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Original Research Article

The Effect of Pneumoperitoneum on Arterial Blood Gas and Ventilatory Parameters between Smokers and Non-Smokers in Patients Undergoing Laparoscopic Cholecystectomy under General Anaesthesia: A Comparative Study

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Conflict of interest: Nil

Abstract

Background and Aim: Laparoscopic cholecystectomy, while minimally invasive, involves creation of pneumoperitoneum, inducing physiological changes that can be exacerbated by smoking. This study compares the impact of pneumoperitoneum on arterial blood gas (ABG) and ventilatory parameters in smokers versus non-smokers undergoing this procedure.

Methodology: A prospective, comparative study was conducted on smokers and non-smokers undergoing laparoscopic cholecystectomy under general anaesthesia. ABG parameters (pH, pCO2, HCO3, Lactate) and ventilatory parameters (ETCO2, PEEP, Ppeak) were measured at baseline, during pneumoperitoneum, and post-extubation. Hemodynamic parameters, oxygen saturation and occurrence of complications were also compared.

Result: Smokers exhibited significantly lower pH, higher pCO2, and elevated lactate levels compared to non-smokers during pneumoperitoneum and post-extubation ($p<0.05$). ETCO2 levels were higher in smokers at all time intervals ($p<0.001$) and Ppeak was significantly higher in smokers post-pneumoperitoneum. There were significant haemodynamic changes in smokers compared to non-smokers at various time intervals. There were no statistically significant differences in complication rates between the two groups.

Conclusion: Smokers demonstrated altered ABG and ventilatory parameters during laparoscopic cholecystectomy with pneumoperitoneum, indicating greater respiratory and metabolic stress. This highlights the need for tailored perioperative management in smokers.

Keywords: Laparoscopic Cholecystectomy, Pneumoperitoneum, Smoking, Arterial Blood Gas, Ventilatory Parameters.

Introduction

Advancements in minimally invasive surgical techniques have revolutionized surgical practices over the past few decades. Laparoscopic cholecystectomy, often performed for symptomatic gallstone disease, is one such procedure that exemplifies the benefits of minimally invasive surgery due to their reduced morbidity, shorter hospital stays, and quicker recovery times compared to traditional open surgeries.[1] Despite its advantages, the technique involves the creation of pneumoperitoneum, which induces a variety of physiological changes that can influence perioperative management, particularly in patients with pre-existing comorbidities or risk factors such as smoking.[2] Pneumoperitoneum however, leads to increased intra-abdominal pressure and subsequent alterations in respiratory mechanics, cardiovascular function, and acid-base balance.[3] Arterial blood gas (ABG) analysis is a critical tool for monitoring these physiological changes, providing real-time data on acid-base status, oxygenation, and ventilation.[4] Smoking, a well-established risk factor for various perioperative complications, adds another layer of complexity to

the management of patients undergoing laparoscopic cholecystectomy.[5] Chronic exposure to cigarette smoke leads to pathological changes in pulmonary and cardiovascular systems, including airway inflammation, impaired mucociliary clearance, increased airway resistance, and reduced gas exchange efficiency.[6,7] Nicotine and other chemicals in tobacco also have systemic effects, including increased sympathetic tone, higher peripheral vascular resistance, and altered cardiac function.[8] These changes predispose smokers to adverse intraoperative and postoperative outcomes, particularly during surgeries involving pneumoperitoneum.

Aim & Objective: The aim is to compare the changes in metabolic and gas exchange status between chronic smokers versus non-smokers undergoing laparoscopic cholecystectomy by analysing arterial blood gas and ventilatory parameters. The objectives are to compare and evaluate the effect of pneumoperitoneum between smokers and non-smokers in view of -

1. ABG parameters like pH, partial pressure of CO2 in arterial blood PCO2, bicarbonate [HCO3] and lactate levels and ventilatory parameters like ETCO2, positive end expiratory pressure (PEEP) and Ppeak (peak airway pressure).
2. Perioperative haemodynamic and oxygen saturation changes.
3. Occurrence of complications.

Material & Methods

Study Design: Comparative observational study.

Study Site: Department of Anaesthesiology and Critical Care, Fakhruddin Ali Ahmed Medical College and Hospital, Barpeta.

Study Duration: One year.

Sample Size: A total of **60 patients** fulfilling the inclusion criteria were included in the study, with **30** patients in each group i.e. smoker and non-smoker.

Inclusion Criteria

Patients were included in the study based on the following criteria:

- Age group: 30 to 70 years.
- Sex: Male (considering cultural prevalence).
- ASA grading of physical status: Grade 1 and 2.
- Patients scheduled for laparoscopic cholecystectomy under general anaesthesia.

Exclusion Criteria

The following patients were excluded from the study:

- Patients who refused to participate.
- ASA Grade 3 and 4 patients.
- Patients with systemic infections.
- History of malignancy.
- Patients with renal or hepatic insufficiency.
- Those with endocrine or metabolic disorders.
- Emergency surgical cases.
- Patients with a history of drug abuse.
- Cases which needed to be converted to open procedure.

Preoperative Preparation: A comprehensive pre-anaesthetic evaluation was conducted preoperatively. Smokers were asked to abstain from smoking for at least 2 weeks prior to surgery to minimize perioperative pulmonary complications. All the routine laboratory investigations were done and recorded. On the evening before the surgery, written informed consent was taken.

Preoperative fasting guidelines were strictly adhered. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and oxygen saturation (SPO2) were recorded.

Intraoperative Preparation

Anaesthesia Induction and Maintenance

Preoxygenation: Conducted for 3 minutes.

Premedication: Inj. Glycopyrrolate (0.2 mg), Inj. Fentanyl (1 mcg/kg), and Inj. Ondansetron (4 mg) were administered intravenously.

Induction: Inj. Propofol (2 mg/kg) intravenous (iv) was used for induction.

Neuromuscular Blockade:

- Inj. Succinylcholine (1.5 mg/kg) iv for intubation.
- Inj. Atracurium besylate (0.5 mg/kg) iv for loading dose and 0.1mg/kg for maintenance intravenously, repeated at 20-25 minutes intervals.

Maintenance of Anaesthesia: Achieved with a mixture of nitrous oxide (N_2O) and oxygen (O_2) in a 2:1 ratio, along with Sevoflurane (1-1.5 MAC).

Reversal of Neuromuscular Blockade: Inj. Neostigmine (0.05 mg/kg) and Inj. Glycopyrrolate (0.01 mg/kg) were administered intravenously before extubation.

