Original Article

Immediate Effect of Proprioceptive Neuromuscular Facilitation on Chest Mobility, Pain and Range of Motion of Thorax in Patients of Intercostal Drainage: A Randomised Control Trial

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Chest tube, Chest expansion, Flexion, Rotation.

ABBRIVATIONS USED IN THIS ARTICLE

ICD = Intercostal tube drain

PNF = Proprioceptive neuromuscular facilitation

VAS = Visual analogue scale

GTO = Golgi tendon organ

Abstract

Objective. Intercostal muscle strain leading to pain, muscle spasm and related morbidities is common in pleural diseases following insertion of intercostal tube drain (ICD). Hence, suitable lengthening of soft tissue and muscles around the chest wall using various stretching techniques can help in improving the efficiency of respiratory muscles and chest movement.

Methods. Thirty patients who underwent ICD insertion were randomly allocated to control group (receiving chest mobility exercises only) and treatment group (receiving proprioceptive neuromuscular facilitation [PNF] stretches), in addition to chest mobility exercises. Pain assessed by visual analogue scale (VAS), thoracic spine range of motion (flexion and rotation) and chest expansion values at 2nd, 4th and 6th rib (R2, R4 and R6) were recorded before and after a single intervention session in both the groups.

Results. There was statistically significant improvement in VAS, thoracic ranges and chest expansion at all R2, R4 and R6 levels ($P<0.05$) in the treatment group.

Conclusions. Proprioceptive neuromuscular facilitation was more effective in reducing pain, increasing chest mobility and range of thoracic motion in patients with ICD insertion.

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Introduction

Intercostal tube drainage (ICD) is done by making a small cut in the intercostal muscles. Hence, strain of intercostal muscles leading to pain, muscle guarding and related morbidities are observed in these patients. Intercostal muscles arise from a ridge on the inner surfaces of 1st to 11th ribs and are inserted into the superior border of the rib below. The sternal fibres of intercostal muscles take a part in breathing and the lateral intercostals from both sides also play a role in axial rotation of the thorax.[1] When a person breathes, the rib cage expands to accommodate the movement of lungs. If the rib cage is tight, the amount of air taken in by the lungs is reduced due to pain and muscle strain in intercostals leading to reduced chest mobility and range of motion of the thorax. Suitable lengthening of soft tissue around the chest wall and respiratory muscles is required for better efficiency of respiratory muscles, and hence, improved chest movement.[2]

Due to the ICD insertion, there is decrease in chest mobility due to pain, muscle strain in intercostals that affects the pulmonary ventilation.[3] Therefore, for improving the flexibility of the tight muscles of chest, use of proprioceptive neuromuscular facilitation (PNF) techniques[4,5] along with chest mobility exercises can be effective to reduce patient's perioperative stress response, thereby to reduce the potential complications and hospital stay and enable patients to return more quickly to their functional status.

Conventionally, to increase flexibility of muscles techniques, such as passive stretching, PNF stretching[3,5-7] self-stretching[6], passive mobilisation of joints, chest mobility exercises and massage are recommended. PNF is a more advanced technique of manoeuvre to improve flexibility of muscles, and increasing range of motion which involves recruitment, relaxation and stretching of the muscle group being targeted. The technique targets nerve receptors of a muscle to extend its length. It is usually a combination of passive stretching and isometric contraction.[4] Intercostal stretch is a facilitatory stimulus which is effective in restoring normal breathing pattern, beneficial in improving the chest wall mobility and chest expansion. This technique utilises the autogenic inhibition, which relaxes a muscle after a sustained contraction has been applied to it. Hence, the posture and the range which is reduced due to pain, muscle guarding can be improved with the help of PNF treatment.[5]

In the present study, PNF stretches along with routine chest mobility exercises were used with the aim of tackling decrease in pain using VAS and reduction in chest wall mobility and thoracic range of motion associated with ICD insertion and muscle strain.

