Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Effects on Arterial Blood Gas Parameters and Gastric Volume with or Without Facemask Ventilation during Induction in Patients Undergoing Laparoscopic Surgeries

Veena Chatrath[1], Joginder Pal Attri[1], Sanjeet Kaur[2], Pankaj[3]

[1]Professor and Head, Department of Anesthesia and Critical Care, Government Medical College, Amritsar, Punjab, India, [2]Senior Resident, Department of Anesthesia and Critical Care, Government Medical College, Amritsar, Punjab, India, [3]Associate Professor, Department of Anesthesia and Critical Care, Government Medical College, Amritsar, Punjab, India

Abstract

Background: This study aimed to assess the outcome of facemask oxygenation with or without positive pressure on gastric volume and arterial blood gas (ABG) parameters in patients undergoing laparoscopic surgeries.

Materials and Methods: 60 adult patients aged 18–60 years, with American Society of Anesthesiologists status I and II scheduled for laparoscopic surgery, were randomly divided into two groups of 30 each. Group ventilated (V) (n = 30) received facemask ventilation with positive pressure for 3 min followed by ventilation during the apnea period, while Group non-V (NV) (n = 30) received facemask oxygenation without positive pressure ventilation (PPV). ABG parameters: pH, PaO_2, $PaCO_2$, and HCO_3^- were measured at baseline (T1), following preoxygenation (T2), subsequently following loss of consciousness (T3) and at T4 and T5, i.e., before and after intubation, respectively. Gastric antral volume was measured ultrasonographically with a curvilinear probe both before and after intubation. Hemodynamic parameters, complications, and surgeon satisfaction scores were also monitored.

Results: The PaO_2 in V group at T5 (1 min after intubation - 374.73 mmHg) was stastistically higher than in NV group (335.10 mmHg) at T5. On the contrary, the $PaCO_2$ levels at T5 were more in NV group compared to V group. Furthermore, when gastric volumes were compared, there was an increase in gastric cross-sectional area in Group V than Group NV.

Conclusion: Oxygenation via facemask and without PPV offers a safer and more balanced approach as it preserves surgical outcomes due to minimal gastric distension with lesser complications and better surgical laparoscopic view and ensures safety of patients with minimal impacts on various ABG parameters.

Key words: Arterial blood gas, Facemask ventilation, Laparoscopic surgery, Preoxygenation, Ultrasonography

INTRODUCTION

Laparoscopic surgery, a mainstay of minimally invasive procedures, helps in minimizing recovery time and also had lesser complications when compared to methods like traditional open surgery.[1] General anesthesia is a gold standard and an ideal anesthetic modality for laparoscopic surgeries.[2,3]

Preoxygenation with 100% oxygen for 3 min is standard to prevent desaturation during apnea, but the use of positive pressure ventilation (PPV) during this period remains controversial due to its potential to exacerbate gastric insufflation.[4] During oxygenation at the time of apnea, oxygen continues to flow, which is unaccompanied by lung movement and is a result of mass flow of the gases as a gradient is created by the continuous oxygen consumption.[5,6] Due to continuous diffusion of oxygen from alveoli to blood vessels, pressure gradients build up in the respiratory tract, resulting in flow of oxygen from

Access this article online

www.ijss-sn.com

Month of Submission : 07-2026
Month of Peer Review : 08-2026
Month of Acceptance : 09-2026
Month of Publishing : 09-2026

Corresponding Author: Dr. Pankaj, Associate Professor, Department of Anesthesia and Critical Care, Government Medical College, Amritsar, Punjab, India.

the facemask down to the alveoli and blood vessels during the apneic period. Safe apnea time/tolerable apnea time is defined as the delay in time until the oxygen saturation level reaches up to 90%, which can be prolonged up to almost 10 min, with preoxygenation for at least 3 min of duration.[7]

However, anesthesia induction poses challenges, particularly with facemask ventilation using PPV, which can result in gastric insufflation.[8] This increases gastric volume, elevating the chances of regurgitation and pulmonary aspiration and may impair surgical visibility.[4]

Conventionally, gastric insufflation has been detected by auscultation during ventilation. More recently, ultrasonography has flourished as a method to measure increased gastric volume by evaluating the antral cross-sectional area (CSA). A low-frequency curvilinear probe is preferred for imaging the gastric antrum, offering enhanced penetration to capture deeper anatomical details.[9]

Another important step in assessing the oxygenation status of the patients during the induction phase is by doing arterial blood gas (ABG) analysis. ABG analysis assesses the oxygen content and carbon dioxide content in the blood and also measures the pH and bicarbonate levels. To assess the oxygenation adequacy in the peri-intubation period, ABG assessment needs to be done at frequent time intervals, i.e., before intubation, during intubation, and after intubation.

