

A prospective comparative study of arterial blood gas parameters in smoker versus non-smoker patients undergoing laparoscopic cholecystectomy

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ABSTRACT

Background and Aims: Smoking is a risk factor for postoperative pulmonary complications in patients undergoing general anaesthesia. These may get amplified with effects of pneumo-peritoneum and carbon dioxide (CO₂) insufflation during laparoscopic surgeries. Our aim was to compare metabolic and blood gas analysis of smokers versus non-smoker patients during laparoscopic surgeries under general anaesthesia. **Methods:** After permission from institutional review board, 60 patients undergoing laparoscopic cholecystectomy were divided into two groups, smokers and non-smokers (30 each). Along with baseline haemo-dynamic parameters, arterial blood gas sampling was done to assess and compare PCO₂, pH and bicarbonate (HCO₃) values at various time intervals with respect to pneumo-peritoneum creation, between smokers and non smokers. **Results:** Baseline systolic blood pressure was higher and oxygen saturation was significantly lower in smoker group. PCO₂ and end-tidal CO₂ were significantly higher in smokers at all intervals ($P < 0.001$). pH was significantly lower and HCO₃ higher, in smokers after creation of pneumo-peritoneum. Increase in PCO₂ due to pneumo-peritoneum was higher in the smoker group (3.49 ± 8.5) mmHg versus non smoker (0.56 ± 4.86) mmHg, although statistically not significant. Change in pH and HCO₃ was similar between smokers and non-smokers. **Conclusion:** There is a significant difference in baseline arterial blood gas characteristics between smokers and non-smokers. Metabolic effects of CO₂ insufflation and increased intraabdominal pressure appears to be more enhanced in smokers.

Key words: Blood gas analysis, laparoscopic cholecystectomy, pneumoperitoneum, smoking

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INTRODUCTION

Laparoscopic procedures have almost completely replaced open procedures in a certain subset of surgeries. One of them includes laparoscopic cholecystectomy. It offers numerous advantages such as smaller incisions, reduced blood loss, postoperative pain and other complications leading to a reduced overall hospital stay.^[1] Although this type of surgery is minimally invasive, creation of pneumo-peritoneum and postural changes associated with it causes a number of physiological alterations which may have an effect on the anaesthesia management and warrant specific caution. Absorption of carbon dioxide (CO₂) used in insufflation can cause hypercapnia and respiratory acidosis. This further activates the sympathetic nervous and also sensitises the myocardium to catecholamines.

This along with a decrease in preload and venous return due to increased intraabdominal pressure may cause a gross decrease in cardiac output.^[2-4]

Tobacco smoking is an internationally accepted health hazard. Its use is estimated to kill nearly six million people worldwide every year. According to the World

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Health Organization estimates, globally, around 100 million premature deaths occurred due to tobacco in the 20th century. This number is expected to rise to 1 billion during the 21st century. The overall death rate for male smokers is 70% greater than that for male non-smokers.^[5] Chronic smoking (more than 20 pack-year at least for 10 years) causes a number of pathological changes in the respiratory system which includes inflammatory changes in the lung parenchyma, the imbalance between protease and anti-protease, oxidative stress, ciliary dysfunction, mucosal hypersecretion, airflow limitation, and pulmonary hypertension.^[6,7] As the lung function is already in a compromised state in chronic smokers, creation of pneumoperitoneum for laparoscopic surgeries in such patients further aggravates and causes an alteration in the acid-base status of the body.

The aim of this study was to compare the changes in metabolic and gas exchange status between

chronic smokers versus non-smokers in patients posted for laparoscopic cholecystectomy by analysing blood gas parameters. The objective was to evaluate and compare the effect of insufflated carbon dioxide during laparoscopic cholecystectomy on arterial blood gas (ABG) parameters like PH, PCO₂, and bicarbonate (HCO₃) during the pre-operative, intra-operative and post-operative period between smokers and non-smokers. The secondary outcome was a comparison of the change in the above blood gas parameters due to effect of pneumo-peritoneum between smokers and non-smokers.

