

## Assessment of Lung Recruitment by Ultrasound in Patient Undergoing Upper Abdominal Surgery

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### Abstract

Atelectasis and poorly ventilated lung areas are negative consequences of general anesthesia observed in adult as well as in children. The reported incidence of this anesthesia-induced atelectasis is high and comes from 83 % to almost 100 %. The diagnosis of this entity is difficult to do at the bedside; they are commonly small and mostly invisible to standard chest X-ray images. Several methods have been suggested to reduce the impact of atelectasis during surgery. However, few intraoperative modalities for the diagnosis and monitoring of atelectasis are available. Lung ultrasound imaging is a promising non-invasive, non-radiant, portable and easy to use tool that as yet to be studied in the intraoperative setting. 80 adult patients with different ventilation strategies were divided into four groups, 20 patients were included in the 1<sup>st</sup> group conventional ventilation with large tidal volume 10ml/kg, with FiO<sub>2</sub> 1 with neither PEEP nor recruitment, 20 patients were included in the 2<sup>nd</sup> group conventional ventilation with large tidal volume 10ml/kg, with FiO<sub>2</sub> 0.6 with neither PEEP nor recruitment, 20 patients were included in the 3<sup>rd</sup> group protective lung ventilation with tidal volume 6ml/kg, with FiO<sub>2</sub> 1 plus recruitment and PEEP, and 20 patients were included in the 4<sup>th</sup> group protective lung ventilation with tidal volume 6ml/kg, with FiO<sub>2</sub> 0.6 plus recruitment and PEEP comparative study between lung ultrasound atelectasis score (LUS), the median and Interquartile range (IQR) of lung ultrasound score was done. There was statistically significant difference between the four groups of the study at all times except for baseline reading (P<0.001). There might have been noteworthy distinction in the same one assembly viewing the sum lung score readings following incitement from claiming anesthesia in examination with benchmark perusing clinched alongside non initiate Assemblies same time no Contrast to same one assembly correlations for benchmark perusing Previously, initiate one assembly separated starting with T4( T4 vs T0 p<0. 001). Those intend  $\pm$  standard deviation (SD) for fractional weight of oxygen will portion propelled oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) proportion were finished. There might have been statistically huge Contrast between gatherings of the consider with higher P/F proportion On recruitment gathering in the least times but at benchmark (P<0. 001). Additionally there might have been no Contrast in the same bunch correlations in regards P/F proportion readings after incitement about anesthesia in examination with benchmark perusing over both aggregations separated from P/F proportion at T4 which need critical distinction starting with benchmark Previously, both groups( T4 vs T0 bunch a Also aggregation b p<0. 001, P=0. 006). There might have been a negative correspondence between lung ultrasonography score Also P/F proportion with measurable significances toward T1 (r=-0. 61, P<0. 001), In T2 (r=-0. 42, P=0. 006), during T3 (r=-0. 6, P<0. 001) Furthermore In T4(r=-0. 35, P=0. 023), there might have been no noteworthy Contrast over heart rate and in addition Circulatory strain between four Assemblies Furthermore and in addition no Contrast to inside aggregation correlations for benchmark. In decision CPAP recruitment manet trailed by peep essentially diminished those occurrence for anesthesia-induced atelectasis evaluated Toward a lung ultrasonography and moved forward P/F proportion On patients undergoing abdominal surgery for upper abdominal entry point.

**Keywords:** Operative lung atelectasis, Lung ultrasound, Recruitment maneuver, Protective lung ventilation.

### 1. Introduction

General anesthesia brings about the improvement from claiming atelectasis in the indigent zones of the lungs exposing patients on an expanded danger of hypoxemia. Upper abdominal surgeries builds recently exhibit atelectasis [1]. A few routines need been recommended to decrease the effect from claiming atelectasis Throughout surgery. However, few intraoperative modalities for the analysis Also observing for atelectasis are accessible. Lung ultrasonography imaging will be a guaranteeing non-invasive, non-radiant, transportable Furthermore not difficult to utilize device around that so far with make concentrated on in the intraoperative setting. [2]. Lung-protective ventilation, which alludes of the utilization of low tidal volumes What's more certain end-expiratory weight (PEEP), Furthermore which might additionally incorporate the utilization for recruitment maneuvers (periodic hyperinflation of the lungs), need

been demonstrated to decrease mortal sin Around patients with the intense respiratory misery syndrome and may be currently recognized best act in the forethought for a number critically sick patients [3]. Despite this methodology might be valuable for An more extensive population, exactly medical practitioners have doubted the profits of utilizing lung protective ventilation in the surgical setting, particularly since the utilization about helter skelter tidal volumes and no peep will be still regular put and less 20% from claiming patients accept protective ventilation done schedule analgesic act.