Material and Methods

Thirty patients who had an ICD insertion having pain (4/10 on VAS) were recruited in the study. Written informed consent was taken from all the patients. Patients who had unstable vitals and trauma to rib cage were excluded from this study. The sample size was calculated using Cochrane's formula by referring to all previous studies. The patients were recruited from September 2019 to February 2020 for this randomised control trial (RCT) from a tertiary care hospital. Recruited patients were randomly allocated to two groups, controls (n=15) and study group which include patients with intercostal drainage who were divided by simple random sampling technique (equal randomisation 1:1) using computer generated charts. There was single blinding done in this study where assessor was blinded. Ethical Committee approved the study.

Before beginning with the treatment, blood pressure, respiratory rate, pulse rate, and chest expansion was measured at 3 levels at R 2, R 4, R 6 using a measuring tape; the patients were asked to exhale completely and then inhale deeply and exhale, the tape was placed at all the 3 levels, pain was assessed by visual analogue scale, range of motion of thorax was assessed-flexion by using gravity dependent dual inclinometer (reliability >0.81, validity >0.86)[8] by keeping the inclinometer on spinous process at T1 and T12 and asking patient to bend forward from trunk[9] and rotation by using universal goniometer (reliability >0.82, validity >0.95).[10]

Procedure of Intervention for Study Group

Subjects were treated with PNF stretching and, chest mobility exercises. Each stretch was held for 30 seconds with a rest period of 10 seconds. Each exercise was repeated three times with a rest period of 10 seconds.

PNF Stretches-Hold–Relax Technique of PNF

This technique was used for trunk flexors. Patient in sitting position was asked to flex and hold the position for 10 seconds and relax and stretch.[11]

Rhythmic Stabilisation

For trunk rotators, isometric contractions of the agonist, followed by an isometric contraction of the antagonistic muscle group, which was to be given to both the sides.[12]

Intercostal stretch

This was done by applying pressure to the upper border of a rib (3,4,6,7) in a direction that will widen the intercostal space above it. The pressure was to be applied in a downward direction, not pushing inward. The stretch was timed with an exhalation and was maintained as the patient continues to breathe in his usual manner. As the stretch was maintained, there was gradual increase in inspiratory movements in and around the area being stretched. This was done on the side of drain insertion.[5,13]

Chest Mobility Exercises

Chest expansion exercise.[14,15] Patient was asked to exhale completely first, then patient was asked to abduct his arms and take a deep breath in and slowly exhale while lowering his arms.

Trunk side flexion in sitting position. Patient was asked to sit comfortably, then exhale completely, and to do side flexion on the side of the ICD so that opposite side of the chest gets stretched out, exhale and release the stretch and come to neutral position.[16]

Procedure of intervention for Control group.

Chest mobility exercises were do not by the controls and each intervention was repeated three times with a rest period for 30 seconds.[5] Assessment of the vitals, chest expansion, pain, range of motion of thorax was done.

Statistical Analysis

For analysis of range of motion and chest expansion, between the groups unpaired 't' test was used. For within the group analysis, paired 't' test was used. For the pain analysis, between the groups Mann-Witney test was used and within the groups Wilcoxon signed rank test was used.

Results

Thirty-five patients were screened, five patients were excluded (3 did not meet the inclusion criteria and 2 declined to participate), therefore, 30 patients were included in the study. There is a significant difference in pain, chest expansion and range of motion of thorax (P<0.001) with symmetrical distribution in both within and between the group analysis (Table 1). The mean and the sum of ranks was greater of study group. Hence, pain was reduced post PNF intervention (Table 2).

Table 1. Baseline data of the study patients

Within Group Analysis					
Variables	Control Group Mean±SD		Study Group Mean±SD		P value
	Pre	Post	Pre	Post	
Within Group Analysis					
Thoracic flexion	21.67±7.72	22±7.75	24±4.71	27.67±4.17	0.002
Thoracic rotation	15±7.07	15.33±6.94	14±7.37	16.33±7.67	0.033
Chest expansion (R 2)	1.03±0.35	1.07±0.37	1.07±0.53	1.20± 0.53	0.001
Chest expansion(R 4)	0.92±0.5	0.98±0.5	0.9±0.43	1.3±0.37	0.001
Chest expansion(R 6)	1.07±0.65	1.11±0.63	0.83±0.56	1.2±0.62	0.001
Between Group Analysis					
Flexion difference	2.0±3.055				0.002
Rotation difference	1.33±2.56				0.033
R2 difference	0.083±0.226				0.242
R4 difference	0.2316±0.273				<0.05
R6 difference	0.2±0.2768				<0.05

