ORIGINAL RESEARCH

TO DETECT EARLY ATELECTASIS IN PATIENTS UNDERGOING LAPAROSCOPIC CHOLECYSTECTOMY WITH LUNG ULTRASOUND IN PREOPERATIVE, INTRAOPERATIVE AND POST OPERATIVE PERIOD

[1]Sumit Bansal, [2]Shailendra Kumar Patel, [3]Raziullah Siddiqui, [4]Arun Puri

[1]Associate Consultant, Department of Anaesthesia, Max Super Specialty Hospital, Patparganj, Delhi, India
[2,3]Senior Resident, Department of Anaesthesia, Dr. Hedgewar Arogya Sansthan Hospital, Delhi, India
[4]HOD & Director, Anaesthesia Critical Care and Pain Management, Max Super Specialty Hospital, Patparganj, Delhi, India

Correspondence:
Dr. Sumit Bansal
Associate Consultant, Department of Anaesthesia, Max Super Specialty Hospital, Patparganj, Delhi, India
Email: sumitbansal05@gmail.com

ABSTRACT

Background: Atelectasis is one of the frequently encountered postoperative pulmonary complication (PPC), with wide spectrum of causes related to perioperative events. The present study was conducted to detect early atelectasis in patients undergoing laparoscopic cholecystectomy with lung ultrasound in preoperative, intraoperative and post operative period.

Materials and Methods: In this observational study, seventy-two ASA grade I-III patients of either sex undergoing elective laparoscopic cholecystectomy who met the inclusion criteria were recruited. Mechanical ventilation was standardized. Images were obtained at five pre-defined time points and LUS scoring was done at these points. In pre-operative period(time point A), five minutes after induction(time point B), five minute after insufflation of pneumoperitoneum(time point C), at the end of surgery before extubation(time point D) and after 1 hour of post-extubation in postoperative room(time point E). Aeration loss was assessed by calculation of the LUS score. Each of the 12 lung quadrants were assigned a score of 0 to 3 according to a simple grading system. The LUS score (0–36) was calculated by adding up the 12 individual quadrant scores: with higher scores indicating more severe aeration loss. For Statistical analysis, difference between the proportions was tested by chi square test or Fisher "sex act test while difference between quantitative variable for more than group were tested by "ANNOVA" or Kruskal Wallis H test followed by post hoc test. Correlation between quantitative variables were seen by spearman correlation coefficient. P value lessthan 0.05 was considered statisticallysignificant.

Results: The vital parameters such as pulse rate, respiratory rate, oxygen saturation & non-invasive blood pressure were continuously monitored and recorded at time points A, B, C, D & E. Hemodynamics were stable and there was no clinically significant change in parameters at any point of time. Mean LUS score at time point A was

0.56±1.37, at time point B was 3.53±2.65, at time point C was 5.35±3.22, at time point D was 7.74±3.01 and at time point E was 2.97±1.98. Change in LUS score at each time point was statistically significant (p value <0.01). After induction of general anaesthesia, we observed an increased in LUS scores which further increased on production of pneumoperitoneum. In our study LUS score persistently increased throughout the period of pneumoperitoneum and anaesthesia. LUS score decreased one hour after extubation, however still did not reach preoperative score, hence some amount of aeration loss was there but it was clinically insignificant in our study.None of our patients had any episode of desaturation in postoperative period in recovery room. Although in our study has shorter duration of anaesthesia range (35 mins to 100 mins), we observed even in such short duration atelectasis occurred in dependent portion as noted by high LUS score. We observed a positive correlation between age of patient and change in LUS score in different time points. There was positive correlation between ASA status and loss of aeration(atelectasis).

Conclusion: In our study we observed that atelectasis does occur even during short duration of surgery like laparoscopic cholecystectomy. Bedside lung ultrasonography is feasible and useful point of care tool in detection of perioperative atelectasis.

