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The Effect of Transcutaneous Electrical Nerve Stimulation on Forced Vital Capacity and Pain in Patients with Median Sternotomy

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Abstract

Background: *Median sternotomy is the thoracic incision through the midline of the sternum, which is used to gain access to the heart and mediastinal structures. A significant reduction in lung volumes were reported in patients after Median Sternotomy performed during cardiac surgery. Pain is considered as one of the most relevant factor influencing the reduction of lung volume. Subsequently, abnormalities in the chest wall mechanics may also occur that may influence the reduced lung function. TENS is a low frequency modality used to relieve pain and is been reported to be effective in reducing post-operative pain and improving lung function.*

Specific Objective - *To determine the effect of Transcutaneous Electrical Nerve Stimulation on Forced Vital Capacity and Pain in patients with Median sternotomy.*

Methods:

Design – *Pre test – Post test with Comparison group (Quasi experimental design).*

Study Setting - *Dept of Cardio Thoracic and Vascular Surgery,* Narayana Medical College And Hospital

Participants - *A total of 30 patients who underwent Median sternotomy for open heart surgeries.*

Intervention - *Group A-15 participants received TENS and conventional physiotherapy (duration of 20 minutes of TENS and 30 minutes of conventional physiotherapy/session for 2 sessions/ day) and Group B-15 Participants received conventional physiotherapy (30 minutes of conventional physiotherapy/ session for 2 sessions/day) for 5 days.*

Outcome Measures - *FVC using Hand Held Spirometer, Numerical pain rating scale and X-ray grading for Atelectasis.*

Results - *The patients in TENS with conventional physiotherapy group, showing the mean difference in FVC, Pain and Atelectasis were 0.85, 5.40 and 1.66 respectively. The patients with conventional physiotherapy alone, showing the mean difference of FVC, Pain and Atelectasis were 0.43, 3.53 and 1.13 respectively The FVC of patients in TENS with conventional physiotherapy and Conventional physiotherapy alone showed a mean difference of 0.42. Pain in TENS with conventional physiotherapy and conventional physiotherapy alone showed a mean difference of 1.87 and Atelectasis in TENS with conventional physiotherapy and conventional physiotherapy showed a mean difference of 0.53 using Independent't' test.*

Conclusion - *This study reveals that there was significant difference of improvement in FVC and Pain following TENS with conventional physiotherapy when compared to Conventional physiotherapy alone in patients undergoing Median sternotomy.*

Key words: *CABG, TENS, FVC and VAS*

INTRODUCTION

Median sternotomy is the thoracic incision through the midline of the sternum, which is used to gain access to the heart and mediastinal structures. The sternum is divided longitudinally in the midline and retracted. The structures incised are the skin and the subcutaneous tissue over the sternum. No muscle is divided but, the action of pectoralis major may be compromised if presternal aponeurosis of pectoralis major is cut. This incision is made just below the suprasternal notch and it extends up to tip of xiphoid process.

This incision is done for Open Heart Surgeries and Pulmonary Surgeries like Myocardial revascularization, Valve replacement surgeries and surgical treatment of congenital heart diseases.

Post-operative pulmonary complications (PPC) following surgery were first described by Pasteur in 1908 and remains an important cause of post-operative morbidity, contributing to significant increase in patients discomfort, length of stay in hospital, use of resources and overall hospital costs. Post-operative pulmonary complications are defined as pulmonary abnormality that produces identifiable disease or dysfunction that is clinically significant and adversely affects the clinical source (O'Donohue 1992).

Pulmonary complications in post-operative period of cardiac surgery can contribute to reduction of muscle strength, lung volumes and capacities and atelectasis; atelectasis is one of the most common of them, affecting approximately 64% of patients undergoing cardiac surgery (Cristie Gregorini et al 2009).

A restrictive ventilatory defect follows Median sternotomy (T J Locke et al, 1990). FVC reduction post CABG was more than FEV_1 reduction that suggested that a restrictive impairment was present. (F. S. Vargas et al.1997).

A significant impairment in pulmonary function can occur after Median sternotomy. Substantial reduction in lung volumes were reported in patients after Median sternotomy performed during cardiac surgery. The mechanism of volume reduction after Sternotomy is unclear. But Pain is considered as one of the most relevant factor in immediate postoperative days. Subsequently, abnormalities in the chest wall mechanics may also occur (Chetta et al.2006).

The pain stimulus can make physical therapy even slower due to the lack of cooperation. The surgical wound pain restricts lung expansion to a certain extent, thus favoring respiratory complications (Cristie Gregorini et al 2009).

Pain the main manifestation reported by patients who undergo heart surgery, has a multiple factors. The factors that influence pain may be the surgical incision, dissection of tissue, sternal retraction, multiple cannulations, chest drainage tubes and the invasive procedure which patient undergoes during the treatment (Baumgarten et al.2009).

