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Effect of Flow-Incentive Spirometry & Volume-Incentive Spirometry on Chest Expansion in Modified Radical Mastectomy Patients: A Comparative Study

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Abstract

Introduction: A mastectomy is a surgical procedure involving the removal of all or part of the breast. Mastectomy classifies into partial, simple, modified-radical, and radical. Other variations in terminology or technique include skin-sparing mastectomy and nipple-sparing mastectomy, which are techniques that often accompany breast reconstruction. Mastectomy leads to cardiac and pulmonary complications due to lack of lung inflation which include respiratory dysfunction, pleural effusion, lung collapse etc. Chest expansion measurements are used to evaluate the patient’s baseline status, treatment effectiveness and progression of respiratory disease with regards to chest wall mobility and respiratory muscle function.

Method: 30 sample sizes were undergone modified radical mastectomy surgery which was randomly divided as follows: 15 subjects performed flow-oriented incentive spirometer group, and other 15 subjects performed volume-oriented incentive spirometer group. All of them underwent evaluations and Data was obtained by measuring chest expansion with chest exposed and with the help of non-stretchable inch tape the chest expansion was measured at three levels that is 2nd intercostal space (Axilla level), 4th intercostal space (Nipple level), and xiphoid process.

Results: A total of 30 patients who underwent modified radical mastectomy were randomly divided into two groups; Group A (flow incentive spirometry) and Group B (volume incentive spirometry), with 15 patients in each group. Chest expansion was measured at three anatomical levels—axillary, nipple line, and xiphoid—on Day 1 (pre-intervention) and Day 7 (post-intervention). Within-group comparison: Group A (FIS): Showed a moderate increase in chest expansion at all three levels. The average improvement at the axillary level was 0.8±0.3 cm, nipple level 0.9±0.4 cm, and xiphoid level 0.7±0.3 cm. Group B (VIS): Demonstrated a significantly greater increase. The average improvement was 1.3±0.4 cm at axillary, 1.5±0.5 cm at nipple, and 1.2±0.4 cm at xiphoid.

Conclusion: The study concluded that,” Volume-incentive spirometry is more effective than Flow-incentive spirometry in improving chest expansion in Modified radical mastectomy surgery patients.”

Keywords: Incentive Spirometry, Modified radical mastectomy Surgery, Flow-Incentive Spirometry, Chest Expansion, Volume-Incentive Spirometry.

1. Introduction

Mastectomy is a surgical procedure involving the removal of all or part of the breast. The term originates from the Greek word” mastos”, meaning “woman’s breast,” and the Latin term” ectomia” which signifies “excision of.” Mastectomy classifies into partial, simple, modified-radical, and radical. Other variations in terminology or technique include skin-sparing mastectomy and nipple-sparing mastectomy, which are techniques that accompany breast reconstruction [1]. The most frequent indication for mastectomy is a malignancy of the breast. In most cases, the mainstay of treatment of breast cancer necessitates localized surgical treatment (Either mastectomy or breast-conserving surgery) and can be in combination with neoadjuvant or adjuvant therapy, including radiation, chemotherapy, or hormone antagonist medications, or a combination there of, Tumor characteristics like size and location and patient preference are a significant part of the decision-making process, given that in many circumstances, survival rates are equivalent among patients undergoing mastectomy or lumpectomy with adjuvant radiation therapy [2].

Modified radical mastectomy (MRM): Modified radical mastectomy (removal of the breast and the level 1, level 2 axillary lymph nodes), has replaced radical mastectomy (removal of breast, lymph nodes, and pectoralis muscle) as the standard of care for patients with node-positive disease who undergo mastectomy. The pectoralis minor muscle can be removed with minimal morbidity in a modified radical mastectomy to facilitate dissection of the highest (level III) lymph nodes (if involved), although most surgeons are not trained in this technique today [3].