Keywords: Lung Ultrasonography, Perioperative Atelectasis, Laparoscopic Cholecystectomy.

INTRODUCTION

Atelectasis is one of the frequently encountered postoperative pulmonary complication (PPC), with wide spectrum of causes related to perioperative events. General anesthesia causes atelectasis within the first few minutes of induction in the most dependent part of lung.[1] Approximately, 15-20% of lung tissue near diaphragm or about 10% of total lung mass in supine posture may develop atelectasis during surgery.[2] Lung ultrasonography has emerged as an indispensable tool in perioperative and critical care practice. Evidence suggests that clinicians outside the practice of radiology can be skilled in a limited time frame in ultrasonography. Anesthesiologists can easily adapt lung ultrasound (LUS), in their routine anesthetic practice and explore its true potential in perioperativecare.[2] Conventional chest radiography does not detect minimal atelectasis in the early postoperative period unless it becomes massive. CT scan is a gold standard tool to detect minimal atelectasis, but unfeasible in the operation theater, LUS is a reliable, real-time, cheaper alternative tool to detect and review the progression of atelectasis.[2,3] In recent years, laparoscopic surgery has been preferred to open techniques because its results in less incisional pain, fewer pulmonary complications, and shorter hospital stays. However, pneumoperitoneum decreases pulmonary compliance due to cephalad displacement of the diaphragm. Cephalad displacement of the diaphragm can cause intraoperative lung volume changes, consequently leading to the possibility of atelectasisformation.[4]It is the endeavour of this study to detect early atelectasis in patients undergoing laparoscopic cholecystectomy with lung ultrasound in preoperative, intraoperative and post operative period.

MATERIALS AND METHODS

This observational study was conducted in the Department of Anaesthesiology at Max Super specialityHospital, Patparganj after approval from the institutional ethical committee. 72 ASA grade 1-3 patients of either sex who undergone elective laparoscopic cholecystectomy under general anaesthesia who met the inclusion criteria of the study were recruited. The duration of the study was 18 months. Patients having ASA grade1-3, aged 18-65years, Patients with BMI<40kg/m^2 were included in the study. ASA grade4-5, pregnantpatients, severe respiratorydisease, patients with active evidence of coronary arterydisease and patients who were morbidly obese (BMI>40kg/m^2 were excluded from the study. After considering the inclusion and exclusion criteria, the patients accepted for the study were informed of the procedure and written informed consent was taken.

METHODS OF MEASUREMENT OF OUTCOME OF INTERESTS

Aeration loss was assessed by calculation of the LUS score[30]. Each of the 12 quadrants were assigned a score of 0 to 3 according to a simple grading system. The LUS score (0–36) was calculated by adding up the 12 individual quadrant scores; with higher scores indicating more severe aeration loss.

	Normal Aeration	**Small Loss of Aeration**	**Moderate Loss of Aeration**	**Severe Loss of Aeration**
Quotation	0	1	2	3
Lung ultrasound score	0–2 B lines	≥3 B lines	Multiple coalescent B lines	Consolidation

Lung ultrasound scores were calculated by adding up the 12 individual pulmonary quadrant scores which yielded a score between 0 (no aeration loss) and 36(complete aeration loss).

PROCEDURE

PREMEDICATION

All the patients were kept nil per orally for 6 hours prior to surgery, except for the premedications prescribed.

In the pre-operative area, patients were monitored for

- HeartRate
- Noninvasive arterial bloodpressure
- Pulseoximeter
- ECG
- Respiratoryrate
- Parameters to be charted: Age, sex, weight & height of thepatient.

