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The effect of tens and incentive spirometer on lung function in subjects following upper abdominal surgery

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Abstract
Objective: The objective of this study is to find out the effect of Transcutaneous Electrical nerve stimulation (TENS) and Incentive spirometer following upper abdominal surgery on pain and lung function. As post-surgical dysfunction of the respiratory muscles leads to reduction in the vital capacity, tidal volume, total lung capacity and thus insufficient cough. This may cause atelectasis in the basal lung segments and a decrease in functional residual capacity, which in turn leads to ventilation / perfusion (v/q) mismatch.
Methodology: 40 patients following upper abdominal surgery was selected from Kempegowda Institute of Medical Sciences and Research Institute. Routine chest physiotherapy including deep breathing exercises and Incentive spirometer was used following TENS near incision site. Peak expiratory flow rate and thoracic excursion measurements and VAS score of all the subjects were recorded on 1st, 5th and 7th post-operative day.
Result: Results of the study showed statistically significant improvement (p<0.001) in PEFR and Thoracic Excursion measurement from 1st to 7th day following the intervention.
Conclusion: The significant improvement in PEFR and Thoracic excursion measurements observed in the subjects showed that TENS and Incentive spirometer is effective in physical therapy intervention to reduce incisional pain and improve lung volumes due to increased neurological arousal and a greater stimulus to deeper breath.

Keywords: Atelectasis, TENS, incentive spirometer, peak expiratory flow rate, thoracic excursion measurement

1. Introduction
More than 4 million abdominal surgeries are performed in India every year. Patients undergoing abdominal surgery are at increased risk for pulmonary complications postoperatively with increased morbidity, mortality and hospital length of stay [1]. Post-operative pulmonary complications were identified as early as 1910 by Pasteur, who thought it was due to a failure of respiratory power [2].
Upper abdominal surgical procedures are associated with a high incidence of postoperative pulmonary complications which are defined as “pulmonary abnormalities occurring in the postoperative period producing clinically significant identifiable disease or dysfunction that adversely affects the clinical course”. Pulmonary complications following upper abdominal and chest surgery have a relatively higher incidence rate when compared to surgeries performed on other parts of the body. The main reason for this is a severe and prolonged alteration in the pulmonary mechanics caused by these surgical incisions; thereby causing impaired ventilation and ineffective expectoration. This results in failure in expansion and collapse of the particular lung segment, thus providing an excellent chance for chest infection [3]. Postoperative complication following upper abdominal surgery reported in the literature is 20%-30%. The incidence of atelectasis ranges from 20% to 69% and for the post-operative pneumonia from 9% to 40% [4].
The manipulation of abdominal cavity during upper abdominal surgery (UAS) decreases lung volume and capacity. This leads to shallow and rapid breathing, absence of deep breaths and paradoxical abdominal movements, which may cause pulmonary complications with altered ventilation-perfusion or pulmonary shunts that result in hypoxemia and atelectasis [5].

As there is an increased need for alveolar ventilation due to the shunt induced by carbon dioxide retention, the work of breathing increases, the abdominal wall stiffens and there is a possible diaphragmatic dysfunction. Severe postoperative pain is another factor that limits pulmonary function and depending on severity it may contribute to a higher morbidity and mortality [6].

Following surgery, it is believed that mucociliary clearance is adversely affected due to effects of general anaesthesia, intubation and pharmacological agents such as narcotic analgesics used in the peri-operative period. Reduced ability to cough effectively due to incisional pain and mechanical disruption of the major expiratory muscles with a decrease in regional ventilation provides a good potential for pulmonary secretion formation [7].

Peak expiratory flow rate is an objective measure of airflow resistance in the lungs. The peak expiratory flow rate is considered as a surrogate for the forced expiratory volume in 1 second (FEV1).

The rationale for use of thoracic expansion measurement is the range of motion of thorax, including the thoracic vertebrae, sternum and ribs, which serves the respiration.

2. Materials and methods

The purpose of the study was to evaluate the effect of TENS and incentive spirometer on the lung function in post upper abdominal surgery subjects. To achieve this 40 subjects were selected by purposive sampling at Kempegowda Institute of Medical Science and Research Centre, Bangalore.

All the 40 subjects were given routine chest physiotherapy including deep breathing exercises and Incentive spirometer was used following TENS near incision site.

Peak expiratory flow rate and thoracic excursion measurements and VAS score of all the subjects were used as the outcome measure on 1st, 5th and 7th post-operative day.

