Intraoperative low tidal volume ventilation strategy has no benefits during laparoscopic cholecystectomy

Vandna Arora¹,², Asha Tyagi¹,², Surendra Kumar¹,², Aanchal Kakkar¹,², Shukla Das²

Departments of ¹Anaesthesiology and Critical Care and ²Microbiology, University College of Medical Sciences and GTB Hospital, New Delhi, India

Abstract

Background and Aims: Benefits of intraoperative low tidal volume ventilation during laparoscopic surgery are not conclusively proven, even though its advantages were seen in other situations with intraoperative respiratory compromise such as one-lung ventilation. The present study compared the efficacy of intraoperative low tidal volume ventilatory strategy (6 ml/kg along with positive end-expiratory pressure [PEEP] of 10 cmH₂O) versus one with higher tidal volume (10 ml/kg with no PEEP) on various clinical parameters and plasma levels of interleukin (IL)-6 in patients undergoing laparoscopic cholecystectomy.

Material and Methods: A total of 58 adult patients with American Society of Anesthesiologists physical status I or II, undergoing laparoscopic cholecystectomy were randomized to receive the low or higher tidal volume strategy as above (n = 29 each). The primary outcome measure was postoperative PaO₂. Systemic levels of IL-6 along with clinical indices of intraoperative gas exchange, pulmonary mechanics, and hemodynamic consequences were measured as secondary outcome measures.

Results: There was no statistically significant difference in oxygenation; intraoperative dynamic compliance, peak airway pressures, or hemodynamic parameters, or the IL-6 levels between the two groups (P > 0.05). Low tidal volume strategy was associated with significantly higher mean airway pressure, lower airway resistance, greater respiratory rates, and albeit clinically similar, higher PaCO₂ and lower pH (P < 0.05).

Conclusion: Strategy using 6 ml/kg tidal volume along with 10 cmH₂O of PEEP was not associated with any significant improvement in gas exchange, hemodynamic parameters, or systemic inflammatory response over ventilation with 10 ml/kg volume without PEEP during laparoscopic cholecystectomy.

Key words: Intraoperative ventilation, laparoscopic cholecystectomy, low tidal volume

Introduction

Ventilation using lung protective strategy consisting of low tidal volume (6 ml/kg) along with positive end-expiratory pressure (PEEP) has well-established benefits in patients of acute respiratory distress syndrome (ARDS).¹ It is associated with improved organ function, decreased levels of inflammatory mediators, and a reduction in mortality.¹

Consequent to the dramatic improvement in morbidity and mortality, use of low tidal volume ventilation strategy for shorter duration during intraoperative period in patients without ARDS has also been investigated.²⁻¹¹ In certain trials, it was associated with decreased inflammatory markers and improved lung functions.²⁻⁴,⁶,⁷

Laparoscopic cholecystectomy is a commonly performed surgery that is associated with pneumoperitoneum-induced respiratory compromise and altered pulmonary mechanics intraoperatively.¹² As a consequence, various ventilatory...
strategies have been investigated for use during laparoscopic cholecystectomy.\cite{12} Recently, the role of lung protective ventilatory strategy using low tidal volumes was evaluated in laparoscopic gynecologic\cite{13} as well as urologic surgeries\cite{14} and showed improved gas exchange but no decrease in inflammatory markers. However, its use has not been evaluated during laparoscopic cholecystectomy, where the patient positioning varies as compared to other investigated laparoscopic surgeries.

Against this background, we aimed to evaluate and compare the efficacy of intraoperative ventilatory strategy employing low tidal volume with one using higher tidal volume in patients scheduled for elective laparoscopic cholecystectomy. The outcome measures involved parameters indicating gas exchange, pulmonary mechanics, and hemodynamic consequences as well as systemic levels of interleukin (IL)-6.

**Material and Methods**

This study was conducted after approval by the Institutional Ethical Committee, and obtaining informed written consent from all participants.

Patients aged between 18 and 65 years of either gender with American Society of Anesthesiologists physical status I or II and body mass index <30 kg/m² scheduled for elective laparoscopic cholecystectomy under general anesthesia were included in the study. Those who refused consent for participation in the study, or with a history of chronic lung disease, acute respiratory tract infection, smoking, or recent exposure to mechanical ventilation (<1 year) and those having clinical signs of a systemic infection were excluded from the study. Intraoperative usage of airway device other than endotracheal tube for airway maintenance, conversion to laparotomy, and ventilation continued in the postoperative period were also defined as exclusion criteria.

