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Effect of flow versus volume incentive spirometry on chest expansion in coronary artery bypass graft surgery patients: a comparative study

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ABSTRACT

Introduction

Cardiac Surgeries lead 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.

Aim

To evaluate the effects of flow and volume incentive spirometer on chest expansion in CABG surgery patients.

Materials and method

Fifty six sample sizes were undergone CABG surgery which was randomly divided as follows: 18 subjects performed flow oriented incentive spirometer group, and other 18 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 an 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.

Conclusion

The study concluded that," Volume incentive spirometry is more effective than Flow incentive spirometry in improving chest expansion in CABG surgery patients."

Keywords: Incentive Spirometry; CABG Surgery; Flow Incentive Spirometry; Chest Expansion; Volume Incentive Spirometry.

INTRODUCTION

Cardiac surgeries such as Coronary artery bypass graft (CABG), MVR, AVR etc. are widely performed surgeries across India with prevalence about 60000 surgeries done annually [1]. These surgeries are used to correct the various abnormalities of the heart which including coronary artery disease, mitral & aortic stenosis. Open heart surgeries involves cutting of sternum into 2 halves

and it redirects blood around clogged arteries to increase blood flow and oxygen to the heart muscle as well as the replacement of the cardiac valves to improve the blood flow from atria to ventricles [2].

As these are major surgeries, postoperative cardiac and pulmonary complications are at high incidence in most of the common CABG surgeries. A basic postoperative complication is a lack of lung inflation secondary to sternotomy suture pain & prolonged recumbence that results from a change in breathing to a shallow, monotonous pattern without periodic sighs and temporary diaphragmatic dysfunction. Many complications may arise due to lack of lung inflation which includes atelectasis, hypoxemia, pneumonia, respiratory dysfunction and pleural effusion [3]. In patients undergoing CABG surgery, systemic inflammatory response, positive fluid balance & cardiac wall enema may contribute to an increased weight of the heart causing compression of the lower lobe of the lung leading to its collapse. Pulmonary infection, arise due to prolong intubation, reduced mucocilliary clearance and resistant atelectasis. Due to this inflammatory reactions may be triggered causing deterioration of lung function in post-operative period [4]. Another complication Pleural effusion – develop as a consequence of the surgical procedure itself and also may occur with post-peri-craniotomy syndrome (PPCS), which is a subgroup of the more general category of conditions called post-cardiac injury syndrome (PCIS) [5]. Also general anesthesia seems to reduce functional residual capacity (FRC) following sternotomy and the presence of pleural drains reduce residual volume(RV), total lung capacity (TLC), vital capacity(VC) and forced residual capacity(FRC), leading to the formation of atelectasis. All these complications lead to reduced chest expansion [3].

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 [6]. 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 CABG surgery patients. For decreased chest expansion, Incentive Spirometry is a widely used therapeutic modality which can be used as a lung expansion therapy [7].

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 [8]. 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 [8]. 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 the patency of the smaller airways [3].

There are two types of incentive spirometer:

1 – Volume incentive spirometer.

2 – Flow 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) [7].

Volume Incentive Spirometer

Flow Incentive Spirometer

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

Need of study

- Pulmonary complications such as atelectasis, pleural effusion & secretion accumulation occurring after CABG surgery are a major problem and a significant cause of post - operative morbidity [3].
- Due to these pulmonary complications, lung function including chest expansion is reduced.
- Generally, 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 [7].
- Another study was conducted for comparing the flow and volume incentive spirometry on pulmonary function and exercise tolerance in open abdominal surgery [3].
- But, as far as our search we found that no studies have showed the comparative effect of flow versus volume incentive spirometer on chest expansion after CABG surgery.
- Thus the study aims to compare the effect of flow versus volume oriented incentive spirometer on chest expansion following CABG surgery.

AIM AND OBJECTIVES

Aim

To evaluate the effects of flow and volume incentive spirometry on chest expansion in CABG surgery patients.

