http:// ijp.mums.ac.ir
Original Article (Pages: 1787-1794)

# Effect of Lung Recruitment Maneuver in Children with Acute Lung Injury

*Nemat Bilan [1], Samira Molayi [2]

[1]Pediatric Health Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.
[2]Medical Education Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.

***Abstract***

***Background***

Acute lung injury (ALI) is defined as PaO2/FiO2 less than 300 with bilateral pulmonary infiltrates, without pressure is the top of the left atrium. Early diagnosis and treatment of pediatric ALI and find new cases is very important. Accurate diagnosis and effective steps to treating these patients is essential in the outcome of ALI. This study was conducted to show the impact of recruitment in the treatment of ALI patients.

***Materials and Methods***

This clinical trial study was conducted in Pediatric Educational-Medical center of Tabriz University of Medical Sciences (Tabriz, Iran) and 42 patients with ALI were enrolled. All patients were underwent echocardiography. The patients were divided in 2 groups randomly (intervention and control groups consisted of 21 patients for each group). Patients were followed for 6 months to be evaluated in terms of clinical status and mortality.

***Results***

Difference on level of PaO2 in intervention group was -26±4 in comparison to the control group which was -4±4 (P<0.05). Difference on time of dependence on mechanical ventilation in intervention group was 8.05±3 in comparison to control group which was 11.05±8 (P<0.05). Mortality rate of intervention group (28%) was lower than the control group (47%)(P<0.05).

***Conclusion***

Implementation of recruitment could play an important role in decreasing of mortality in patients with acute lung injury.

***Key Words*****:** Adolescents, Anxiety, Depression, Diabetes, Group training.

*Please cite this article as: Bilan N, Molayi S. Effect of Lung Recruitment Maneuver in Children with Acute Lung Injury. Int J Pediatr 2016; 4(5): 1787-94.

---

****Corresponding Authors:***

Prof. Nemat Bilan**,** Medical Education Research Center, Tabriz University of Medical Sciences. Tabriz Iran.

Email: bilannemat@yahoo.co.uk

Received date Feb23, 2016; Accepted date: Mar 22, 2016

## 1- INTRODUCTION

Acute lung injury (ALI) is a condition where blood oxygenation as a role of lungs is not completely satisfied. In other words the ratio of inspired oxygen to oxygen transferred into blood in lungs is low (PaO2/FiO2<300). Moreover this condition is accompanied by bilateral lung opacity in C-ray images and lack of high pressure of left atrium (1-3).

One of the major problems and a cause of mortality alongside with long hospitalization in children is acute respiratory failure(4). Hypoxia is one of the most important reasons for acute respiratory failure(5). On time diagnosis and treatment of acute respiratory failure decreases mortality and prolonged hospitalization time. Rapid diagnosis and treatment as well as finding new ALI cases of children is very important(6).

Prevalence of ALI in children is unknown and basic information about children's ALI is drawn from adults (7). In some studies, ALI and its more severe form, acute respiratory distress syndrome (ARDS) have been reported in 4% of all children hospitalized in children's Intensive Care Unit (ICU) an in 8 to 10% of children requiring mechanical ventilation (3). Also factors comorbid with children's ALI are unknown and unidentified, but due to high mortality of ALI finding comorbid risk factors is of great importance (8). Taking correct diagnostic steps based on vital signs, arterial blood gas, saturation rate of hemoglobin with oxygen (SaO2), chest radiography, and other comorbidities to find ALI and efforts to find effective therapy all have high importance in future of these patients (6). Some studies have reported pneumonia as the most prevalent children's ALI comorbid risk factor (9, 10). There are factors in ALI children, sufferingALI increasing mortality rate that increased mortality rate such as need such as need for invasive actions and underlying diseases(11). In ALI population, lung segments can be categorized in 3 subgroups based on their function(12):

- ❖ Part of lung with proper ventilation susceptible to barotrauma caused by poor ventilation,
- ❖ Air spaces filled with exudate which are not capable to recruitment,
- ❖ Areas with collapses due to infiltration of interstitial lung tissue which are potentially capable to recruitment.