Any co-morbidities & regular medications. Diagnosis, Surgery. Intra venousline was established. Injection ranitidine and on dansetron was administered a spremedication

PERIOPERATIVE PROCEDURE

A baseline measurement of heart rate, blood pressure were recorded prior to administration of anaesthesia. Anaesthesia was then induced with propofol [2-2.5 mg/kg] was used in combination with fentanyl [2mcg/kg]. Tracheal Intubation/supraglottic device (LMA or I-GEL) was facilitated by neuromuscular relaxation [Atracurium]. Maintenance of Anaesthesia was achieved with sevoflurane or isoflurane in a mixture of air & O_2 [0.9 to 1.2 MAC]. Analgesia was achieved with NSAIDs, IV Paracetamol. All patients were mechanically ventilated with tidal volume

8 ml/kg & Respiratory rate was set to maintain normocapnia [$ETCO_2$: 30 – 35 mmHg].

Images were obtained at 5 predefined time points and LUS scoring was done in these points. Lung ultrasound was done by anesthesiologist who had >3 yrs of experience with ultrasound.

1. Preoperative period 12 quadrant ultrasound (time pointA)
2. 5 min After induction 12 quadrant ultrasound(time pointB)
3. 5 min After pneumoperitoneum 12 quadrant ultrasound(time pointC)
4. At the end of surgery but before extubation 12 quadrant ultrasound (time point D)
5. after 1 hour of post extubation in post-operative room(time pointE)

STATISTICAL ANALYSIS

The collected data was entered in Microsoft Excel and then analysed and statistically evaluated using SPSS-PC-17 version. Quantitative data was expressed by mean, standard deviation and while qualitative data was expressed in percentage. Difference between the proportions was tested by chis quare test or Fisher "sex act test while difference between quantitative variable for more than group were tested by "ANNOVA" or Kruskal Wallis H test followed by post hoc test. Repeated measure ANNOVA test was used to see the improvement in quantitative variable at different point of time. Correlation between quantitative variables were seen by spearman correlation coefficient. P value less than 0.05 was considered statisticallysignificant.

RESULTS

This observational study was conducted among 72 ASA grade 1-3 patients of either sex undergoing elective laparoscopic cholecystectomy under general anaesthesia who met the inclusion criteria were recruited. Age distribution of study population showed that 22 (30.6%) patients were in the age group of 25-35 years, 20 (27.8%) patients were in the age group 36-45 years, 17 (23.6%) patients were in the age group 46-55 years and 13 (18.1%) patients were in the age group of 56-65 years. In study population female patients outnumbered the male patients. Majority of the patients 34 (47.2%) were ASA grade II. 28 (38.9%) patients were ASA I and 10 (13.9%) patients were ASA grade III in our study population. Mean age of patients was 43.44±11.05 years, mean weight was 69.96±8.64 kg, mean height was 163.76±7.78 cm and mean BMI was 26.04±2.83 kg/m^2. Mean duration of anaesthesia was 63.4±14.4 mins, mean duration of surgery was 46.76±13.45 mins and mean duration of pneumoperitoneumwas 40.07±13.25 minsin our study. Vital parameters such as pulse rate, respiratory rate, oxygen saturation & non-invasive blood pressure were recorded at all time points. Hemodynamics were stable and there was no clinically significant change in parameters. The ventilator parameters are adjusted as per standard anaesthesia protocol. All patients were mechanically ventilated with tidal volume of 6-8 ml/kg and respiratory rate was maintained to keep normocapnia.