Serpa Neto, et al led those Intraoperative Protective ventilation (IMPROVE) trial with figure out if An multifaceted method of prophylactic lung-protective ventilation that joined low tidal volumes, PEEP, and recruitment maneuvers Might move forward conclusions following abdominal surgery, Likewise compared with the standard act for non-protective

mechanical ventilation [3]. General anesthesia abatement practical lingering limit (FRC) and reasons atelectasis then afterward upper abdominal surgery, FRC stays diminished in the prompt postoperative time et cetera recovers gradually through a few times.

Upper abdominal surgery will be likewise connected with diminishments Previously, constrained indispensable ability (FVC) and constrained expiratory volume after 1s (FEV-1). However, those modification On FRC will be All the more clinically applicable since it camwood bring about little aviation route Conclusion Also ventilation-perfusion mismatch, conceivably prompting postoperative hypoxemia and respiratory difficulties [4]. Ultrasonography (US) will be a standout amongst the mossycup oak broadly utilized imaging advances On prescription. It will be portable, free of radiation risk, What's more generally modest The point when compared for different imaging modalities, for example, such that attractive reverberation What's more figured tomography.

Those point of the introduce worth of effort will be with investigation the effectiveness for utilizing lung ultrasonography imaging for intraoperative following for atelectasis Throughout upper abdominal surgery with customary ventilation Furthermore lung protective ventilation Also lung recruitment.

## 2. Materials and methods

Prospective, comparative, single blind randomized study was utilized in the current study. The study sample was divided into four groups as the following:

### 2.1 The first group

Conventional ventilation with large tidal volume 10ml/kg, with FiO<sub>2</sub> 1 with neither PEEP nor recruitment. An arterial line for sampling and a lumbar epidural catheter inserted prior to anesthesia for analgesia. Lung aeration ultrasound score (LUS) in 12 lung regions Table (1), Partial pressure of oxygen to fraction inspired oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) ratio, heart rate, systolic and diastolic blood pressure were recorded before induction of anesthesia, five min. after induction of anesthesia, 15 min. after induction, before extubation and after extubation in the recovery.

### 2.2 The second group

Conventional ventilation with large tidal volume 10ml/kg, with FiO<sub>2</sub> 0.6 with neither PEEP nor recruitment. An arterial line for sampling and a lumbar epidural catheter inserted prior to anesthesia for analgesia. Lung aeration ultrasound score (LUS), Partial pressure of oxygen to fraction inspired oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) ratio, heart rate, systolic and diastolic blood pressure were recorded before induction of anesthesia, five min. after induction of anesthesia, 15 min. after induction, before extubation and after extubation in the recovery.

### 2.3 The third group

Protective lung ventilation with tidal volume 6ml/kg, with FiO<sub>2</sub> 1 plus recruitment and PEEP. An

arterial line for sampling and a lumbar epidural catheter inserted prior to anesthesia for analgesia. Lung aeration ultrasound score (LUS), Partial pressure of oxygen to fraction inspired oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) ratio, heart rate, systolic and diastolic blood pressure were recorded before induction of anesthesia, five min. after induction of anesthesia, 15 min. after induction, before extubation and after extubation in the recovery.

### 2.4 The forth group

Protective lung ventilation with tidal volume 6ml/kg, with FiO<sub>2</sub> 0.6 in addition to recruitment and peep. A blood vessel accordance for inspecting Furthermore a lumbar epidural catheter embedded former with anesthesia to absense of pain. Lung air circulation ultrasonography score (LUS), half way weight of oxygen should portion propelled oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) ratio, heart rate, systolic and diastolic Circulatory strain were recorded preceding incitement for anesthesia, five min. Then afterward incitement of anesthesia, 15 min. After induction, When extubation What's more following extubation in the recuperation.

Lung recruitment might have been carried following intubation utilizing fast method Eventually Tom's perusing utilizing secondary recruitment weight (PIP =40 cm H<sub>2</sub>O for 40 second) this will be called si (Sustained inflation) manet Furthermore this will be rehashed each 30 moment for those operation, after recruitment peep 6 cm H<sub>2</sub>O.