Ventilation Management

Pre-Pneumoperitoneum: Tidal volume (TV) of 6 mL/kg and respiratory rate (RR) of 12 breaths/min.

After Pneumoperitoneum when ABG sampling results received and ventilatory parameters were recorded:

- TV adjusted to 7 mL/kg.
- RR increased to 16 breaths/min to compensate for CO_2 absorption.

- Intra-abdominal pressure maintained at 12 mmHg.
- Permissive hypercapnia allowed unless haemodynamic instability occurred.

Post-Pneumoperitoneum:

CO_2 evacuated at the end of the surgery, and ventilation adjusted to baseline parameters.

1. Ventilatory parameters ($ETCO_2$, PEEP, Ppeak) were recorded.

Arterial Blood Gas Sampling

Procedure: Modified Allen's test was performed to ensure the patency of the collateral vessels of the hand.

Drawing the sample

- Site cleaned with alcohol swab.
- Artery palpated and stabilised.
- Needle inserted at a 30-45^{o} angle for the radial artery.
- Pulsatile blood flow into the syringe seen.
- Needle withdrawn and firm pressure applied with gauze for at least 5 minutes.

Sample Handling

- Air bubbles removed from the syringe.
- Syringe capped and sample was gently mixed by rolling it.
- Sample given at the cartridge and put into the analyser.

Sampling Points

Pre-induction: 5 minutes before anaesthesia induction.

During Surgery: After completion of pneumoperitoneum and establishment of Reverse Trendelenburg position.

Post-Surgery: 1 hour post operatively.

Parameters Assessed: pH, PCO_2, bicarbonate (HCO_3^-), and lactate levels.

Postoperative Monitoring: Patients were monitored for 12 hours postoperatively for vital parameters, oxygen saturation, and any complications related to pneumoperitoneum or anaesthesia. Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), Heart Rate (HR) and Oxygen saturation (SPO2) were recorded at various time intervals both in the intraoperative and postoperative periods.

Results

Table 1: Comparison of Arterial blood gas parameters between Smokers and Non-smokers.

ABG Parameters	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
pH						
5 mins before induction	7.36	0.01	7.38	0.01	-6.52	**.336**
after PP	7.33	0.01	7.36	0.01	-9.42	**.018**
1 hr after extubation	7.34	0.01	7.36	0.01	-9.15	**<0.001**
pCO2 (mmHg)						
5 mins before induction	40.99	1.16	36.88	0.91	15.29	**<0.001**
after PP	45.24	0.84	38.39	1.01	28.61	**<0.001**
1 hr after extubation	44.03	1.04	37.47	0.96	25.24	**<0.001**
HCO3 (mmol/L)						
5 mins before induction	23.65	0.82	22.85	0.35	4.93	**<0.001**
after PP	24.85	0.76	23.53	0.42	8.39	**.023**
1 hr after extubation	23.73	0.85	22.71	0.40	5.96	**<0.001**
Lactate (mmol/L)						
5 mins before induction	1.07	0.27	0.52	0.08	10.65	**.045**
after PP	2.10	0.36	1.02	0.34	12.04	**<0.001**
1 hr after extubation	1.72	0.35	0.47	0.15	17.97	**.003**

Table 1 compares arterial blood gas (ABG) parameters—pH, pCO2, HCO3, and lactate—at different time points (5 minutes before induction, after pneumoperitoneum, and 1 hour after extubation) between smokers and non-smokers.

pH: Before induction, pH values were comparable ($p = 0.336$). After pneumoperitoneum and 1 hour after extubation, smokers showed significantly lower pH levels ($p = 0.018$ and <0.001, respectively).

pCO2 (mmHg): Smokers consistently exhibited higher pCO2 levels at all time points, with highly significant differences ($p = <0.001$).

HCO3 (mmol/L): Smokers had significantly higher HCO3 levels at all time points ($p = <0.001$, except after pneumoperitoneum where $p = 0.023$).

Lactate (mmol/L): Smokers demonstrated significantly elevated lactate levels across all time points ($p = 0.045$, <0.001, and 0.003, respectively).

Overall, smokers had altered ABG parameters compared to non-smokers, reflecting potential differences in respiratory function and metabolic response during laparoscopic cholecystectomy.