A total of 58 patients were randomized to receive one of two ventilatory strategies using a computer-generated random number table (n = 29 each) [Figure 1]. The ventilatory strategies included either low tidal volume of 6 ml/kg along with PEEP of 10 cmH₂O (low tidal volume group) or a higher tidal volume of 10 ml/kg with no PEEP (high tidal volume group). The tidal volumes in both groups were calculated based on the ideal body weight (IBW). Herein, IBW in males = 50 + 0.91 (height in cm – 152.4) kg and in females = 45.5 + 0.91 (height in cm – 152.4) kg.\cite{1}

Respiratory rate was initiated at 10 breaths/min and then titrated in increments or decrements of 2 breaths/min to maintain an end-tidal carbon dioxide of 35–40 mmHg. The ratio of inspiratory to expiratory time (1:2) and fraction of inspired oxygen concentration (FiO₂) were same in both groups; the FiO₂ was initiated at 0.3 and then titrated to maintain SpO₂ above 97%.

The attending anesthesiologist was allowed to alter the mechanical ventilation whenever required to ensure patient safety.

---

**Figure 1:** Consort flow diagram
Besides, the difference in ventilatory strategy, all other interventions were similar in both groups. In the operating room, routine monitoring included lead II electrocardiography, pulse oximetry, capnography, spirometry, and noninvasive oscillometric blood pressure measurements (Datex-Ohmeda®, Madison, Wisconsin, USA). An intravenous (IV) access was established and Ringer’s lactate infusion initiated at 10 ml/kg/h. Radial artery was cannulated and the arterial line connected to FloTrac™ sensor and Vigileo™ monitor for invasive hemodynamic monitoring (Edwards Lifesciences®, Irvine, CA, USA). Anesthesia was induced using fentanyl 2 µg/kg IV followed by propofol 1–2.5 mg/kg IV titrated to loss of eyelash reflex. Vecuronium (0.1 mg/kg IV) was used to facilitate tracheal intubation. Anesthesia was maintained with a mixture of O₂ and N₂O along with isoflurane (minimal alveolar concentration \(= 1 \pm 0.1\)), and further drugs and fluids were administered as clinically indicated, while maintaining patient’s heart rate and blood pressure within 20% of baseline.

Pneumoperitoneum was created by the surgeon, as per their routine clinical practice by insufflating carbon dioxide to achieve intra-abdominal pressure of 12 mmHg. Patients were positioned in a head-up tilt of 15–20° and the same position was maintained throughout the procedure. After completion of surgery, residual muscle relaxation was reversed using neostigmine 0.05 mg/kg IV and atropine 0.02 mg/kg IV. For prophylaxis of emesis, ondansetron 8 mg IV was administered at the end of surgery.

Patients were transferred to the recovery room after extubation of the trachea, where oxygen was supplemented at \(\text{FiO}_2 = 0.3\), titrated upward to maintain \(\text{SpO}_2 > 97\%\) using a Venturi face mask.

**Outcome measures**

The primary outcome measure of postoperative \(\text{PaO}_2\) was obtained from analysis of arterial blood sample collected just after shifting patient to the postoperative room, before initiating supplemental oxygen. The technician processing the arterial blood sample and the patient, both were unaware of the group allocation.

The intraoperative data was recorded and compared at four time intervals: following intubation and initiation of mechanical ventilation (baseline), at 15 and 30 min after beginning of laparoscopy, and at the end of surgery. These recorded variables indicating gas exchange, pulmonary mechanics, or hemodynamic consequences included tidal volume, respiratory rate, minute ventilation, peak and mean airway pressures, resistance, dynamic compliance, \(\text{EtCO}_2\), heart rate, mean arterial blood pressure, and cardiac index. Variables obtained from an arterial blood gas analysis, i.e., \(\text{PaO}_2\), \(\text{PaO}_2/\text{FiO}_2\) ratio, \(\text{PaCO}_2\), and pH were recorded following intubation and initiation of mechanical ventilation (baseline), 15 min after beginning of laparoscopy, at the end of surgery following desufflation of the abdomen, and in the immediate postoperative period.