Recruitment is defined as reopening of lung tissue with collapses and afterwards keeping high Positive End Expiratory Pressure (PEEP) level to prevent de-recruitment (13). Based on the studies, in patients suffering ALI, mechanical ventilation by PEEP improves oxygenation, on the other hand it has been proven that PEEP decreases cardiac output and venous return (14-17). Also it reduces left ventricular end-diastolic volume(18) and causes drop in mean arterial pressure and central venous pressure and also changes regional blood flow (19).

At the same time it decreases liver and kidney blood flow, glomerular filtration, urine output, and sodium excretion (20). In some studies it has been mentioned that mechanical ventilation may cause additional harms in lung of patient (13, 21-23). But in other studies, this maneuver was associated with considerable lung return of patients and considering short time needed for implementing this method which would benefit patient if therapeutic response exist (24-26).

So, in this study it was aimed to investigate lung recruitment maneuver efficacy in clinical status improvement and therapeutic procedure of ALI patients.

## 2- MATERIALS AND METHODS

During present randomized controlled clinical trial (RCT code: IRCT2015010118949N2) patients with ALI diagnosis who were hospitalized in Pediatrics Intensive Care Unit (PICU) of Pediatric Educational-Medical Center of Tabriz University of Medical Sciences (Tabriz, Iran) for one year between 2014 (July) and 2015 (July), were included in study. They were monitored for 6 months up to January 2016 for follow up. Considering $\alpha=0.05$ and power of 80%, 38 subjects (19 subjects for each of studied groups), were estimated and taking 10% safety margin into account 42 samples (21 samples for each of studied groups) were investigated. Written consent was obtained from parents of patients in group receiving lung recruitment (group A) after explaining stages and methods of the study, and after obtaining written consent these patients were included into the study. In this study, 42 patients acquiring criteria of ALI (The definition of American-European Consensus Committee) including:

- a sample of arterial blood gas with $PaO_2/FiO_2<300$,
- bilateral lung infiltration on chest radiography,
- lack of left atrial high pressure were included in the study.

Also patients younger than 1 month old or older than 14 years old, patients with clinical evidence or echocardiographic evidence of left atrial hypertension, patients with echocardiographic shunt, patients with echocardiographic evidence of moderate to severe left ventricular dysfunction, and patients who had used any kind of neuromuscular blockers were excluded from the study. In this study 42 included patients were randomized using Randlist software version, 1.2 and were divided into two groups of 21 patients (A as intervention and B as control groups). In group A, we increased PEEP suddenly to 40 mmHg and maintained it for 90 seconds and afterwards changed ventilator settings to primary situation and kept ventilation. After 5 minutes a sample of arterial blood was taken to investigate arterial blood gasses. Maneuver was considered successful if PaO2 was more than 300 mmHg and patient's ventilation setting were set on constant PEEP of 15 mmHg, and after investigating secondary variables of study patient were monitored for 6 months. If response of analysis of arterial gases showed PaO2 less than 300 mmHg, maneuver was performed again in a way that PEEP 45 mmHg was implemented for 90 seconds. In case of failure (PaO2 less than 300 mmHg) PEEP 45 mmHg maneuver was performed again for 90 seconds. Finally ventilation setting of patient was set on constant 15 mmHg PEEP. Patients were monitored for 6 months; while patients in group B were only receiving standard therapeutic protocol for ALI. In all patients, scoring of mortality possibility in children was determined based on the last published edition of PRISM (27).

Flowchart of study is shown in (**Figure.1**). Variables such as PH, pressure of carbon dioxide in arterial blood (PaCO2), pressure of oxygen in arterial blood (Pao2) and Base excess(BE) in all patients before starting the study and also values of PEEP and Inspiratory Pressure Peak (PIP) were registered based on primary settings of ventilator. Since the best position to perform this maneuver is prone position, in this study patients were investigated in prone position and results were analyzed and evaluated in terms of clinical status and study variables. Also studied patients were monitored for 6 months after finishing investigation in order to be evaluated in terms of clinical status and mortality rate.