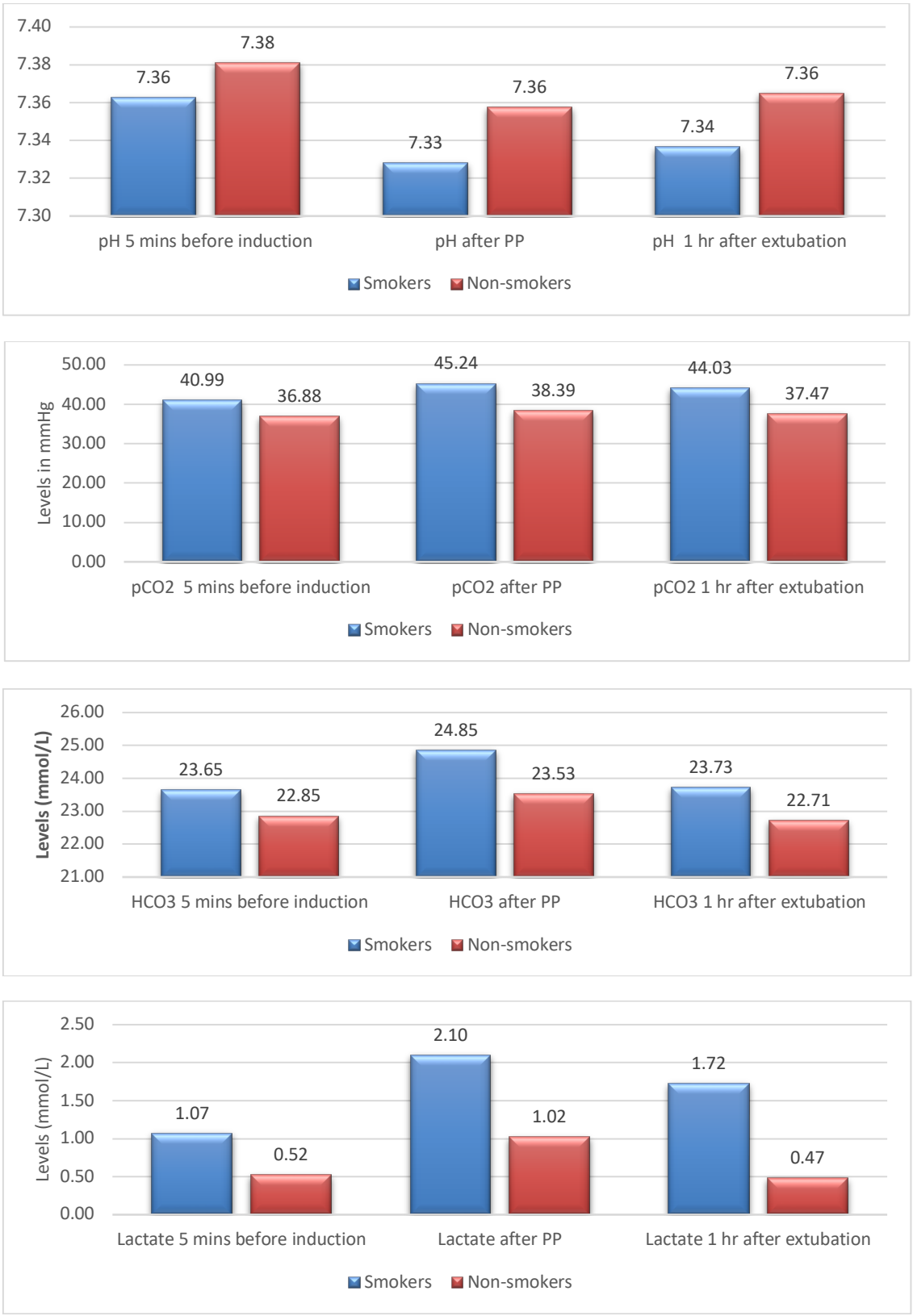


Figure 1: Comparison of Arterial blood gas parameters between Smokers and Non-smokers

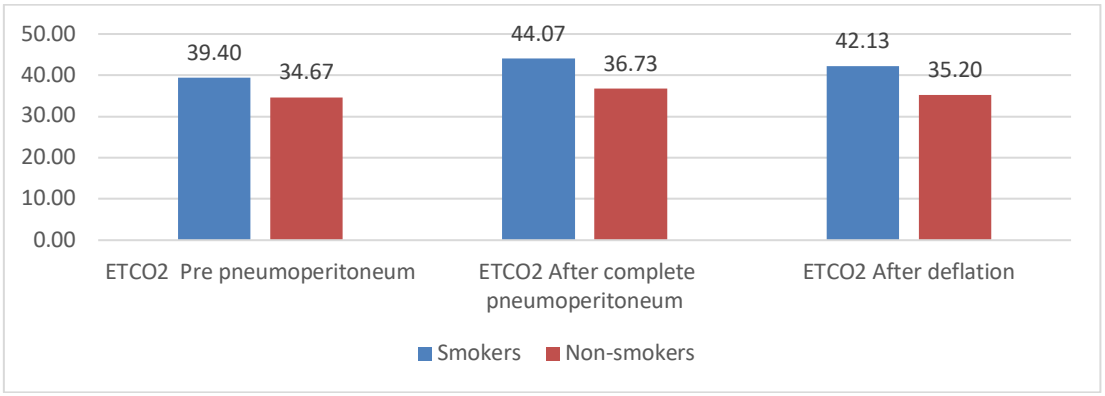
Table 2: Comparison of Ventilatory parameters between Smokers and Non-smokers.

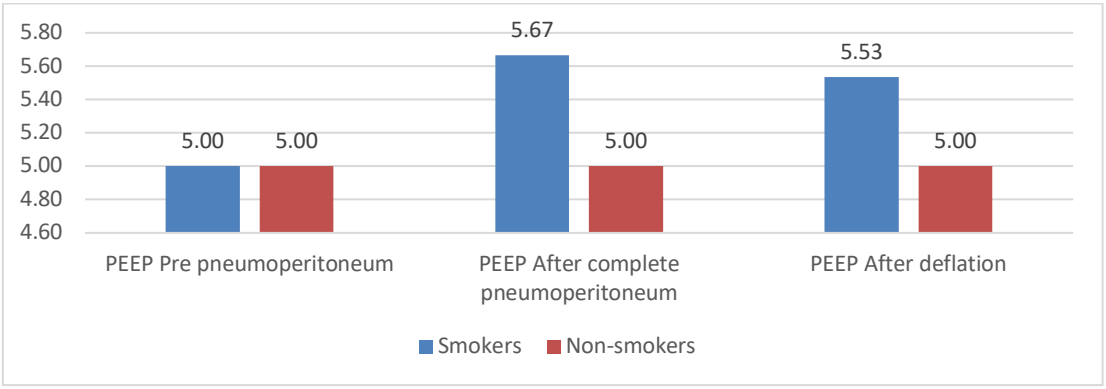
Ventilatory Parameters	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
ETCO2 (mmHg)						
Pre pneumoperitoneum	39.40	0.89	34.67	0.71	22.69	**<0.001**
After complete pneumoperitoneum	44.07	0.87	36.73	0.94	31.31	**<0.001**
After deflation	42.13	0.73	35.20	0.85	33.96	**<0.001**
PEEP (cm of H2O)						
Pre pneumoperitoneum	5.00	.000	5.00	.000	5.13	**0.091**
After complete pneumoperitoneum	5.67	0.48	5.00	0.53	5.76	**0.072**
After deflation	5.53	0.51	5.00	0.00	3.70	**0.056**
Ppeak (cm of H2O)						
Pre pneumoperitoneum	15.13	0.73	14.53	0.51	12.19	**0.072**
After complete pneumoperitoneum	19.93	1.36	16.40	0.81	9.37	**<0.001**
After deflation	18.07	1.41	15.13	0.97	8.57	**0.074**

Table 2:

Compares ventilatory parameters, including ETCO2, PEEP, and Ppeak, between smokers and non-smokers at various time points.

- ETCO2 (mmHg): Smokers had significantly higher ETCO2 levels pre-pneumoperitoneum, after complete pneumoperitoneum, and after deflation ($p < 0.001$ for all comparisons).
- PEEP (cm of H2O): Differences in PEEP between smokers and non-smokers were not statistically significant at any time point ($p > 0.05$).
- Ppeak (cm of H2O): Smokers had significantly higher Ppeak after complete pneumoperitoneum ($p < 0.001$), but differences pre-pneumoperitoneum and after deflation were not statistically significant.