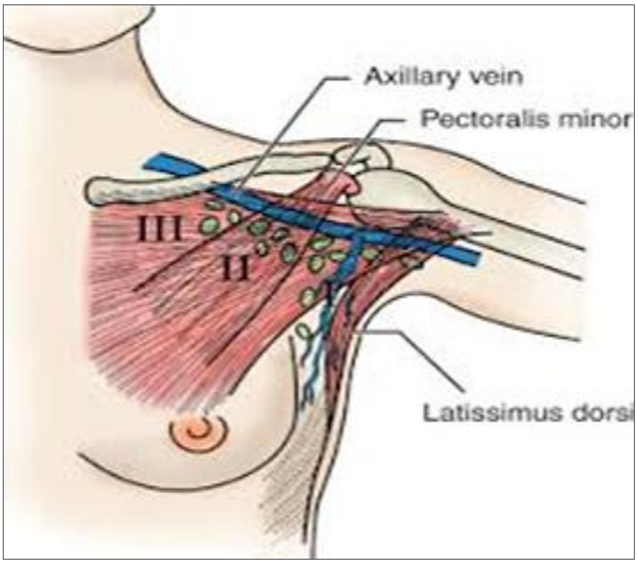

Fig 1: Anatomy of the Axillary Region

Chest expansion measurement is an important assessment in physical examination of cardio-respiratory patients. Chest wall excursion measurements give us a measure of chest wall mobility [4]. It gives us the idea about the compliance of the lung & is a better indicator of lung function. It provides the patient's initial limitations & also useful in monitoring improvement during rehabilitation. It is the easiest method of determining lung function which can be measured by a simple, inexpensive measuring tape, shallow breathing due to suture pain leads to reduced chest expansion among modified radical mestectomy patients. For decreased chest expansion, Incentive Spirometry is a widely used therapeutic modality which can be used as a lung expansion therapy [5].

Incentive spirometry, also referred to as sustained maximum inspiration, is accomplished by using a device that provides feedback when the patient inhales at a predetermined flow or volume and sustains the inflation for at least 5 seconds. Incentive spirometry is designed to mimic natural sighing by encouraging the patient to take long, slow, deep breaths [6]. Incentive spirometry stimulate the generation of a large and sustained increase in the trans pulmonary pressure, with consequent expansion of collapsed alveolar units. It also improves exchange of gases and oxygenation, to reduce pulmonary complication [7]. It decreases pleural pressure, increased lung expansion and better gas exchange. This device is used to encourage patient to take long, slow, sustain deep inspiration which leads to achieving maximal inflation pressure in the alveoli and maximal inhaled volume, and also helps to maintain thepatency of the smaller airways [8].

There are two types of incentive spirometer:

1 – Flow incentive spirometer.

2 – Volume incentive spirometer.

Incentive spirometer is activated by a inspiratory effort, that is, breathing is visualized by an uplifted ball in a transparent cylinder during sustained inspiration. on a calibrated scale on the cylinder, the uplifted ball on the spirometer displays either the inspired volume (a volume –oriented incentive spirometer) or the generated flow (a flow- oriented incentive spirometer) [8].

Fig 2: Flow Incentive Spirometer

Fig 3: Volume Incentive Spirometer

Thus, the study aims to compare the effect of flow & volume incentive spirometry on chest expansion in modified radical mastectomy patients.

Need for study

- Mastectomy is a surgery to remove all breast tissue from a breast as a way to treat or prevent breast cancer. Most patients recover from mastectomy without any problem, but complication such as infection, lymphedema and seroma can occur. Due to these pulmonary complications, lung function including chest expansion is reduced.
- Incentive Spirometer is widely used as a treatment protocol in CVTS & other surgery units to prevent the respiratory complications & to improve chest expansion.
- Recent literatures compared flow and volume-oriented

incentive spirometry on lung function and diaphragm movement after laparoscopic abdominal surgery.
- Another study was conducted for comparing the flow and volume incentive spirometry on pulmonary function and exercise tolerance in open abdominal surgery.
- But, as far as our search we found that no studies have showed the comparative effect of flow and volume incentive spirometer on chest expansion after MRM.
- Thus the study aims to compare the effect of flow and volume-oriented incentive spirometry on chest expansion following Modified radical mastectomy.

Aims
The aim of this study is to compare the effect of flow-incentive spirometry and volume-incentive spirometry on chest expansion in modified radical mastectomy patients.

Objectives
- To find out the effect of flow incentive spirometry on chest expansion in modified radical mastectomy patients.
- To compare the effects of flow incentive spirometry with volume incentive spirometer on chest expansion in Modified radical mastectomy patients.
- To compare the effects of flow incentive spirometry with volume incentive spirometer on chest expansion in Modified radical mastectomy patients.

Materials and Methodology
Materials
1. Flow incentive spirometer.
2. Volume incentive spirometer.
3. Measuring tape.