### Analysis of interleukin-6

Blood samples were assessed for IL-6 at three time intervals: following induction of anesthesia (baseline), at the end of surgery following desufflation of the abdomen, and at 24 h postoperatively. The sample of 5–10 ml of blood was collected aseptically and allowed to stand at room temperature for 1 h to clot. Serum was removed and stored at −80°C till assayed on a 96-well plate using commercially available enzyme-linked immunosorbent assay (Human IL-6 ELISA Kit, Diaclone®).

### Statistical analysis

All observed continuous variables were normal in distribution, except the plasma levels of IL-6. Log-transformation was done for IL-6 values to convert them to a normal distribution. Comparison of continuous variables between both groups was done using unpaired t-test or repeated measure ANOVA followed by Tukey’s test as appropriate. Categorical variables were compared using Chi-square or Fisher’s exact test. \(P < 0.05\) was considered statistically significant.

### Sample size

Taking into account previously published postoperative oxygenation following varying intraoperative tidal volumes,[2] 29 patients were required in each group to detect an effect size of 30% in the postoperative \(\text{PaO}_2\) at an alpha error of 5% and a power of 80%.

### Results

A total of 58 patients were included in the study. The two groups were statistically similar with respect to the demographic profile, baseline hemodynamic parameters before induction, as well as the surgical characteristics including duration of surgery, volume of carbon dioxide insufflated, and IV fluids infused intraoperatively \((P > 0.05)\) [Table 1].

The primary outcome measure, i.e., postoperative \(\text{PaO}_2\) was statistically similar between low tidal volume and high tidal volume group \((80 [12] \text{mmHg vs. 79 [14] mmHg} \ (P = 0.326))\).

The \(\text{PaO}_2/\text{FiO}_2\) ratio was statistically similar between both groups at all observed intraoperative and postoperative time points \((P = 0.998)\) [Table 2]. It was clinically better with a medium effect size (standard error of mean \([\text{SEM}] = 0.5\) intraoperatively. Significantly higher \(\text{PaCO}_2\) and lower pH were seen with low tidal volume group as compared to high
tidal volume group at initiation of ventilation, intraoperative time points as well as the end of surgery ($P < 0.001$), but became statistically similar in postoperative period [Table 2].

Intraoperatively, the respiratory rate required for maintaining eucapnia was significantly higher for the low tidal volume as compared to high tidal volume group ($P < 0.001$), but minute ventilation was statistically similar ($P = 0.363$) [Table 3]. The EtCO$_2$ was maintained in eucapnic range of 35–40 mmHg in both groups, but it was significantly higher with the low tidal volume group at all time points ($P < 0.001$) [Table 3]. The peak airway pressure ($P_{peak}$) and dynamic compliance were statistically similar between both groups ($P = 0.472$ and $P = 0.451$, respectively). The effect size for $P_{peak}$ and dynamic compliance was 0.6 and 0.7, respectively, at 30 min intraoperatively. The mean airway pressure ($P_{mean}$) was significantly higher, and resistance lower, with the low tidal volume group at all times ($P < 0.001$) [Table 3].

Table 1: Baseline and intraoperative data for patients undergoing laparoscopic cholecystectomy

|                      | Group L ($n=29$) | Group H ($n=29$) | $P$  |
|----------------------|------------------|------------------|------|
| Age (years)          | 38±13            | 37±12            | 0.89 |
| Height (cm)          | 152±6            | 152±7            | 0.95 |
| Weight (kg)          | 57±10            | 55±12            | 0.56 |
| BMI (kg/m$^2$)       | 24±3             | 24±4             | 0.37 |
| IBW (kg)             | 46±6             | 46±7             | 0.98 |
| Female (%)           | 28 (96)          | 28 (96)          | 1.00 |
| Heart rate (beats/min) | 82±17           | 79±15            | 0.44 |
| Mean arterial pressure (mmHg) | 94±13       | 99±9             | 0.09 |
| Cardiac index (L/min/m$^2$) | 4.3±1.2      | 4.3±0.8          | 0.93 |
| SpO$_2$ (%)          | 98±1             | 98±2             | 0.46 |
| Duration of surgery (min) | 73±24        | 74±32            | 0.88 |
| Volume of CO$_2$ (L) | 149±121         | 111±95           | 0.19 |
| Intra-abdominal pressure (mmHg) | 12±1        | 12±0             | 0.16 |
| Intravenous fluid (ml) | 1297±190       | 1293±215         | 0.95 |

Values are mean±SD or number (proportion). Group L = Low tidal volume ventilation (6 ml/kg IBW with PEEP), Group H = High tidal volume ventilation (10 ml/kg IBW without PEEP). BMI = Body mass index, PEEP = Positive end-expiratory pressure, SD = Standard deviation, IBW = Ideal body weight.