A number of lung defense mechanism may become impaired or overtly ineffective due to intense incisional pain; deep breathing, Body mobilization in particular, coughing (G. Cipriano Jr. et al. 2008).

Hence reducing the post-operative pain can be one of the most important factors that can contribute to improvement of pulmonary function and prevent the post-operative complications and atelectasis after Median sternotomy. Transcutaneous Electrical Nerve Stimulation is a low frequency electrical modality used to relieve acute or chronic pain. This low frequency current is delivered by two pairs of adhesive electrodes positioned around the region of pain approximately two to three centimeters apart.

The action of TENS is based on two fundamental theories. One is pre synaptic inhibition, in which thick afferent nerves (A-α, A-β and A-γ) are stimulated, so stimulation transmission is blocked at the level of spinal cord. The other method is release of endogen opioids by inhibitor mechanism active in the upper levels into the central nervous system due to stimulation of A-δ and C nerves.

Transcutaneous Electrical Nerve Stimulation has been used as an adjunctive therapy for chronic and acute pain control in several medical and surgical conditions. Rakel; Frantz.et al. demonstrated that the application of TENS reduced pain and improved the Forced vital capacity and pulmonary function in postoperative periods of surgery. There will be a significant difference in improvement of Forced Vital Capacity and reduction of Pain following TENS with conventional physiotherapy when compared to Conventional physiotherapy alone in patients undergoing Median sternotomy.

INCLUSION CRITERIA

Median sternotomy incision for cardiac surgeries, Patients having peri incisional pain, Patient over 18 years ,Pain of 4 or more on NRS Atelectasis of 2 or more on X- ray grading

EXCLUSION CRITERIA

Contraindication for TENS, Permanent pacemakers, Epileptic patients, Sensitivity impairments, Obese patients (BMI > 30), Unhealthy sternal wounds and CVA.

MATERIALS & METHODOLOGY

Quasi Experimental Study Design was adopted for the study. With the help of this study design, the pre test and post test values were assessed for one group before and after the intervention and compared.

In the current study, the pre test measurement of Forced vital capacity, Pain and Atelectasis were measured before the introduction of Transcutaneous Electrical Nerve Stimulation with Conventional physiotherapy (for Group A) or Conventional physiotherapy alone (for Group B). The post test Forced vital capacity, Pain and Atelectasis were measured after the introduction of the technique. Department of Cardio Thoracic and Vascular Surgery, Narayana Medical College and Hospital (NMC&H), Nellore. Total study period was six months in NMCH. Group A-15 participants received Transcutaneous Electrical Nerve Stimulation and Conventional physiotherapy (20 minutes of TENS and 30 minutes of conventional physiotherapy per session, for 2 sessions per day for 5 days). Group B-15 Participants received Conventional physiotherapy alone (30 minutes of conventional physiotherapy per session, for 2 sessions per day for 5 days). Inpatients who underwent Median Sternotomy were selected according to the criteria of the study from the department of Cardio-thoracic and Vascular surgery, in NMC&H, Nellore . A total of 33 patients was selected by the convenience sampling method. In group A who received Transcutaneous Electrical Nerve Stimulation with Conventional physiotherapy, Forced vital capacity, Pain and Atelectasis were measured before and after the treatment session and analyzed. In group B who received Conventional physiotherapy alone, Forced vital capacity, Pain and Atelectasis were measured before and after the treatment session and analyzed. Forced vital capacity was measured using Hand held spirometer, Pain was measured using Numerical pain rating Scale and Atelectasis was measured using X-ray grading for Atelectasis.

RESULTS AND DISCUSSION

This quasi experimental study was conducted to determine the effect of Transcutaneous Electrical Nerve Stimulation (TENS) on FVC and Pain in patients who were submitted to Median sternotomy.

Totally 44 patients were assessed for the study. Out of which 33 patients who met inclusion criteria participated in the study. They were selected by A convenience sampling method and randomly assigned into two groups. Group A (TENS with conventional physiotherapy) consisted of 17 patients and Group B (Conventional physiotherapy alone) consisted of 16 patients. Later, 2 patients in Group A and 1 patient in Group B were not willing to participate in the study. Hence a total of 30 patients (15 patients in each group) completed the study.

Pre Test and Post Test Mean Values of Forced Vital Capacity (FVC) For Group A And Group B

TABLE 1: Forced Vital Capacity (FVC)

GROUPS	MEAN VALUES	n	MEAN DIFFERENCE	SD	t-value	p-value
Group A Pre Test	1.39	15	0.85	0.24	13.70	<0.001
Post Test	2.24					
Group B Pre Test	1.38	15	0.43	0.16	10.40	<0.001
Post Test	1.81					

In table 1 and figure 1, pre and post test measurement of FVC (in liters), are mentioned for both groups.