## 3. Results and discussion

### 3.1 Lung Ultrasound Score and lung atelectatic areas:

From patients of the current study which were presented in (figure 14). Typical A lines appear as repetitive bright horizontal lines below the pleural line. (Fig. 14 B) B lines (vertical, laser-like lines that erase normal A lines) can be observed in (Fig.14 D). Localized iso- or hypoechoic areas arised from the pleural line and thus can be described as juxtapleural consolidations of various sizes. The surface area of this atelectatic region can be measured as observed in Fig (14 A,C).

The median and Interquartile range (IQR) of lung ultrasound score are presented in table (2). There was statistically significant difference between the four groups of the study at all times except for baseline reading (P<0.001). There was significant difference in the same group regarding all lung score readings after induction of anesthesia in comparison with baseline reading in non recruit groups while no difference in same group comparisons with baseline reading in recruit group apart from T4( T4 vs T0 p<0.001).

### 3.2 Partial pressure of oxygen to fraction inspired oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) ratio:

The mean ± standard deviation (SD) about incomplete weight about oxygen will portion propelled oxygen (Po<sub>2</sub>/Fio<sub>2</sub>) proportion are introduced to (figure 16). There might have been statistically huge Contrast between Assemblies of the investigation for higher P/F

proportion clinched alongside recruitment aggregation in table (3) whatsoever times but during benchmark ( $P < 0.001$ ). Likewise there might have been no Contrast in the same one assembly correlations in regards to P/F proportion readings following incitement for anesthesia in examination with benchmark perusing clinched alongside both Assemblies separated starting with P/F proportion toward T4 which need huge distinction from benchmark to both groups (T4 vs T0 bunch An What's more assembly b  $p < 0.001$ ,  $P = 0.006$ ).

It might have been found that there is no noteworthy distinction clinched alongside P/F proportion the middle of patients provided for 100% and 60% oxygen. There might have been An negative correspondence between lung ultrasonography score What's more P/F proportion for Factual significances at T1 ( $r = -0.61$ ,  $P < 0.001$ ), toward T2 ( $r = -0.42$ ,  $P = 0.006$ ), In T3 ( $r = -0.6$ ,  $P < 0.001$ ) What's more at T4 ( $r = -0.35$ ,  $P = 0.023$ ).

### 3.3 Hemodynamic variables

There might have been no huge distinction to heart rate the middle of two bunches and in addition no distinction clinched alongside inside bunch correlations with benchmark. Table (4,5,6) There might have been no huge Contrast in method for systolic and in addition those diastolic Circulatory strain between those two aggregations. Also there might have been no distinction inside gathering values in examination for benchmark.

In this prospective randomized, controlled trial those degree of anesthesia-induced atelectasis and the impacts of a recruitment manet were evaluated utilizing lung ultrasonography to Patients undergoing surgery with upper abdominal entry point. Anesthesia-induced atelectasis struck them habitually What's more instantly then afterward incitement from claiming general anesthesia. Recruitment manet emulated Eventually Tom's perusing peep evaluated Toward lung ultrasonography demonstrated advantageous in diminishing anesthesia-induced atelectasis Furthermore enhancing oxygenation, however, huge tidal volume alternately low portion about propelled oxygen alone might have been not addition will dispose of it.

In this study lung recruitment maneuvers were performed utilizing An supported expansion of the lungs on a particular crest inspiratory weight. There might have been statistically critical distinction between bunches of the ponder in the least times but for benchmark perusing in regards lung ultrasonography score, the average Furthermore (IQR [range]) from claiming lung ultrasonography scores were altogether bring down in the recruitment maneuvers assembly compared for those control aggregation which are in understanding with.

An Monastesse et al who mulled over those possibility from claiming utilizing lung ultrasonography Concerning illustration An safe Furthermore exact bedside imaging modality on identify intraoperative respiratory difficulties and

oxygenation transforms coming about because of perioperative atelectasis. In this prospective observational pilot study, 30 successive patients planned for laparoscopic surgery were recruited. Mechanical ventilation might have been institutionalized. Lung ultrasonic might have been performed at 5 predefined the long haul points: preceding incitement for general anesthesia (GA), then afterward incitement of GA, following pneumoperitoneum insufflation, on landing in the recuperation room, Furthermore in front of recuperation room release. For every echographic examination, 12 pulmonary quadrants were imaged. From these, a semiquantitative score, the lung ultrasonography (LUS) score, might have been computed should assess lung air circulation at every the long run purpose [5].

