Original Article

Physiotherapy and Occupational Therapy Journal
Volume 17 Number 3, July - September 2024
DOI: http://dx.doi.org/10.21088/potj.0974.5777.17324.2

Effect of Blow bottle positive Expiratory Pressure Therapy on Pulmonary Functions of the Children Underwent Median Sternotomy: An Experimental Study

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How to cite this article:

Hetal Tank, Krupa Tank, Hardini Prajapati. Effect of Blow bottle positive Expiratory Pressure Therapy on Pulmonary Functions of the Children Underwent Median Sternotomy: An Experimental Study. Physio. and Occ. Therapy Jr. 2024;17(3):141-146.

Abstract

Context: Respiratory failure, atelectasis, pneumothorax, pleural effusion and sputum retention are all possible pulmonary complications, especially in children in post-operative phase. The objectives of blow bottle PEP are to maximise gas exchange, lessen blockage and enhance ventilation.

Aim: To analyse how blow bottle-positive expiratory pressure affects the pulmonary functions of the children who underwent a median sternotomy.

Methods and Material: A pilot study was carried out on six children, where both groups underwent deep breathing exercises. Additionally, the experimental group received blow bottle expiratory therapy over a period of post-operative 5 days (from 3rd to 7th POD). The deep breathing exercises were performed in four sessions daily, while the blow bottle positive pressure expiratory therapy was given for 4 sessions, each session consists of 3 sets of 10 repetitions, with rest intervals of 5-10 minutes between sets. Following the pilot study, a main study was conducted on 28 additional children, who were randomly assigned to either the experimental or control groups. The same procedures were applied, and no complications were observed during the therapy sessions.

Statistical analysis used: PEFR ($p<0.001$), CE ($p<0.001$)and spo2 ($p<0.004$) all showed substantial improvement within the group as well as between-group analysis.

Conclusions: To improve the pulmonary function of the children who had median sternotomy, deep breathing exercise combined with blow bottle-positive expiratory pressure was more effective than deep breathing exercise alone.

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Recieved on: 10.09.2024

Accepted on: 16.10.2024

Keywords: Mediansternotomy; Deep breathing exercises; Positive Expiratory Pressure; Blow bottle-positive Expiratory Pressure; Arterial oxygenation saturation.

INTRODUCTION

Median Sternotomy is common in cardiothoracic surgery, used to resect tumours, explore pulmonary metastasis and perform cardiac surgeries. It is the gold standard incision for cardiac operations[1] and It is well-known for most cardiac procedures in children.[2] Post-operative Sternotomy can lead to anatomical changes in the thorax, affecting respiratory muscles and mechanics.[3] Post-operative complications can result in restrictive patterns, reduced inspiratory capacity, functional residual capacity and vital capacity.[4] The respiratory system varies between children and adults because full lung maturation is completed at the age of 18 in females and 20 in males.[5] Post-operative physiotherapy minimises non–infectious and infectious pulmonary complications, such as atelectasis and pneumonia.[4] Various airway clearance techniques are used to improve mucociliary clearance, ventilation and gas exchange.[6]

The aim is to determine the impact of blow bottle positive expiratory pressure therapy on the children who had median sternotomy in terms of their pulmonary functions and the objective is to investigate the effects of blow bottle positive expiratory pressure on arterial oxygen saturation (SpO2), chest expansion (4th IC space) and peak expiratory flow rate.

