

# **SAFETY AND EFFICACY OF LUNG RECRUITMENT MANOEUVRE AS AN ADJUNCT TO CHEST PHYSICAL THERAPY IN POST-OPERATIVE PAEDIATRIC CONGENITAL HEART DISEASE PATIENTS ON MECHANICAL VENTILATION. : AN INTERVENTIONAL STUDY.**

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**ABSTRACT:**

**INTRODUCTION-** Paediatric Congenital heart diseases [CHD] after corrective surgeries are under regular chest physical therapy [CPT] care for preventing post-operative complication. Comprehensive literature search was done and have not come across any studies showing the efficacy of combined Lung Recruitment Manoeuvres [LRM] and [CPT]. so study was conducted with aim to assess safety and efficacy of LRM as an adjunct to CPT on oxygenation, ventilation and on adverse events in operative paediatric CHD patients on mechanical ventilation.

**METHOD & METHODOLOGY-** 48 patients operated case of CHD in the age group of Two to Fourteen years intubated more than 6 hours were included in the study. Study populations were divided into two groups. Control Group (Group A) that received CPT and Interventional Group (Group B) that received CPT with LRM. Patients were assessed pre-treatment and 15 minutes post treatment on Oxygenation, Ventilation and adverse events during treatment.

**RESULT-** There were statistically significant improvement in oxygenation and ventilation within the group with  $p < 0.05$ . The study showed that there were no adverse events in both the groups.

**CONCLUSION-** The oxygenation and ventilation improved in both the groups. No adverse events were observed in both groups. Both the interventions are safe and effective

**Keywords –** Congenital Heart Diseases [CHD], Lung Recruitment Manoeuvres [LRM], Chest Physical therapy [CPT].

**INTRODUCTION-**

Congenital Heart Diseases [CHD] are birth defects due to structural or functional heart problems.<sup>1</sup> Types of CHD are categorized into left-to-right shunt lesions, cyanotic lesions, obstructive lesions, and complex lesions.<sup>2</sup> The incidence of CHD is very high in India. It is estimated that over 180,000 children in India are born with CHD every year.<sup>2</sup> Corrective procedures are performed as a treatment of choice.

Postoperative cardiac care is provided by surgeons, anaesthetist, physiotherapist and nurses. This is the spiral approach in cardiac post-operative patient. Children are transferred to ICU after cardiac surgery mostly in intubated condition. The major aim after cardiac surgery is rapid weaning and safe extubation as early and without any complications.<sup>3</sup> Heart surgery patients are under general anaesthesia and are on mechanical ventilation.<sup>4</sup> Impairment or decreased functional residual capacity, lung volumes, capacities and atelectasis are due to mechanical ventilation even in non-diseased lungs.<sup>5,6</sup>

Physical therapy treatment begins immediately after children are shifted in the ICU by positioning the patient to prevent post-operative pulmonary complication. Conventional chest physical therapy includes postural drainage techniques, breathing exercises, incentive spirometer, suctioning of the airways, coughing, huffing and early mobilization.<sup>7,8,9</sup>

Evidence indicates that avoidance of post-operative pulmonary complications care after major surgery needs good analgesia, regular physical therapy care, early mobilization and good oral hygiene adequately.<sup>10</sup>

Another intervention Lung Recruitment Manoeuvre [LRM] is performed by anaesthetics and respiratory therapist. LRM increases the alveoli number participating in respiration for exchange of gases thus decreasing the atelectasis by increasing the trans-pulmonary pressure.<sup>11</sup>LRM can be applied to all the mechanically ventilated patients under the influence of general anaesthesia.<sup>11</sup>LRM improves oxygenation, dynamic respiratory compliance and other parameters. A number of studies on paediatric population has evaluated the effect of lung recruitment on oxygenation.<sup>11,12,13</sup>

Boriosi et al on children with acute lung injury [ALI] showed improvement in oxygenation that was maintained for 12 hours in ALI/Acute respiratory distress syndrome [ARDS].<sup>14</sup> Thus LRM are helpful in preventing lung collapses in mechanically ventilated patients.<sup>15</sup>

After a comprehensive literature search we have not come across any of the study done on lung recruitment along with chest physical therapy in operated CHD However we have come across only one scientific evidence study conducted by Morandi, Tiffany on "Safety and efficacy of Lung Recruitment Manoeuvres in post-operative pediatric cardiac surgical patients".<sup>16</sup>There is lack of evidence on safety and efficacy of Lung Recruitment Manoeuvres along with chest physical therapy in cardiac patients as lung recruitment manoeuvres are used and are effective in many Acute Respiratory Distress Syndrome [ARDS] and Acute Lung Injury [ALI] in both adult and paediatric population.