There was no significant difference in intraoperative heart rate ($P = 0.926$), mean arterial pressure ($P = 0.8$), and cardiac index ($P = 0.090$) between both groups [Table 3]. The median plasma IL-6 values were statistically similar between both groups at initiation of ventilation, end of surgery, and 24 h later ($P = 0.341$) [Table 4]. The protocol of both ventilatory strategies could be adhered to in all patients without any untoward consequences.

Discussion

This study evaluated the effect of intraoperative low tidal volume ventilation on gas exchange, pulmonary mechanics, and hemodynamic consequences, supplemented with levels of IL-6 as a marker of ventilation-induced systemic inflammatory response, as compared to high tidal volume ventilation in patients scheduled for elective laparoscopic cholecystectomy. While there was no significant difference in the oxygenation associated with its use as compared to high tidal volume ventilation, the pulmonary mechanics were better maintained. This advantage was negated by the higher systemic IL-6 levels in postoperative period, albeit statistically similar, as compared to those following higher tidal volume ventilation.

Although there are previous studies regarding the use of various mechanical ventilation strategies during laparoscopic cholecystectomy,[15-18] there are none evaluating the use of low tidal volume strategy. The use of low tidal volume ventilation is firmly established for long-term usage in critically ill patients,[11] and recently benefits have been shown following intraoperative use as well.[2,4,6,7]

We chose 6 ml/kg as a “low tidal volume” and 10 ml/kg as “high tidal volume”. Although tidal volumes as high as 15 ml/kg have been suggested for intraoperative use to prevent atelectasis, conventionally used volumes seldom exceed 10 ml/kg.[18] Previous studies evaluating “high” versus “low” tidal volumes during short-term intraoperative ventilation have compared

Table 2: Blood gas results in patients undergoing laparoscopic cholecystectomy

| Time point       | PaO$_2$/FiO$_2$ | PaCO$_2$ | pH   |
|------------------|----------------|----------|------|
|                  | Group L ($n=29$) | Group H ($n=29$) | Group L ($n=29$) | Group H ($n=29$) | Group L ($n=29$) | Group H ($n=29$) |
| Baseline†        | 594±142        | 601±84   | 40±6* | 33±4 | 7.4±0.03*   | 7.4±0.02   |
| 15 min‡         | 481±98         | 483±82   | 44±7* | 39±5 | 7.4±0.04*   | 7.4±0.03   |
| End of surgery   | 535±153        | 460±73   | 43±7* | 38±6 | 7.4±0.04*   | 7.4±0.04   |
| Postoperative    | 402±62         | 393±77   | 42±6  | 40±8 | 7.4±0.03    | 7.4±0.04   |

*P<0.05 for Group L versus Group H at respective time points; †Following intubation and initiation of mechanical ventilation, ‡15 min after initiation of laparoscopy.

Values are mean±SD. Group L = Low tidal volume ventilation (6 ml/kg IBW with PEEP of 10 cmH$_2$O), Group H = High tidal volume ventilation (10 ml/kg IBW without PEEP). PaO$_2$ = Partial pressure of arterial oxygen, FiO$_2$ = Fraction of inspired oxygen concentration, PaCO$_2$ = Partial pressure of arterial carbon dioxide, PEEP = Positive end-expiratory pressure, SD = Standard deviation, IBW = Ideal body weight.
Table 3: Intraoperative respiratory and hemodynamic data at four different time points in patients undergoing laparoscopic cholecystectomy