Methodology
- **Type of study:** - Comparative study.
- **Sample size:** - Sample size was calculated by Sample size Calculator. Sample size is calculated as 30 with 15 samples in each group.

Group A- Flow-incentive spirometer
Group B- Volume-incentive spirometer
- **Place of study:** - Tertiary Care Hospital.
- **Methods of sample selection:** - Random sampling.
- **Study Duration**: – 6 months.

Selection Criteria
Inclusion criteria
- Women with carcinoma of breast.
- Unilateral lymphedema in breast cancer patients.
- After mastectomy.

Exclusion criteria
- Acute superficial or deep vein thrombosis prolong immobilization.
- Patients having arterial occlusive disease or thrombophilia.
- Patients who were uncooperative.

Method
Subjects undergoing Modified radical mastectomy surgery were included and allocated into flow and volume incentive spirometry groups. Postoperative measurements of chest expansion were taken for both groups.

Design
The flow – incentive spirometer consists of a mouthpiece and corrugated tubing connected to a manifold composed of three flow tubes containing light weight plastic balls. The patient inhales through the mouth piece thereby creating a negative pressure within the tubes. This causes them to rise. The number of balls and the level to which they rise depends on the magnitude of the flow achieved. At lower flows, the first ball rises to a level that depends on the magnitude of flow. As the inspiratory flow increases, the second ball rises, followed by the third ball. The volume-incentive spirometer enables the patient to inhale air through a mouthpiece and corrugated tubing which is attached to a plastic bellows. The volume of air displaced is indicated on a scale located on the device enclosure. After the patient has achieved the maximum volume, the individual is instructed to hold this volume constant for 3 to 5 seconds.

Procedure
Method of performing volume -oriented incentive spirometry
Ask the patient to sit upright in a chair or in bed. Hold the incentive spirometer at eye level. The therapist gave the patient an explanation of inspiratory flow. Now hug or hold a pillow to help splint or brace the incision (surgical cut) while using the incentive spirometer. This will help decrease pain at incision. Put the mouthpiece in mouth and close lips tightly around it. Now the patient will deeply inhale through the mouthpiece & hold for 2-3 seconds during inspiration. While taking deep breath, see the piston rise inside the large column. While the piston rises, the indicator on the right should move upwards. It should stay in between the 2 arrows. Ask the patient to try & get the piston as high as he/she can, while keeping the indicator between the arrows. If the indicator doesn't stay between the arrow's, breathing pattern is either too fast or too slow. When he/she gets it as high as he/she can, hold the breath for 2-3 seconds. While holding breath, the piston will slowly fall to the base of the spirometer. Once the piston reaches the bottom of the spirometer, breathe out slowly through mouth. Rest for few seconds. Repeat 10 times.

Method of performing flow oriented incentive spirometry
Incentive spirometry was administered to the patient who has made to lie at 45° to the horizontal position i.e., half-lying. A pillow was placed beneath the patient's knees. The process was first demonstrated to the patient just to ensure that he/she had understood the technique before performing it. Initially the spirometer was held in front of the patient by the therapist. The therapist gave the patient an explanation of inspiratory flow. The patient exhaled slowly and passively to avoid any forceful expiration, then the patient was asked to place the mouthpiece in mouth and perform full inspiration through the flow incentive spirometer. Following the patient will held the spirometer him/herself and practiced the manoeuvrer. The patient was instructed to perform 3 sets of 5 repeated deep breaths with a hold and do this exercise every
waking hour. The treatment was administered to the patient four times a day and the patient was instructed to perform the same exercises on the rest of the day. A log book record was maintained of the same.

Statistical Analysis
Data was analysed by using Primer of Biostatistics. For

descriptive statistics mean, standard deviation, proportions and percentages were used. For inferential statistics unpaired "t" test and one Analysis of Variance (ANOVA) were used. Statistical significance was taken as < 0.05. All statistical analysis was performed using the Statistical Package for Social Science (SPSS). P-value of < 0.05 with confidence interval of 95% was considered statistically significant. An analysis of variance (ANOVA) and unpaired "t" was used to compare the results of each group obtained chest expansion (AT Axilla, Nipple, Xiphoid) for first, second, third, fourth and fifth post-operative (OP) days.

Results

A total of 30 patients were included in the study; 15 patients were allocated to the Flow Incentive Spirometry group and 15

Fig 1: Distribution of Age Groups in Groups A and B

Variable	Group-A & B	Frequency	Percentage
Age (in years)	Below 40	8	26.66
	41-50	11	36.66
	51-60	9	30
	Above 60	2	6.66

Patients to the Volume Incentive Spirometry group.