METHODOLOGY

A prospective experimental study was carried out in our tertiary care centre over a period of 15 months, after getting permission from the institutional review board. The study was also registered on ClinicalTrials.gov (NCT03133494). 60 participants were finally analysed after the final exclusion of eligible patients at different stages of the study [Figure 1]. Patients who were posted for laparoscopic cholecystectomy were selected for the study. Informed consent was obtained from all the patients and they were allocated into following two groups; Group I: patients with a history of smoking more than 20 pack-year for more than 10 years and Group II: patients with no history of smoking. Inclusion Criteria was participants aged 20 to 60 years of both sexes planned for laparoscopic cholecystectomy. Exclusion criteria were a patient

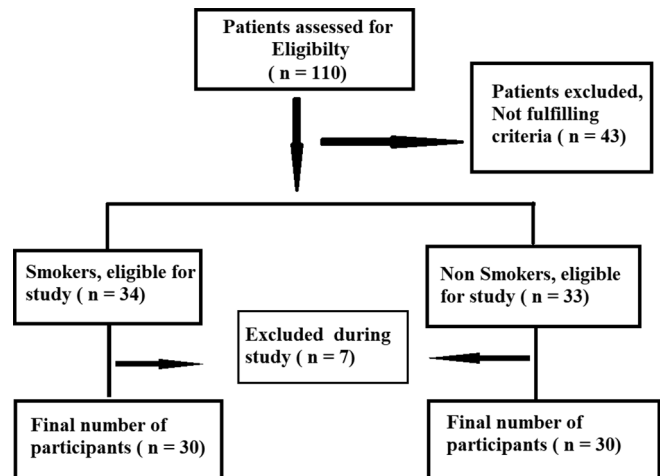


Figure 1: STROBE flowchart for recruitment of participants

refusal, ASA 3 and 4, other lung and cardiac pathologies, hypertension, uncontrolled diabetes mellitus, systemic infection, emergency operation, history of malignancy, history of alcohol or drug abuse.

Participants were recruited at the time of pre-anaesthetic evaluation. Along with that general physical examination, systemic examination and airway examination was also performed. Basic laboratory investigations like haemoglobin, total leukocyte count, differential count and platelet count, liver function test, renal function test, chest x-ray, electrocardiogram (ECG) and coagulation profile were done. Smokers were advised to abstain from smoking for at least two weeks prior to surgery and were advised incentive spirometry and nebulisation with broncho-dilators. History of any bleeding diathesis or consumption of any anticoagulants was also ruled out at that time. They were explained about benefits of smoking cessation, and compliance to advice was assessed at the time of admission (generally 1 to 2 days prior) by history and clinically as for any other routine surgery under general anaesthesia.

On the day of surgery patient after confirming fasting status, signed consent and going through the safety checklist, the patient was shifted to the operation theatre. All the standard monitors were attached which includes ECG monitor, pulse oximeter, non-invasive blood pressure and capnography monitor. Baseline haemo-dynamic parameters were recorded. Intravenous (IV) fentanyl (2 µg/kg) was given prior to induction. Surgery was carried out under general anaesthesia with propofol (1–2.5 mg/kg) for induction and vecuronium (0.1 mg/kg) to facilitate tracheal intubation. After pre-oxygenation with 100% oxygen

for 3 min, the trachea was intubated with appropriate size endotracheal tube, which was confirmed by bilateral equal air entry, adequate chest-rise and capnography. Anaesthesia was maintained with oxygen, air and sevoflurane along with intermittent doses of vecuronium bromide (0.01 mg/kg).

Ventilation was initially maintained with a tidal volume (TV) of 8 ml/kg with a respiratory rate of 12/min followed by TV of 6 mL/kg with the rate of 16/min after the creation of pneumoperitoneum (in both groups). Patients were placed in 15–20° reverse Trendelenburg position during surgery. During laparoscopy, intraabdominal pressure (IAP) was maintained at 12 mmHg. For the purpose of the study, we allowed permissive hypercapnia till the point of any haemo-dynamic derangement or prolongation of pneumo-peritoneum (more than 40 min). The CO₂ was completely evacuated at the end of surgery. After completion of surgery neuro-muscular blockade was reversed with neostigmine and glycopyrrolate. All patients were monitored for 12 h postoperatively.

Before drawing the ABG sample modified Allen's test was performed to check the patency of collateral vessels. Under all aseptic precautions, samples were drawn from the patient after infiltrating the area with 1–2 mL 2% lignocaine with adrenaline (when awake). The sample was drawn in 3 different settings with the help of 2 mL heparinised syringe. The first sample was drawn 10 min before induction, the next sample was drawn 10 min after pneumo-peritoneum and head down position and third and last sample were drawn 30 min after extubation. Demographic parameters, baseline haemodynamic parameters were noted. End-tidal carbon dioxide (ETCO₂) levels were noted before the creation of pneumo-peritoneum, after pneumo-peritoneum and after deflation of pneumo-peritoneum. pH, PCO₂ and HCO₃ were recorded from the three ABG samples drawn.