Fig 1: Error plot showing Pulse rate at different time points

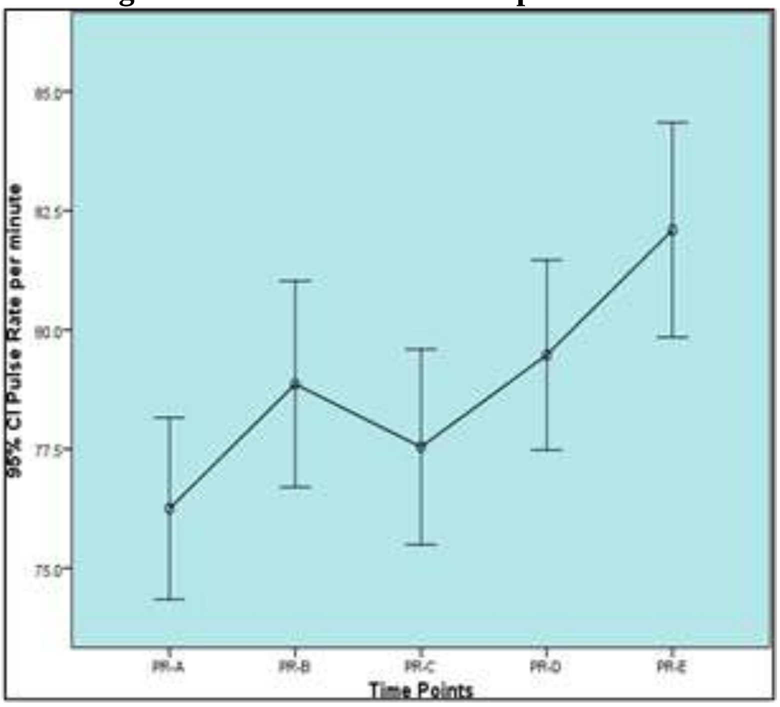

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Fig 2: Error plot showing respiratory rate at different time points