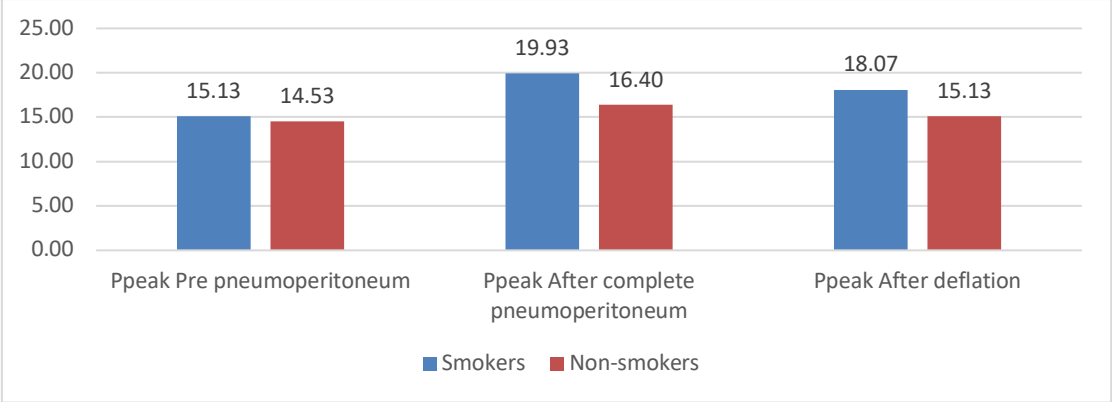


Figure 2: Comparison of Ventilatory parameters between Smokers and Non-smokers.

Table 3: Comparison of Heart rate between Smokers and Non-smokers.

Heart Rate (bpm)	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
Baseline	76.93	7.90	75.47	4.85	0.95	**.348**
Induction	77.67	7.91	76.00	5.51	0.87	**.390**
Intubation	88.53	7.93	83.00	5.32	3.17	**.002**
During pneumoperitoneum	91.07	7.95	85.20	5.22	3.38	**.001**
After positioning	85.80	7.20	79.20	5.11	4.09	**<0.001**
After deflation	82.87	8.10	79.33	5.42	1.99	**.052**
At extubation	85.80	7.91	81.47	4.52	2.61	**.012**
30 min after extubation	79.00	6.87	76.60	5.04	1.54	**.128**
1 hr after extubation	78.60	8.13	77.00	4.86	0.93	**.358**

Table 3:
Shows heart rate comparisons at different time points.

- Smokers had significantly higher heart rates at intubation ($p = 0.002$), during pneumoperitoneum ($p = 0.001$), after positioning ($p < 0.001$), and at extubation ($p = 0.012$).
- Heart rate differences at baseline, induction, 30 minutes after extubation, and 1 hour after extubation were not statistically significant ($p > 0.05$).

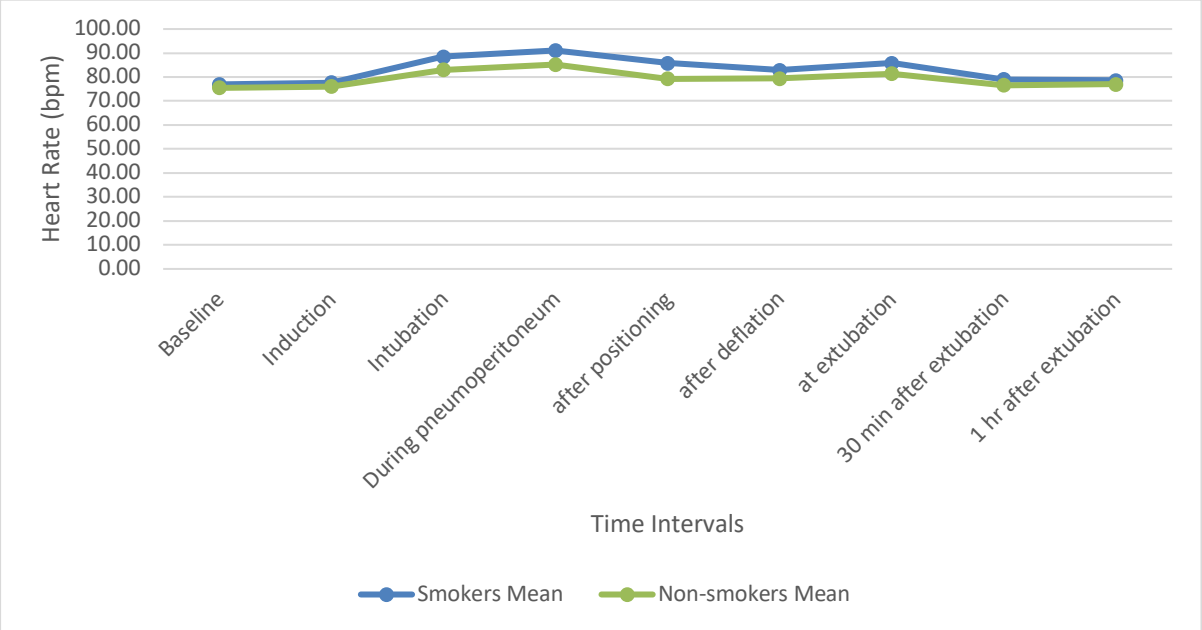


Figure 3: Comparison of Heart rate between Smokers and Non-smokers.

Table 4: Comparison of Systolic Blood Pressure between Smokers and Non-smokers.

Systolic Blood Pressure (mmHg)	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
Baseline	141.80	9.06	134.07	9.64	3.20	**.002**
Induction	141.27	8.53	133.80	9.37	3.23	**.002**
Intubation	145.60	8.97	138.27	9.44	3.08	**.003**
During pneumoperitoneum	146.80	8.40	139.87	9.63	2.97	**.004**
After positioning	144.20	8.62	138.67	9.55	2.36	**.022**
After deflation	143.40	8.19	136.20	9.53	3.14	**.003**
At extubation	146.13	8.35	139.60	10.10	2.73	**.008**
30 min after extubation	143.00	8.30	135.13	9.54	3.41	**.001**
1 hr after extubation	142.60	8.43	135.13	9.82	3.16	**.003**

Table 4:

Compares systolic blood pressure (SBP) at various time points.

- Smokers consistently had significantly higher SBP than non-smokers at all time points, including baseline (p = 0.002), induction (p = 0.002), intubation (p = 0.003), during pneumoperitoneum (p = 0.004), and after deflation (p = 0.003).
- Differences were also significant at extubation (p = 0.008), 30 minutes after extubation (p = 0.001), and 1 hour after extubation (p = 0.003).
- This indicates that smokers exhibited consistently higher haemodynamic responses compared to non-smokers.