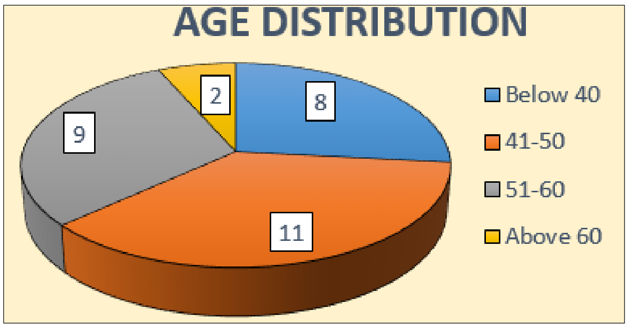

Fig 4: Mean values of chest expansion at axilla level for FIS

Table 2: Mean values of chest expansion at axilla level for flow incentive spirometry (FIS)

Variable	Day	N	Mean	SD	F	p value
AXILLA	1	15	0.44	0.8		
	2	15	0.52	0.8		
	3	15	0.64	0.11		
	4	15	0.74	0.12	57.92	0.00
	5	15	0.86	0.13		

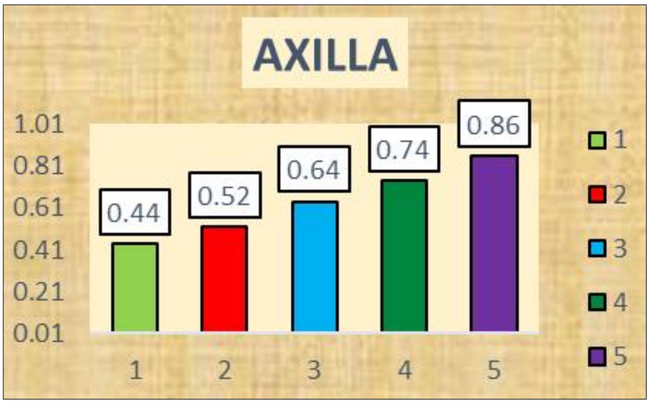

Fig 5: Mean values of chest expansion at axilla level for FIS

Interpretation

There is statistically significant increase seen in mean chest expansion for flow incentive spirometry group at axilla level. which was significantly increasing by mean 0.74 & 0.86(SD=0.13) with "P" value 0.00 which is Highly significant.

Table 3: Mean values of chest expansion at nipple level for flow incentive spirometry (FIS)

Variable	Day	N	Mean	SD	F	p value
NIPPLE	1	15	0.47	0.8	45.68	0.00
	2	15	0.56	0.11		
	3	15	0.64	0.11		
	4	15	0.77	0.12		
	5	15	0.89	0.14		

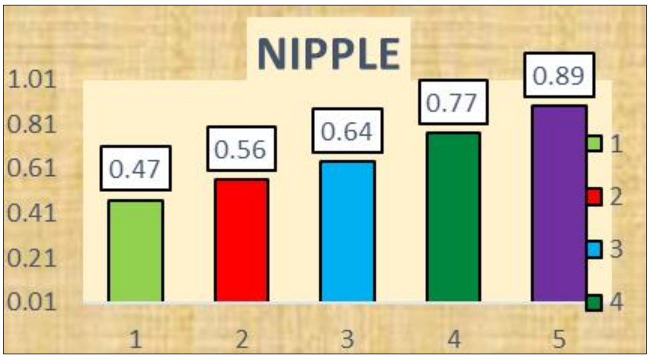

Fig 6: Mean values of chest expansion at nipple level for FIS

Interpretation

There is statistically significant increase seen for flow incentive spirometry group in mean chest expansion at nipple level. which was significantly increasing by mean 0.77 & 0.89(SD=0.14) with "P" value 0.00 which is highly significant.