Objectives

- To find out the effect of flow incentive spirometry on chest expansion following CABG.
- To find out the effect of volume incentive spirometry on chest expansion following CABG.
- To compare the effects of flow incentive spirometer with volume incentive spirometer on chest expansion following CABG.

MATERIAL 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 OpenEpi Sample size Calculator. Sample size is calculated as 56 with 28 samples in each group.
- Place of study: - Dr. Ulhas Patil College of Physiotherapy.
- Methods of sample selection: - Random sampling.
- Study Duration – 6 months.

SELECTION CRITERIA

Inclusion criteria

- Patients underwent CABG surgeries.
- Patients with low surgical risks.
- Patients who are thermodynamically stable after CABG surgeries.
- Age between 20-70 years.
- Both male and female were included.

Exclusion criteria

- Patients with unstable cardiovascular status.
- Patients with artificial ventilation for more than 24 hours.
- Patients who had emergency CABG.
- Patients haemodynamically unstable.
- Patients who were uncooperative.

METHOD

Subjects undergoing CABG 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 arrows, breathing pattern is either too fast or too slow. When he/she get 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 patients 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 manoeuver. 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) version 13.0 software. 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.

RESULT

A total of 56 patients were included in the study; 28 patients were allocated to the Flow Incentive Spirometry group and 28 patients to the Volume Incentive Spirometry group.

Table 1: Mean values of chest expansion at axilla level for flow incentive spirometry (FIS)

Variable	Day	N	Mean	SD	F	p value
AT	1	28	0.46	0.08	57.97	0.000
AXILLA	2	28	0.57	0.08		
	3	28	0.66	0.13		
	4	28	0.76	0.12		
	5	28	0.88	0.13		

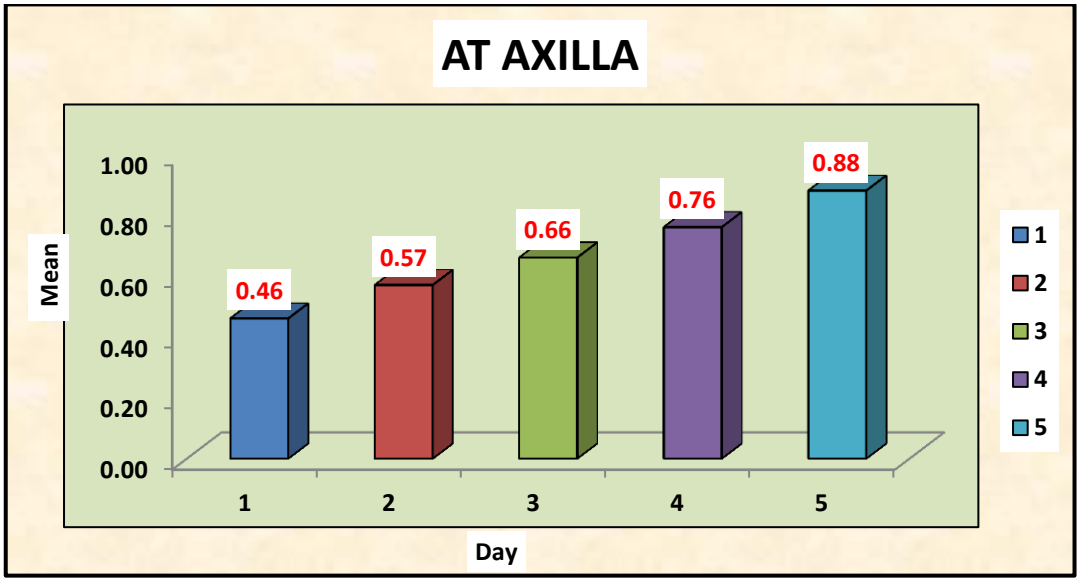

Figure 1: Mean values of chest expansion at axilla level for FIS

INTERPRETATION

There is statistically significant decrease seen in Mean chest expansion for flow incentive spirometry group at axilla level on 1st, 2nd & 3rd POD rather than 4th & 5th POD which was significantly increasing by mean0.76 & 0.88(SD=0.13) with "P" value 0.00 which is Highly significant.