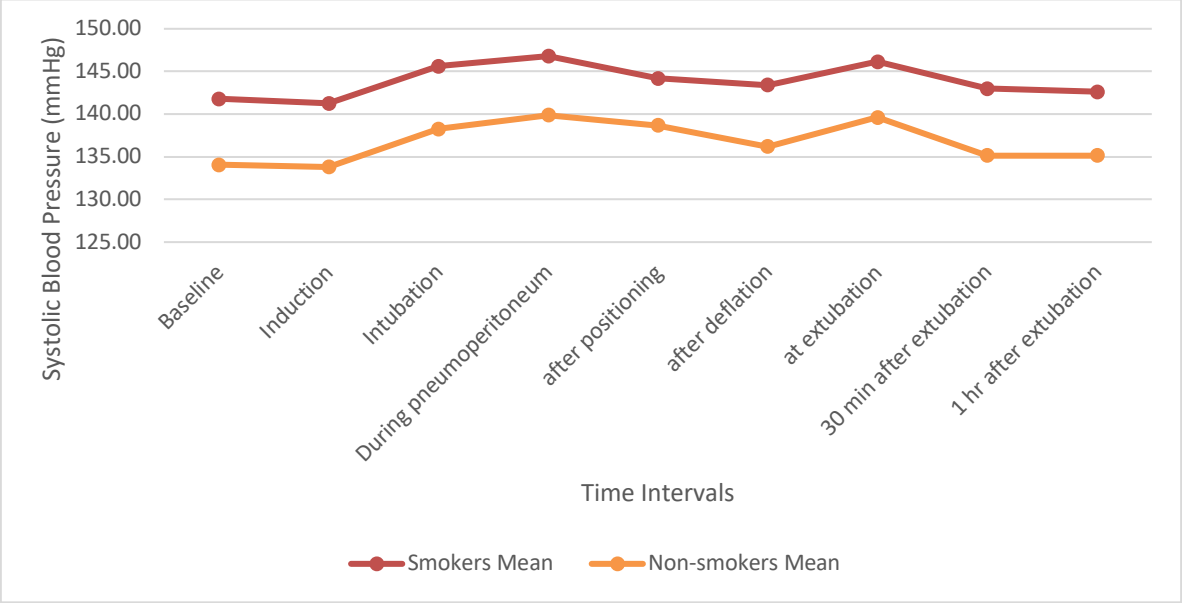


Figure 4: Comparison of Systolic Blood Pressure between Smokers and Non-smokers.

Table 5: Comparison of Diastolic Blood Pressure between Smokers and Non-smokers.

Diastolic Blood Pressure (mmHg)	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
Baseline	92.53	19.15	86.60	5.31	1.64	**.107**
Induction	87.00	7.03	86.07	5.34	0.58	**.565**
Intubation	91.60	6.54	90.73	5.36	0.56	**.049**
During pneumoperitoneum	92.87	4.99	92.47	5.66	0.29	**.043**
After positioning	91.73	5.30	91.20	5.76	0.37	**.710**
After deflation	88.73	6.20	90.00	5.37	-0.85	**.401**
At extubation	91.73	5.83	92.87	5.76	-0.76	**.037**
30 min after extubation	88.40	5.34	87.60	5.17	0.59	**.558**
1 hr after extubation	87.73	6.35	86.40	4.44	0.94	**.350**

Table 5 Compares diastolic blood pressure (DBP) at different time points.

- Smokers showed slightly higher DBP at intubation (p = .049), during pneumoperitoneum (p = .043), and at extubation (p = .037).
- At other time points (baseline, induction, after positioning, after deflation, and during recovery), the differences were not statistically significant (p > .05).

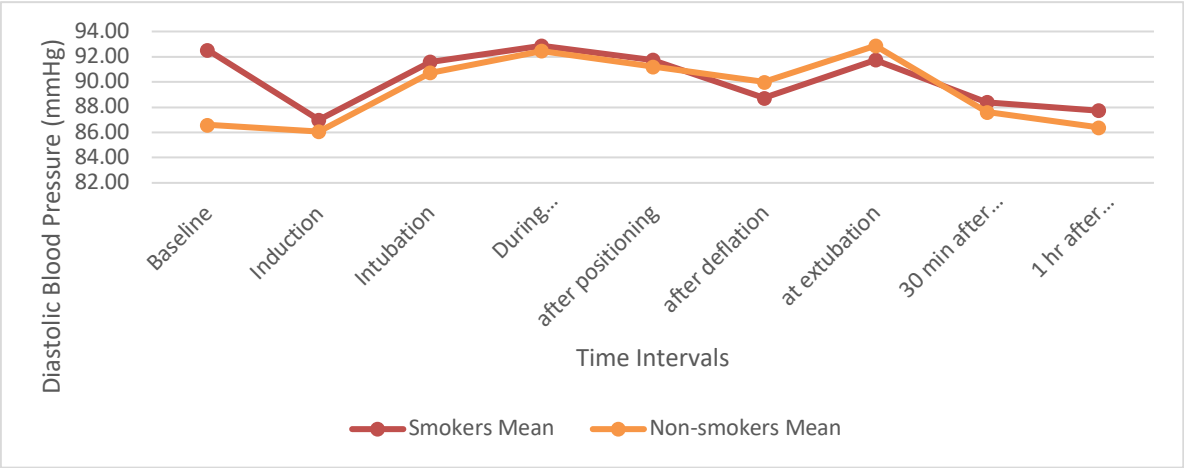


Figure 5: Comparison of Diastolic Blood Pressure between Smokers and Non-smokers.

Table 6: Comparison of Mean Arterial Pressure between Smokers and Non-smokers.

Mean arterial Pressure (mmHg)	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
Baseline	105.80	6.67	102.53	6.17	1.97	**.044**
Induction	105.13	6.82	101.87	5.79	2.00	**.053**
Intubation	109.60	6.70	106.47	6.09	1.89	**.043**
During pneumoperitoneum	110.87	5.24	108.20	6.40	1.77	**.024**
After positioning	109.47	5.29	107.00	6.38	1.63	**.108**
After deflation	106.87	6.06	105.13	6.63	1.06	**.295**
At extubation	109.87	6.09	108.47	6.76	0.84	**.003**
30 min after extubation	106.80	5.92	103.53	6.00	2.12	**.058**
1 hr after extubation	105.53	6.36	102.60	5.57	1.90	**.062**

Table 6 compares mean arterial pressure (MAP) between smokers and non-smokers.