Melody et al who concentrated on those impacts from claiming an alveolar recruitment maneuvers guided Toward lung ultrasonography ahead anesthesia-induced atelectasis clinched alongside babies undergoing minor surgeries for general anesthesia. Forty infants, haphazardly allocated on Possibly a recruitment maneuvers gathering alternately a control group, lung ultrasonography examination might have been performed twice to each patient, the Initially each moment after beginning mechanical ventilation of the lungs and the second at those wind about surgery those average (IQR [range]) lung ultrasonography scores to merging and B-lines on the second examination were bring down in the recruitment maneuvers assembly compared for the control gathering [7].

Tusman et al who mulled over impacts about recruitment manet ahead atelectasis over anesthetized know youngsters over which 24 Youngsters who met american pop culture of Anesthesiologists physical status i alternately ii criteria, were age-old 6 months–6 yr, What's more were undergoing cranial attractive reverberation imaging under three gatherings. After anesthesia induction, in the alveolar recruitment system (ARS) group, a alveolar recruitment manet might have been performed by manually ventilating the lungs with An crest aviation route weight from claiming 40 cm H<sub>2</sub>O Furthermore a peep about 15 cm H<sub>2</sub>O for 10 breaths. Peep might have been then lessened with and held during 5 cm H<sub>2</sub>O. [8]. Those nonstop certain aviation route weight (CPAP) aggregation gained 5 cm H<sub>2</sub>O for nonstop certain aviation route weight without recruitment. Those zero end expiratory weight (ZEEP) bunch accepted not peep or those recruitment manet. The greater part patients relaxed spontaneously Throughout the system. Then afterward cranial attractive reverberation imaging, thoracic attractive reverberation imaging might have been performed. Those atelectatic volume (median, initial What's more third standard quartiles) distinguished in the ZEEP aggregation might have been 1.25 (0.75–4.56) cm<sup>3</sup> in the straight lung and 4.25 (3.2–13.9) cm<sup>3</sup> in the exited lung. Those CPAP one assembly required 9.5 (3.1–23.7) cm<sup>3</sup> from claiming broken down lung tissue in the correct lung and 8.8 (5.3–28.5) cm<sup>3</sup> in

the left lung. Special case tolerant in the ARS aggregation introduced an atelectasis for under 2 cm<sup>3</sup> which need aid in understanding for aftereffect.

The display outcome Additionally would steady for Martelius et al, who found that the amount of B-lines evaluated Eventually Tom's perusing lung ultrasonography correlates for those degree about parenchymal transforms once ct. Different parenchymal transforms were seen clinched alongside patients for B-lines around sonography. B-lines were All the more every now and again seen for patients for no transforms on ct The point when imaged Throughout general anesthesia.

In the available examine P/F proportion might have been measured at distinctive times When induction, Throughout surgery then afterward extubation, it might have been fundamentally higher Previously, recruitment bunches over non recruitment you quit offering on that one which would in understanding for Weingarten et al who contemplated a lung recruitment methodology On elderly patients which enhances intraoperative oxygenation What's more lung mechanics Throughout laparotomy clinched alongside which open lung' ventilation (recruitment maneuvers, tidal volume 6 ml kg predicted figure weight, Furthermore 12 cm H<sub>2</sub>O PEEP) (RM group) might have been compared for customary ventilation (no recruitment maneuvers, tidal volume 10 ml kg predicted muscle to weight, and zero end-expiratory pressure) for elderly patients (. 65 yr. ) undergoing real open abdominal surgery with respect to oxygenation. Those RM one assembly tolerated open lung

ventilation without huge hemodynamic precariousness. Intraoperative P/F proportion enhanced in the RM one assembly Also deteriorated to controls. Those recruitment manet progressed intraoperative PaO<sub>2</sub> [mean (SD) intense build in PaO<sub>2</sub> /FIO<sub>2</sub> from 41. 5 (12. 8) on 54. 9 (6. 4) kPa (P<0. 01)] which stayed raised [54. 5 (10. 7) kPa, P< 0. 01] In 60 min then afterward those principal RM. Conversely, those PaO<sub>2</sub> /FIO<sub>2</sub> during 60 min for anesthesia declined by 15% again the Initially 60 min [from 47. 2 (13. 1) vs 40 (12. 7) kPa in the control one assembly (P=0. 018)] [9].