|                     | Group L (n=29) | Group H (n=29) |
|---------------------|----------------|----------------|
|                     | T1             | T2             | T3             | T4             |                     | T1             | T2             | T3             | T4             |
| Tidal volume (ml)   | 277±38*        | 280±38*        | 282±38*        | 290±39*        | 451±68           | 446±70          | 444±68          | 456±69          |
| Respiratory rate (/min) | 10±0          | 19±2*          | 19±2*          | 20±2*          | 10±0             | 11±2            | 11±2            | 11±2            |
| Minute ventilation (L/min) | 2.9±0.7       | 5.4±0.8        | 5.5±0.9        | 5.7±0.8        | 4.6±1.0          | 4.7±0.9         | 4.9±0.9         | 5.2±1.0         |
| EtCO₂ (mmHg)        | 40±3*          | 41±1*          | 40±2*          | 40±2*          | 36±3             | 39±1            | 38±2            | 38±2            |
| Pₐₐ₉ (cmH₂O)        | 17±2           | 22±3           | 22±2           | 19±2           | 15±2             | 24±3            | 24±3            | 18±2            |
| Compliance (ml/cmH₂O) | 38±9          | 27±6           | 26±6           | 37±7           | 40±12            | 23±5            | 22±5            | 34±9            |
| Resistance (cmH₂O/L/s) | 12±1*         | 13±1*          | 13±1*          | 12±1*          | 6±1              | 8±1             | 8±1             | 6±1             |
| Heart rate (beats/min) | 84±10        | 75±10          | 75±9           | 74±11          | 85±15            | 72±12           | 74±11           | 73±11           |
| Mean arterial pressure (mmHg) | 82±16     | 96±15          | 92±12          | 88±10          | 83±13            | 94±13           | 91±12           | 89±10           |
| Cardiac index (L/min/m²) | 3.3±0.8     | 3.3±0.6        | 3.2±0.6        | 3.2±0.6        | 3.4±0.6          | 3.6±0.6         | 3.5±0.7         | 3.6±0.7         |

*p<0.05 for Group L versus Group H at respective time points. T1 = Baseline after intubation, T2 = 15 min, and T3 = 30 min after laparoscopy, T4 = End of surgery, values are mean±SD, Group L = Low tidal volume ventilation (6 ml/kg IBW with PEEP of 10 cmH₂O), Group H = High tidal volume ventilation (10 ml/kg IBW without PEEP), Pₚₐ₉ = Peak airway pressure, Pₐ₉ = Mean airway pressure, PEEP = Positive end-expiratory pressure, SD = Standard deviation, IBW = Ideal body weight

Table 4: Comparison of plasma interleukin-6 levels in patients undergoing laparoscopic cholecystectomy

| Time point                      | IL-6 levels (pg/ml) |
|---------------------------------|---------------------|
|                                 | Group L (n=29) | Group H (n=29) |
| Baseline⁴                       | 3.5 (1.9-3)      | 4 (1.9-46)     |
| End of surgery                  | 7 (2-142)        | 7.5 (2-128)    |
| 24 h postoperatively            | 56.5 (12-152)    | 37 (3-224)     |

Following induction. Values are median (range), Group L = Low tidal volume ventilation (6 ml/kg IBW with PEEP of 10 cmH₂O); Group H = High tidal volume ventilation (10 ml/kg IBW without PEEP), PEEP = Positive end-expiratory pressure, IL-6 = Interleukin-6, IBW = Ideal body weight

The lack of improved oxygenation with low tidal volume as compared to high tidal volume ventilation is in contrast to the benefit observed during laparoscopic urologic surgeries. Thus, laparoscopic cholecystectomy may involve less respiratory compromise as compared to urologic surgeries consequent to variations in patient positioning. This inference of benefit of low tidal volume ventilation in the presence of greater respiratory compromise is also proven by the improved oxygenation associated with its use during one-lung ventilation. At the same time, there was an insignificant trend toward better oxygenation intraoperatively, toward the end of surgery, with the use of low tidal volume strategy. Although statistically insignificant, the effect size is not small (SEM = 0.5). This could demand further studies powered to detect intraoperative oxygenation indices as the primary outcome.

Low tidal volume ventilation resulted in significantly higher PaCO₂ and lower pH values. However, in the low tidal volume group, the baseline values of PaCO₂ measured just following the initiation of mechanical ventilation were also significantly higher than in high tidal volume group. This would likely be the reflection of period of manual ventilation using a face mask and breathing system during induction of anesthesia before intubation and not the ventilation strategy per se. Following initiation of mechanical ventilation, the respiratory rate was titrated to maintain ETCO₂ between 35 and 40 mmHg. As a result, the values of PaCO₂ and pH though statistically different were clinically similar between both groups and within normal physiologic range (35–45 mmHg and 7.35–7.45, respectively). Thus, the intraoperative higher PaCO₂ and lower pH cannot be used to conclude a lesser efficacy of low tidal volume ventilation for CO₂ elimination.
of low versus high tidal volume ventilation in laparoscopic urologic surgery used predetermined, similar minute volumes in both groups rather than a titrated to maintain eucapnia, making a comparison with our study inappropriate.