Review of Literature: A 2009 case report by Khaled Ashor *et al.* describes median sternotomy as a well-established, classical approach for most pediatric cardiac procedures.[2] Elisabeth Westerdahl (2004) conducted a study on patients who underwent CABG surgery via median sternotomy. The study highlighted that common post-operative complications include atelectasis and pleural effusion. It was noted that patients exhibit restricted respiratory function, reduced lung volume, and severely decreased mucociliary clearance due to anesthesia, intubation, and analgesia.[3] In 2005, Westerdahl and Erikson explored DBE's effect on pulmonary function post-CABG. Their findings showed that patients using blow bottle PEP had less reduction in pulmonary function, reinforcing the importance of DBE with PEP in reducing post-operative complications.[8] Peter A. Gliney *et al.* (2005) conducted a study on osteopathic manipulative treatment in pediatric asthma patients. The treatment was shown to positively influence respiratory function, as measured by peak expiratory flow rates.[9] Mohan V., Dzulkifli NH *et al.* (2012) assessed the intrarater reliability of chest expansion measurement at different anatomical landmarks. Their study concluded that tape measurements are reliable and can be used as an outcome measure in cardiorespiratory management.[10]

SUBJECTS AND METHODS

An experimental study was conducted in the pediatric department of U.N. Mehta Institute of Cardiology and Research, located in Ahmedabad, Gujarat. Ethical approval was obtained from the institutional ethical committee, and a pilot study was conducted on 6 subjects who were selected according to the inclusion and exclusion criteria. The study included school-age children (6-12 years), both boys and girls, who had stable vital signs (respiratory rates, heart rates, blood pressure, and temperature) and were able to cooperate with the exercises. Children on ventilators or oxygen therapy, those with pleural or mediastinal drains, infections at the incision site, associated cardiopulmonary or neurological complications, systemic disorders, or postural malalignment were excluded.

Subjects were selected and allocated using simple odd-even random number sampling and were divided equally into an experimental group and a control group. Group A, the control group, received deep breathing exercises, while Group B, the experimental group, received blow bottle PEP training along with deep breathing exercises. The subjects performed the exercises for 5 days, from the 3rd to the 7th post-operative day (POD). Informed written consent was obtained from the guardians, and the procedure was explained to them. Baseline outcome measures, including PEFR, chest expansion, and SPO2, were recorded (Fig. 1-3 respectively). Deep breathing exercises (Fig. 4) were performed 4 times per day, with each session consisting of 3 sets, and each set included 10 repetitions. A 5 to 10-minute interval was provided between sets. Blow bottle PEP (Fig. 5) training was also performed for 5 days, with 4 sessions, each session consisting of 3 sets, and each set included 10 repetitions, with 5 to 10-minute intervals between sets. No complications were reported during or after the intervention. On the last day of the protocol, all outcome measures were recorded and analysed using IBM SPSS version 20.0

RESULTS

For this experiment, 28 children were split into Groups A and B. To evaluate pulmonary functionality, measures of PEFR, CE, and Spo2