The purpose of this study was to correlate changes occurring in the gastric volume by assessing changes in the gastric antral CSA via ultrasonography both before and after intubation along with comparison of ABG at various time intervals to ensure safety of apnea time during the induction process with or without the PPV.

Primary Objectives

The primary objective of the study is to compare the effect of facemask ventilation with or without positive pressure on gastric antral volumes measured by portable ultrasound and on various ABG parameters and also to assess surgeon's satisfaction during surgery.

Secondary Objectives

The secondary objective of the study is to compare the risk of gastric content regurgitation and any complications related to the procedure.

MATERIALS AND METHODS

This prospective, randomized, double blind study was conducted at our institution after approval from the institutional ethics committee was obtained with reference number (_356_/D-26/2022) during the period August 2024–May 2025. Written informed consent of patients was obtained before enrolling in the study. It was conducted on sixty patients aged 18–60 years, with American Society of Anesthesiologists (ASA) status I and II and admitted to our institution undergoing laparoscopic surgeries under general anesthesia. The registration of the study was done on the Clinical Trials Registry of India (CTRI) with CTRI registration number CTRI/2024/08/072975.

Exclusion criteria included patient refusal, pregnant/nursing mother, diaphragmatic palsy, patients with a history of cardiac, respiratory, hepatic or renal disease, patients allergic to drugs involved in the study or on drugs which affect gastrointestinal dynamics, patients with occurrence of gastroesophageal regurgitation or presenting with prior history of gastrointestinal surgery/trauma, body mass index (BMI) >30 kg/m^2.

To achieve effective blinding and randomization, a random number table was generated with the help of computer with a 1:1 allocation ratio. Patients were assigned to one of two groups – facemask oxygenation with PPV or facemask oxygenation without PPV – based on assignments disclosed from sealed envelopes. These envelopes were opened 5–10 min before the patient's entry into the operating theater by an anesthesiologist who was not participating in the procedure. The surgeon, patient, and anesthesiologist performing ultrasonography were blinded to the group assignments. An investigator, aware of the group allocations, conducted and documented ABG analyses. The attending anesthesiologist, while not blinded, remained unaware of the study's objectives and did not participate in gastric ultrasound evaluations or data analysis.

A day before surgery, a thorough history was taken, general physical examination and systemic examination, along with airway assessment, were done. Written informed consent was obtained from all the patients after explaining possible risks and benefits of the intervention. Premedication included alprazolam 0.25 mg the night before surgery. Patients were randomly allocated into two groups.

- Group V (ventilated): Patients received 3 min of facemask oxygenation, followed by PPV
- Group NV: Patient underwent 3 min of facemask oxygenation, which persisted during the apnea phase without PPV.

Standard monitoring such as electrocardiogram, pulse oximetry, and non-invasive blood pressure was established in the operating room, and a 20-gauge arterial cannula was inserted for ABG sampling. Baseline ABG (pH, PaO_2, $PaCO_2$, HCO_3^-) and vital signs were recorded.

Gastric antral CSA was evaluated using ultrasonography (curvilinear probe) by a blinded sonographer before induction. Fentanyl (2 μg/kg) was given at the time of induction, followed by propofol (2 mg/kg) and succinylcholine in a dose of 1.5 mg/kg, in the apnea period. Patients were either given PPV or no ventilation, according to the group allocation, and thereafter, the trachea was intubated. ABG samples were collected at five intervals: Baseline (T1), following pre-oxygenation (T2), subsequently following loss of consciousness (T3), and at T4 and T5, i.e., before intubation and after intubation, respectively. Once the trachea was intubated, the sonographer, who was blinded to allocated groups, performed USG to assess the gastric CSA again. Hemodynamic parameters were monitored every 5 min for 60 min. Complications (e.g., nausea, aspiration) and surgeon satisfaction scores (Grades 1–4) were recorded.