2.1 Intervention

Transcutaneous Electrical nerve stimulation (TENS) is delivered by a portable stimulator the electrical current delivered by two surface electrodes (10/3,5cm), which were placed on either side of the incision, approximately 2-3cm from the suture line. Treatment parameters used for study was conventional mode TENS at the frequency of 80 HZ with 20 minutes each session twice a day.

Incentive spirometer: Subjects will be positioned comfortably. Subjects will be instructed to exhale by letting all the breath out and then to close the lips around mouthpiece of the spirometer and inhale slowly. Subjects will ask to hold the breath for 2-3 seconds then exhale slowly. This process should repeat 10 times each hour while the subject is awake.

2.2 Outcome measures

Thoracic excursion Measurement: The purpose and technique was explained to the subjects. The part to be assessed is exposed for taking measurements. Having the patient positioned comfortably circumferential measurements will be taken at two levels, That is – Upper thoracic level and Lower thoracic level.

For upper thoracic region the point on the fifth spinous process at the back and third inter costal space at the mid clavicle line at front was taken. For lower thoracic region, the point on the tenth thoracic spinous process and the tip of the xiphoid process was considered. Marker pen is used for marking the reference point for tape placement.

Readings were taken by keeping measure tape flat against subject's skin at the end of full inspiration and expiration. The tape was held snugly but not tightly, so the contour of soft tissue remained unchanged. Three measurements were taken for each subject from 1st, 5th and 7th post-op day

Peak expiratory flow rate (PEFR) is an objective measure of airflow resistance in the lungs. PEFR is the largest expiratory flow achieved with a maximally forced effort from a position of maximal inspiration. The peak expiratory flow rate is considered as a surrogate for the forced expiratory volume in 1 second (FEV1). The pointer is checked for zero. The mouthpiece of the peak flow rate meter is placed in the patient's mouth and sealed by the lips. The tongue should not be placed in the front opening of the meter. Peak expiratory flow meter is held horizontal and patient is asked to take a deep breath and blow, short, sharp and hard as possible. These steps were repeated 3 times. The mean of 3 values is taken for the study.

Visual Analog Scale (VAS) is a widely used pain rating scale which consist of a horizontal line of 10cms where intensity of pain perceived by patient is been asked to mark over it. This was used as a subjective measure of the post-operative pain by the subjects.

3. Results & Discussion

Following the study conducted to evaluate the effect of Tens and Incentive spirometer on lung function in subjects following upper abdominal surgeries, results of the study showed that there is significant improvement in PEFR and Thoracic excursion measurement in a group of 40 subjects in comparison between the 1st, 5th and 7th postoperative day.

Reduction in the lung mechanic test parameters (FVC, FEV1 and PEF) maybe due to general anaesthesia, the site and the length of the incision, postoperative pain which causes splinting of the ribs and the diaphragm, and diaphragmatic dysfunction. Reduction in the efficiency of the respiratory muscles will reduce the chest expansion. PEFR recorded in the study is considered as a surrogate for the forced expiratory volume in 1 second.

At the 7th postoperative day results showed significant (p<0.001) improvement in mean value of PEFR of 288.22lts /min with SD 51.05, compared with mean value of PEFR of 248.37lts/min with SD 47.10 and 211.6lts/min and SD 49.44 on the 1nd and 5th postoperative day respectively. There is gradual improvement shown from the 1st post op day to the 7th post op day which is also statistically significant.

Thoracic excursion was measured using the inch tape to measure chest expansion both at upper and lower thoracic level. Thoracic excursion measurements taken showed significant (p<0.001) improvement in 7th postoperative day in comparison with the 5thand 1st postoperative day, for both the upper thoracic excursion and lower thoracic excursion.

For upper thoracic excursion measurement with mean of 4.49cms with SD 0.68 on 7th postoperative day, while 3.41cms with SD 0.76 on 5th postoperative day and.2.24 cms with SD 0.61 on 1st post op day.

Lower Thoracic excursion measurements also showed significant (p<0.001) improvement with the mean of 3.81cms with SD 0.31 on 7th postoperative day, while 3.08cms with SD 0.59 on 2nd postoperative day and 2.18 and SD 0.48 in 1st post-operative day.

At the 7th postoperative day results showed significant (p<0.001) improvement in mean value of PEFR of 288.22lts /min with SD 51.05, compared with mean value of PEFR of 248.37lts/min with SD 47.10 and 211.6lts/min and SD 49.44 on the 1nd and 5th postoperative day respectively. There is

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For upper thoracic excursion measurement with mean of 4.49cms with SD 0.68 on 7th postoperative day, while 3.41cms with SD 0.76 on 5th postoperative day and.2.24 cms with SD 0.61 on 1st post op day.