Table 2: Mean values of chest expansion at nipple level for FIS

Variable	Day	N	Mean	SD	F	p value
	1	28	0.49	0.10		
	2	28	0.57	0.11		
AT NIPPLE	3	28	0.66	0.11	45.71	0.000
	4	28	0.76	0.10		
	5	28	0.88	0.15		

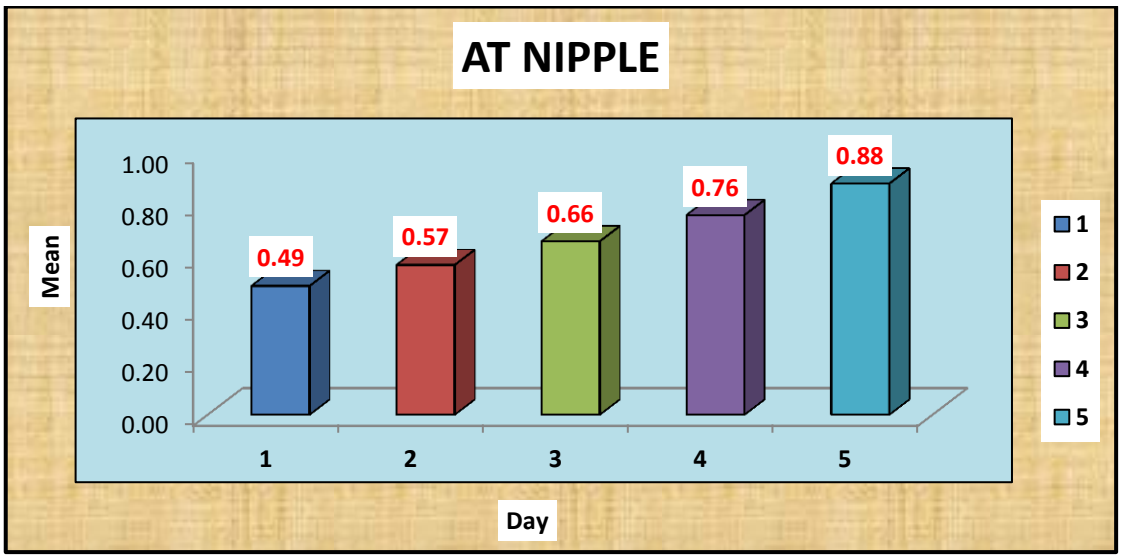

Figure 2: Mean values of chest expansion at nipple level for FIS

INTERPRETATION

There is statistically significant decrease seen for flow incentive spirometry group in Mean chest expansion at nipple level on 1st, 2nd & 3rd POD rather than 4th & 5th POD which was significantly increasing by mean 0.76 & 0.88(SD=0.15) with "P" value 0.00 which is Highly significant, also there was statistically increase seen in SD from axilla level on 4th & 5th POD's.

Table 3: Mean values of chest expansion at xiphoid level for FIS

Variable	Day	N	Mean	SD	F	p value
AT XIPHOID	1	28	0.51	0.11	40.25	0.000
	2	28	0.58	0.12		
	3	28	0.67	0.11		
	4	28	0.79	0.13		
	5	28	0.90	0.15		

