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Original Article

Anaesthesia Section

Haemodynamics and Arterial Blood Gases in Smokers versus Non Smokers during General Anaesthesia for Abdominal Surgeries: A Prospective Observational Study

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ABSTRACT

Introduction: Tobacco smoking is a worldwide accepted health hazard and its effect on cardiopulmonary system is a well known fact. In a long run, it results in to gross derangements in haemodynamics and Arterial Blood Gases (ABG) which can lead to further complications during general anaesthesia.

Aim: To evaluate the effect of smoking on cardiopulmonary system and also to compare its effects on haemodynamics and ABG during general anaesthesia for abdominal surgeries in smokers and non smokers.

Materials and Methods: This prospective observational analytical study was conducted in the Department of Anaesthesiology, Mahatma Gandhi Memorial Medical Colledge, Indore, Madhya Pradesh, India, from May 2020 to April 2021. The study included 74 male patients of American Society of Anaesthesiologist (ASA) grade I and II, aged 20-70 years, undergoing elective abdominal surgeries. The patients were divided into two groups, smokers and non smokers, depending on their smoking status. Haemodynamic monitoring was done from preinduction time till 48 hours after extubation and ABG analysis was also done before induction and two hours after extubation in both the groups. T-test and Mann-whitney test were applied according to the requirement. A p-value <0.05 was taken as statistically significant. The statistical software Statistical Package for Social Sciences (SPSS) version 20.0 and Medcalc 19.5 were used for the analysis.

Results: Significant increase in Heart Rate (HR) and Mean Arterial Pressure (MAP) was observed in smokers as compared to non smokers at all time intervals (p-value <0.001). End-tidal carbon dioxide concentration ($EtCO_2$) values were found to be significantly higher in smokers (37.77±2.63 mmHg) than non smokers (32.99±2.83 mmHg) (p-value <0.001). Regarding arterial blood gas analysis significant difference was observed in preoperative and postoperative arterial carbon dioxide concentration ($PaCO_2$) (p-value <0.0001) and pH levels (p-value <0.0001) in both the groups. A significant difference was also seen in preoperative and postoperative $PaCO_2$ levels of the smokers (p-value=0.0004) with a corresponding change in their pH levels also (p-value=0.0012). Peak Expiratory Flow Rate (PEFR) was lower in smokers in comparison to non smokers (p-value <0.0001).

Conclusion: Smoking has significant effects on haemodynamic status and ABG of smokers which can be aggravated during general anaesthesia.

Keywords: Cardiopulmonary, End-tidal carbon dioxide, Mean arterial pressure, Peak expiratory flow rate

INTRODUCTION

Tabaco smoking is the leading cause of high mortality and morbidity, and it is a serious challenge to the healthcare system worldwide. The association between smoking and perioperative complications is well documented in various studies [1]. There is an increased risk of mortality, while complications like, cardiac, pulmonary, wound infections, delayed wound healing and reduced bone fusion may occur. Post surgery, smokers require an extended time in intensive care, in the ward and during recovery [2,3]. The relative risk of complications after surgery in smokers compared to non smoker has been reported to increase 4.3-fold [4]. Nicotine, the chief ingredient in tobacco stimulates adrenal response leading to increase sympathetic tone which results in increase in peripheral vascular resistance and cardiac excitability. An increase in coronary vascular resistance leads to a decrease in the coronary blood flow, resulting in decrease in the supply of oxygen. Increase in excitability lead to more frequent contractions and increase in oxygen consumption. These lead to a decrease in the myocardial oxygen supply demand ratio [5]. Smoking also causes various inflammatory changes in lung parenchyma. As the lung function is already in a compromised state in smokers, administration of general anesthesia can further aggravate it and cause an alteration in the acid base status of the patients which can be predicted by ABG analysis. It has been also reported that cessation of smoking before abdominal surgeries help improve the results.

There have been few studies on the duration of smoking cessation required before surgery to effectively reduce postoperative complications. At least four weeks of abstinence is needed to reduce the risks of Postoperative Pulmonary Complications (PPCs). Abstinence from smoking for more than four and eight weeks before surgery reduced the risk of PPCs by 23% and 47%, respectively [6]. So, hypothesising that smoking may serve as an independent risk factor for perioperative cardiopulmonary complications, the present study was conducted to evaluate and compare the effect of smoking on the haemodynamics and ABG in perioperative period of abdominal surgeries done under general anaesthesia in smokers and non smokers.

MATERIALS AND METHODS

This prospective observational analytical study was conducted in the Department of Anaesthesiology, Mahatma Gandhi Memorial Medical Colledge, Indore, Madhya Pradesh, India, from May 2020 to April 2021. Approval from the Institutional Ethics and Scientific Committee was obtained [IEC/M.G.M/July-20/101].