- Smokers had significantly higher MAP at baseline (p = .044), intubation (p = .043), during pneumoperitoneum (p = .024), and at extubation (p = .003).
- The differences at induction, positioning, deflation, and recovery were either marginal or not statistically significant (p > .05).

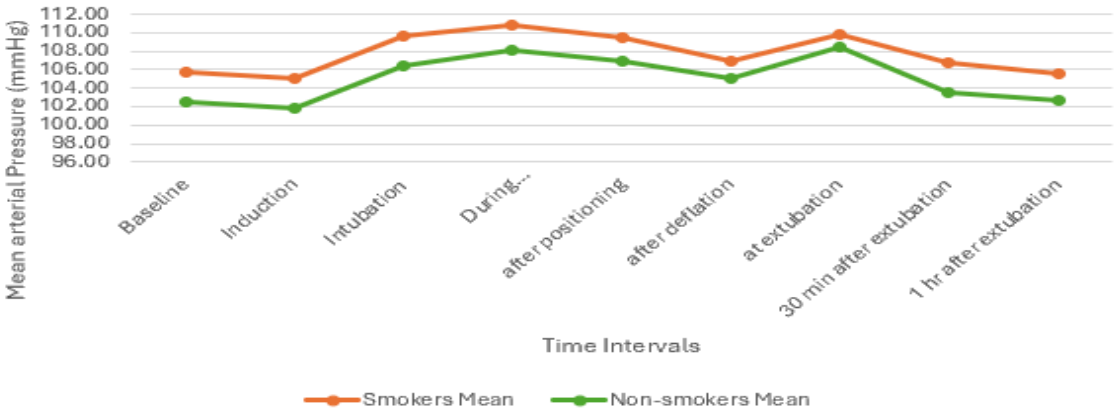


Figure 6: Comparison of Mean Arterial Pressure between Smokers and Non-smokers.

Table 7: Comparison of SpO2 between Smokers and Non-smokers.

SpO2 (%)	Smokers		Non-smokers		t	P-value
	Mean	Standard Deviation	Mean	Standard Deviation		
Baseline	98.33	1.09	98.93	0.69	2.54	**.014**
Induction	99.93	0.25	100.00	0.00	1.44	**.155**
Intubation	99.87	0.35	99.93	0.25	0.85	**.398**
During pneumoperitoneum	97.73	0.78	98.73	0.58	5.60	**<0.001**
After positioning	98.07	0.58	98.93	0.45	6.44	**<0.001**
After deflation	98.80	0.55	98.93	0.45	1.03	**.309**
At extubation	98.73	0.87	99.33	0.48	3.31	**.002**
30 min after extubation	97.93	0.94	98.40	0.50	2.39	**.020**
1 hr after extubation	97.47	1.04	98.20	0.66	3.25	**.002**

Table 7:

Presents SpO2 levels between smokers and non-smokers across various time points.

- Smokers consistently exhibited significantly lower SpO2 at baseline ($p = 0.014$), during pneumoperitoneum ($p < .001$), after positioning ($p < .001$), at extubation ($p = .002$), and during recovery at 30 minutes ($p = .020$) and 1 hour ($p = .002$) post-extubation.
- At induction, intubation, and deflation, the differences were less pronounced or non-significant ($p > .05$).

This indicates smokers had reduced oxygen saturation during critical surgical and recovery phases compared to non-smokers.

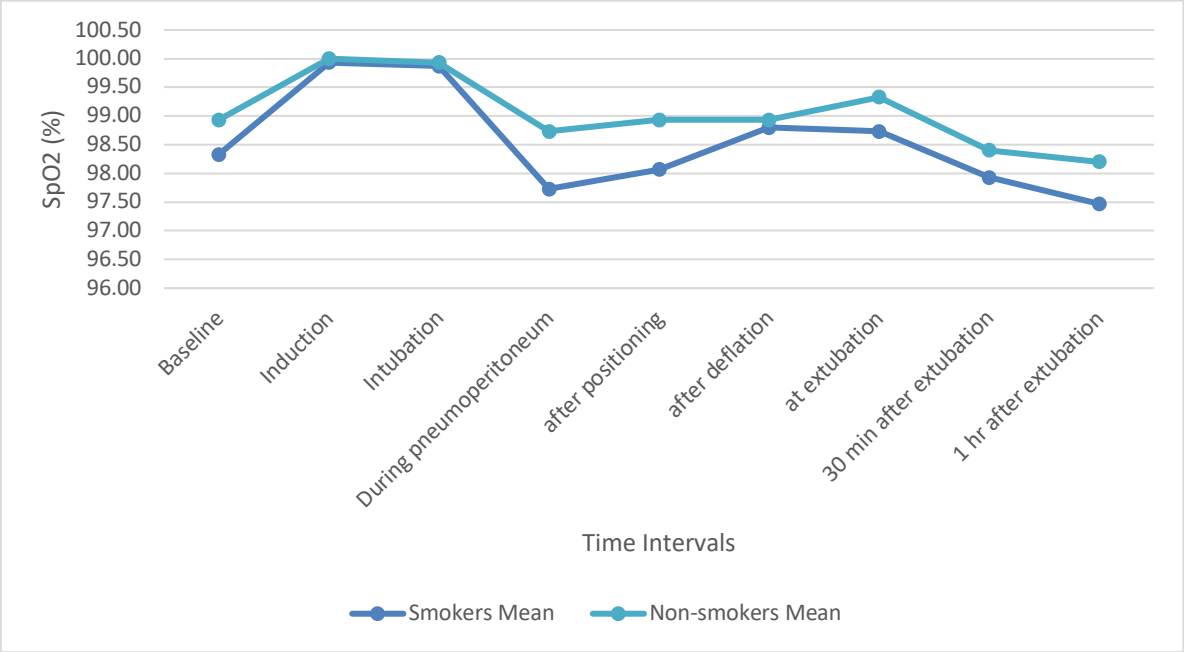


Figure 7: Comparison of SpO2 between Smokers and Non-smokers.

Table 8: Comparison of complications occurring after Laparoscopic Cholecystectomy between Smokers and Non-smokers.