In order to investigate descriptive statistics of population under study t-test and ثhi square test were used. In all case value of

P<0.05 is considered significant. All demographic information was collected and data were analyzed using IBM® SPSS® release 16.0.0.

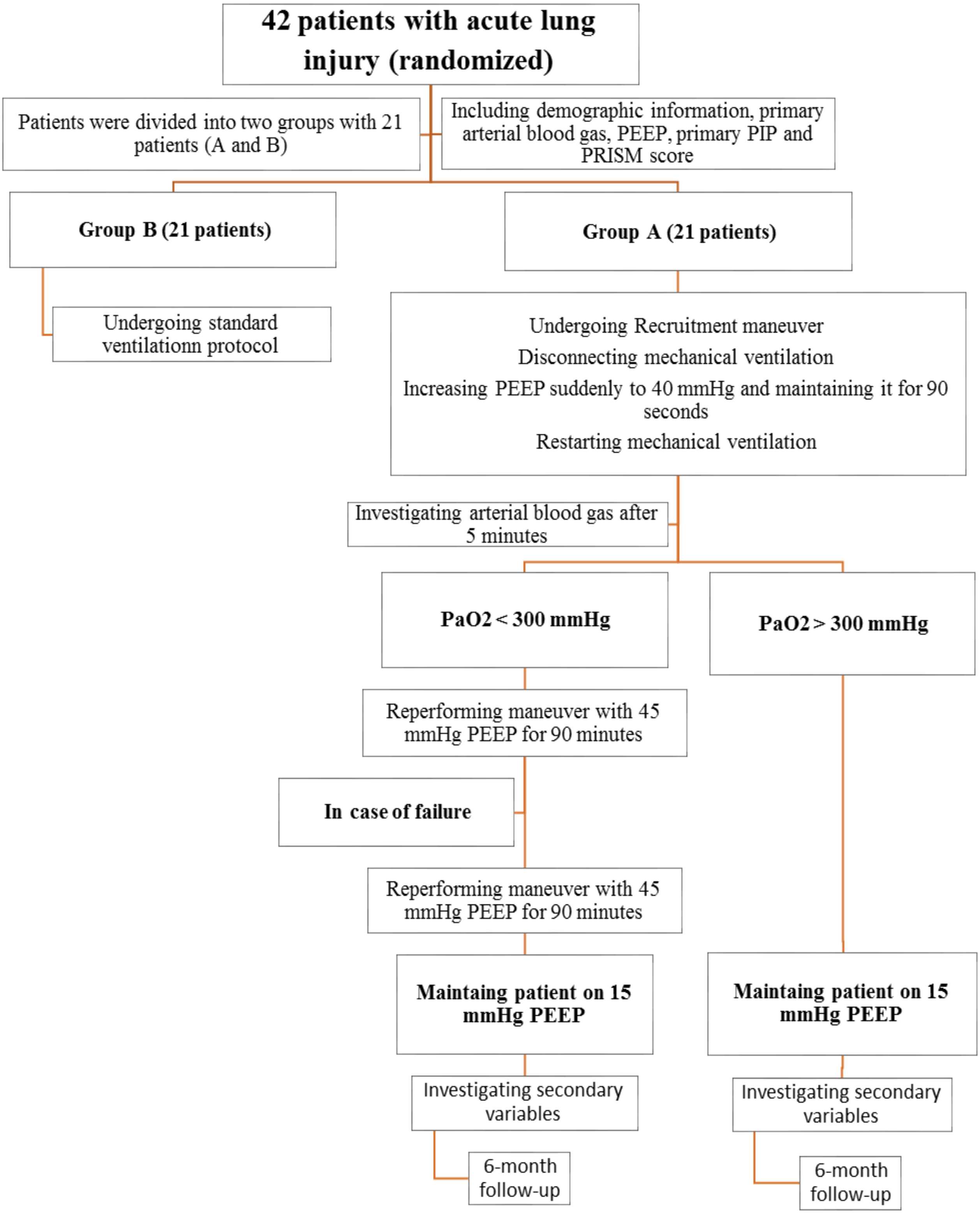


**Fig. 1**: Flowchart of study; explaining the patients' randomization and the intervention process

## 3-RESULTS

In this study 21 patient in intervention group and 21 people in control group were investigated which were similar in terms of demographic characteristics based on Mann Whitney U- test = 0.389. Mean age of studied population was 15±4 months, with 14±6 months in intervention group and 16±7 months in control group.