Hence this study was conducted to assess the safety and efficacy of Lung Recruitment Manoeuvres as an adjunct to chest physical therapy in post-operative children with Congenital Heart Disease on mechanical ventilation.

## **MATERIAL AND METHODS –**

This study was conducted in the Surgical Intensive Care Unit [CardioVascular and Thoracic Surgery department ] of rural tertiary care centre. After the approval of Institutional Ethical Committee Written informed consent /assent was obtained from guardians of the participants.

Post-operated cases of congenital heart disease [cyanotic& acyanotic] on Mechanical ventilation for at-least six hours between the age group of two to fourteen of either sex were considered for inclusion.

Patients with history suggestive of any respiratory disease, thoracic deformity, bronchopleural fistula were excluded also children on intercostals catheter with continuous leak, children with unstable hemodynamics life threatening arrhythmias, acute heart failure, or hypotension [Systolic blood pressure< 65 mmHg in infants, <70 mmHg in one to four years,<80mmHg in five to 12 years and <90 mmHg in children over 12 years of age were excluded from the study.

## **OUTCOME MEASURES-**

1. Oxygenation measured using ABG analysis by collecting blood sample (radial or femoral artery line) and using monitor for SpO<sub>2</sub>. Value of PaO<sub>2</sub> and SpO<sub>2</sub> corresponds to oxygenation .A normal value for arterial blood gas is 80-100mmHg The SaO<sub>2</sub> represents the amount of oxygen bound to hemoglobin. A normal SaO<sub>2</sub> value for arterial blood gas is 95-100%
2. Ventilation measured using ABG analysis by collecting blood sample and the value of PaCO<sub>2</sub> corresponds to ventilation. A PaCO<sub>2</sub> level below 35 mm Hg causes alkalosis, and a level above 45 mm Hg causes acidosis.normal value is 35-45 mmHg .

3. Safety of the treatment observed by no adverse events [such as hypotension, bradycardia, arrhythmias, hypoxemia, pneumothorax].

Patients in the present study were randomised into two groups [Control Group (CG) and Intervention Group (IG)] using a computer generated random sequence randomisation system, in a 1:1 ratio.

Participants in the control group received only conventional chest physical therapy, while participants in Interventional group received lung recruitment manoeuvre as an adjunct to conventional chest physical therapy

Conventional chest physical therapy technique included percussion, vibration, shaking, and positioning.

- a. Percussion- was performed by cupped hand on the chest by alternate flexion and extension movement at wrist joint.
- b. Vibration –was performed by placing hand over the on chest wall during exhalation using vibrating force through the shoulder joint.
- c. Shaking – was performed during exhalation phase using coarse movement along with the movement of ribs.
- d. Positioning- different positions supine and side lying were used for bronchial hygiene and for improving ventilation and perfusion.
- e. Lung Recruitment manoeuvre- were performed by the trained personnel under the supervision of anaesthetist. Ventilator was shifted to pressure control mode and tidal volume of 6 cc/kg was set. Positive end expiratory pressure [PEEP] was increased in 1-2 cmH<sub>2</sub>O interval and the increase was maintained for 1 min. Tidal volume [TV] increases with increasing PEEP values and the point at which TV started decreasing the increase in PEEP was stopped and PEEP value was noted. Then PEEP was decreased in the similar manner as it was increased that is by 1-2 cm H<sub>2</sub>O and waiting for one min after each decrement. this was continued until decruitment was observed. Decruitment was recognised as a significant decrease in tidal volume with a small decrease in pressure level. The patient was then shifted on the original mode of ventilation with the PEEP adjusted to the original PEEP on an average. Recruitment was done in this manner with proper monitoring of hemodynamic of the patients.<sup>16</sup>

Maximum PEEP range given was upto 10-15 cmH<sub>2</sub>O.

In control group and in interventional group If needed repeat interventions were given after 6-8 hours of first intervention or as per the need of the patient after assessing the chest

Each time pre intervention reading were taken 2 minutes before the session and post intervention reading of outcome measure were recorded 15 minutes after the session. Interventions were continued until the patients were extubated.

Each session in both the groups were continued till the target time was reached or the consultant physiotherapist judges to stop the intervention. The session was stopped immediately any of the stopping criteria was observed; such as hemodynamic instability, arrhythmias .