Ultrasonography enables evaluation of gastric volume by assessing the antral CSA with the patients lying down in the supine position. A curvilinear probe generating low frequency (chosen for its capacity to image deeper tissues) is placed below the xiphoid process in the sagittal plane to visualize the contents of the gastric antrum. The ultrasound settings are adjusted to clearly depict the gastric antrum, left hepatic lobe, superior mesenteric artery, and abdominal aorta in sagittal view.[10] The outer perimeter of the gastric antrum is traced in the parasagittal plane to determine its CSA, which typically appears elliptical.

Statistical Analysis

The data were collected and systematically reviewed and then entered into a computerized database for statistical analysis. The Statistical Package for the Social Sciences (SPSS) version 22 (SPSS Inc., Chicago, IL, USA) was used. Descriptive statistics were employed to summarize the data: Continuous variables were expressed as mean ± standard deviation, and categorical variables were presented as frequencies and percentages. To evaluate differences between the V and NV groups, inferential statistics were applied and independent samples *t*-test was utilized for continuous variables, while Chi-square test was employed for categorical variables. The results were systematically displayed through tables and graphical representations to enhance clarity and interpretation. A $P < 0.05$ was considered to be statistically significant.

RESULTS

Change in hemodynamic parameters and complications such as hypoxemia, bradycardia, hypotension/hypertension, and gastric aspiration were not seen in both the groups. The baseline characteristics in terms of age, gender, BMI, and ASA physical status were similar between the groups [Table 1].

The baseline ABG parameters (T1) such as pH, paO_2, $paCO_2$, HCO_3- levels were comparable in both the groups. pH values were similar in both the groups, $P > 0.05$ at all time intervals [Figure 1]. However, PaO_2 levels at T2 (3 min after oxygenation via facemask) were higher in Group V (362.93 ± 11.56 mmHg) and Group NV (368.77 ± 14.09 mmHg) compared to baseline in Group V (100.00 ± 2.02 mmHg) and Group NV (101.00 ± 2.98 mmHg). However, at T4 and T5, PaO_2 values were significantly higher in Group V (415 ± 5.17 mmHg and 374.73 ± 55.03 mmHg, respectively) as compared to Group NV (345.97 ± 9.06 mmHg) at T4 and 335.10 ± 16.14 mmHg at T5 [Figure 2]. While $PaCO_2$ levels were significantly higher in Group NV (48.37 ± 1.58 mmHg) when compared to Group V (39.49 ± 1.49 mmHg) at T4 and at T5 (48.50 ± 1.62 mmHg) in Group NV compared to (40.10 ± 1.65 mmHg) in Group V [Figure 3]. HCO_3- values at T4 were higher in Group NV (24.57 ± 1.78 mmHg) when compared to Group V (22.81 ± 1.93 mmHg) [Figure 4].

Gastric antral CSA was similar in both groups at baseline (3.21 ± 0.70 cm^2 vs. 3.22 ± 0.78 cm^2) in Group V and Group NV with $P > 0.05$. Whereas, after intubation, it was significantly higher in Group V (4.10 ± 0.91 cm^2) compared to Group NV (3.56 ± 0.77 cm^2, $P < 0.05$), confirming increased gastric insufflation with PPV [Table 2].

Surgeon satisfaction score was assessed according to laparoscopic surgical grade, higher in Group V, with 24 patients reporting Grade 4 (impaired visibility due to gastric distension) compared to 5 patients in Group NV [Figure 5].