A trend toward improvement in respiratory mechanics, i.e., clinically lower peak airway pressure, higher dynamic compliance, and a significantly decreased resistance was seen with low tidal volume ventilation. Although the $P_{\text{peak}}$ and compliance were statistically similar, and with a small effect size, they do appear to be clinically better with the use of low tidal volume ventilation. The significantly lesser resistance is a result of the lower inspiratory flow requirement consequent to decreased tidal volume delivery with low tidal volume ventilation, and it has been evidenced earlier also.\textsuperscript{[2,3,5-8]}

In contrast, when combined with recruitment maneuver or used in patients with preexisting lung pathology undergoing thoracic surgery, low tidal volume ventilation is associated with significantly higher peak airway pressures.\textsuperscript{[4,11]}

There was no significant difference in the mean arterial pressure or cardiac index between both ventilation strategies despite higher mean airway pressures with low tidal volume ventilation.\textsuperscript{[4,5]} Previous trials noting blood pressure or cardiac index with these two ventilatory strategies have also suggested a lack of any appreciable difference in the hemodynamics.\textsuperscript{[2,3]}

We chose IL-6 as a marker to estimate the mechanical ventilation-induced pro-inflammatory systemic response. Several inflammatory mediators have been previously measured to evaluate ventilation-induced inflammatory response and of these IL-6 appear very commonly studied and correlate with the clinical outcome following various modalities of ventilation.\textsuperscript{[1,2,4,5,9,11]} The serum levels of pro-inflammatory IL-6 increased over time with both ventilatory strategies. There was, however, no significant difference between the two groups although the level was clinically higher in postoperative period with low tidal volume ventilation. Most of the earlier studies have also noted a lack of significant difference in IL-6 following low and high tidal volume ventilation.\textsuperscript{[2,4,5,7,13]}

**Conclusion**

Thus, the strategy using 6 ml/kg tidal volume along with 10 cmH$_2$O of PEEP was not associated with any significant improvement in gas exchange, hemodynamic parameters, or systemic inflammatory response over ventilation with 10 ml/kg volume without PEEP during laparoscopic cholecystectomy.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. The Acute Respiratory Distress Syndrome Network. N Engl J Med 2000;342:1301-8.

2. Wolthuis EK, Choi G, Dessing MC, Bresser P, Lutter R, Dzoljic M, et al. Mechanical ventilation with lower tidal volumes and positive end-expiratory pressure prevents pulmonary inflammation in patients without preexisting lung injury. Anesthesiology 2008;108:46-54.

3. Choi G, Wolthuis EK, Bresser P, Levi M, van der Poll T, Dzoljic M, et al. Mechanical ventilation with lower tidal volumes and positive end-expiratory pressure prevents alveolar coagulation in patients without lung injury. Anesthesiology 2006;105:689-95.

4. Wrigge H, Uhlig U, Zinserling J, Behrends-Calles E, Ottersbach G, Fischer M, et al. The effects of different ventilatory settings on pulmonary and systemic inflammatory responses during major surgery. Anesth Analg 2004;98:775-81.

5. Wrigge H, Zinserling J, Stüber F, von Spiegel T, Hering R, Wetegrove S, et al. Effects of mechanical ventilation on release of cytokines into systemic circulation in patients with normal pulmonary function. Anesthesiology 2000;93:1413-7.

6. Treschan TA, Kaisers W, Schaefer MS, Bastin B, Schmalz U, Wanja V, et al. Ventilation with low tidal volumes during upper abdominal surgery does not improve postoperative lung function. Br J Anaesth 2012;109:263-71.

7. Weingarten TN, Whalen FX, Warner DO, Gajic O, Schears GJ, Snyder MR, et al. Comparison of two ventilatory strategies in elderly patients undergoing major abdominal surgery. Br J Anaesth 2010;104:16-22.

8. Determann RM, Wolthuis EK, Choi G, Bresser P, Bernard A, Lutter R, et al. Lung epithelial injury markers are not influenced by use of lower tidal volumes during elective surgery in patients without preexisting lung injury. Am J Physiol Lung Cell Mol Physiol 2008;294:L344-50.