### OUTCOME MEASURES-

1. oxygenation measured using ABG analysis by collecting blood sample(radial or femoral artery line) and monitor and value of PaO<sub>2</sub> and SpO<sub>2</sub> corresponds to oxygenation .A normal value for arterial blood gas 80-100mmHg The SaO<sub>2</sub> represents the amount of oxygen bound to hemoglobin. A normal SaO<sub>2</sub> value for arterial blood gas is 95-100%
2. ventilation measured using ABG analysis by collecting blood sample and the value of PaCO<sub>2</sub> corresponds to ventilation. A PaCO<sub>2</sub> level below 35 mm Hg causes alkalosis, and a level above 45 mm Hg causes acidosis. normal value is 35-45 mmHg .
3. Safety of the treatment observed by no adverse events [such as hypotension, bradycardia, arrhythmias, hypoxemia,pneumothorax].

### DATA ANALYSIS-

The statistical analysis was performed using MICROSOFT EXCEL [version 2010]Descriptive statistics was presented on the patient characteristics. Comparison was done using paired and unpaired t test within and between the groups on PaO<sub>2</sub> and PaCO<sub>2</sub>.A significance level of .05 was used for all statistical tests.

### RESULTS-

Forty Eight patients were studied between August 2018 and June 2019.

There was no significant difference in age and gender in both control and interventional group as shown in table 1 and 2. Type of surgical procedure performed is shown in table 3.PaO<sub>2</sub> was statistically significantly improved in between and within the group with more improvement in experimental group (table4).PaCO<sub>2</sub> was statistically significantly improved in between and within the group was similar.(table 5).No adverse events were observed in both the groups during intervention(table 6).

TABLE 1- shows Age, Gender and Type of surgical procedure performed.

Groups	Age	Gender		Type of surgical procedures					
	Mean +SD	Male Number (%)	Female Number (%)	ASD	VSD	ASD AND VSD	TOF	OTHER	Total
Control	7.42 +3.25	14[58.33%]	10[41.67%]	5	11	3	5	1	24
Interventional	6.17 +3.34	09[37.5%]	15[62.5%]	6	6	5	7	0	24
Pvalue	1.67866	-	-	-	-	-	-	-	-

Results-In this present study total forty eight patients were studied out of which 24 were in control group and 24 were in interventional group. In control group mean age of subjects was 7.42 years this group included 14 males and 10 females. In Interventional group mean age of subjects was 6.17. years this group included 09 males and 15 females. Subjects characteristics and type of surgical procedures are shown in table 1 and it shows that there was no significant difference in the age and gender of the interventional and control groups. various type of surgical procedure followed were ASD, VSD, ASD &VSD, TOF& other surgeries are there numbers in control and interventional group are observed in table 1.

TABLE 2- PaO2 values at baseline and post intervention in control and interventional group.

PaO2			
	CONTROL	INTERVENTIONAL	P VALUE
PRE	198.5	213.42	0.073
POST	217.08	247.38	0.0093
P VALUE	0.039	0.0038	

Interpretation- There is statistically significant improvement in PaO2 within the individual group but between the group there was statistically significant improvement in experimental group.

Table 2 shows PaO2 values at baseline and post intervention in control and interventional group. In control group there is statistically significant improvement in The PaO2 values post intervention ( values at baseline are 198.5 and post intervention value are 217.08.) with p value of 0.039. similarly in interventional group also there is statistically significant improvement in The PaO2 values post intervention ( values at baseline are 213.42 and post intervention value are 247.38.) with p value of 0.0038. There is statically significant improvement in PaO2 values post intervention in interventional group as compared to control group with p value of 0.0093

TABLE 3- comparing PaCO2 values pre and post intervention in control and Interventional group.

PaCO2			
	CONTROL	INTERVENTIONAL	P VALUE
PRE	41.96	40.54	0.094104
POST	38.46	37.21	0.111234
P VALUE	0.00104	0.000835	

Interpretation- There is statistically significant improvement in PaCO2 within the individual group but between the groups there was no statistically significant improvement in experimental group.

Table 3- shows PaCO2 values at baseline and post intervention in control and interventional group. In control group there is statistically significant improvement in The PaCO2 values

post intervention ( values at baseline are 41.96 and post intervention value are 38.46.) with p value of 0.00104. similarly in interventional group also there is statistically significant improvement in The PaO<sub>2</sub> values post intervention ( values at baseline are 40.54 and post intervention value are 37.21) with p value of 0.000835. There is no statically significant improvement in PaO<sub>2</sub> values post intervention in interventional group as compared to control group with p value of 0.111234.

TABLE 6- Adverse events in both the groups.