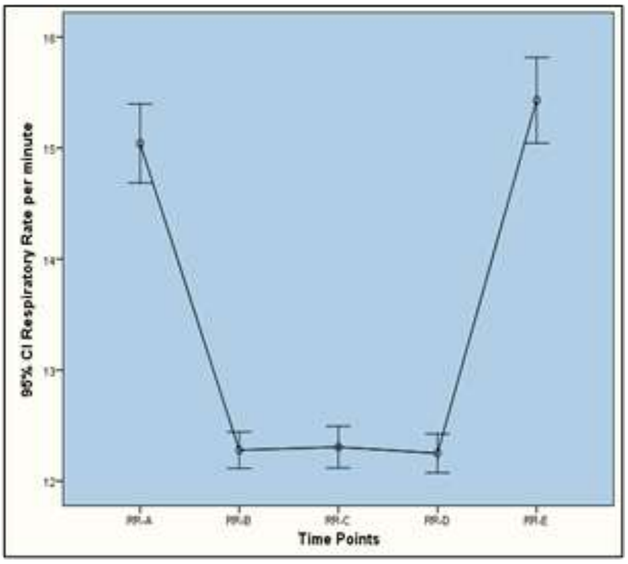


Fig 3: Error plot showing SPO2 at different time points

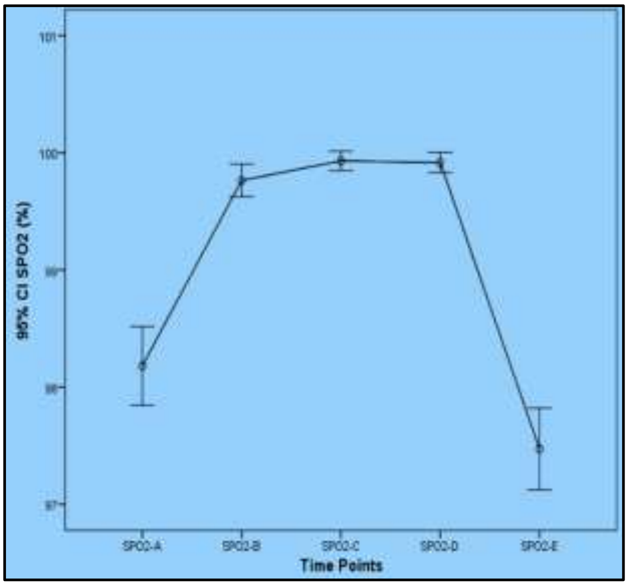


Fig 4: Error plot showing systolic BP at different time points

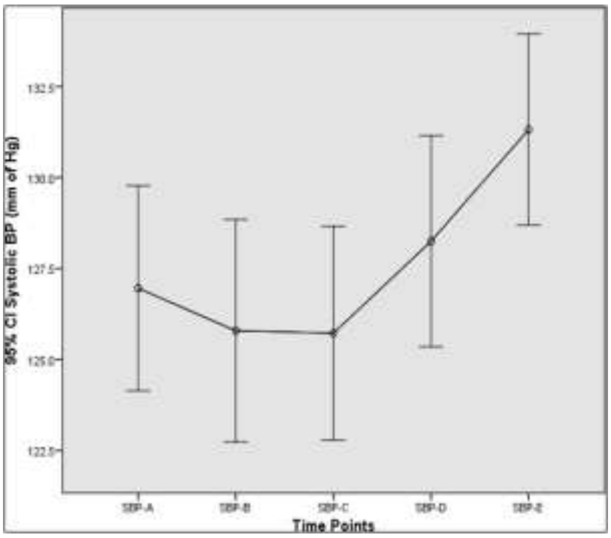


Fig 5: Error plot showing total lung ultrasound score at different time points

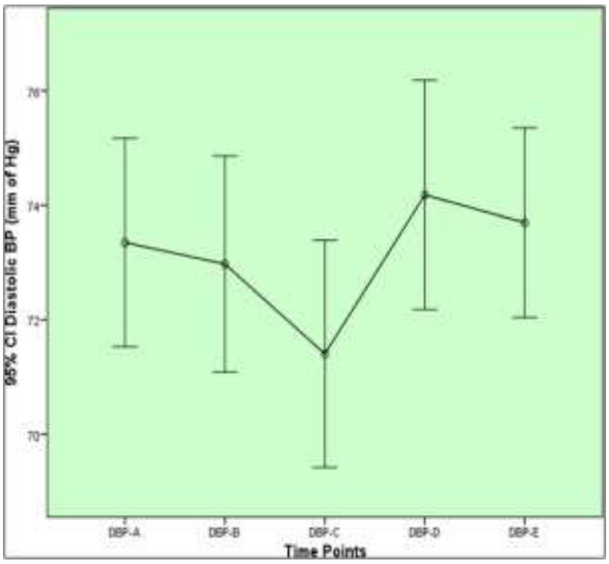
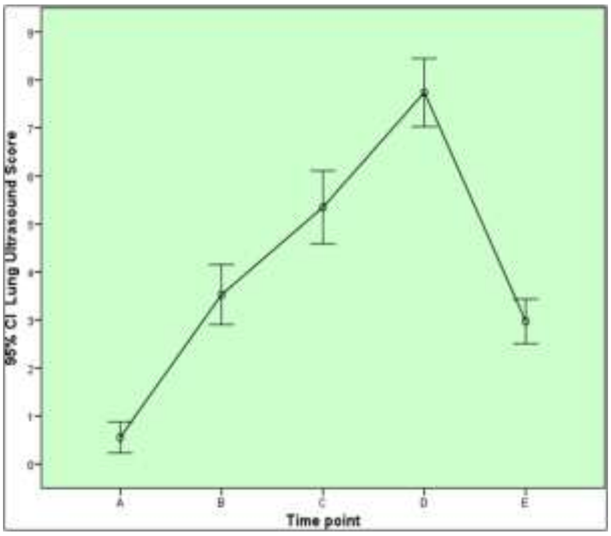


Fig 6: Temporal evolution of the lung ultrasound score (LUS) Time points: A = before general anaesthesia induction, B = 5 min after general anaesthesia induction, C = 5 min after insufflation of the pneumoperitoneum, D = at the end of surgery but before extubation, and E = after 1 hr of post extubation in post operative room.