Sample size calculation: Sample size was obtained using the formula:

$$2\times\sigma^2 (Z_{\alpha/2}+Z_{\beta})/d^2$$

Z=coefficient of difference, d=degree of differentiation, α=level of significance, β=type two error, σ=standard deviation. Adequate sample size based on above given information was 37 cases in each group.

Inclusion criteria: Male patients scheduled for abdominal surgeries under general anaesthesia with American Society of Anaesthesiologist (ASA) grade I and II, with 20-70 year of age and minimum duration of smoking 10 years were included in the study.

Exclusion criteria: The patients with Chronic Obstructive Lung Disease (COPD), renal and hepatic insufficiency endocrine and metabolic disorder, severe cardiac disease or those with drug allergy were excluded from the study.

The study included 74 male patients which were further divided into two group depending upon the smoking history:

- Smokers: n=37
- Non smokers: n=37

Study Procedure

A careful preanaesthetic assessment of all the selected patients was done and required investigations were ordered. Patients were kept nil orally for six hours before elective procedure. Upon arrival of the patient in the operation theatre, intravenous access was established. Patients were premedicated with injection (inj.) glycopyrolate 0.2 mg and inj. midazolam 1 mg both intravenously. Baseline haemodynamic parameters like heart rate (beats per minutes), non invasive blood pressure (mmHg) and oxygen saturation (SpO_2) were noted down. A 22 gauge cannula was placed in the radial artery of the non dominant hand, after confirmed negative Allen test, under all aseptic precautions before intubation. Before induction 1 mL of arterial blood sample was collected in 2 mL heparinised syringe and sent for arterial blood gas analysis. After this it was kept flushed with heparinised normal saline to prevent blockage. Then 18 gauge epidural catheter was placed at desired level and epidural analgesia was achieved with inj. bupivacaine (0.25%) 10 mL after confirming the correct placement of the catheter with test dose of lidocaine 1-5%. General Anaesthesia (GA) was administered as per standard protocol. Preoxygenation was done for 3 minutes. Anaesthesia was induced with inj. fentanyl 2 mcg/kg and inj. propofol 2 mg/kg intravenously. Endotracheal intubation was facilitated with inj. succinylcholine 1.5 mg/kg intravenously and loading dose of non depolarising muscle relaxant inj. atracurium 0.5 mg/kg was given intravenously. Maintenance of anaesthesia was achieved with inj. atracurium 0.1 mg/kg repeated at 25-30 minute interval and N_2O:O_2 50%: 50% along with isoflurane 0.6-1.2%. Analgesia was also supplemented via epidural route as mentioned earlier, if required. After the completion of surgery neuromuscular blockade was reversed with inj. neostigmine (0.05 mg/kg) and inj. glycopyrrolate (0.01 mg/kg) both intrvenously. When clinically adequate tidal volume was achieved, extubation was performed.

Values for Heart Rate (HR), Mean Arterial Pressure (MAP), Oxygen saturation (SpO_2) were recorded at different time intervals. All patients were administered oxygen by face mask at a rate of 4 L/minutes during recovery period. Postoperative epidural analgesia was maintained with inj. buprenorphine 2 mcg/kg diluted in 10 mL of normal saline. A second arterial blood sample was also taken two hours after extubation and the same heamodynamic parameters were measured at different time intervals.

Peak Expiratory Flow Rate (PEFR): The PEFR values were recorded on day one and day one of surgery at the interval of 24 hours by using peak flow meter at bed side. To measure PEFR the patient was asked to sit up straight and take deep breath. Then he was asked to hold the flow meter parallel to the ground and to make a tight seal around it with his lips. He then exhaled as fast and as forcibly through the flow meter as he could. Before blowing, red mark of the flow meter was set to zero. The procedure was repeated two more times. The highest of the three readings were noted down.

STATISTICAL ANALYSIS

The collected data were compiled in a Microsoft versus sheet and statistical analyses were carried out. Results on continuous measurements were presented as Mean±SD and results on categorical measurements were presented as number (%). Chi-square test of association was also used to find if there was any relationship between two categorical variables. T-test and Mann-whitney test were applied according to the requirement. A p-value <0.05 was taken as statistically significant. The statistical software Statistical Package for Social Sciences (SPSS) version 20.0 and Medcalc 19.5 were used for the analysis.