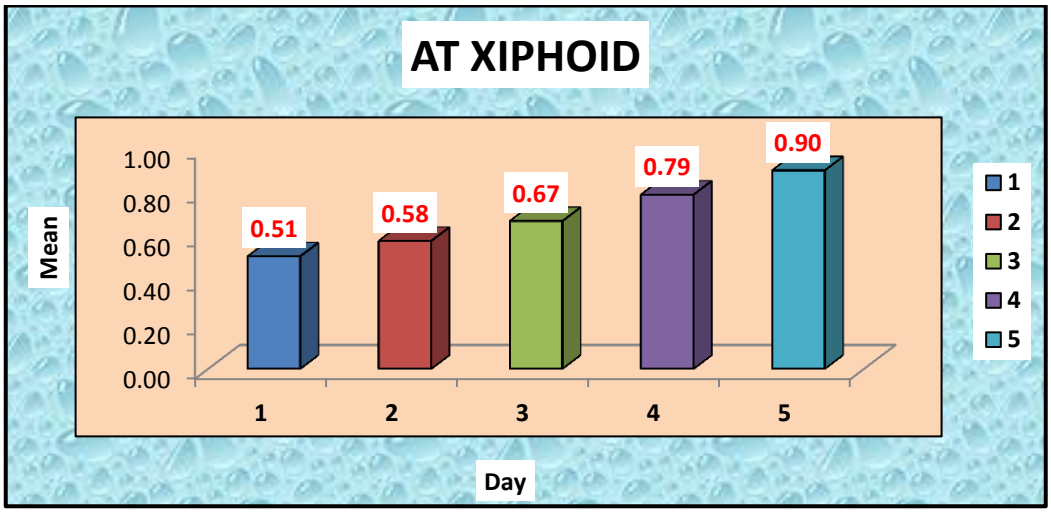

Figure 3: Mean values of chest expansion at xiphoid level for FIS

INTERPRETATION

This graph of flow incentive spirometry of xiphoid level shows statistically comparative decrease in Mean chest expansion on 1st, 2nd & 3rd POD rather than 4th & 5th POD which was significantly increasing with 0.79 & 0.90,aslo from axilla & nipple level. The "P" value again 0.00 with highly significance.

Table 4: Mean value of chest expansion at axilla level for volume incentive spirometry (VIS)

Variable	Day	N	Mean	SD	F	p value
AT AXILLA	1	28	0.43	0.06	367.76	0.000
	2	28	0.58	0.07		
	3	28	0.78	0.07		
	4	28	0.96	0.08		
	5	28	1.18	0.10		

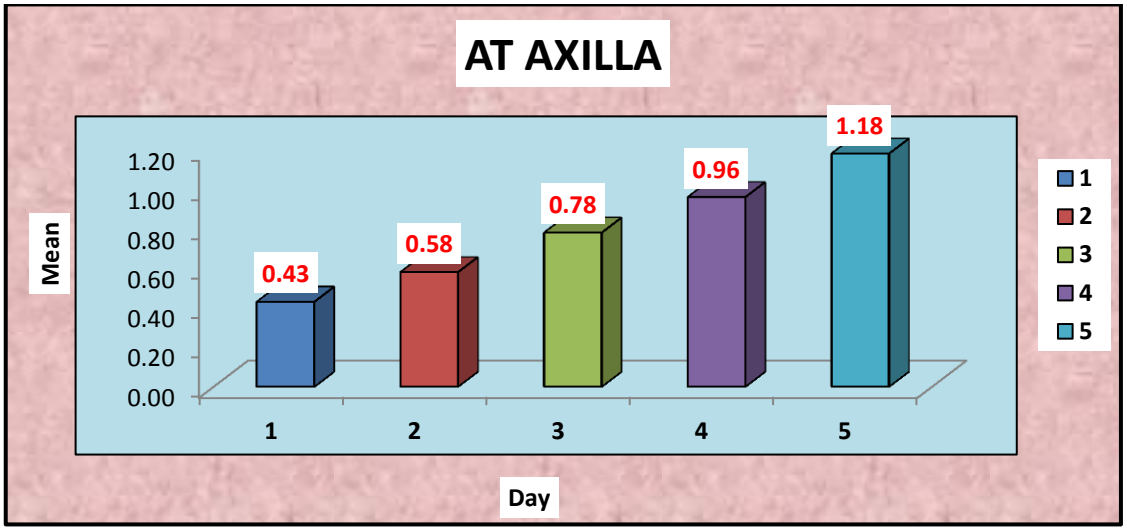

Figure 4: Mean values of chest expansion at axilla level for VIS

INTERPRETATION

This graph of volume incentive spirometry group shows statistically significant decrease in Mean chest expansion at axilla level on 1st & 2nd POD rather than 3rd, 4th & 5th POD which was comparatively increasing by mean 0.78,0.96 & 1.18 from flow incentive spirometry group at same level & also "P" value same 0.000 which is Highly significant.