Fig. 1: Measuring PEFR

Fig. 2: Measureing Chest expansion

Fig. 3: Measuring SpO_2

Fig. 4: Child Performing Deep Breathing Exercise

Fig. 5: Performing Blow Bottle PEP

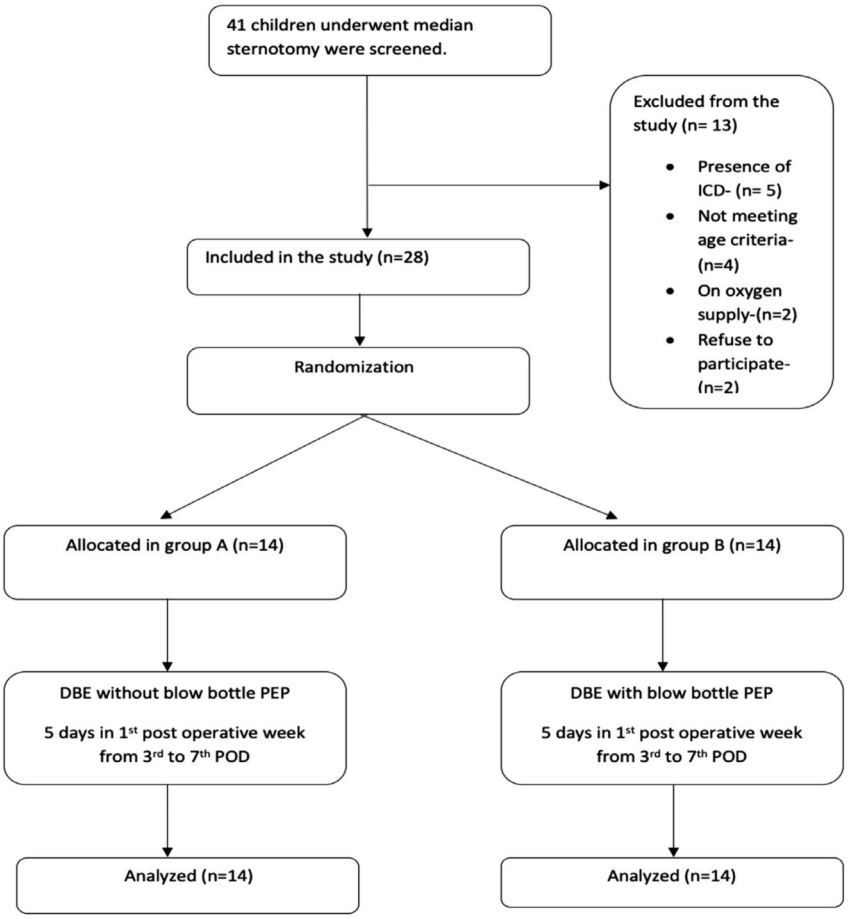

Fig. 6: Screening and Allocation of the subjects into groups

were taken on the third and seventh post-operative days. IBM SPSS v 20.0 was the data analysis tool utilised. The normality test was performed using IBM SPSS version 20.0.

Table 1: Values of PEFR, Chest Expansion and SPO_2 for Group- A

	PRE DBE Mean (SD)	POST DBE Mean (SD)	z-VALUE	p- VALUE
PEFR	82.86(22.67)	102.87 (23.01)	-3.352	0.001
Chest Expansion	1.679(0.46)	2.157 (0.427)	-3.312	0.001
SpO_2	92.29(2.71)	93.94 (2.56)	-4.101	0.001

*DBE – Deep Breathing Exercise, PEFR – Peak Expiratory Flow Rate

The p-value indicates that all outcome measures improved after implementing deep breathing exercises.

Table 2: Values of PEFR, Chest Expansion and SPO2 for Group-B

	PRE BB-PEP Mean (SD)	POST BB-PEP Mean (SD)	z-VALUE	p- VALUE
PEFR	84.29(18.27)	121.43 (22.13)	-3.334	0.001
ChestExpansion	1.59(0.51)	2.35 (0.58)	-3.320	0.001
SpO_2	92.57(2.41)	95.50 (1.99)	-3.198	0.001

*BBPEP = Blow Bottle Positive Expiratory Pressure

The p-value indicates that all outcome measures showed improvement following the inclusion of blow bottle PEP and deep breathing exercises.

Table 3: Comparative Values of PEFR, Chest Expansion and SPO2 for Group-A & B

	GROUP-A Mean (SD)	GROUP-B Mean (SD)	u-VALUE	p- VALUE
PEFR	20.0(8.77)	37.14 (10.69)	20.50	0.001
ChestExpansion	0.4570.15)	0.78 (0.19)	18.51	0.001
SpO_2	1.64 (1.49)	2.93 (1.54)	55.00	0.04

The p-value indicates that Blow Bottle PEP demonstrated greater improvement in all outcome measures compared to group A.