Complications	Smokers		Non-smokers	
	Frequency	Percentage	Frequency	Percentage
Present (Bowel injury)	**0**	**0.00%**	**1**	**3%**
Absent	**30**	**100.00%**	**29**	**97%**
Total	**30**	**100.0%**	**30**	**100.0%**

Table 8: Presents the incidence of post-operative complications in smokers and non-smokers following laparoscopic cholecystectomy. In the study population, no bowel injuries were observed among smokers (0.00%), whereas one case (3%) of bowel injury occurred in the non-smoker group. The majority of patients in both groups did not experience any complications, with 100% of

smokers and 97% of non-smokers remaining complication-free. These findings suggest a low overall complication rate in both groups, with no significant difference between smokers and non-smokers regarding bowel injury in this study.

Discussion

Smoking has long been recognised as a significant factor influencing perioperative outcomes, particularly in patients undergoing laparoscopic cholecystectomy.[6,7,8]

Primary Objectives

ABG parameters comparison: The observed differences in ABG parameters between smokers and non-smokers reflect potential disparities in respiratory function and metabolic response during laparoscopic cholecystectomy. The findings suggest that smokers may experience more pronounced metabolic effects due to CO2 insufflation and pneumoperitoneum.

In a study by Barik et al. (2020) between smokers and non-smokers undergoing laparoscopic surgeries under general anaesthesia, the results showed pH was significantly lower and HCO3 was higher in smokers after creation of pneumoperitoneum aligning with our study where pH after creation of pneumoperitoneum and 1 hr after extubation showed significantly lower levels in smokers ($p=0.018$ and $p <0.001$) and HCO3 was consistently higher at all time intervals with a significant difference between smokers and non-smokers ($p<0.05$).[9]

A study by Ibraheim et al. (2006), comparing lactate and acid-base changes during laparoscopic cholecystectomy found high-pressure pneumoperitoneum (12–14 mmHg) during laparoscopic cholecystectomy caused a statistically significant elevation in arterial lactate levels (peaking at 30 minutes post-insufflation and remaining elevated until 1 hour postoperatively) compared to low-pressure pneumoperitoneum (6–8 mmHg). This was attributed to reduced splanchnic perfusion and anaerobic metabolism under high intra-abdominal pressure.[10]

In contrast, our study observed significantly higher lactate levels in smokers versus non-smokers at all time points (with means at pre-induction: 1.07 vs. 0.52 mmol/L; post-pneumoperitoneum: 2.10 vs. 1.02 mmol/L; 1-hour post-extubation: 1.72 vs. 0.47 mmol/L; (all $p < 0.05$).

Comparison of ventilatory parameters between smokers and non-smokers:

1. In our study, ETCO2 (mmHg): Smokers exhibited significantly higher ETCO2 levels at all measured time points—pre-pneumoperitoneum, after complete pneumoperitoneum, and after deflation—with p-values less than 0.001 for all comparisons. This indicates a tendency for CO2 retention in smokers, likely due to impaired respiratory function.

2. PEEP (cm of H2O): There were no statistically significant differences in PEEP between smokers and non-smokers at any time point ($p > 0.05$). This suggests that the baseline settings for mechanical ventilation were comparable between the two groups.

3. Ppeak (cm of H2O): Smokers had significantly higher Ppeak values after complete pneumoperitoneum ($p < 0.001$). However, there were no significant differences pre-pneumoperitoneum or after deflation, indicating that the increased pressure may be related to the effects of pneumoperitoneum rather than inherent differences in lung mechanics.

Impact on ETCO2 Levels: A study by Barik et al. (2020) found that both ETCO2 and arterial PCO2 were significantly higher in smokers at all intervals during laparoscopic surgeries, reinforcing the idea that smokers experience greater CO2 retention due to impaired ventilation.[9]

Pneumoperitoneum Effects: Research has shown that pneumoperitoneum can exacerbate altered respiratory mechanics in smokers, leading to increased airway pressures and altered gas exchange dynamics.

Ventilatory Strategies: The literature suggests that tailored ventilatory strategies may be necessary for smokers undergoing laparoscopic surgery to mitigate the risks associated with CO2 retention and elevated airway pressures. Adjustments in ventilation settings can help optimise respiratory function during procedures where pneumoperitoneum is employed.

Secondary objectives

Comparison of heart rate: The comparison of heart rate between smokers and non-smokers reveals significant differences during key surgical events. Table 3 indicates that smokers had significantly higher heart rates at intubation ($p = 0.002$), during pneumoperitoneum ($p = 0.001$), after positioning ($p < 0.001$), and at extubation ($p = 0.012$). Heart rate differences at baseline, induction, 30 minutes after extubation, and 1 hour after extubation were not statistically significant ($p > 0.05$).

In contrast to our study, a study by Patel et al. (2023) found heart to be significantly higher in smokers, compared to non-smokers only post-pneumoperitoneum ($p<0.05$).[11]

Comparison of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Mean Arterial Pressure (MAP) between Smokers and Non-smokers.

The comparison of Systolic Blood Pressure (SBP) between smokers and non-smokers during laparoscopic cholecystectomy reveals significant differences at various time points, as detailed in Table 4. Smokers consistently exhibited higher SBP compared to non-smokers across all measured intervals, including baseline ($p = 0.002$), induction ($p = 0.002$), intubation ($p = 0.003$), during pneumoperitoneum ($p = 0.004$), after positioning ($p = 0.022$), after deflation ($p = 0.003$), at extubation ($p = 0.008$), and both 30 minutes ($p = 0.001$) and 1 hour ($p = 0.003$) after extubation.

The comparison of Diastolic Blood Pressure (DBP) between smokers and non-smokers during laparoscopic cholecystectomy, as presented in Table 5, highlights some significant findings. Smokers exhibited slightly higher DBP at specific time points: intubation ($p = 0.049$), during pneumoperitoneum ($p = 0.043$), and at extubation ($p = 0.037$). However, the differences in DBP at baseline, induction, after positioning, after deflation, and during recovery were not statistically significant ($p > 0.05$).

Haemodynamic levels – Study by Pal et al (2022) comparing haemodynamic and arterial blood gases in smokers versus non-smokers showed significant increase in Heart Rate (HR) and Mean Arterial Pressure (MAP) in smokers at all time interval ($p<0.001$).[12] Study by Barik et al.(2020) showed significantly higher baseline SBP and lower oxygen saturation.[9]

Impact of Smoking on Blood Pressure: Research shows that smoking is associated with acute increases in blood pressure due to nicotine-induced vasoconstriction and increased sympathetic nervous system activity. The World Health Organization indicates that smoking can significantly elevate the risk of cardiovascular complications during and after surgery, aligning with our findings of higher SBP in smokers.