63 patients were enrolled in this study, out of which 3 patients were excluded because of lack of visibility of

Table 1: Demographic data

Parameter	Group V (*n*=30)	Group NV (*n*=30)
Age (years)	42.3±10.2	41.8±9.8
Male/female (cases [%])	16 (53)/14 (47)	15 (50)/15 (50)
BMI (kg/m^2)	24.5±2.3	24.2±2.1
ASA status I/II (cases [%])	27 (90)/3 (10)	28 (93)/2 (7)

V: Ventilated, NV: Non-ventilated, BMI: Body mass index, ASA: American Society of Anesthesiologists

Table 2: Gastric antral cross-sectional area (cm^2)

Time interval	Group V		Group NV		"*t*" value	"*P*" value
	Mean	SD	Mean	SD		
Baseline	3.21	0.70	3.22	0.78	0.070	0.470
After intubation	4.10	0.91	3.56	0.77	-2.590	0.010

V: Ventilated, NV: Non-ventilated, SD: Standard deviation. *P*>0.05 is NS, *P*<0.05 is S, *P*<0.001 is HS

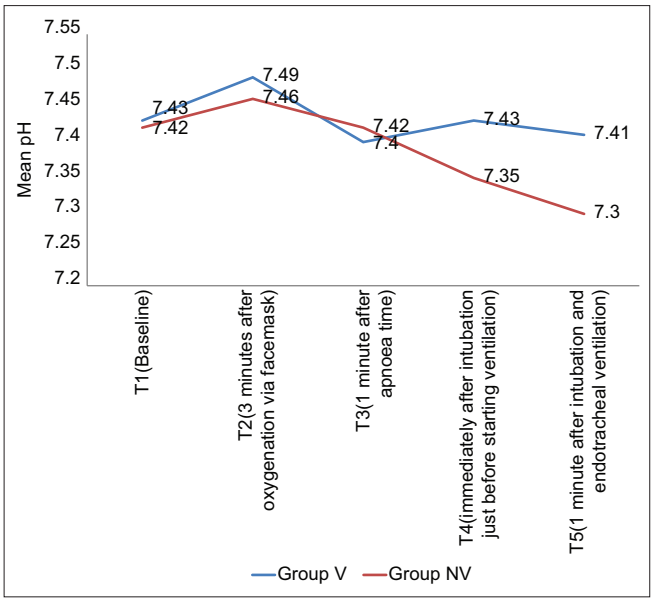


Figure 1: pH distribution

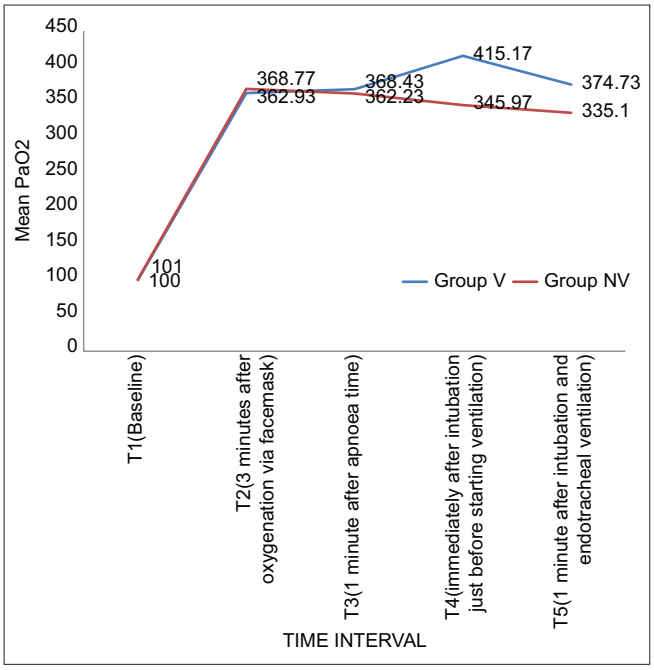


Figure 2: PaO_2 distribution

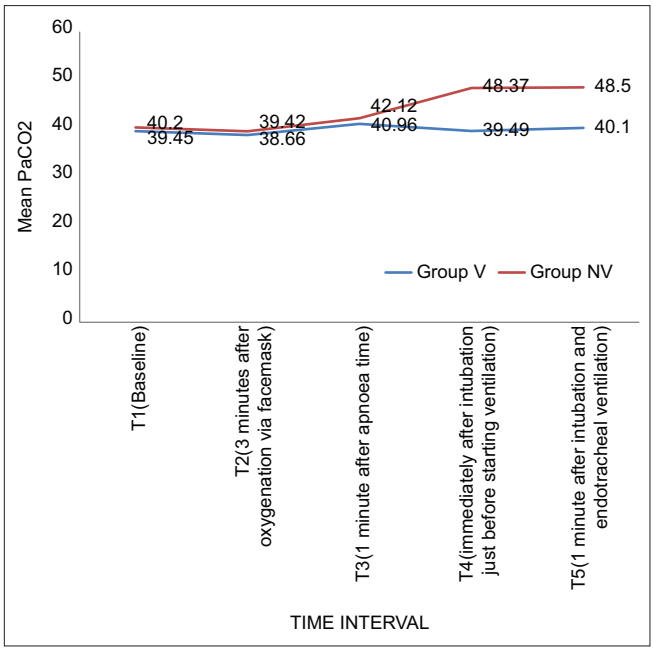


Figure 3: $PaCO_2$ distribution

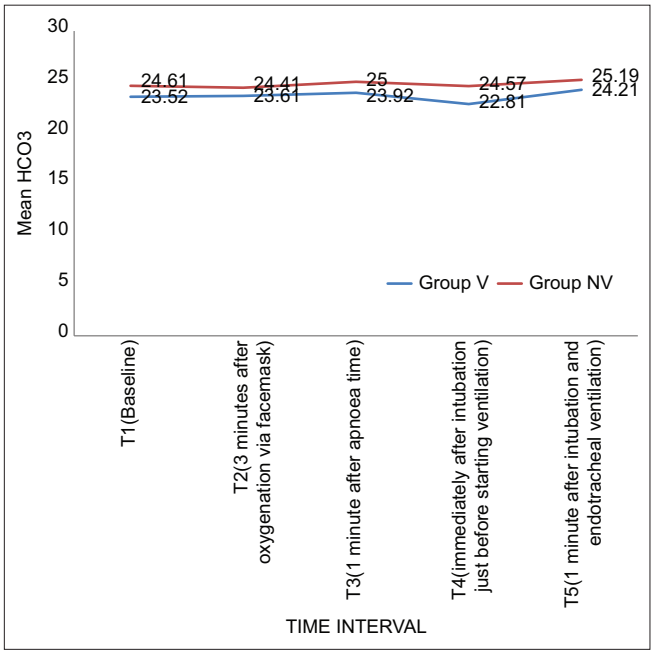


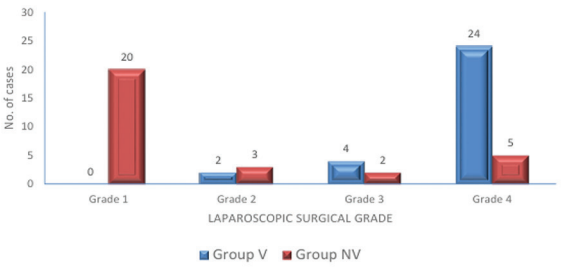
Figure 4: $HCO3^-$ distribution

gastric CSA; the remaining 60 patients were randomly divided into 2 groups of 30 each [Figure 6].

DISCUSSION

Laparoscopic procedures carried out under general anesthesia have become increasingly preferred over traditional open surgeries due to their minimally invasive nature. The selection of oxygenation and ventilation strategies during induction significantly impacts patient outcomes. The induction phase of anesthesia is particularly susceptible to adverse events, including hypoxemia, hypercapnia, and gastric content aspiration. To overcome these effects, preoxygenation with 100% oxygen for 3 min is a preferred technique to prevent desaturation during the apnea period. Safe apnea time is the period where with adequate preoxygenation saturation is maintained >90%.

This is why, in both the groups, PaO_2 levels at T2 and T3 were more compared to baseline values at T1, highlighting



LAPAROSCOPIC SURGICAL GRADES:

Grade 1: Minimal gastric insufflation occurred

Grade 2: Mild insufflation was present but did not interfere with surgery.

Grade 3: Surgery remained feasible without interventions like artificial decompression.

Grade 4: Surgery was not possible without interventions such as artificial decompression.

• In Group V gastric insufflation obscured the surgical view thus surgeons were not much satisfied and ryles tube insertion was required to make the operative view better.