DISCUSSION

The result of present study showed significant improvement in pulmonary functions in both the groups, when compared with PEFR, CE and SpO_2 were showed significant improvement in group B than in group-A. Children in group A who were treated with only DBE, showed significant improvement in all 3 outcomes because DBE opens collapse airways and prevent atelectasis. Due to this effect lung volume might increase which leads to improvement in pulmonary functions during post- operative period. The immediate effect of DBE on atelectasis and oxygenation after cardiac surgery was studied by **Westardehal** suggested that immediately after DBE, atelectasis area was decreased with improvement in oxygenation.[3] Also, a national survey done in Sweden on chest physiotherapy after cardiac surgery concluded that DBE with or without PEP devices were reported to be first choice of treatment in hospital stay.[7] Many literatures suggest that the blow-bottle PEP have been used in post-operative period to mobilize the secretions and it is mainly used in children in which manual techniques as well as other chest physiotherapy are contraindicated. In present study the added effect of blow-bottle PEP was examined when it was given with DBE in children underwent median sternotomy. The possible efficiency of the technique may be depending on the combination of deep inspiration and the positive air way pressure, and this combination may promote airway expansion and maintenance of alveolar and airway integrity. According to **Falk and Anderson** with PEP treatment, the increase in lung volume may allow air to get behind secretions blocking small airways and assist in mobilizing them. In present study group-B showed significantly better improvement in all 3 outcomes than in group-A, this might be due to the added effect of blow bottle PEP, deep inspiration followed by PEP effect might be responsible for the significant result between the groups. **Westardehal** suggested that during post-operative period after CABG, the participants who were treated by blow bottle PEP had significantly better-preserved total lung capacity and, tendency to less reduction in FRC than the IR PEP and simple DBE.[8] Another advantage of blow bottle PEP is that it is low in cost and easily available. Moreover, it provides positive feedback to the children for exercise in the post-operative period. Children enjoyed a lot, using a blow bottle PEP as a part of play therapy and it is an additional encouragement for children to perform exercises during their hospital stay.

CONCLUSION

The current study demonstrates that the blow bottle PEP has a highly significant impact on enhancing pulmonary function in children who have undergone median sternotomy. Using deep breathing exercises (DBE) combined with blow bottle PEP is an effective method to improve pulmonary function in the early postoperative phase, particularly in children, as they often view the blow bottle PEP as a fun activity rather than just an exercise.

Future research could explore the impact of blow bottle PEP on additional pulmonary function parameters, childhood asthma, and children recovering from abdominal surgery.

REFERENCES

1. Wu Q, Luo G, Li S, Shen X, Lu F. Comparison of different approaches for pediatric congenital heart diseases. Asian Cardiovascular and Thoracic Annals. 2003 Sep;11(3):226-8.
2. Nešpor D, Fabián J, Němec P. Retrospektivní analýza hlubokých poruch hojení podélné střední sternotomie. Cor et Vasa. 2015 Apr 1;57(2):e75-81.
3. Westerdahl E. Effects of Deep Breathing Exercises after Coronary Artery Bypass Surgery (Doctoral dissertation, Acta Universitatis Upsaliensis).

4. Sturat porter"Tidy Physiotherapy" Elsevier, Fourteenth edition, chapter-8, page- 199 –221
5. Joanne Watchie "Cardiovascular and pulmonary physical therapy" Elsevier second addition, Chapter-8, page-342-393
6. Jennifer A. Pryor, S Ammani Prasad "Physiotherapy for Respiratory and cardiac problem"Elsiver, Fourth Editation, Chapter -5, Page-134-217.
7. Westerdahl E, OlsÃ MF. Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden-a national survey of practice. Monaldi archives for chest disease. 2011;75(2).
8. Westerdahl E, Lindmark B, Eriksson T, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. Chest. 2005 Nov 1;128(5):3482-8.
9. Guiney PA, Chou R, Vianna A, Lovenheim J. Effects of osteopathic manipulative treatment on pediatric patients with asthma: a randomized controlled trial. Journal of Osteopathic Medicine. 2005 Jan 1;105(1):7-12.
10. Mohan V, Dzulkifli NH, Justine M, Haron R, Rathinam C. Intrarater reliability of chest expansion using cloth tape measure technique. Bangladesh journal of medical science. 2012 Nov 13;11(4):307-11.