Table 5: Mean values of chest expansion at nipple level for VIS

Variable	Day	N	Mean	SD	F	p value
AT NIPPLE	1	28	0.48	0.03	317.73	0.000
	2	28	0.61	0.08		
	3	28	0.81	0.07		
	4	28	0.98	0.09		
	5	28	1.17	0.10		

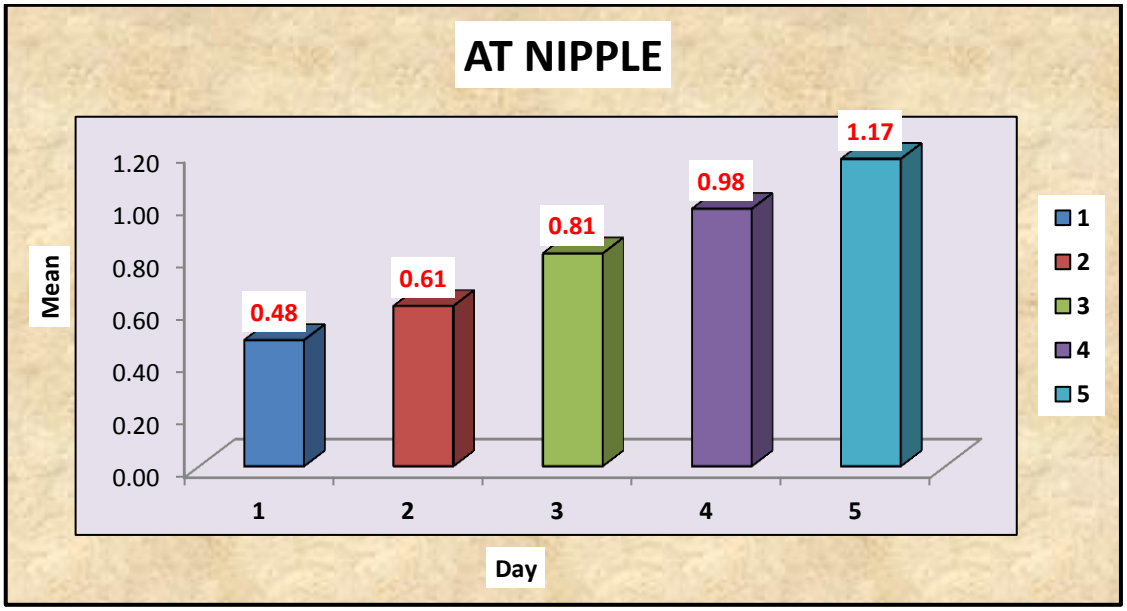

Figure 5: Mean values of chest expansion at nipple level for VIS

INTERPRETATION

This graph of volume incentive spirometry group shows statistically significant decrease in Mean chest expansion at nipple level on 1st & 2nd POD rather than 3rd, 4th & 5th POD which was comparatively increasing by mean 0.81, 0.98 & 1.17 from flow incentive spirometry group at same level & also "P" value remains same 0.000 which is Highly significant.