Figure 5: Surgeons' satisfaction score

the role of maintaining oxygen reserves by adequate preoxygenation. The PaO_2 in NV group was significantly reduced after endotracheal intubation (T4) compared to V group, but not to an extent to cause desaturation since passive oxygenation occurred in patients in Group NV. These differences indicate that PPV enhances oxygenation during induction by preventing atelectasis and maintaining alveolar ventilation, unlike the NV group, where muscle tone loss and atelectasis reduced arterial oxygen levels. PaO_2 levels were well maintained and did not fall below 300 mmHg at any point in time. The higher PaO_2 in Group V reflects preoxygenation supported with effective PPV.

A previous study also suggests that the loss of respiratory muscle tone with muscle relaxants can decrease functional

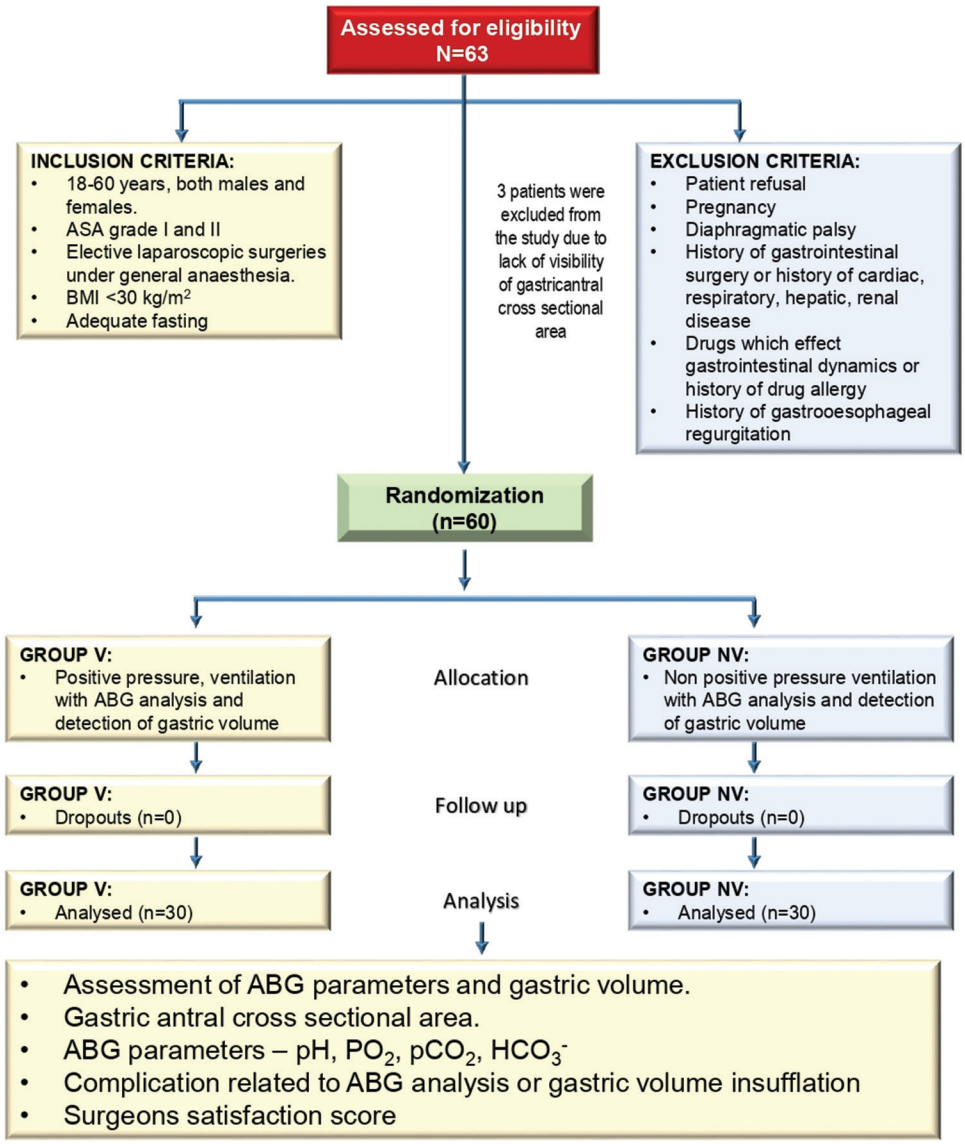


Figure 6: Consort diagram

residual capacity, causing alveolar collapse and increasing the chances of atelectasis causing impaired oxygenation.[11] Furthermore, decreased oxygen pressure gradient, due to accumulation of CO_2, weakens the effects of apneic oxygenation. A similar study by Sunil *et al*., witnessed higher PaO_2 levels in Group C given CPAP during induction compared to the group who did not need CPAP, supporting the role of PPV in maintaining oxygenation.[5]