Mean LUS score at baseline (time point A) was 0.56±1.37, 5 min after general anaesthesia induction (time point B) was 3.53±2.65, 5 min after insufflation of the pneumoperitoneum (time point C) was 5.35±3.22, at the end of surgery before extubation (time point D) was 7.74±3.01 and after 1 hr post extubation in post operative room (time point E) was 2.97±1.98. Induction of general anaesthesia caused a significant increase in LUS score and pneumoperitoneum insufflation also led to an additional increase in LUS score as shown in (figure: 9). LUS score was persistently increased throughout the period of pneumoperitoneum and anaesthesia. LUS score again improved at 1 hour post extubation, however still did not reach to preoperative period, hence some amount of aeration loss was there but it was clinically insignificant in our study.
In our study change in LUS score between ach time point was statistically significant (p value<0.01)

IN EACH PATIENT RIGHT AND LEFT LUNG QUADRANT(N-144)
In our study when LUS score was analysed each quadrant of both the lung right and left side, the inferolateral, supero-posterior and infero-posterior quadrants significantly deteriorated from the baseline as reflected by loss ofaeration.
In our study we observed positive correlation between the age of patient and with change in LUS score statistically significant atthree time points, time point D & E(pvalue<0.038),timepointB&E(pvalue<0.03),andtimepointA&B(pvalue< 0.015). We did not observe any significant correlation between BMI of patients with change in LUS score.
In our study we observed that as ASA grade increases the change in LUS score also increases at all time points, at time point A, B, C and D with ASA I, II, III (p value
<0.01), (p value <0.001),(p value<0.001) and (p value= 0.01) are statistically significant. At time point E with ASA I, II,III (p value = 0.15) which is statistically not significant.
In our study post-hoc test p value at time point A, between ASA grade I & III (p value <0.01) and between ASA grade II & III (p value <0.01)), at time point B, between ASA grade I & III (p value <0.01) and between ASA gradeII & III (p value<0.01), at time point C, between ASA grade I & III (p value <0.01) and between ASA grade II & III (p value <0.01), at time point D, between ASA grade I & III (p value <0.01) and between ASA grade II & III (p value = 0.03).

Table 1: Significant p values

Variable	Time point	P value
Lung Ultrasound score	Between Time point A & B	<0.01
	Between Time point A & C	<0.01
	Between Time point A & D	<0.01
	Between Time point A & E	<0.01
	Between Time point B & C	<0.01
	Between Time point B & D	0.01
	Between Time point B & E	0.03
	Between Time point C & D	<0.01
	Between Time point C & E	<0.01
	Between Time point D & E	<0.01

Table2: Atelectasis in different quadrant

	Time Point				
Variables	**A**	**B**	**C**	**D**	**E**
Superoanterior					
Small Loss of Aeration	0	0	2	4	0
Moderate Loss of Aeration	0	0	0	0	0
Inferoanterior					
Small Loss of Aeration	2	4	5	8	2
Moderate Loss of Aeration	1	0	2	4	0
Superolateral					
Small Loss of Aeration	1	9	16	31	4
Moderate Loss of Aeration	0	0	1	2	0
Inferolateral					
Small Loss of Aeration	8	42	58	87	30
Moderate Loss of Aeration	0	4	8	15	0
Superoposterior					
Small Loss of Aeration	8	68	90	88	69
Moderate Loss of Aeration	0	8	14	43	0
Inferoposterior					
Small Loss of Aeration	16	79	82	63	89
Moderate Loss of Aeration	1	14	41	74	10

Table 3: Correlation of age and BMI with change in Lung ultrasound score at different time period

Total Lung score		Age (in yrs.)	BMI (in kg/m2)
Time point between B & C	r value	-.086	.102
	p value	.470	.394
Time point between D & C	r value	-.043	-.172
	p value	.723	.148
Time point between D & E	r value	.245	.109
	p value	**.038**	.360
Time point between D & B	r value	-.026	-.054
	p value	.828	.652
Time point between B & E	r value	.256	.150
	p value	**.030**	.207