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

Variable	Day	N	Mean	SD	F	p value
	1	28	0.47	0.04		
	2	28	0.64	0.07		
AT XIPHOID	3	28	0.82	0.05	483.69	0.000
	4	28	1.02	0.08		
	5	28	1.20	0.07		

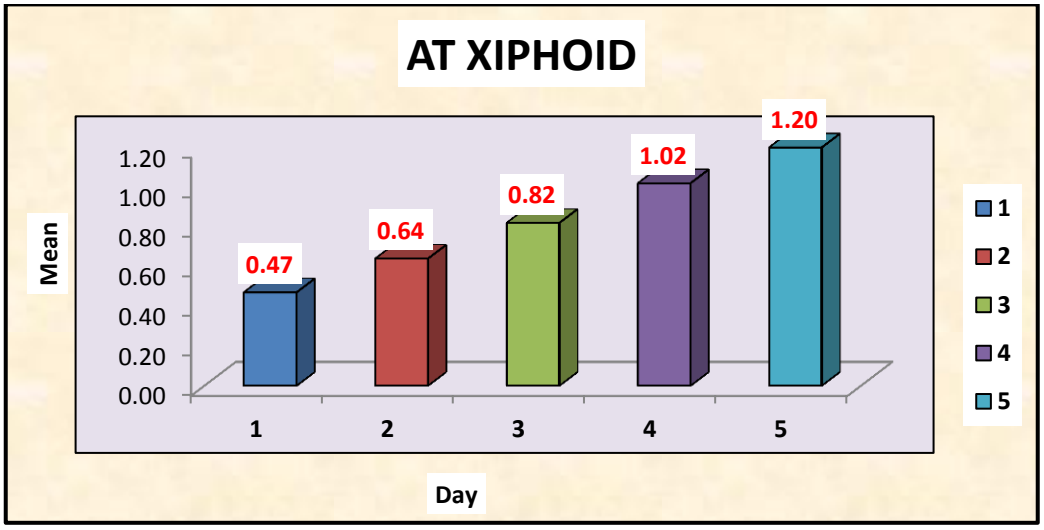

Figure 6: Mean values of chest expansion at xiphoid level for VIS

INTERPRETATION

This graph of volume incentive spirometry group shows statistically significant decrease in Mean chest expansion at xiphoid level on 1st & 2nd POD rather than 3rd, 4th & 5th POD which was comparatively increasing by mean 0.82, 1.02 & 1.20 from flow incentive spirometry group at same level & also "P" value remains same 0.000 which is Highly significant.

Table 7: Comparison of mean values at axilla level for flow and volume incentive spirometry

AT AXILLA	N	Mean	SD	t value	p value
Flow	28	0.88	0.13	9.47	0.00
Volume	28	1.18	0.10		