Those present outcomes are reliable with Whalen et al who mulled over the impacts of the alveolar recruitment manet What's more sure end-expiratory weight with respect to blood vessel oxygenation Throughout Laparoscopic Bariatric surgery to which pneumoperitoneum might have been accomplished, those recruitment aggregation accepted dependent upon 4 maintained lung inflations with top inspiratory weights up to 50 cm H<sub>2</sub>O, which might have been took after Eventually Tom's perusing ventilation for 12 cm H<sub>2</sub>O certain end-expiratory weight (PEEP). [10]. As stated by later meta-analyses Also deliberate reviews, An mix about recruitment manoeuvres Furthermore peep need aid advantageous On keeping postoperative lung difficulties to mature people undergoing general anesthesia.

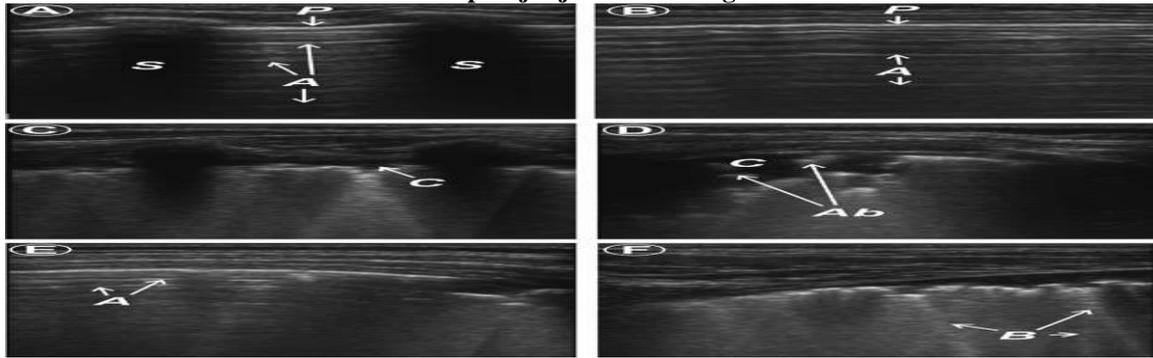
The available comes about are in understanding for past investigations which exhibited that general anesthesia induces atelectasis Also that this anesthesia-induced atelectasis develops inside the primary couple minutes of general anesthesia incitement.



**Fig (1)** The LUS assessment will be segmented in anterior , lateral (L) and posterior (P) regions in both lungs. The dotted black axial line separated the lungs in superior and inferior portions.

**Table (1)** lung aeration score [7] .

<b>Normal aeration (N): 0;</b>	line sliding sign associated with respiratory movement or less than 3 B lines.
<b>Moderate loss of lung aeration: 1</b>	a clear number of multiple visible B-lines with horizontal spacing between adjacent B lines $\leq 7$ mm (B7 lines)
<b>Severe loss of lung aeration: 2</b>	multiple B lines fused together that were difficult to count with horizontal spacing between adjacent B lines $\leq 3$ mm (B3 lines);
<b>Pulmonary consolidation: 3</b>	hypoechoic lung tissue, accompanied by dynamic air bronchogram.



**Fig (2)** Lung sonographic signs associated with anesthesia- induced atelectasis.

Lung sonographic signs associated with anesthesia- induced atelectasis. (A) The classical lung sonographic approach showing the *bat sign* in normal lungs: the pleural line (P) appears as a *hyperechoic blunt, thick, and flat horizontal line* between the ribs. Typical A lines appear as repetitive *bright horizontal lines* below the pleural line and between the acoustic shadows (S) of both ribs. (B) Normal lung viewed by

the intercostal posterobasal approach showing the pleural line (P) and A lines but without the acoustic shadows of the ribs. (C and D) Anesthesia induced-atelectasis is commonly observed as hypoechoic juxtaleural consolidations (C) in both, the classical and the intercostal posterobasal approach, respectively. Air bronchograms (Ab) can be observed within the consolidation in D. (E and F. [7].