RESULTS

Both the groups were comparable demographically i.e. age, weight and ASA status (p-value >0.05) [Table/Fig-1]. Heart rate and MAP were found to be higher in smokers than non smokers (p-value <0.001) [Table/Fig-2]. The End-tidal carbon dioxide concentration ($EtCO_2$) levels were also seen to be higher in smoker group as

Variables	Smoker (n=37) Mean±SD	Non smoker (n=37) Mean±SD	p-value
Age (years)	41.64±14.54	45.32±13.90	0.860*
Weight (kg)	67.97±5.48	65.78±4.82	0.182*
ASA grade II/I	35/2	30/7	0.152#

[Table/Fig-1]: Comparison of demographic data of two groups.
p-value <0.05 was considered statistically significant; *calculated by chi-square test; #calculated by Fischer's-exact test

Time intervals	Heart rate (beats/minutes) Smokers (Mean±SD)	Non smokers (Mean±SD)	p-value	Mean arterial pressure (mmHg) Smokers (Mean±SD)	Non smokers Mean±SD	p-value
Before intubation	90.42±7.25	70.56±5.35	<0.0001	78.14±4.04	93.19±7.74	<0.0001
After intubation						
At 1 min	91.48±6.88	72.87±6.32	<0.0001	77.24±3.45	93.70±9.42	<0.0001
At 5 min	92.37±9.13	70.12±5.66	<0.0001	76.78±3.29	92.84±8.32	<0.0001
At 10 min	90.26±12.34	69.29±5.87	<0.0001	80.41±6.19	90.81±7.23	<0.0001
At 15 min	89.00±8.56	69.25±4.23	<0.0001	79.24±6.13	90.27±8.28	<0.0001
At 30 min	85.22±7.87	62.38±5.66	<0.0001	78.76±6.47	90.05±7.87	<0.0001
At 1 hr	86.26±12.56	61.45±8.43	<0.0001	79.68±6.60	90.70±7.79	<0.0001
At 2 hr	87.18±10.32	66.86±1.95	<0.0001	79.27±5.89	91.19±8.03	<0.0001
After extubation						
At 1 min	95.87±8.83	74.84±4.78	<0.0001	77.65±4.32	91.83±7.52	<0.0001
At 30 min	89.46±7.16	68.47±7.55	<0.0001	78.41±6.18	91.46±7.60	<0.0001
At 1 hr	85.59±12.45	68.95±8.12	<0.0001	78.97±5.82	90.08±7.72	<0.0001
2 hr	86.11±8.15	67.87±11.74	<0.0001	78.46±5.12	87.89±8.38	<0.0001

[Table/Fig-2]: Comparisons of HR and MAP in smokers and non smokers at various time intervals.
*Significant (p-value <0.05); t-test

compared to non smoker group (p-value <0.0001) [Table/Fig-3]. Preoperative and postoperative pH values were lower in smokers as compared to non smokers (p-value <0.0001) [Table/Fig-4]. There was no significant difference in the preoperative and postoperative PaO_2 and HCO_3 levels of the two groups [Table/Fig-4]. On intra group comparison, a statistically significant difference was noted in preoperative and postoperative levels of $PaCO_2$ (p-value=0.0004) and pH (p-value=0.0012) of the two groups [Table/Fig-4]. Although, PEFR improved progressively from day one to day two, it remained lower in smoker group as compared to non smoker at all times of measurements (p-value <0.0001) [Table/Fig-5]. Mean $EtCO_2$ in smoker and non smoker group was significant (p-value <0.0001) (37.77±2.63, 32.99±2.83) respectively.

Time intervals	$EtCO_2$		
	Smoker (Mean±SD)	Non smoker (Mean±SD)	p-value
After intubation			
At 1 min	37.48±2.42	33.02±2.39	<0.0001
At 5 min	37.89±2.81	33.51±2.64	0.0011
At 10 min	37.89±2.48	32.24±5.63	<0.0001
At 15 min	37.83±2.64	33.10±2.19	<0.0001
At 30 min	37.64±2.71	33.05±2.29	<0.0001
At 1 hr	37.75±2.66	33.18±2.11	<0.0001
At 2 hr	37.94±2.72	32.83±2.58	<0.0001
Before extubation	37.89±2.63	32.99±2.83	<0.0001

[Table/Fig-3]: Comparison of $EtCO_2$ of smoker group and non smoker group at various time intervals.
*Significant (p-value <0.05); t-test