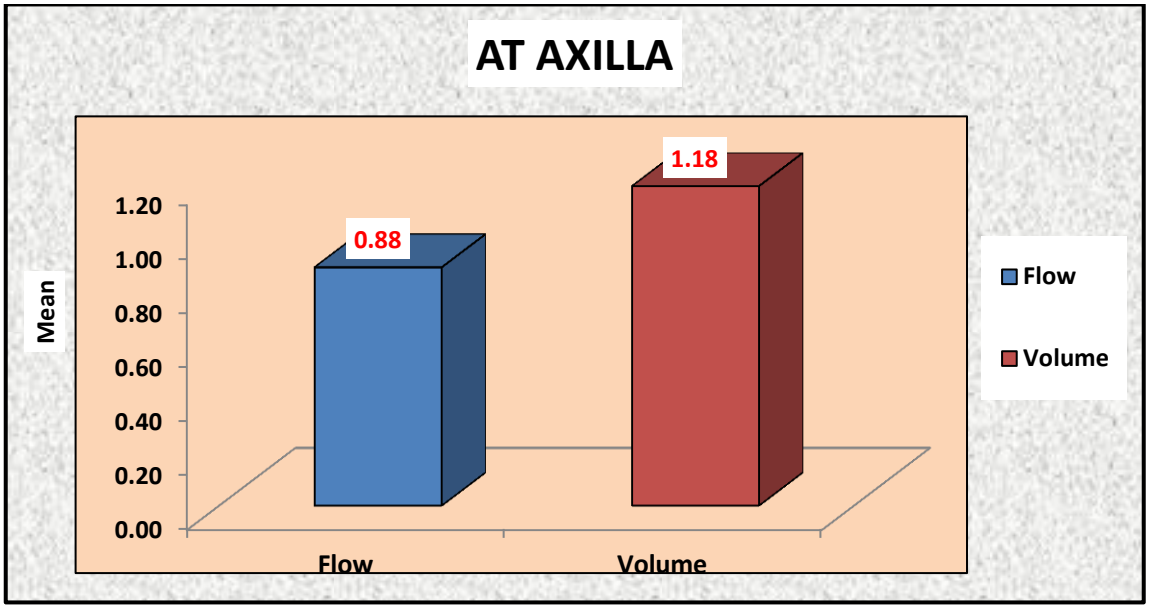

Figure 7: Comparison of mean values at axilla level for flow and volume incentive spirometry

INTERPRETATION

This graph shows statistically significant decrease in Mean chest expansion at axilla level for flow incentive spirometry group rather than from volume incentive spirometry group by 0.88 to 1.18 & also "P" value remains same 0.000 which is highly significant.

Table 8: Comparison of flow and volume incentive spirometry mean values at nipple level

AT NIPPLE	N	Mean	SD	t value	p value
Flow	28	0.88	0.15	8.06	0.00
Volume	28	1.17	0.10		

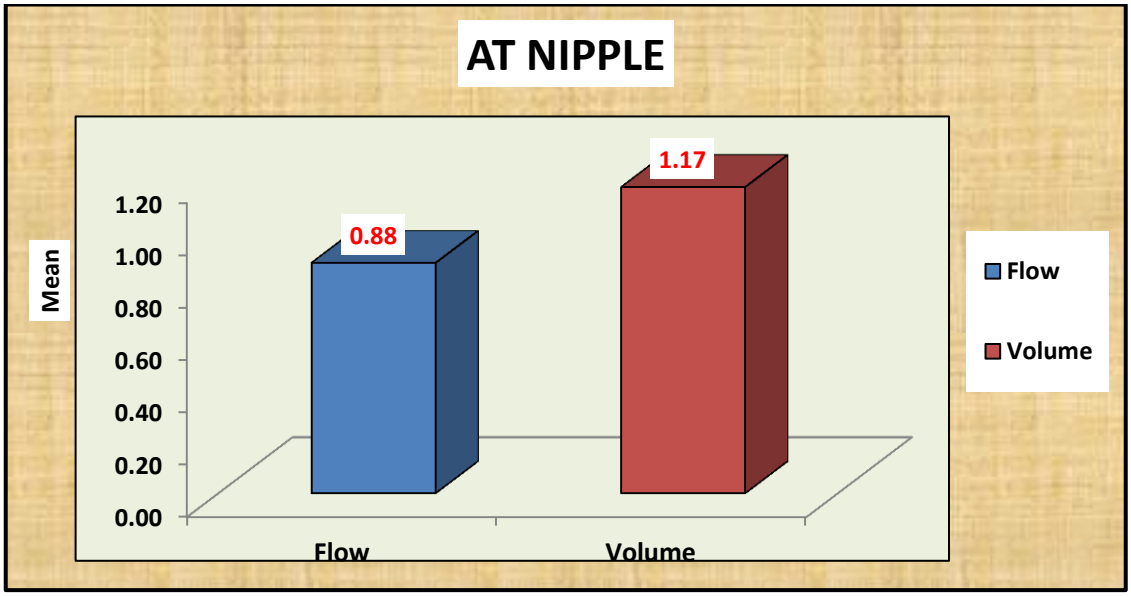

Figure 8: Comparison of flow and volume incentive spirometry mean values at nipple level

INTERPRETATION

This graph shows statistically significant decrease in Mean chest expansion at nipple level for flow incentive spirometry group rather than of volume incentive spirometry group by 0.88 to 1.17 & also the "P" value remains same 0.00 which is highly significant.