The pre test and post test mean difference in Group A is 0.85 and for Group B is 0.43. The obtained 't' value for Group A is 13.70 and in Group B is 10.40. The corresponding 'P' value for the Group A and Group B is the same i.e., less than 0.001. Therefore, the result shows there is a significant difference between Group A and Group B and it also indicates the pretest - post test mean difference of FVC for Group A is statistically significant than Group B.

FIGURE 1

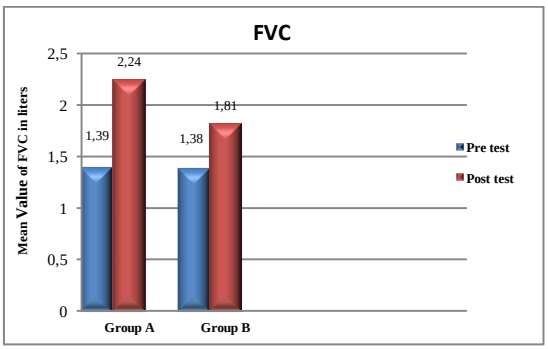


TABLE 2 Pain- Numerical Pain Rating Scale

GROUPS	MEAN VALUES	n	MEAN DIFFERENCE	SD	t-value	p-value
Group A Pre Test	8.13	15	5.40	1.05	19.81	<0.001
Post Test	2.73					
Group B Pre Test	8.20	15	3.53	1.06	12.88	<0.001
Post Test	4.67					

In table 2 and figure 3, pre test and post test measurement of Pain are mentioned for both groups. The pre test and post test mean difference in Group A is 5.40 and for Group B is 3.53. The obtained 't' value for Group A is 19.81 and for Group B is 12.88. The corresponding 'p' value for the Group A and Group B is the same i.e., less than 0.001. Therefore, the result shows there is a significant difference between Group A and Group B and it also indicates the pre test - post test mean difference of Pain level for Group A is statistically significant than Group B.

FIGURE 2

Pre Test And Post Test Mean Values Of Numerical Pain Rating Scale (NRS) For Group A And Group B

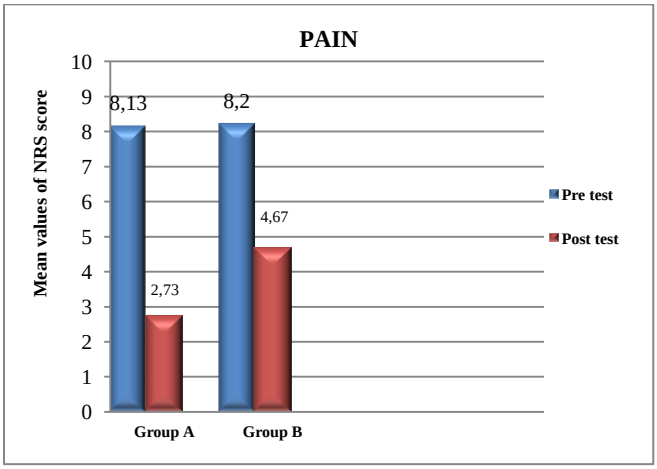


TABLE 3 Atelectasis – X-Ray Grading

GROUPS	MEAN VALUES	n	MEAN DIFFERENCE	SD	t-value	p-value
Group A Pre Test	2.46	15	1.66	0.61	10.45	<0.001
Post Test	0.8					
Group B Pre Test	2.60	15	1.13	0.67	5.90	<0.001
Post Test	1.47					

In table 3 and figure 3, pre and post test measurement of Atelectasis are mentioned for both groups.

The pre test and post test mean difference in Group A is 1.66 and for Group B is 1.13. The obtained 't' value for Group A is 10.45 and for the Group B is 5.90. The corresponding 'p' value for

the Group A and Group B is the same i.e., less than 0.001. Therefore, the result shows there is a significant difference between Group A and Group B and it also indicates the pre test-post test mean difference of Atelectasis grading for Group A is statistically significant than Group B.

FIGURE 3

Pre Test and Post Test Mean Values Of X-Ray Grading Of Atelectasis For Group A And Group B

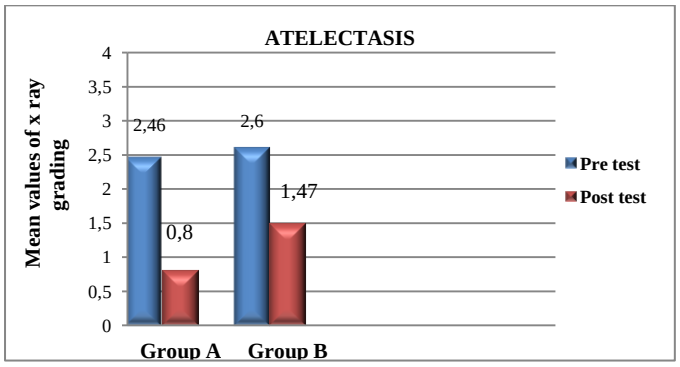


TABLE 4: Mean Difference Of FVC, Numerical Pain Rating Scale And X Ray Grading Of Atelectasis Between Group A & Group B