In patients undergoing maneuver, PH of arterial blood gasses (acidosis – alkalosis status) before maneuver was (7±0.041) and mean PH after maneuver was (7±0.054) which showed a significant difference between these two groups (t= -4, P<0.01). Difference of mean PH before and after maneuver in intervention group was (0±0.318) and difference of mean PH after receiving standard therapy in control group was (0±0.233) which led to a significant difference between two groups (t=0.00, P<0.01). There was statistically significant difference between mean PaO2 before maneuver (40±1 mmHg) and mean PaO2 after maneuver (66±20 mmHg) (t=4.00, P<0.01). Difference in mean PaO2 before and after performing maneuver in control group was -26±4 mmHg and difference in mean PaO2 after receiving standard in case group was -4±4 mmHg which represents a significant difference between these two (t=3.00, P<0.01). Time of dependence on mechanical ventilation in patients after maneuver in intervention group was 8.05±3 which comparing with that of the control group, 11.05±8) shows a significant difference (t=-1, P<0.01). Comparison of mortality rate between two groups showed a significant difference between them (28% in intervention group (6 cases) and 47% in control group (10 cases), respectively (P<0.01).

## 4- DISCUSSION

In our study there was significant difference before and after intervention. Moreover there was a significant relevance in time period of dependence on mechanical ventilation in patients after maneuver with comparison of control group. Therefore implementing this maneuver could decrease period of hospitalization in PICU and need for ventilator and consequently would reduce risk of future complications and infection and prevent secondary mortality.

In comparison of amount of arterial blood gasses (acidosis–alkalosis status) in patients before and after maneuver, there was a slight significant difference and also in comparison of amount of arterial blood gasses (acidosis–alkalosis status) in patients before and after maneuver and comparing it with control group significant difference was observed between these two groups, where this difference is slight. Comparing mortality rate of patients in two groups of intervention and control at the end of the course showed that it was significantly lower in the group receiving recruitment.

In study of the ARDS Clinical Trials Network which aimed to evaluate magnitude and duration of recruitment maneuver effect on PaO2 in patients with ALI it was concluded that In ALI patients receiving low tidal volumes and high PEEP, short-term effects of recruitment maneuver are variable and beneficial effects are brief in duration(27); this is in contrast with the present study. This difference might be due to the selection of study population which included patients over 18 years old, or could be due to different strategies in recruitment maneuver performance which in this study continuous positive airway pressure of 35–40 cm H2O for 30 secs; which is different with present study. In a study by Borges, which assessed efficacy of stepwise recruitment maneuver (a fixed PEEP of 15 cm H2O and progressive PEEP levels of 25, 30, 35, 40, and 45 cm H2O) in clinically stable ARDS patients, for successful lung recruitment (defined as

Pao2 + PaCO2 > 400 mmHg at Fio2 of 100%) it was concluded that recruitment maneuver lead to persistent rise in PaO2 among patients undergoing this maneuver(28); in this study despite minimal differences in performed recruitment maneuver and recruitment goal, results are similar to what the present study shows. In a randomized clinical trial administered by the Acute Respiratory Distress Syndrome Network to investigate efficacy of recruitment maneuver it was concluded that a ventilation setting designed to protect the lungs from excessive expansion resulted in improvements in several important clinical aspects in patients with ALI and ARDS, but it was also suggested that higher priorities should be given to preventing excessive lung expansion during modifications to mechanical ventilation, and low tidal volume protocol should be used in patients with ALI and ARDS(29); this study was similar to present study considering the results, but this study was performed in different setting of ventilation and study population.