Table 9: Comparison of flow and volume incentive spirometry mean values at xiphoid level

AT XIPHOID	N	Mean	SD	t value	p value
Flow	28	0.86	0.19	8.68	0.00
Volume	28	1.20	0.07		

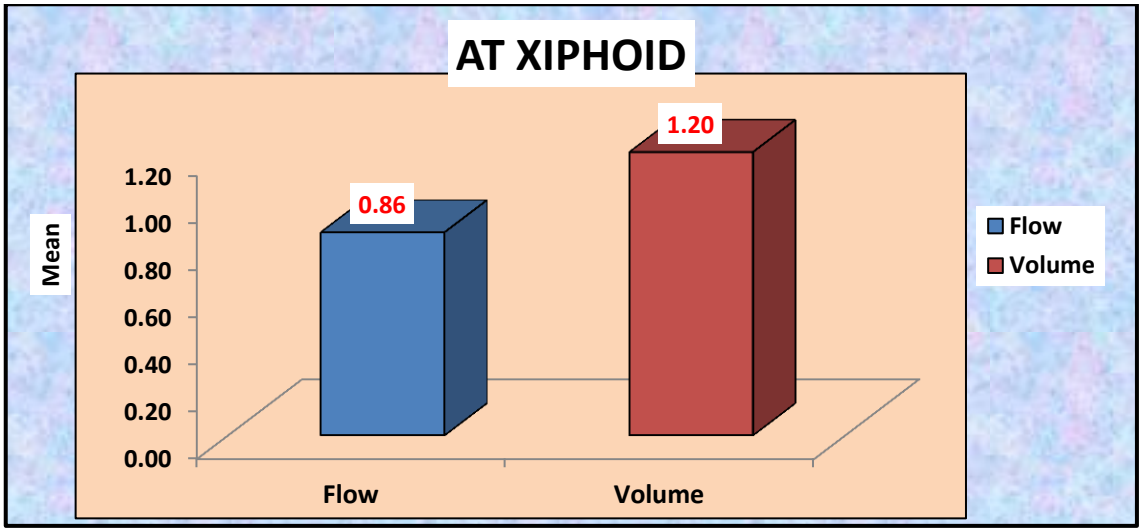

Figure 8: Comparison of flow and volume incentive spirometry mean values at nipple level.

INTERPRETATION

This graph shows statistically significant decrease in Mean chest expansion at xiphoid level for flow incentive spirometry group rather than of volume incentive spirometry group by 0.86 to 1.20 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 CABG surgery. The outcome measures from this study depicts that volume incentive spirometry is more effective than flow incentive spirometry on chest expansion in CABG surgery patients. In our study we included 56 patients who had undergone CABG 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 hypothesis is accepted as flow and volume incentive spirometry effect on chest expansion showed a significant difference [3]. This study was carried out to determine reference values of chest expansion for post CABG surgery patients after the use of flow 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 decrease in both flow- 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 anaesthesia 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 [3].

In this present study mean chest expansion for Flow incentive spirometry group at Axilla level

was 0.88, at Nipple level was 0.88 at Xiphoid level was 0.88. Mean chest expansion for Volume incentive spirometry group at Axilla level was 1.18, at Nipple level was 1.17 at Xiphoid level was 1.20. 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 prophylaxis and treatment of pulmonary complications during abdominal, cardiac, and thoracic surgeries. The use of IS favours the early recovery of lung function & prevention of PPC [11].

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

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 Chuter showing that FIS does not increase the abdominal contribution to total chest wall volume in patients who have had abdominal & cardiac surgery [12].

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 thoraco abdominal asynchrony. Because FIS induced a higher breathing frequency and accessory respiratory muscle activity than did VIS [13].

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

CONCLUSION

The study concluded that," Volume incentive spirometry is more effective than Flow incentive spirometry in improving chest expansion in CABG surgery patients." The VIS promotes a greater chest wall volume with a higher abdominal contribution and lower muscle activity, without inducing thoracoabdominal asynchrony, compared to FIS, in post CABG surgery patients.

LIMITATIONS

1. 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.
2. Further research can be done on a larger sample size with a control group.
3. 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.

PRACTICAL IMPLICATION

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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