Pain and trauma of surgical procedures, particularly in UAS, leads to splinting of the ribs and diaphragm, which in turn leads to further collapse of basal lung units. TENS is used in various conditions including post-surgical pain as a form of electro analgesia. The post-surgical pain in this study was assessed using Visual analog on the 1st and 7th post op day. Decrease in pain perception following treatment with the mean±SD of the score on day 1 was 8.28 ±.64 as compared to 3.45 ±.63 on 7th post op day. The post-surgical pain on the subjects assessed with VAS score showed a statistically significant (P<0.001) decrease in pain.

The results observed in the study has shown that the TENS and incentive spirometer are effective for decreasing incisional pain and improving lung function in the immediate post op period following upper abdominal surgery. This is noted with the significant improvement in PEFR and Thoracic excursion measurements.

3.1 An Experimental study of 40 subjects undertaken to find the effect of TENS and Incentive spirometer on PEFR and Thoracic excursion measurement following upper abdominal surgery

Table 1: Comparative Evaluation of PEFR in Ltr/Min

PEFR (LTS/Min)	Mean	SD	Mauchlys Chi-Squre Value	P Value	Greenhouse-Geisser	P Value
1st Post op day	211.60	49.44	47.51	.000	133.78	.000 (<0.001)
1st Post op day	248.38	47.10				
1st Post op day	288.23	51.05				

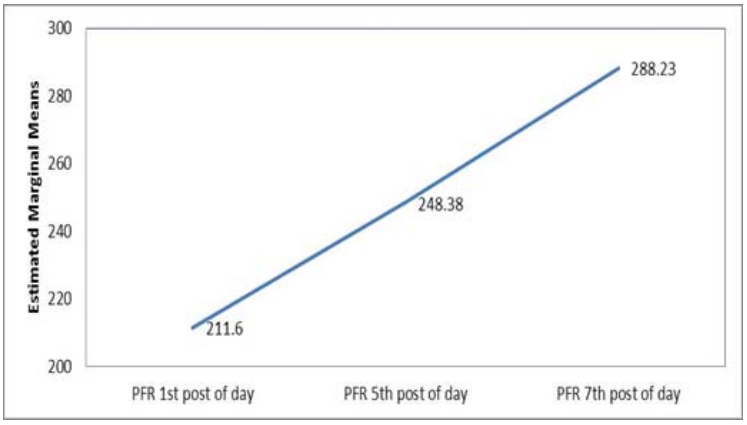

Fig 1: The scores assessed on patient with effect of TENS and Incentive spirometer using PEFR had a significant effect (F=133.78.P<0.001).The mean ±SD of the score on day 1 was 211.60 ±49.44 as compared to 248.38 ±47.10 and 288.23 ±51.05 on 5th and 7th post op day respectively (fig 1).there was a gradual increase in the PEFR readings from the 1st post op day to the 7th post op day (fig1).

Table 2: Comparative evaluation of upper thoracic excursion measurement

Upper thoracic excursion measurement	Mean	SD	Mauchlys Chi-Squre Value	P Value	Greenhouse-Geisser	P Value
1st Post op day	2.24	.61	.698	.705	519.78	.000
1st Post op day	3.41	.76				
1st Post op day	4.49	.68				

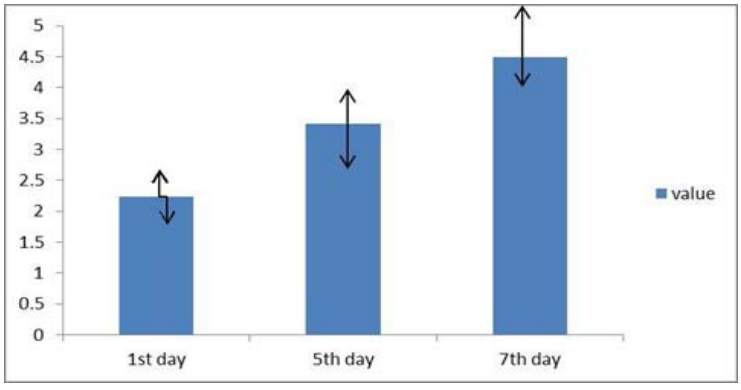

Fig 2: The scores assessed on patient with effect of TENS and Incentive spirometer by using. Upper thoracic excursion measurement had a significant effect (F=519.78.P<0.001).The mean±SD of the score on day 1 was 2.24 ±.61 as compared to 3.41 ±.76 and 4.49 ±.68 on 5th and 7th post op day respectively Shown in figure2.