Sample size: In a pilot study conducted by us, the response (PCO₂) within each subject group was normally

distributed with a standard deviation of 7.5 mmHg. To be able to detect a difference in the smoker versus non-smoker groups of 6.53 mmHg (pilot study), we needed to study 28 experimental subjects and 28 control subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with a power 0.9 and type I error of 0.05. A total of 62 participants was the final number to account for 10% attrition.

Statistical Analysis: The statistical analysis was done using SPSS for Windows version 16.0 software. For categorical data, the Chi-square test was used. For comparing two independent study groups unpaired student 't' test was used. Normality of data was tested using the Kolmogorov-Smirnov test. The critical value of 'P' indicating the probability of significant difference was taken as <0.05 for comparison.

RESULTS

Demographic data: in the smoker group, out of 30 participants 25 were male (83.3%) and 5 were females (16.7%). In the non-smoker group, females (60%) were more than male (40%). Mean duration of pneumo-peritoneum was similar in both groups (25.1 ± 2.93 min in smokers versus 24.96 ± 2.72 min in non-smokers, *P* value = 0.875). Both groups had no differences in mean age (*P* = 0.221), [Table 1]. There was no significant difference between mean heart rate, diastolic blood pressure, and mean arterial pressure between two groups. But the difference between systolic blood pressure (*P* = 0.002) and oxygen saturation were significant (*P* = 0.001), [Table 1].

Values of PCO₂ and ETCO₂ were significantly higher in the smoker group at all stages of sampling and measurement (*P* < 0.001). There was no significant difference in mean baseline pH values but was significantly lower in smokers after pneumo-peritoneum and after extubation. Bicarbonate values were significantly higher in the smoker group at all time intervals [Table 2].

Table 1: Comparison of demographic and baseline clinical parameters between smokers and non-smokers

Parameter	Smokers	Non-smokers	t	P#
Age (years)	44.07±6.68	43.50±8.072	2.911	0.221
Heart rate	79.20±7.48	77.07±6.43	1.185	0.241
Systolic blood pressure (mmHg)	131.80±8.83	123.07±11.66	3.271	0.002*
Diastolic blood pressure (mmHg)	77.60±7.17	74.60±7.17	1.621	0.110
Mean arterial pressure (mmHg)	85.93±6.11	83.13±6.45	1.726	0.090
SPO ₂ (%)	98.47±0.51	98.87±0.35	-3.568	0.001*

#Unpaired Student t-test, **P*<0.01 significant

Table 2: Comparison of blood gas parameters at various intervals between smokers and non-smokers

Parameter	Smokers	Non Smokers	t	P*
ETCO ₂ values (mmHg)				
Pre pneumo-peritoneum	40.63±4.81	35.30±2.20	5.523	<0.001
During pneumo-peritoneum	45.80±5.06	37.73±2.10	8.064	<0.001
After pneumo-peritoneum	43.77±5.52	35.67±2.34	7.401	<0.001
pH				
Pre pneumo-peritoneum	7.39±0.049	7.40±0.034	-0.968	0.337
During pneumo-peritoneum	7.36±0.049	7.38±0.035	-2.508	0.015
After pneumo-peritoneum	7.36±0.043	7.40±0.030	-4.211	<0.001
HCO ₃ (mmol/L)				
Pre pneumo-peritoneum	24.91±2.98	22.24±2.19	3.970	<0.001
During pneumo-peritoneum	25.11±3.132	23.20±1.38	3.056	0.003
After pneumo-peritoneum	24.47±2.99	22.44±1.22	3.446	<0.001
PCO ₂ (mmHg)				
Pre pneumo-peritoneum	42.34±6.77	36.37±3.31	4.343	<0.001
During pneumo-peritoneum	45.83±6.18	36.93±3.00	7.098	<0.001
After pneumo-peritoneum	44.53±5.72	36.82±3.015	6.523	<0.001

*Unpaired student t-test, P<0.05 is significant

Increase in PCO₂ due to creation of pneumo-peritoneum was higher in the smoker group, although not statistically significant (P = 0.107). Increase in HCO₃ and decrease in pH due to pneumo-peritoneum was similar in both smokers and non-smokers [Table 3].

