) 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[47].

In the current study there was sharing of the diaphragm or abdominal compartment in the increase in Vt. through the volume I.S postoperative. This is confirmed with **Shu-Chuan et al., (2000), Parreira et al., (2005), Tomich et al., (2007), Paisani et al**., **(2013) do Nascimento et al., (2014), Udayamala et al., (2016) and Alaparthi et al., (2016)[48-49-50-52-51].**

The postoperative diaphragmatic movement through I.S. application may be depended on type of I.S itself where **Shu-Chuan et al., 2000** compare the efficiency of two I.S, coach (volume oriented) and triflo (flow-oriented) in the works of breathing in chronic obstructive pulmonary disease patients. It was found that patients in the coach group significantly increased chest wall expansion as compared with patients using triflo-Il similarly. There was also a significantly increased abdominal wall expansion in the coach group compared with that in the trifilo-II group[48].

Parreira et al., 2005 Also supported that abdominal motion was larger during the use of volume-oriented I.S compared to flow-oriented devices through a study included 16 healthy subjects and the results showed that rib cage and abdominal motion contributions to Vt. were similar for the two volume- oriented devices and for the two flow oriented devices, but not when volume and flow-oriented devices were compared. A larger abdominal motion contribution to Vt. occurred during I.S with volume-oriented devices, which could be considered to be an advantage of these devices, since a larger abdominal displacement is desired during I.S[49].

There were two studies related to the evaluation of breathing pattern and thoraco-abdominal motion during I.S. Initially, four different I.S analyzed, two volume-oriented and two flow-oriented. The results showed that there was a significantly higher abdominal motion during the use of volume oriented I.S compared to flow-oriented devices[50].

Udayamala et al., 2016 also supported recently that Volume-Oriented Incentive Spirometer promoted greater diaphragmatic excursion than the Flow-Oriented Incentive Spirometer and the Diaphragmatic Breathing Exercise. They compare via ultrasound the diaphragmatic excursion of One Hundred and eleven healthy subjects (males and females) during rest and three different types of breathing exercises: Volume-Oriented Incentive Spirometer, Flow-Oriented Incentive Spirometer and Diaphragmatic Breathing. The reason would be less use of accessory respiratory muscles which facilitates more diaphragmatic movement in Volume-Oriented Incentive Spirometer as compared to that produced by Flow- Oriented Incentive Spirometer and Diaphragmatic Breathing Exercise[51].

Paisani et al., **2013** 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[52].

do Nascimento et al., (2014) – Paisani et al., (2013) suggest a physiologically significant difference in the effect of the flow- and volume-oriented incentive spirometer. Flow-oriented devices (Triflow device) enforce more work of breathing and increase muscular activity of the upper chest. Volume-oriented devices (Coach 2 device) enforce less work of breathing and improve diaphragmatic activity**.** Also; Volume rather than flow incentive spirometry is effective in improving chest wall expansion and abdominal displacement using optoelectronic plethysmography[53]**.**

Also, **Tomich et al., 2010** approved that the volume oriented I.S provides a greater increase in thoraco-abdominal motion through a study including 24 patients after open elective gasteroplasty to evaluate thoraco-abdominal motion during breathing exercises on the second postoperative day, the evaluation was through respiratory inductive plethysmography. Their result revealed that there was increase in thoraco-abdominal motion especially during I.S. with the volume oriented device as it allowed slower deeper inhalation[54].

Alaparthi et al., 2016 compare diaphragmatic breathing exercise, flow- and volume-oriented incentive spirometry, on pulmonary function and diaphragmatic excursion in 260 patients undergoing laparoscopic abdominal surgery 65 patients for each pattern of breathing, and diaphragm excursion measurement by ultrasonography before the operation and on the first and second postoperative days. Pulmonary function and diaphragm excursion showed a significant decrease on the first postoperative day in all four groups. On the second postoperative day significant differences between volume incentive spirometry and diaphragmatic breathing exercise group as compared to that flow incentive spirometry group and the control group[55].

Conclusion

It was concluded that volume I.S maneuver resulted in significant increase in D.E during deep breathing after upper abdominal surgery. Also D.E contributed mainly to deep breathing maneuver through I.S post-

Recommendations:

Additional studies with larger sample sizes are needed to explore the possibility of sex differences in D.E after upper abdominal surgery. In addition, more trials are needed to compare between the effect of I.S and different modalities of physical therapy on D.E. Also, further researches are needed to evaluate D.E. by different types of I.S using U.S assessment

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