Comparison of peripheral oxygen saturation (SpO2): The comparison of peripheral oxygen saturation (SpO2) levels between smokers and non-smokers during laparoscopic cholecystectomy, as detailed in Table 7, reveals significant differences at baseline, during pneumoperitoneum, after positioning, at extubation, 30 minutes after extubation and 1 hour after extubation (all $p<0.05$). Smokers consistently exhibited lower SpO2 levels compared to non-smokers, particularly during critical phases of the surgical procedure and recovery. Impact on Oxygen Saturation: Smoking is known to impair lung function and reduce oxygen delivery to tissues due to the effects of nicotine and carbon monoxide present in cigarette smoke. This aligns with the findings that smokers had lower SpO2 levels during surgery.

Comparison of complications occurring after laparoscopic cholecystectomy between smokers and non-smokers: Table 8 indicates a low overall complication rate in both groups. Notably, no bowel injuries were reported among smokers (0.00%), while one case (3%) of bowel injury occurred in the non-smoker group. The majority of patients in both groups remained complication-free, with 100% of smokers and 97% of non-smokers not experiencing any complications.

Complications Associated with Smoking: Research indicates that smokers are generally at a higher risk for postoperative complications, including wound infections and delayed healing. A study by the World Health Organization highlights that smoking significantly increases the risk of various surgical complications due to impaired immune function and reduced oxygenation during recovery.[13]

Wound Complications: A large-scale analysis indicated that active smokers have increased odds of developing wound complications after cholecystectomy procedures. Specifically, smokers had an odds ratio of 1.20 for developing complications after laparoscopic cholecystectomy.[14] This suggests that while our study found no bowel injuries in smokers, the broader literature indicates a potential risk for other types of complications.

Summary

In this study, smokers showed impaired perioperative ABG values, reduced lung compliance, lower oxygen saturation and greater cardiovascular stress. Pneumoperitoneum effects were more pronounced, though post-operative complication rates matched smokers. Comparable demographics confirmed smoking as the key factor, highlighting the need for vigilant monitoring, tailored ventilation, and preoperative optimisation.

Conclusion

Smoking adversely affects perioperative physiology by gas exchange, causing CO_2 retention, reducing lung compliance, and increasing airway pressures, all of which heighten the risk of intraoperative respiratory compromise. Cardiovascular strain is also greater, with elevated heart rate, blood pressure and higher likelihood of haemodynamic instability. Lower oxygen saturation further compromises tissue oxygenation and delays recovery. These patients require tailored anaesthetic and ventilatory management, close monitoring, and proactive haemodynamic support. Therefore, continued research is needed to refine evidence-based strategies for managing smokers in the surgical setting.

References

1. Shi Z. Laparoscopic vs open surgery: a comparative analysis of wound infection rates and recovery outcomes. Int Wound J. 2023 Oct 31; 21(3):e14474.
2. Hassler KR, Collins JT, Philip K, Jones MW. Laparoscopic Cholecystectomy. In: StatPearls [Internet]. Treasure Island (FL):StatPearls Publishing; 2025 [cited 2025 Jan 28]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK448145
3. Özdemir-van Brunschot DMD, van Laarhoven KCJHM, Scheffer GJ, Pouwels S, Wever KE, Warlé MC. What is the evidence for the use of low-pressure pneumoperitoneum? A systematic review. Surg Endosc. 2016; 30(6):2049–65.
4. Castro D, Patil SM, Zubair M, Keenaghan M. Arterial Blood Gas. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 [cited 2025 Jan 28]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK536919
5. Giger UF, Michel JM, Opitz I, Th Inderbitzin D, Kocher T, Krähenbühl L, et al. Risk factors for perioperative complications in patients undergoing laparoscopic cholecystectomy: analysis of 22,953 consecutive cases from the Swiss Association of Laparoscopic and Thoracoscopic Surgery database. J Am Coll Surg. 2006 Nov; 203(5):723–8.
6. Prevention (US) C for DC, Promotion (US) NC for CDP and H, Health (US) O on S and. pulmonary diseases. In: How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease: A Report of the Surgeon General [Internet]. Atlanta (GA) Centers for Disease Control and Prevention (US); 2010 [cited 2025 Jan 28]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK53021
7. Lugade AA, Bogner PN, Thatcher TH, Sime PJ, Phipps RP, Thanavala Y. Cigarette smoke exposure exacerbates lung inflammation and compromises immunity to bacterial infection. J Immunol. 2014 Jun 1; 192(11):5226–35.
8. Klein LW. Pathophysiologic mechanisms of tobacco smoke producing atherosclerosis. Curr Cardiol Rev. 2022 Nov 18; 18(6):e110422033 89.
9. Barik AK, Kumar A, Dhar M, Ranjan P. A prospective comparative study of arterial blood gas parameters in smoker versus non-smoker patients undergoing laparoscopic cholecystic tomy. Indian J Anaesth. 2020 May; 64(5):397–402.
10. Ibraheim OA, Samarkandi AH, Alshehry H, Faden A, Farouk EO. Lactate and acid base changes during laparoscopic cholecystectomy. Middle East J Anaesthesiol. 2006 Feb; 1 8(4):757–68.
11. Patel K. A Prospective Comparative Study of Arterial Blood Gas Parameters In Smoker Vs Nonsmoker Patients Undergoing Laparoscopic Abdominal Surgery.
12. Pal R, Patel H, Arora K, Gupta N. Haemodynamics and Arterial Blood Gases in Smokers versus Non-Smokers during General Anaesthesia for Abdominal Surgeries: An Analytical Study. JCDR [Internet]. 2022 [cited 2025 Feb 20]; Available from: https://www.jcdr.net//article_fulltext.asp?issn=0973-709x&year=2022&month=June&volume=16&issue=6&page=UC01-UC04&id=16429
13. Smoking greatly increases risk of complications after surgery [Internet]. [cited 2025 Feb 20]. Available from: https://www.who.int/news/item/20-01-2020-smoking-greatly-increases-risk-of-complications-after-surgery
14. Selvarajah S, Ahmed AA, Schneider EB, Canner JK, Pawlik TM, Abularrage CJ, et al. Cholecystectomy and wound complications: smoking worsens risk. J Surg Res. 2014 Nov; 192(1):41–9.