Table 4: Mean values of chest expansion at xiphoid level for flow incentive spirometry (FIS)

Variable	Day	N	Mean	SD	F	p value
XIPHOID	1	15	0.51	0.11		
	2	15	0.58	0.12		
	3	15	0.69	0.13	40.11	0.00
	4	15	0.81	0.13		
	5	15	0.93	0.15		

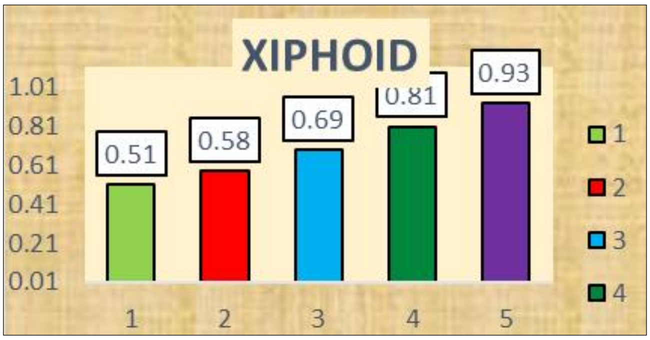

Fig 7: Mean values of chest expansion at xiphoid level for FIS

Interpretation

There is statistically significant increase in mean chest expansion for flow incentive spirometry group at xiphoid level. which was significantly increasing with 0.81 & 0.93 with "P" value again 0.00 with highly significance.

Table 5: Mean value of chest expansion at axilla level for volume incentive spirometry (VIS)

Variable	Day	N	Mean	SD	F	p value
AXILLA	1	15	0.48	0.8		
	2	15	0.55	0.8		
	3	15	0.72	0.11		
	4	15	0.94	0.12		
	5	15	1.11	0.13	360.71	0.00

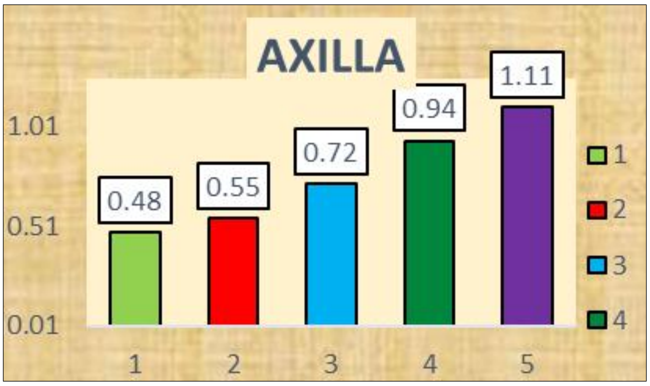

Fig 9: Mean values of chest expansion at axilla level for VIS

Interpretation

There is statistically significant increase in mean chest expansion for volume incentive spirometry group at axilla level. which was significantly increasing with 0.94 & 1.11, with "P" value again 0.00 with highly significance.

Table 6: Mean values of chest expansion at nipple level for VIS.

Variable	Day	N	Mean	SD	F	p value
NIPPLE	1	15	0.49	0.8		
	2	15	0.65	0.8		
	3	15	0.79	0.11		
	4	15	0.99	0.12		
	5	15	1.21	0.13	320.69	0.00

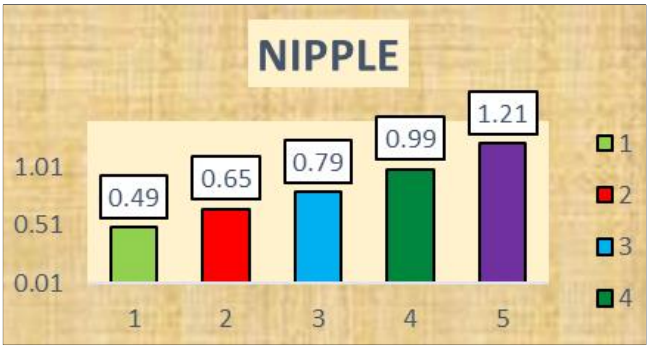

Fig 10: Mean values of chest expansion at nipple level for VIS

Interpretation

There is statistically significant increase in mean chest expansion for volume incentive spirometry group at nipple level. which was significantly increasing with 0.99 & 1.21, with "P" value again 0.00 with highly significance.