List of adverse events	Control group	Interventional group
Hypotension(monitor)	Nil	Nil
Pneumothorax(x –ray)	Nil	Nil
Arrhythmias (monitor)	Nil	Nil
Tachycardia(monitor)	Nil	Nil

Interpretation-There were no incidences of any adverse events in both the groups.

## DISCUSSION

This interventional study was conducted to assess the safety and efficacy of LRM as an adjunct to CPT on oxygenation, ventilation and adverse events in operative CHD children on mechanical ventilation.

The study found that the intervention provided in control group and in Interventional group resulted in:

1. Improvement in oxygenation in both the groups However;there was statistically significant improvement in Interventional group.
2. Improvement in ventilation was observed in both the groups However; there was no statistically significant improvement in Interventional group.
3. None of participants in both groups had any adverse events.

LRM Improves oxygenation in ventilated patients after cardiac surgeries.<sup>17</sup> Lung recruitment Manoeuvres helps in opening the collapse alveoli by redistribution of gases in collapsed alveoli and resulting in improving oxygenation, ventilation, decreasing hypoxia and pulmonary vascular resistance thus helps in early weaning in postoperative days. Thus LRM benefits in many way apart from atelectasis reversal it plays many vital role in mechanical ventilated patients by improving V/Q mismatch.<sup>18</sup> Physical therapy within critical care helps in improving V/Q mismatch, helps in removal of secretion thus optimizes oxygenation and ventilation and thus preventing atelectasis.<sup>18,19</sup>

Studies on Lung Recruitment Manoeuvres in adults after cardiac surgeries have found that LRM resulted in preventing atelectasis and thus improving oxygenation and it also helps in early extubation in post-operative period.<sup>20,21</sup>

There are few studies involving LRMs in paediatric patients in an another study done by Tiffany Morandi<sup>16</sup> in 2013 stated that lung recruitment manoeuvre is performed in pediatric patients with cardiac disease on mechanical ventilation and helps in improving lung functions and it can be safely tolerable as there was no significant changes in BP, HR and on oxygen saturation. In there study 7 patients were diagnosed with Pneumonia, 5 patients were intubated and 5 had self resolving pneumothorax and in this present study there were no

adverse events in both the group this may be because complex surgical patients having cardiac issues, Patient with unstable hemodynamic, hypotension, life threatening arrhythmias, Acute heart failure were excluded in this present study. Another difference was in the age of study population in there study age of study population was below 9 years and in this present study we included population between 2-14 years. another difference was there study included only one group and no control group was included where as in our study we included control group [chest physical therapy group] and Interventional group.

Similarly a study done by Scohy TV et al <sup>22</sup> in 2009 concluded that alveolar recruitment and PEEP improves oxygenation end expiratory lung volume and dynamic compliance of lung in pediatric patients after cardiac CHD surgeries. This is accordance to the present study.

Tusman et al. also stated that in thoracic surgery patients on general anaesthesia, lung recruitment manuevers resulted in improvement in oxygenation and decrease in dead space by better ventilating the lungs by increasing the collateral ventilation and thus decreasing V/Q mismatch.<sup>23</sup>

LRM along with CPT was safe and tolerated by paediatric patients. In the present study both the interventions were safe as there were no change in saturation, BP, no cases of hypoxemia, bradycardia, arrhythmias and barotrauma were observed.

The result of the present study are supported by a meta-analysis done by Cui Y, et al in 2019 on “The effect of lung recruitment Manoeuvres on post-operative pulmonary complications for patients undergoing general anaesthesia: A meta-analysis” stated that lung recruitment manuevre was performed on patients on general anaesthesia and resulted in prevention of alveoli collapse. LRM also decreases the post pulmonary complications and is safe intervention.<sup>24</sup>

The finding of the present study are positive for LRM as well as for CPT in children’s with CHD on mechanical ventilation as both the technique resulted in improvement in oxygenation ,ventilation and are safe without any adverse events so this can utilized by the clinicians to improve the patient care in post operative paediatric CHD patients on mechanical ventilator as techniques are safe and effective.

There were few limitations. Complex surgical patients were excluded in this study and time of cardiopulmonary bypass time was not correlated with the outcomes.

## **CONCLUSION-**

The present study concluded that both interventions resulted in improvement in oxygenation and ventilation and both the interventions are safe and well tolerated in post-operative paediatric congenital heart disease patients on mechanical ventilation.

## **NO CONFLICT OF INTEREST**

**SOURCE OF FUNDING-**Datta Meghe University Of Medical Sciences, Sawangi ,Wardha.

**ETHICAL CLEARANCE-** Approval number- DMIMS(DU)/IEC/2018-19/7242

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