In a review study by Guerin, it was concluded that the efficacy of recruitment maneuver on oxygenation is only inadequate and the complete evaluation, as for any ventilation strategy in ARDS, must consider the effects on hemodynamics, lung recruitment, biotrauma and over-distention (30); but in contrast, present study represents a promising result for recruitment maneuver which not also led to iatrogenic consequences but increased survival. Considering time limit of conducting this study it is possible to recommend a more comprehensive study with longer period of time to increase power and reliability by increasing sample numbers. Also it is possible to take the most benefits of this therapeutic method and prevent its consequent complications by more clearly identifying criterion to choose patients for implementing recruitment.

## 5- CONCLUSION

Recruitment maneuver administration in treatment of patients suffering ARDS/ALI in case of correct selection of patients leads to decrease in mortality rate. Taking prognostic steps and trying to present effective therapies have great importance in future of these patients. Therefore since ALI is one of the main problems and is a major mortality factor alongside with long hospitalization periods in children, implementing recruitment could play an important role to decrease mortality and also consequences.

## 6- CONFLICT OF INTEREST: None.

## 7- ACKNOWLEDGMENTS

This research was financially supported by Medical Education Research Center, Tabriz University of Medical Sciences, Tabriz-Iran, and Pediatric Health Research Center, Tabriz University of Medical Sciences, Tabriz- Iran.

## 9- REFERENCES

1. Fan E, Dowdy DW, Colantuoni E, Mendez-Tellez PA, Sevransky JE, Shanholtz C, et al. Physical complications in acute lung injury survivors: a 2-year longitudinal prospective study. Critical care medicine 2014;42(4):849.

2. Force ADT. Acute respiratory distress syndrome. JAMA 2012;307(23):2526-33.

3. Goss CH, Brower RG, Hudson LD, Rubenfeld GD, ARDS N. Incidence of acute lung injury in the United States. Critical care medicine 2003;31(6):1607-11.

4. Kliegman RM, Stanton B, Geme JS, Schor NF, Behrman RE. Nelson textbook of pediatrics: Elsevier Health Sciences; 2015. 529 p.

5. Patel RM, Kandefer S, Walsh MC, Bell EF, Carlo WA, Laptook AR, et al. Causes and timing of death in extremely premature infants from 2000 through 2011. New England Journal of Medicine 2015;372(4):331-40.

6. Flori HR, Glidden DV, Rutherford GW, Matthay MA. Pediatric acute lung injury: prospective evaluation of risk factors associated with mortality. American journal of respiratory and critical care medicine 2005;171(9):995-1001.

7. Bernard GR, Artigas A, Brigham KL, Carlet J, Falke K, Hudson L, et al. The American-European Consensus Conference on ARDS. Definitions, mechanisms, relevant outcomes, and clinical trial coordination. American journal of respiratory and critical care medicine 1994;149(3):818-24.

8. Erickson S, Schibler A, Numa A, Nuthall G, Yung M, Pascoe E, et al. Acute lung injury in pediatric intensive care in Australia and New Zealand—A prospective, multicenter, observational study. Pediatric Critical Care Medicine 2007;8(4):317-23.

9. Group ICCT. Acute lung injury and the acute respiratory distress syndrome in Ireland: a prospective audit of epidemiology and management. Critical care 2008;12(1):1-8.

10. Polin RA, Carlo WA, Papile L-A, Carlo W, Tan R, Kumar P, et al. Surfactant replacement therapy for preterm and term neonates with respiratory distress. Pediatrics 2014;133(1):156-63.

11. Freishtat RJ, Mojgani B, Mathison DJ, Chamberlain JM. Toward early identification of acute lung injury in the emergency department. Journal of Investigative Medicine 2007;55(8):423-9.

12. Murray JF, Matthay MA, Luce JM, Flick MR. An expanded definition of the adult respiratory distress syndrome. Am Rev Respir Dis 1988 Sep;138(3):720-3

13. Habashi Na, Reynolds H, Cottingham C, Borg U, Aswad M. New directions in ventilatory management. Advanced therapy in thoracic surgery. B.C. Decker Inc. Hamilton, London: 1998; 24-35.