Time point between C & E	r value	.219	.208
	p value	.065	.079
Time point between B & A	r value	.286	.211
	p value	**.015**	.075
Time point between C & A	r value	.229	.230
	p value	.053	.052
Time point between D & A	r value	.233	.078
	p value	**.049**	.517
Time point between E & A	r value	.052	.068
	p value	.663	.568

Table4: Comparison of Total lung ultrasound score at different time period with ASA grade

Time Points	**I**	**II**	**III**	**P value**
Time Point A	0.14±0.59	0.47±1.05	2.00±2.62	<0.01
Time Point B	2.36±1.73	3.65±2.51	6.40±3.21	<0.001
Time Point C	4.04±2.18	5.32±2.78	9.10±4.28	<0.001
Time Point D	6.57±2.30	7.97±2.57	10.20±4.49	0.01
Time Point E	2.54±1.64	2.91±1.69	4.40±3.06	0.15

Table 5: Post-hoc test p value

Time points		**P value**
Time Point A	Between Grade I & III	<0.01
	Between Grade II & III	<0.01
Time Point B	Between Grade I & III	<0.01
	Between Grade II & III	<0.01
Time Point C	Between Grade I & III	<0.01
	Between Grade II & III	<0.01
Time Point D	Between Grade I & III	<0.01
	Between Grade II & III	0.03

DISCUSSION

In our study the mean age of our study population was 43.42±11.05 years. The mean weight, mean height and mean BMI was 69.96±8.64 kg, 163.76±7.78 cm and 26.03±2.84 kg/m^2. respectively.There were 46 (63.9%) female patients and 26(36.1%) male patients in our study population.Majority of the patients 34 (47.2%) were ASA grade II. There were 28 (38.9%) ASA grade I and 10 (13.9%) ASA grade III patients in our study population.The mean duration of anaesthesia was 63.40±14.43 minutes, mean duration of surgery was 46.76±13.45 minutes and mean duration ofpneumoperitoneumwas 40.07±13.25 minutes in ourstudy.Vital parameters such as pulse rate, respiratory rate, oxygen saturation & non-invasive blood pressure were continuously monitored and recorded at time points A, B, C, D& E. Hemodynamics were stable and there was no clinically significant change in parameters at any point oftime.

Mean baseline LUS score in preoperative period (time point A) was 0.56±1.37, 5 min after general anaesthesia induction (time point B) was 3.53±2.65, 5 min after insufflation of the pneumoperitoneum (time point C) was 5.35±3.22, at the end of surgery before extubation (time point D) was 7.74±3.01 and after 1 hr of post extubation in postoperative room (time point E) was 2.97±1.98. Change in LUS score at each time point was statistically significant (p value <0.01). After induction of general anaesthesia we observed an increased in LUS scores which further increased on production of pneumoperitoneum. In our study LUS score persistently increased throughout the period of pneumoperitoneum and anaesthesia. LUS score decreased one hour after extubation, however still did not reach to preoperative score, hence some amount of aeration loss was there but it was clinically insignificant in our study. None of our patients had any episode of desaturation in postoperative period in recoveryroom.