9. Memtsoudis SG, Bombardieri AM, Ma Y, Girardi FP. The effect of low versus high tidal volume ventilation on inflammatory markers in healthy individuals undergoing posterior spine fusion in the prone position: A randomized controlled trial. J Clin Anesth 2012;24:263-9.

10. Futier E, Constantin JM, Paugam-Burtz C, Pascal J, Euirin M, Neuschwander A, et al. A trial of intraoperative low-tidal-volume ventilation in abdominal surgery. N Engl J Med 2013;369:428-37.

11. Michelet P, D’Journo XB, Roch A, Doddoli C, Marin V, Papazian L, et al. Protective ventilation influences systemic inflammation after esophagectomy: A randomized controlled study. Anesthesiology 2006;105:911-9.

12. Valenza F, Chevallard G, Fossali T, Salice V, Pizzoci M, Gattinoni L. Management of mechanical ventilation during laparoscopic surgery. Best Pract Res Clin Anaesthesiol 2010;24:227-41.

13. Kokulu S, Günay E, Baki ED, Ulusali SS, Yilmazer M, Koca B, et al. Impact of a lung-protective ventilatory strategy on systemic and pulmonary inflammatory responses during laparoscopic surgery: Is it really helpful? Inflammation 2015;38:361-7.

14. Ela Y, Baki ED, Ates M, Kokulu S, Keles I, Karalar M, et al. Exploring for the safer ventilation method in laparoscopic urologic patients? Conventional or low tidal? J Laparoendosc Adv Surg Tech A 2014;24:786-90.
15. Tyagi A, Kumar R, Sethi AK, Mohta M. A comparison of pressure-controlled and volume-controlled ventilation for laparoscopic cholecystectomy. Anaesthesia 2011;66:503-8.
16. Kim JY, Shin CS, Kim HS, Jung WS, Kwak HJ. Positive end-expiratory pressure in pressure-controlled ventilation improves ventilatory and oxygenation parameters during laparoscopic cholecystectomy. Surg Endosc 2010;24:1099-103.
17. Karsten J, Luepschen H, Grossherr M, Bruch HP, Leonhardt S, Gehring H, et al. Effect of PEEP on regional ventilation during laparoscopic surgery monitored by electrical impedance tomography. Acta Anaesthesiol Scand 2011;55:878-86.
18. Putensen C, Wrigge H. Tidal volumes in patients with normal lungs: One for all or the less, the better? Anesthesiology 2007;106:1085-7.
19. Hubmayr RD. Perspective on lung injury and recruitment: A skeptical look at the opening and collapse story. Am J Respir Crit Care Med 2002;165:1647-53.
20. Rimensberger PC, Cox PN, Frmdova H, Bryan AC. The open lung during small tidal volume ventilation: Concepts of recruitment and “optimal” positive end-expiratory pressure. Crit Care Med 1999;27:1946-52.
21. Neumann P, Rothen HU, Berglund JE, Valtysson J, Magnusson A, Hedenstierna G. Positive end-expiratory pressure prevents atelectasis during general anaesthesia even in the presence of a high inspired oxygen concentration. Acta Anaesthesiol Scand 1999;43:295-301.
22. Tusman G, Böhm SH, Suarez-Sipmann F, Turchetto E. Alveolar recruitment improves ventilatory efficiency of the lungs during anesthesia. Can J Anaesth 2004;51:723-7.

---

**CONFERENCE CALENDAR January-March 2017**

| Name of conference                                      | Dates       | Venue                                      | Name of organising Secretary with contact details                                      |
|---------------------------------------------------------|-------------|--------------------------------------------|-----------------------------------------------------------------------------------------|
| Regional Anesthesiology and Acute Pain Medicine Meeting | April 6th-8th, 2017 | Marriott Marquis, San Francisco, California | https://www.asra.com/page/284/regional-anesthesiology-and-acute-pain-medicine-meeting |
| The 2017 SOAP 49th Annual Meeting                       | May 10th-14th, 2017 | Hyatt Regency, Bellevue, Washington | https://soap.org/future-meetings.php                                                   |
| 14th Conference of Asian Society of Paediatric Anaesthesiologists (ASPA 2017) with Preconference workshops | June 3rd-4th, 2017 | Grand Hyatt, Mumbai, India | Website: www.aspa2017.com Organising Secretary: Dr. Vrushali Ponde |
|                                                          | June 2nd, 2017 | Surya Children Hospital, Mumbai, India     |                                                                                         |