CO_2 accumulation during apnea causes an increase in HCO_3^- levels and hypercapnia. Our study indicates that the $PaCO_2$ levels in NV group were significantly higher before and after intubation compared to the ventilation group. With changes in CO_2 and HCO_3^- levels, a fall in pH was observed in NV group, suggesting an increase in $PaCO_2$ leading to transient respiratory acidosis.

There is an increase risk of regurgitation of gastric contents in patients receiving general anesthesia because of impaired gastric esophageal sphincter tone and loss of respiratory muscle tension.

This study demonstrates that facemask ventilation without PPV (Group NV) offers significant advantages over PPV during anesthesia induction for laparoscopic surgery. There is significantly increased gastric antral CSA in the ventilation group, suggesting increased intragastric pressures causing gastric insufflation with PPV. A prior study conducted by He *et al*. proved that the median antral CSA was higher in the ventilation group compared to the non-ventilation group, indicating gastric insufflation cannot be avoided even when inspiratory pressures of <10 cm H_2O were used. Increased gastric volume increases aspiration risk and complicates surgical visualization, as evidenced by lower surgeon satisfaction scores in Group V.[11]

The lower surgeon satisfaction in Group V reflects the practical impact of gastric insufflation on laparoscopic procedures, where a clear surgical field is critical. Almost 2/3rd of the patients in Group V required nasogastric tube insertion for gas release. These findings suggest that the risks of ventilating patients by positive pressure outweigh its benefits in this context, particularly when safe apnea times can be achieved with oxygenation alone.[6]

Complications such as nausea and vomiting, risk of aspiration, though not statistically significant, were more frequent in Group V, likely due to gastric distension; a positive correlation was identified between the antral CSA and the volume of aspirated fluid. An antral CSA cutoff of 340 mm^2 for identifying a risk stomach (marked by solid particles and/or gastric fluid volume >0.8 mL/kg) yielded a sensitivity of 91% and a specificity of 71% as per study conducted by Bouvet *et al*. These results indicate that ultrasonographic measurement of the antral CSA is a dependable method for reducing the risk of pulmonary aspiration of gastric contents during general anesthesia.[12]

The primary outcome was the assessment of gastric antral CSA as a surrogate for gastric volume/insufflation, changes in ABG parameters (PaO_2, $PaCO_2$, and pH) during anesthesia induction, and surgeon satisfaction during the surgery. Gastric antral CSA was significantly higher in the PPV group (Group V) compared to the NV group (Group NV), indicating greater gastric insufflation with PPV. ABG analysis showed maintenance of PaO_2 in both the groups ensuring safety of the procedure. Surgeon satisfaction was significantly lower in Group V due to impaired surgical visualization from gastric distension, with nearly two-thirds of patients requiring nasogastric tube insertion. Secondary outcomes included risk of gastric regurgitation and aspiration and other complications. The risk of gastric regurgitation and aspiration was higher in the V group owing to increased gastric volume, though not statistically significant. Complications such as nausea and vomiting were also more frequent in Group V.

The strengths of study address a clinically relevant question by directly comparing the effects of facemask ventilation with and without positive pressure during anesthesia induction in laparoscopic surgeries, focusing on both oxygenation efficacy and gastric insufflation risk. The randomized controlled design with a well-defined patient population (ASA I-II) allowed for balanced comparison between groups. Objective and standardized data collection using ultrasonography for gastric antral CSA and serial ABG analysis provided reliable, quantitative measurements. Statistical analysis appropriately identified significant differences in key outcomes like gastric CSA and ABG parameters.

The findings indicate that while PPV improves PaO_2 and reduces $PaCO_2$, it significantly increases gastric insufflation, thereby elevating the risk of regurgitation and aspiration with poorer surgical conditions. These results align with prior evidence highlighting the trade-off between better gas exchange and gastric distension during induction. In the context of current evidence, this supports preferring simple facemask oxygenation without PPV as a safer default technique for routine laparoscopic cases, potentially reducing aspiration risk and improving operative efficiency while maintaining adequate oxygenation.