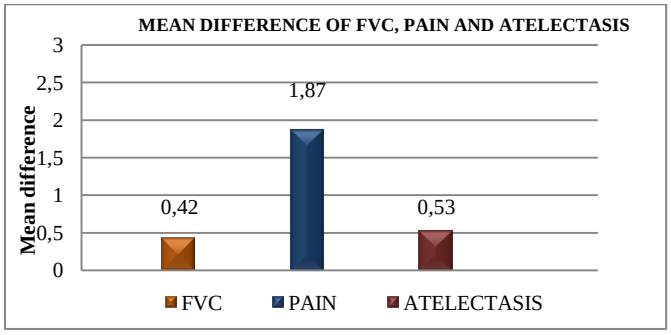
OUTCOME MEASURES	n	MEAN DIFFERENCE	SD	t-value	p- value
FVC	30	0.42	0.20	5.73	<0.01
PAIN	30	1.87	1.05	4.88	<0.01
ATELECTASIS	30	0.53	0.67	2.13	<0.05

In table 4 and figure 4, mean difference, Standard deviation, Independent‘t’ value of FVC, Pain and Atelectasis are mentioned for both groups. The mean difference of FVC is 0.42, Pain is 1.87 and for Atelectasis is 0.53. The obtained Independent‘t’ value for FVC is 5.73, for Pain is 4.88 and for Atelectasis is 2.13. The corresponding ‘p’ value for FVC and Pain between both groups is the same i.e., less than 0.01. The corresponding ‘p’ value for Atelectasis between both groups is the less than 0.05.

Therefore, the result shows there is a statistical significance difference in FVC, Pain and Atelectasis between two groups.

FIGURE 4

Pre Test and Post Test Mean Difference of FVC, Pain And X-Ray Grading For Atelectasis Between Group A And Group B (N=30)



From the above data it is clearly understood that a combination of TENS along with conventional physiotherapy is much more efficient than Conventional physiotherapy alone to improve the FVC and Pain and reduce the Atelectasis in patients undergoing Median sternotomy. Thus these data points out the relevant role of TENS, not only in improving pain but also on improving the FVC and in reducing atelectasis following Median sternotomy.

The present study mainly focused on applying Transcutaneous Electrical Nerve Stimulation with conventional physiotherapy in order to improve the FVC, reduce Pain and reduce risk of Atelectasis. Patients in both groups have shown a significant improvement in FVC and reduction of pain and reduction of Atelectasis, but TENS with conventional physiotherapy group showed a better improvement when compared to group with Conventional physiotherapy alone.

One important finding of this study was that, patient who received TENS with conventional physiotherapy had a better and early mobility and also had a better ventilatory pattern and ability to cough when compared to Conventional physiotherapy.

In my current study I had followed Conventional physiotherapy for both groups and the Transcutaneous electrical nerve stimulation was added only to one group to compare the results. Shorter duration of TENS was applied to find its

effect on FVC, and Pain, and in addition, to find the effect of FVC on reducing Atelectasis. The results of my study showed that there is a significant improvement in FVC and reduction of Pain and Atelectasis following TENS with conventional physiotherapy when compared to Conventional physiotherapy alone.

LIMITATIONS

Patients undergoing Median sternotomy, only for cardiac surgeries have participated in this study.

This study tests only the Forced vital capacity, Atelectasis and the Pain level in Median sternotomy patients.

In this study, the measurement of FVC and Pain were not blinded to the evaluator.

Another potential limitation of this study was related to the fact that patients underwent a number of different cardiac surgery procedures. However, the same surgical access (Median sternotomy) was used in all patients.

Another limitation was that the intervention was carried out only during the hospitalization period and since the length of hospital stay of patients undergoing open heart surgery is very short, the patients were not able to receive longer duration of the treatment.

CONCLUSION

TENS is an easy to apply, inexpensive and non-toxic procedure. From the statistical analysis of the data obtained and from the literature available, the study concludes that, "There is a significant difference in improvement of Forced Vital Capacity (FVC) and reduction of Pain following Transcutaneous Electrical Nerve Stimulation (TENS) with conventional physiotherapy than Conventional physiotherapy alone in patients undergoing Median sternotomy" Patients with Median sternotomy having reduced Forced vital capacity, and severe pain will have more benefits if TENS could be given more frequently and for more days. It will be beneficial to prevent several post-operative respiratory complications by reducing pain, improving the pulmonary function and improving the restricted ventilatory pattern and thus reducing the risk of atelectasis, better mobility and quality of life.

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