In 2016, Audrey Monastesse et al study shows that lung ultrasonography was possible in all patients. 30 patients completed the study. The mean age was 50 years, with females outnumbering males (26 to 4). The mean height was 164 cm, and mean weight 74.3 kg with mean BMI of 27.6 kg/m^2. Mean length of pneumoperitoneum was 82.7 min, and anesthesia was 157 min. The surgeries involved cholecystectomy, hysterectomy, diagnostic laparoscopy, pelvic lymphadenectomy, incisional hernia repair, intestinal resection, oophorectomy and inguinal hernia repair. General anesthesia induction caused a significant increase in both the original (P =.0057) and the modified (P =.0002) LUS scores. This increase persisted throughout the study period. Pneumoperitoneum insufflation led to an additional increase in both LUS scores. Changes in the LUS score between the postinduction period and arrival in the recovery room were correlated with changes in oxygenation (Spearman r = −0.43, P=.018). Induction of GA was associated with an increase in the LUS score, which gradually worsened at all time points until recovery room discharge. This increase was significantly worse in the basal and dependent lung zones. Small pneumothoraces were also discovered in the right inferoanterior quadrant of 2 patients at time point C. In both cases, pneumothoraces had no discernible clinical repercussion and could not be imaged again 15 minutes after the arrival of patients in the recovery room (time point D). Finally, in 1 patient, lung ultrasonographic examination at time point D revealed a frank deterioration of both LUS scores. The researchers concluded that Lung ultrasonography in the perioperative period is feasible, allows tracking of perioperative atelectasis and facilitates the diagnosis of respiratory complications. The evolution of aeration loss correlates moderately with changes in oxygenation.[4]

In a study by A Monastesse et al. they observed that the induction of general anaesthesia significantly increased both the original and modified LUS score. This persisted throughout the study period. Pneumoperitoneum insufflation led to an additional increase in both LUS score.[5]

In laparoscopic cholecystectomy patient is positioned with reverse trendelenburg position with angulation of operating table towards left after pneumoperitoneum. When we analysed LUS scores per quadrant in both right and left lungs. The infero- lateral, supero-posterior and infero-posterior quadrant of both right and left lung had higher LUS score at time point D (at the end of surgery before extubation), which shows that position of patient has an effect on loss of aeration (atelectasis).

Similarly, Rashwan D et al. also observed that laparoscopic surgery requires pneumoperitoneum and the Trendelenburg position. The increase in abdominal pressure during laparoscopic surgery impairs respiratory function, inducing atelectasis in the dependent lung region.[6]

In their study Kim et al. observed that the lung compliance was also decreased following transiently decreased diaphragmatic excursion during major laparoscopic pelvic surgery with steep trendenlenburg position and pneumoperitoneum. Thus, concluding that general anaesthesia and abdominal surgery leads to atelectasis and decreased respiratory function.[4]

In our study duration of anaesthesia has significant correlation with change in LUS scores between two time points, the time point B & D (p value < 0.000) and time point C & D (p value <0.001). Duration of surgery has significant correlation with change in LUS scores

between two time points, the time point C & D (p value<0.001), and time point D&E(pvalue<0.015).
In demographic distribution we observed a positive correlation between ageof patient and change in LUS score in different time points is statistically significant between three time points, time point D & E (p value <0.038), time point B & E (p value <0.03),and time point A & B (p value < 0.015). We did not observe any correlation between BMI ofpatients and loss of aeration(atelectasis) in our study.
In a study by A Monastesse et al. also observed that there is no significant correlation between change in both LUS score and patientBMI.[5]
In our study the mean BMI was 26.04±2.83 kg/m^2. There was no correlation between BMI and LUS scores at any time points. It may be the result that we did not recruit patient with BMI >40 kg/m2.
The study by Pedoto A. shows that induction of general anaesthesia causes decrease in functional residual capacity, which is inversely related to the increase Body Mass Index. A low FRC, paired with increased intrapulmonary shunt, decreased chest wall and lung compliance, increased airway resistance and atelectasis predispose the obese patient to rapid desaturation on induction. The supine position causes a further decrease in FRC, due to both a cephalad displacement of diaphragm and increase in pulmonary blood volume.
In our study we observed that as ASA grade increases, the LUS scores also increase at all time points. At time point A, B, C and D with ASA I, II, III are (p value <0.01),(p value <0.001),(p value<0.001) and (p value= 0.01) were statistically significant.

CONCLUSION

In our study we observed that atelectasis does occur even during short duration of surgery like laparoscopic cholecystectomy. Bedside lung ultrasonography is feasible and useful point of care tool in detection of perioperative atelectasis.

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