Table 7: Mean values of chest expansion at xiphoid level for VIS

Variable	Day	N	Mean	SD	F	p value
XIPHOID	1	15	0.45	0.8		
	2	15	0.63	0.8		
	3	15	0.86	0.11		
	4	15	1.06	0.12	477.78	0.00
	5	15	1.19	0.13		

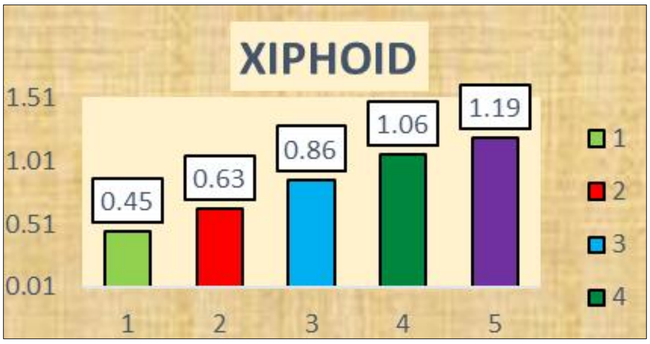

Fig 11: Mean values of chest expansion at xiphoid level for VIS

Interpretation

There is statistically significant increase in mean chest expansion for volume incentive spirometry group at xiphoid level. which was significantly increasing with 1.06 & 1.19, with "P" value again 0.00 with highly significance.

Table 8: Comparison of mean values at axilla level for flow incentive spirometry (FIS) and volume incentive spirometry 9VIS)

AXILLA	N	Mean	SD	t value	p value
Flow	15	0.86	0.14	9.32	0.00
Volume	15	1.17	0.1		

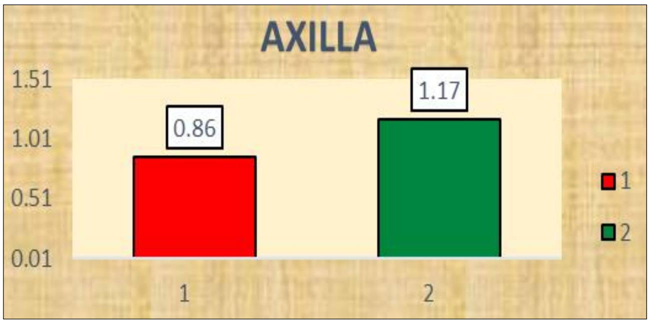

Fig 12: Comparison of flow and volume incentive spirometry mean values at axilla level.

Interpretation

This graph shows statistically significant increase in Mean chest expansion at axilla level for volume incentive spirometry group rather than flow incentive spirometry group by 0.86 to 1.17 & also "P" value remains same 0.00 which is highly significant.

Table 9: Comparison of mean values at nipple level for flow incentive spirometry (FIS) and volume incentive spirometry (VIS)

NIPPLE	N	Mean	SD	t value	p value
Flow	15	0.86	0.15	8.02	0.00
Volume	15	1.18	0.10		

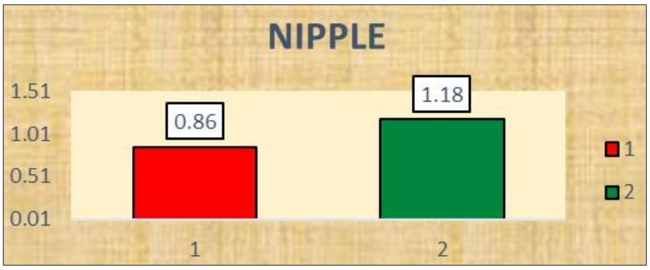

Fig 13: Comparison of flow and volume incentive spirometry mean values at nipple level.

Interpretation

This graph shows statistically significant increase in mean chest expansion at nipple level for volume incentive spirometry group rather than of flow incentive spirometry group by 0.86 to 1.18 & also the "P" value remains same 0.00 which is highly significant.

Table 10: Comparison of mean values at xiphoid level for flow incentive spirometry (FIS) and volume incentive spirometry (VIS)

XIPHOID	N	Mean	SD	t value	p value
Flow	15	0.84	0.17	8.06	0.00
Volume	15	1.17	0.10		

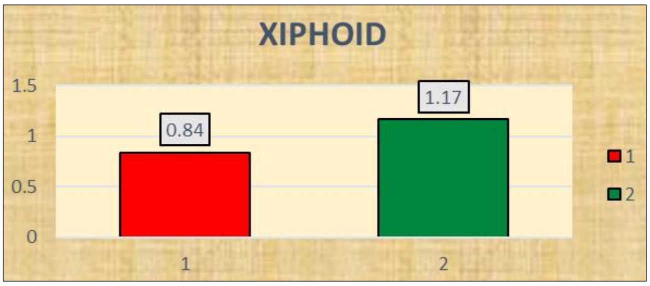

Fig 14: Comparison of flow and volume incentive spirometry mean values at xiphoid level.