Table 3: Comparative evaluation of lower thoracic excursion measurement

Lower thoracic excursion measurement	Mean	SD	Mauchlys Chi-Squre Value	P Value	Greenhouse-Geisser	P Value
1st post op day	2.12	.48				
5th post op day	3.08	.59	.996	.608	299.74	.000
7th post op day	3.81	.31				

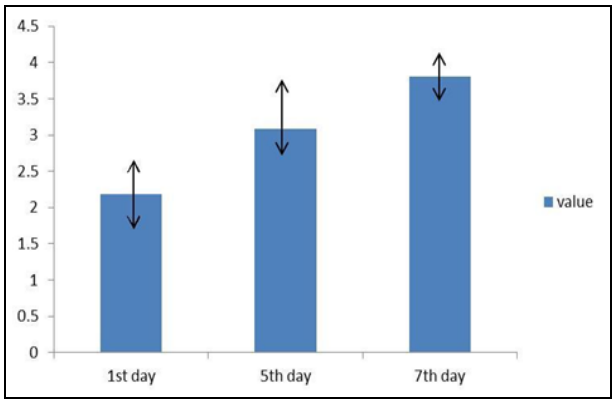

Fig 3: The scores assessed on patient with by effect of TENS and Incentive spirometer by using Lower thoracic excursion measurement had a significant effect (F=299.74.*P*<0.001).The mean SD of the score on day 1 was 2.12 ±.48 as compared to 3.08 ±.59 and 3.81 ±.31 on 5th and 7th post op day respectively

Table 4: Comparative evaluation of VAS

Vas Scale	Mean	SD	P value
1st post op day	8.28	.64	.000
7st post op day	3.45	.63	

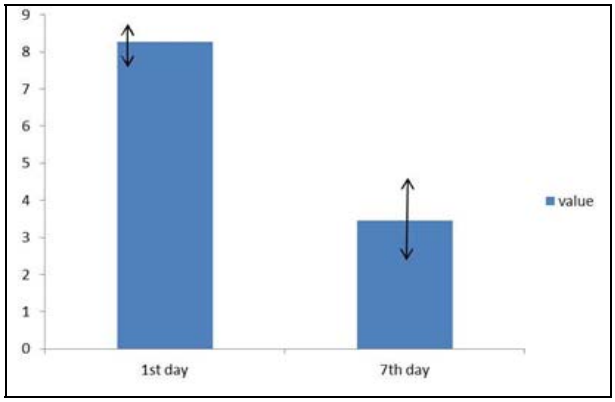

Fig 4: The scores assessed on patient with effect of TENS and Incentive spirometer on VAS scale by using paired sample test had a significant effect (*P*<0.001).The mean ±SD of the score on day 1 was 8.28 ±.64 as compared to 3.45 ±.63 on 7th post op day, shown in figure 4.

Fig 5: Use of incentive spirometer

Fig 6: Use of PFR

4. Conclusion

The mechanism of the analgesia produced by TENS is explained by the gate-control theory proposed by Melzack and Wall in 1965. The TENS reduces pain through nociceptive inhibition at the presynaptic level in the dorsal horn, thus limits its central transmission. The proposed mechanism for closing the gate is inhibition of the C-fibers nociception by impulses in the activated myelinated fibres. The reduction in post-op pain in the study was measured on VAS scale and it showed significant decrease in pain following treatment.

Incentive spirometers, also known as sustained maximal inspiration devices, are used to promote deep breathing thus enhance pulmonary ventilation, overcome the effects of anaesthesia or hypoventilation, loosen respiratory secretions, assist respiratory gaseous exchange, and help with re-expansion of collapsed alveoli in this way they help to avoid compromised inspiration and reduced tidal volume. They are also valuable in providing patients with visual feedback of their respiratory effort.

The results observed in the subjects included in the study following upper abdominal surgery showed that TENS and Incentive spirometer is effective in physical therapy intervention to reduce incisional pain and improve lung volumes. The physical therapy interventions like TENS and Incentive spirometer increases neurological arousal and greater stimulus to breath is observed. Following intervention with TENS and Incentive spirometer it allows more effective secretion clearance, which may be especially useful for those patients demonstrating sub-optimal coughing or huffing. This is noted with the significant improvement in PEFR and Thoracic excursion measurements taken following the study.

The study has emphasised that TENS and incentive spirometer are effective for decreasing incisional pain and improving lung function in the immediate post op period following upper abdominal surgery. This is noted with the significant improvement in PEFR and Thoracic excursion measurements.

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