Table 2. Pain analysis between the groups (Wilcoxan Signal Rank Test) and within the groups (Mann-Whitney Test)

Variables	Control Group		Study Group	
	Pre	Post	Pre	Post
Wilcoxan Signal Rank Test				
Pain	5.40±1.40	6.27±1.62	5.20±1.24	4.40±1.40
Mann-Whitney Test				
Mean Rank	8.90		22.10	
Sum of Ranks	133.50		331.50	

A P value <0.001 indicates that pain difference was significant post PNF intervention.

Discussion

On the basis of data analysis, it is observed that patients who were treated with PNF had reduced pain, increased chest expansion and thoracic range of motion. Pain was primary outcome of our study which caused reduction in the muscle strain, hence, we achieved increase in chest expansion and range of motion.[17,18] PNF reduces intercostal muscle stress, as it stretches the intercostal muscle and increases muscle length that improves functional capacity and chest expansion.[19] PNF has been proved to produce analgesic effect through pain-gate control mechanism. Nociceptors transmit the pain stimulus through the unmyelinated C fibres or through small myelinated A-delta fibres and these relay onto the spinal level. PNF techniques activate these fibres and inhibit pain at the spinal level. Pain relief and an increase in the pain threshold was obtained in patients who received stretching therapy along with PNF techniques and the stabilisation exercises, thereby, stimulating the proprioceptive myoreceptors of the muscles and tendons which led to an increased efficiency of the nervous control of muscles and normalised muscle tone, and increase in the circulation of blood and tissue fluid to the muscles.[18]

Improvements in flexibility using the passive technique was one of the reasons which led to an increase in range of motion as a result of enhanced stretch tolerance. Passive stretching does not activate the stretch reflex; it causes the stretched muscle to contract instead of lengthening. During a passive stretch, reciprocal inhibition is accomplished by simultaneously contracting the muscle opposing the muscle being stretched. The tension in the contracting muscle stimulates the Golgi tendon organ (GTO), which causes a simultaneous reflex relaxation in the opposite muscle. It has been reported that the biomechanical effects of sustained stretching were because of the changes in the viscoelastic characteristics and stretch tolerance.[20] Due to ICD insertion, there is limited range of motion caused by pain, reflex spasm of intercostals on movement. Soft tissue mobilisation and PNF improve range of motion and minimise pain level in shoulder impingement.[18] PNF is effective in increasing the range of motion and its reciprocal activation of agonist and antagonist provides the greatest potential for muscle tendon as it lengthens the GTO which stimulates relaxation of the antagonist muscles. When PNF is applied for trunk rotation, the patient is told to contract the muscle in trunk rotation against the resistance and the muscle tension develops, the GTO fibres inhibits alpha motor neurons activity and decreases tension in the muscle tendon. There is inhibition which is the state of decreased neuronal activity and altered synaptic potential which reflexively diminishes the capacity of a muscle to contract. As the capacity of muscle to contract decreases, the trunk is rotated to opposite side which causes the antagonists to contract and agonist muscles are relaxed. Thus, GTO monitors the excessive tension during muscle contraction, and thus, inhibits the excessive contractions.[17] PNF techniques, such as hold relax, rhythmic stabilisation can cause controlled stretching and movement which leads to improved mobility of thorax and functional status.[14]

Theoretically, PNF stretching techniques are superior to static stretching techniques because these activate not only the muscle fibres but also the sensory receptors within the agonist and antagonist muscle as well. Hence, PNF stretches were used rather than using self or passive stretches for treating these patients. However, the resistance to musculotendinous stretching targets not only the viscoelastic properties of muscle and connective tissue but also the neurological reflex and voluntary components of muscular contraction.[21]

Conclusion

PNF reduces pain and increases range of motion of thorax and chest expansion at all three levels, R2, R4 and R6.

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