Interpretation

This graph shows statistically significant increase in mean chest expansion at xiphoid level for volume incentive spirometry group rather than of flow incentive spirometry group by 0.84 to 1.17 i.e. significantly increased & also the "P" value remains same 0.00 which is highly significant

Discussion

Current study was conducted to determine the efficacy of flow and volume incentive spirometry on chest expansion in patients undergoing Modified radical mastectomy surgery. The outcome measures from this study depicts that volume incentive spirometry is more effective than flow incentive spirometry on chest expansion in MRM patients. In our study we included 30 patients who had undergone Modified radical mastectomy surgery. The patients were equally and randomly assigned to 2 groups: a) the flow incentive spirometry group (FIS); b) the volume incentive spirometry group (VIS).

Our research is accepted as flow and volume incentive spirometry effect on chest expansion showed a significant difference. This study was carried out to determine reference values of chest expansion for post Modified radical mastectomy surgery patients after the use of flow-incentive spirometry and volume-incentive spirometry.

Based on our study results, the chest expansion on 1st & 2nd post-operative day when compared to the 3rd,4th,5th post-operative period had a significant reduced in both flow-incentive and volume-incentive spirometry groups. This is possibly owing to the fact that in the postoperative period there is shallow, monotonous breathing without periodic sighs and prolonged restraint in bed due to postoperative pain, incision site, analgesics, duration of anesthesia and surgery, all of which decrease the ventilation to dependent lung regions. This result pointed out that chest expansion between 1st and 2nd postoperative day were lesser in the FIS group compare to VIS group.

In this present study mean chest expansion for Flow-incentive spirometry group at Axilla level was 0.86, at Nipple level was 0.89 at Xiphoid level was 0.93. Mean chest expansion for Volume-incentive spirometry group at Axilla level was 1.11, at Nipple level was 1.21 at Xiphoid level was 1.19. Thus showing, lesser values of Chest expansion in FIS group as compared to VIS group.

Incentive spirometry is used to encourage deeper breaths and provide increased respiratory capacity, thus reversing alveolar collapse and improving oxygenation. Also it is used for the treatment of pulmonary complications during abdominal, cardiac, and thoracic surgeries. The use of IS favors the early recovery of lung function.

Our results show that Volume-incentive spirometry and Flow-incentive spirometry increased pulmonary volumes in patients; however, Volume-incentive spirometry induced a greater total chest wall volume, especially at the nipple compartment, and lower respiratory muscle activity, compared to Flow-incentive spirometry. Also, Volume-incentive spirometry induces higher chest wall expansion, compared to Flow-inventive spirometry.

It is in accordance with the study done by [13] which showed that VIS induced a higher pulmonary volume compared to FIS, although both devices induced similar displacement of the abdominal and thoracic compartments. In addition, they showed that FIS induced a higher breathing frequency and accessory respiratory muscle activity than did VIS [14].

VIS induces a greater abdominal displacement, which optimizes diaphragmatic excursion and improves the expansion of the basal area of the chest wall. Our data are supported by results obtained by Cuter showing that FIS does not increase the abdominal contribution to total chest wall volume in patients who have had abdominal & cardiac surgery.

Previous studies have also suggested that using FIS requires an increase in the activity of the respiratory muscles, compared to VIS. Based on all these results, we can suggest that FIS can impose an additional load on the respiratory system, leading to thoracoabdominal asynchrony. Because FIS induced a higher breathing frequency and accessory respiratory muscle activity than did VIS [14].

Thus, our study reflects that VIS shows better results than FIS in improving chest expansion in post MRM surgery patients.

Conclusion

The study concluded that both volume-incentive spirometry and flow-incentive spirometry are effective in chest expansion with modified radical mastectomy.

The Volume-incentive spirometry promotes a greater chest wall volume with a higher abdominal contribution and lower muscle activity compared to Flow-incentive spirometry, in post Modified radical mastectomy surgery patients.

Limitations

The patients' adherence to incentive spirometry was not assessed, as a result of which we are not sure that the patients have strictly followed the instructions.

Further research can be done on a larger sample size with a control group.

Similar, type of study can be done on thoracic surgeries along with other techniques such as diaphragmatic breathing exercises and inspiratory muscle training can be focused in future researches.

Clinical Implications

We suggest that in patients with reduce lung expansion VIS should be used rather than FIS as; it reduces postoperative pulmonary complications and prolongs hospital stay.

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