DISCUSSION

There have been numerous studies conducted to analyse the effect of pneumo-peritoneum on clinical and biochemical parameters.^[8-12] To the best of our knowledge, very few studies have analysed the effect of chronic smoking on such surgeries and on the changes produced by the effect of CO₂ and pneumo-peritoneum,^[13-15] more so on biochemical changes. Smoking is known to decrease pulmonary function and is associated with physical abnormalities of the chest wall. Reduction in chest expansion arising from reduced flexibility could lead to a vulnerability to CO₂ retention.^[16,17] Robot-assisted pelvic laparoscopic surgeries, which may extend for longer durations can further increase chances of postoperative pulmonary complications, especially in smokers.^[18]

In the current study, no differences were observed in baseline hemodynamic parameters except systolic blood pressure and oxygen saturation. Systolic blood pressure was significantly higher in the smoker group possibly due to the effect of stimulation of the sympathetic system in such patients. Oxygen saturation was lower in the smoker group, which is also in keeping with most literature including a study published by Tait *et al.* on smokers undergoing general anaesthesia.^[7]

Table 3: Comparison of change in blood gas parameters due to pneumo-peritoneum between smokers and non-smokers

Parameter	Smokers	Non-smokers	t	P*
Increase in PCO ₂ (mmHg)	3.49±8.5	0.56±4.86	1.64	0.107
Increase in HCO ₃ (mmol/L)	0.2±0.96	0.97±1.92	1.59	0.117
Decrease in pH	0.004±0.006	0.002±0.04	1.27	0.209

*Unpaired student t-test, P<0.05 is significant

The relationship between ETCO₂ and PCO₂ during laparoscopic surgeries is well established.^[19] In the present study, ETCO₂ and PCO₂ values were significantly higher in the smoker group at all time intervals including the baseline. Kelman *et al.* in a study on arterial blood gas tension during laparoscopy observed that there was a significant increase in ETCO₂ from the baseline (34 ± 0) at 30 and 40 min interval (39 ± 0.4) and (41 ± 0.3), respectively after insufflations and after exsufflation the ETCO₂ became comparable with the baseline (36 ± 0.8).^[8] Although not observed in smokers these findings are in keeping with the present study.

In our current study, pH values were significantly lower and bicarbonate was significantly higher during the period of pneumo-peritoneum in the smoker group compared to non-smokers. This is in keeping with the higher chances of metabolic acidosis which may occur due to the effects of CO₂ insufflation and hypoventilation during such surgeries. A study by Zulfikaroglu *et al.* also brought out similar metabolic changes in patients undergoing laparoscopic surgery, although not specifically in smokers.^[10]

In the current study, the change in PCO₂ value due to the effect of pneumo-peritoneum in the smoker group

was higher than a non-smoker, which although not statistically significant, indicates that CO₂ retention may be more common in smokers undergoing laparoscopic procedures. Similarly, change in pH and bicarbonate due to effect of pneumo-peritoneum was also not significantly different between smokers and non-smokers. The reason for this might be the shorter duration of these surgeries and head-up position; which might not be sufficient to bring out any substantial or significant metabolic difference between smokers and non-smokers.

Graybill *et al.* in a study assessing peri-operative outcomes in gynaecological laparoscopic procedures concluded no significant difference between smokers and non-smokers.^[14] In contrast, Landin *et al.* found smoking to be a modifiable risk factor in laparoscopic inguinal hernia surgeries and found a significant association between smoking and postoperative pulmonary complications.^[15]

Limitations of the study were as follows. PO₂ changes were not analysed. This was a single-centre study; multi-centric studies can be planned in the future. Gender distribution was not similar in the two study groups. Duration of surgeries was not long enough to be able to appreciate the significant change in blood gas parameters with the effect of pneumo-peritoneum. Head up surgical position might offset effects of increased IAP, and thus may not produce significant effects as compared to other laparoscopic procedures like urological surgeries requiring head-down tilt. Also, most of the smokers were optimised prior to surgery, thus stark differences due to any acute changes could not have been demonstrated due to ethical issues related to the continuation of smoking in the peri-operative period.

CONCLUSIONS

There is a significant difference in baseline arterial blood gas characteristics between smokers and non-smokers. Metabolic effects of CO₂ insufflation and increased IAP appear to be more enhanced in smokers. Laparoscopic cholecystectomy, because of its shorter duration and head-up position may offset the effects of pneumo-peritoneum and CO₂ retention to a certain extent. Smokers coming for laparoscopic surgery should be optimised aggressively, with special caution in longer duration surgeries with steep positions.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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