Time of measuring	Smoker (Mean±SD)	Non smoker (Mean±SD)	p-value
Partial Pressure of Oxygen (PaO_2) (mmHg)			
Preoperative	93.43±6.30	97.11±7.49	0.0553
Postoperative	113.97±9.59	118.32±11.01	0.0740
$PaCO_2$ (mmHg)			
Preoperative	38.22±3.01	34.41±1.47	<0.0001
Postoperative	40.43±1.94	35.31±2.00	<0.0001
Intra group $PaCO_2$ (p-value)	0.0004	0.0893	
pH			
Preoperative	7.35±0.02	7.37±0.02	0.0001
Postoperative	7.33±0.03	7.36±0.03	<0.0001
Intra group pH (p-value)	0.0012	0.0959	
Bicarbonate (HCO_3)			
Preoperative	20.03±1.30	20.57±1.61	0.1163
Postoperative	21.84±1.76	22.08±1.99	0.1191

[Table/Fig-4]: Comparison of preoperative and postoperative arterial blood gases in two groups.
*Significant (p-value <0.05), t-test

Time intervals	Smoker (Mean±SD)	Non smoker (Mean±SD)	p-value
Postoperative day 1 (L/min)	554.05±31.31	615.95±40.58	<0.0001
Postoperative day 2 (L/min)	581.35±35.68	634.32±44.69	<0.0001

[Table/Fig-5]: Comparison of postoperative PEFR in smokers and non smokers.
*Significant (p-value <0.05) t-test

DISCUSSION

Postoperative pulmonary complications are defined as pulmonary abnormalities occurring in postoperative period which produce clinically significant, identifiable disease or dysfunction that adversely affects the patient's clinical course and manifests changes in blood gas coefficients. Abdominal surgical procedures are associated with a high risk of Postoperative Pulmonary Complications (PPCs) which manifest as changes in haemodynamics and ABG of the patients. Despite recent advances in preoperative management, postoperative respiratory morbidity is still a common problem, especially following abdominal surgery [7,8]. Furthermore, these conditions may be more complicated in case of smoking, old age, and co-existing pulmonary diseases.

So, this prospective observational study was conducted to compare the haemodynamics and ABG of smokers and non smokers who received general anesthesia for abdominal surgeries. The study also evaluated the changes in ABG within the groups, following GA. This can help in predicting the importance of abstinence from smoking before planned surgeries and anaesthesia in chronic smokers. The results of the present study show that the smokers are more prone to changes in haemodynamics and ABG levels as compared to non smokers and these parameters can further deteriorate after GA in smokers.

A significant rise in HR and BP was observed in smokers in comparison to non smokers at all time intervals (p-value <0.0001). Salman IA and Jahn MY, in their study also found higher BP in smokers undergoing GA for lower abdominal surgeries. However, they did not find any change in HR of the smoker and non smoker patients [9].

There was no significant difference in mean SpO_2 of smokers and non smokers in the present study, whereas it was found to be significantly lower in smokers in the study done by Salman IA and Jahn MY [9]. There was no statistically significant difference observed in oxygen saturation in both the groups.

In the present study, the difference in preoperative $EtCO_2$ values was found to be statistically significant in smoker and non smoker patients (p-value <0.0001), which, is in concordance with those observed in smoker and non smoker patients by Barik A et al., [10].

There was statistically significant difference in preoperative and postoperative $PaCO_2$ levels of the two groups in the present study (p-value=0.0001). The both pH levels in smoker patients were also lower than non smoker patients (p-value <0.0001). These findings are supported by a study done by Barik A et al., on ABG parameters in smoker and non smoker patients, undergoing laparoscopic cholecystectomy [10]. There was no significant difference in pre and postoperative HCO_3 levels of the two groups in the present study, whereas they were found to be statistically significant in the study done by Barik A et al., (p-value <0.001) [10].

On intraoperative comparison, it was found that in smoker patients both the $PaCO_2$ and pH levels changed significantly from preoperative to postoperative time. This exclusive finding of the patient study is in contrast to the findings of a study done by Hansen G et al., conducted on patients scheduled for upper abdominal surgeries, where no definite changes in arterial pH and $PaCO_2$ were found [11].

There was a statistically significant difference in the postoperative PEFR of the smoker and non smoker patients (p-value <0.0001). This finding is in accordance with a study by Medabala T et al., who also observed lower PEFR in smokers (p-value <0.0001) [12]. Thus, haemodynamic as well as ABG changes were more common in smokers than in non smokers.

Limitation(s)

Although, this study has tried to meet its aims and objectives in all aspects, there were limitations also. It was a single-centre study and only male patients were included in the study, so further studies are needed on a larger number of patients for the findings to be more conclusive.

CONCLUSION(S)

Smokers show exaggerated haemodynamic response perioperatively and alteration in ABG suggesting respiratory insufficiency when compared to non smokers and they are more prone to wide

cardiovascular and respiratory insults that affect perioperative outcomes following general anaesthesia and hence they should be optimised prior to it with special attention to long duration surgeries.

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