**Table (2)** Comparison between results of different follow up periods within each studied group according to Lung U/S.

	Media n	IQR	Media n	IQR	Media n	IQR	Median	IQR	KW test	
Lung U/S before induction	0.0	0.0-0.0	0.0	8	0.0	0.0-0.0	0.0	0.0-0.0	0.0	1.0
Lung U/S 5m	3.0	2.25-4.0	2.0a	2.0-3.0	0.0ab	0.0-0.0	0.0ab	0.0-0.0	66.43	<0.001**
Lung U/S 15m	5.0	3.0-5.0	3.0a	2.0-3.75	0.0ab	0-0.75	0.0abc	0.0-0.0	66.29	<0.001**
Lung U/S before extubation	6.0	6.0-7.75	4.0a	2.25-4.0	2.0ab	1.0-2.0	0.0abc	0.0-2.0	58.5	<0.001**
Lung U/S after extubation	8.0	5.25-8	5.5a	4.0-6.0	2.0ab	2.0-4.0	2.0abc	0.5-2.75	48.18	<0.001**

**Table (3)** Comparison between results of different follow up periods within each studied group according to P/F ratio.

	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	F test	
P/F ratio before induction	421.1	23.21	438.95	12.71	414.4b	12.3	427.5bc	15.9	7.88	<0.001*
P/F ratio 5m after induction	436.3	28.54	456.15	28.5	482.5ab	32.3	480.6ab	33.6	10.14	<0.001*
P/F ratio 15m after induction	429.8	39.78	442.0	83.75	491.15a	18.0	482.8ab	26.1	7.54	<0.001*
P/F ratio before extubation	426.8	34.87	429.9a	42.79	510.1ab	26.8	507.0ab	26.5	38.44	<0.001*
P/F ratio after extubation	372.0	28.34	415.0a	32.61	589.6ab	29.5	596.75a	40.1	250.3	<0.001*

**Table (4)** Comparison between results of different follow up periods within each studied group according to heart rate.

Beat/min.	Group 1	Group 2	Group 3	Group 4	p-value
Before induction	80±10.3	75.1±12.9	84±9.4	80.5±12.4	0.11
5 min. after induction	75.6±8.4	74.6±11.6	77.6±7.3	75±8.3	0.73
15 min. after induction	78.9±9.7	73.3±10.8	80.6±5.7	77.2±7.87	0.6
Before extubation	79.3±8.8	73.2±8.7	80.4±7.3	75.1±8.3	0.02*
After extubation	80.8±9.6	76.2±10.6	81.7±7.2	78.8±8.9	0.23

Data were presented as mean and SD

**Table (5)** Comparison between results of different follow up periods within each studied group according to systolic blood pressure.

mmHg	Group 1	Group 2	Group 3	Group 4	p-value
<b>Before induction</b>	127.3±15.8	126.2±10.7	126.5±13.8	124.9±13.2	0.9
<b>5 min. after induction</b>	118.9±13.5	119.75±7.6	119.7±8.9	117.6±6.8	0.89
<b>15 min. after induction</b>	113.7±9.6	110±7.14	106.8±7.9	109±7.5	0.06
<b>Before extubation</b>	126.9±12.8	131.7±6.2	134.7±6.1	134.6±6.3	0.013*
<b>After extubation</b>	130.8±9.9	128.3±9.5	126.9±5.3	126±6.1	0.26

Data were presented as mean and SD

**Table (6)** Comparison between results of different follow up periods within each studied group according to diastolic blood pressure.

mmHg	Group 1	Group 2	Group 3	Group 4	p-value
<b>Before induction</b>	79.6±10.8	76.7±8.4	76.6±10.3	77.7±7.6	0.71
<b>5 min. after induction</b>	76.5±9.6	75.4±8.2	76±6.1	71.4±7.4	0.16
<b>15 min. after induction</b>	72.7±8.8	69.2±8.6	66.9±5.9	65.8±6.1	0.2
<b>Before extubation</b>	81.5±7.9	83.7±3.5	82.3±4.6	83.5±3.7	0.5
<b>After extubation</b>	80.8±6	79±6	79.15±4.1	78.6±4.1	0.55

Data were presented as mean and SD.

#### 4. Conclusion

The present study concludes that CPAP recruitment maneuver followed by PEEP significantly reduced the incidence of anesthesia-induced atelectasis assessed by a lung ultrasound and improved P/F ratio in patients undergoing abdominal surgery with upper abdominal incision. There is a negative correlation between lung ultrasound score and P/F ratio. Lung ultrasound is a reliable tool to guide the effectiveness of lung recruitment.

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