14. Jellinek H, Krenn H, Oczenski W, Veit F, Schwarz S, Fitzgerald R. Influence of positive airway pressure on the pressure gradient for venous return in humans. Journal of applied physiology 2000;88(3):926-32.

15. Jubran A, Mathru M, Dries D, Tobin MJ. Continuous recordings of mixed venous oxygen saturation during weaning from mechanical ventilation and the ramifications thereof. American journal of respiratory and critical care medicine 2012;8(15):184.

16. Ingaramo OA, Ngo T, Khemani RG, Newth CJ. Impact of positive end-expiratory pressure on cardiac index measured by ultrasound cardiac output monitor. Pediatric Critical Care Medicine 2014;15(1):15-20.

17. Sander CH, Hallbäck M, Wallin M, Emtell P, Oldner A, Björne H. Novel continuous capnodynamic method for cardiac output assessment during mechanical ventilation. British journal of anaesthesia 2014;3(1):231-34.

18. Kyhl K, Ahtarovski KA, Iversen K, Thomsen C, Vejlstrup N, Engstrøm T, et al. The decrease of cardiac chamber volumes and output during positive-pressure ventilation. American Journal of Physiology-Heart and Circulatory Physiology 2013;305(7):H1004-H9.

19. Silva S, Jozwiak M, Teboul J-L, Persichini R, Richard C, Monnet X. End-expiratory occlusion test predicts preload responsiveness independently of positive end-expiratory pressure during acute respiratory distress syndrome. Critical care medicine 2013;41(7):1692-701.

20. Cairo JM. Pilbeam's mechanical ventilation: physiological and clinical applications: Elsevier Health Sciences; 2015. 254 p.

21. Flori HR, Ware LB, Milet M, Matthay MA. Early elevation of plasma von Willebrand factor antigen in pediatric acute lung injury is associated with an increased risk of death and prolonged mechanical ventilation. Pediatric Critical Care Medicine 2007;8(2):96.

22. Dahlem P, Van Aalderen W, Hamaker M, Dijkgraaf M, Bos A. Incidence and short-term outcome of acute lung injury in mechanically ventilated children. European Respiratory Journal 2003;22(6):980-85.

23. Fialkow L, Vieira S, Fernandes A, Silva D, Bozzetti M. Acute lung injury and acute respiratory distress syndrome at the intensive care unit of a general university hospital in Brazil. Intensive Care Medicine 2002;28(11):1644-48.

24. Santos RS, Moraes L, Samary CS, Santos CL, Ramos M, Vasconcellos AP, et al. Fast Versus Slow Recruitment Maneuver at Different Degrees of Acute Lung Inflammation Induced by Experimental Sepsis. Anesthesia & Analgesia 2016;122(4):1089-1100.

25. Cinnella G, Grasso S, Spadaro S, Rauseo M, Mirabella L, Salatto P, et al. Effects of recruitment maneuver and positive end-expiratory pressure on respiratory mechanics and transpulmonary pressure during laparoscopic surgery. The Journal of the American Society of Anesthesiologists 2013;118(1):114-22.

26. Jabaudon M, Hamroun N, Roszyk L, Blondonnet R, Guerin R, Bazin J, et al. Effects of a recruitment maneuver on plasma soluble rage in patients with diffuse ARDS: a prospective randomized crossover study. Critical Care 2015;19(Suppl 1):P241.

27. Network ACT, Health NIo. Effects of recruitment maneuvers in patients with acute lung injury and acute respiratory distress syndrome ventilated with high positive end-expiratory pressure. Critical Care Medicine 2003;31(11):2592-97.

28. Borges JB, Okamoto VN, Matos GF, Caramez MP, Arantes PR, Barros F, et al. Reversibility of lung collapse and hypoxemia in early acute respiratory distress syndrome. American journal of respiratory and critical care medicine 2006;174(3):268-78.

29. Edgar E. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. Internal Medicine 2015;2(11):587-9.

30. Guerin C, Badet M, Rosselli S, Heyer L, Sab J-M, Langevin B, et al. Effects of prone position on alveolar recruitment and oxygenation in acute lung injury. Intensive care medicine 1999;25(11):1222-30.