This study challenges the routine use of PPV during induction, raising controversy regarding the balance between oxygenation benefits and gastric insufflation risks, especially since many anesthesiologists traditionally favor gentle PPV. Limitations such as small sample size

and exclusion of high-risk patients (obese, ASA III-IV) may limit generalizability. Future research should involve larger multicentric trials across diverse populations including obese and pediatric patients, incorporate real-time ultrasound monitoring, standardize inspiratory pressures, and evaluate long-term postoperative outcomes like atelectasis and pulmonary complications.

CONCLUSION

Although PPV enhances PaO_2 and reduces $PaCO_2$, it leads to an increase in gastric volume along with risks of aspiration. Hence, facemask oxygenation without PPV is the preferred and safer technique used during anesthesia induction for laparoscopic surgeries. It significantly reduces gastric insufflation, lowering the chances of aspiration, improving surgical visibility, and at the same time, maintaining adequate oxygenation and other ABG parameters. Clinicians should prioritize NV oxygenation to optimize patient safety and improve surgical outcomes while performing laparoscopic procedures.

REFERENCES

1. Soper NJ, Stockmann PT, Dunnegan DL, Ashley SW. Laparoscopic cholecystectomy: The new 'gold standard'? Arch Surg 1992;127:917-21; discussion 921-3.
2. Miller RD, Eriksson LI, Fleisher LA, Wiener-Kronish JP, Cohen NH. Miller's Anesthesia. 8th ed. Philadelphia, PA: Elsevier Saunders; 2015.
3. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, *et al*. Practice guidelines for management of the difficult airway: An updated report by the American society of anesthesiologists task force on management of the difficult airway. Anesthesiology 2013;118:251-70.
4. Brimacombe J, Berry A. Cricoid pressure. Can J Anaesth 1997;44:414-25.
5. Rajan S, Joseph N, Tosh P, Kadapamannil D, Paul J, Kumar L. Effects of preoxygenation with positive pressure ventilation versus without positive pressure ventilation on oxygenation during intubation: A randomized controlled trial. J Anaesthesiol Clin Pharmacol 2018;34:200-5.
6. Pavlov I, Medrano S, Weingart S. Apneic oxygenation reduces hypoxemia during emergency intubation: A systematic review and meta-analysis. Am J Emerg Med 2017;35:1184-9.
7. Wong DT, Yee AJ, Leong SM, Chung F. The effectiveness of apneic oxygenation during tracheal intubation in various clinical settings: A narrative review. Can J Anaesth 2017;64:416-27.
8. Kim Y, Lee JH, Lee J, Park K, Choi Y, Lee SY, *et al*. Effects of mask ventilation techniques on gastric insufflation in patients undergoing laparoscopic cholecystectomy: A randomized controlled trial. BMC Anesthesiol 2023;23:14-22.
9. Van De Putte P, Perlas A. Ultrasound assessment of gastric content. Br J Anaesth 2014;113:12-22.
10. Kim Y, Lee JH, Lee J, Park K, Choi Y, Lim S, *et al*. Gastric insufflation and surgical view by mask ventilation: RCT. BMC Anesthesiol 2023;23:321.
11. He G, Ma L, Tian K, Cao Y, Qin Z. Effect of facemask oxygenation with and without positive pressure ventilation on gastric volume during anesthesia induction in patients undergoing laparoscopic cholecystectomy or partial hepatectomy: A randomized controlled trial. BMC Anesthesiol 2022;22:412.
12. Bouvet L, Mazoit JX, Chassard D, Allaouchiche B, Boselli E, Benhamou D. Clinical assessment of the ultrasonographic measurement of antral area for estimating preoperative gastric content and volume. Anesthesiology 2011;114:1086-92.

How to cite this article: Chatrath V, Attri JP, Kaur S, Pankaj. Effects on Arterial Blood Gas Parameters and Gastric Volume with or Without Facemask Ventilation during Induction in Patients Undergoing Laparoscopic Surgeries. Int J Sci Stud 2026;14(6):1-7.

Source of Support: Nil, **Conflicts of Interest:** None declared.