International Journal of Advances in Medicine
Kumar P et al. Int J Adv Med. 2022 Mar;9(3):278-285
http://www.ijmedicine.com
pISSN 2349-3925 | eISSN 2349-3933
DOI: https://dx.doi.org/10.18203/2349-3933.ijam20220431

Original Research Article

An observational study to find out changes in arterial oxygen tension during fiberoptic bronchoscopy

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Received: 25 December 2021
Accepted: 02 February 2022

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ABSTRACT

Background: Arterial hypoxaemia is the commonest complication, since respiratory depressant drugs are used for premedication, and the airway is also partially occluded by the bronchoscope. The study is therefore designed to find out the changes in arterial oxygen tension during (FOB) along with effect on central hemodynamics, pre and post procedure ECG and PFT. Objectives were to find out the changes in arterial oxygen tension during FOB, to study the effects of FOB on central hemodynamics, electrocardiographically and pulmonary function tests.
Methods: One hundred patients aged above 20 years undergoing FOB were evaluated for the arterial oxygen tension and cardiac rhythm changes at KNCH, Jodhpur during 12 months study period from 2019 to 2020.
Results: All patients developed a fall in PaO_2 following FOB but hypoxaemia was noted only in 18 cases. Bronchial washing, punch biopsy and brush biopsy did contribute to hypoxaemia significantly. There was a uniform rise in heart rate in all the patients after FOB which was statistically significant. There was slight sinus tachycardia in most of the cases although ECG indicated no major arrhythmias. The pulmonary functions which include change in VC, FVC, FEV_1 and PEFR after FOB, on statistically comparison no statistical difference could be observed. There was no significant change in $PaCO_2$ level and pH level. Mean of SBP and mean of DBP was statistically significant.
Conclusions: All patients showed a decline in arterial PaO_2 after FOB which was highly significant. There was slight sinus tachycardia in most of cases. FOB itself does not endanger the patients with any significant or serious complications.

Keywords: Arterial oxygen tension, FOB, Electrocardiogram, Pulmonary function test

INTRODUCTION

Bronchoscopy was established by Jackson in 1907 for the investigation of pulmonary diseases. Flexible bronchoscope was introduced by Ikeda in 1964 for the early diagnosis of bronchial carcinoma and fiberscopes became available commercially in 1967.[1] Flexible bronchoscopy (FB) is a safe and frequently performed procedure for the assessment, diagnosis, and treatment of patients with respiratory diseases. FB is now established as an essential diagnostic and therapeutic tool in respiratory medicine. The trans nasal approach is most often used. Broncho fiberscopy is preferred over straight bronchoscopy as it eliminates heavy sedation to the patient and when performed in sitting position there is less hypoxaemia. Arterial hypoxaemia is the commonest complication of FOB. Patients with COPD have an even higher risk of hypoxaemia and of associated major arrhythmias. When bronchoscopy is performed under conscious sedation without supplemental oxygen, oxygen desaturation will occur rapidly giving a good indication of ventilatory status. The British thoracic society (BTS) guidelines recommend that oxygen supplementation should be used to achieve an oxygen saturation (SpO_2) of at least 90% to reduce the risk of significant arrhythmias during the procedure and also in the post-operative recovery period. The mechanisms responsible for the arterial PaO_2 decline during FOB were not

defined by this investigation. It appears that the procedure includes both a mode of intrapulmonary shunt and zones of low ventilation-perfusion ratio. It seems likely that loss of lavage fluid and induction of bronchospasm by tracheal stimulation during the procedure both play roles.

Objectives

Objectives of the study were to find out the changes in arterial oxygen tension during FOB, to study the effects of FOB on central hemodynamics, electrocardiographically and pulmonary function tests.

METHODS

Type of study

The type of study was of observational study

Study place

This study was done in 100 patients above 20 years of age irrespective of their sex and occupation suffering from various pathologies, at various wards of K. N. chest and T. B. h ospital, Jodhpur from November 2019 to October 2020.

Selection criteria

Inclusion criteria

All patients above 20 years of age, irrespective of their gender and occupation and having PaO_2>60 mm Hg were included in the study posted for FOB.

Exclusion criteria

Uncooperative patients, hemodynamically unstable patients, any severe acute illness and those who refused to undergo the procedure, Insufficient platelet number (<50,000 cells/μL) and coagulation disorders.

The patients were thoroughly evaluated by a clinical history and physical examination along with an informed valid consent.

Local anaesthetic effect of the pharynx, nasal mucosa, and larynx were achieved by 2-3 puffs of 10% xylocaine spray and its effect was checked by gag reflex.

Procedure

A fiberoptic bronchoscope (Olympus model TH 190) was used in the study. Arterial blood samples were taken from femoral artery both before and after bronchoscopy.

ECG recordings were taken just before and within 15 minutes after completion of the procedure. For arterial blood samples, 2 ml. disposable syringes with needle were required which were heparinized by pushing heparin solution (5000 I.U.).

Samples were immediately subjected on blood gas analyzer for examination within half an hour after withdrawal. Patients after bronchoscopy were kept in the observation room for 2 hours and complications if any occurred after the procedure were recorded and managed accordingly.

Ethical approval

The study was carried out after institutional ethical committee approval, Dr. Sampurnanand medical college, Jodhpur dated 13/02/2020.

Data analysis

A database was created in SPSS statistical software, version 24.0 for Windows. Continuous data were summarized with means (M) and standard deviations (SD). Absolute numbers and percentages were used for categorical data. Comparison of quantitative variables among groups, when these followed a normal distribution, was done with the student t test for independent samples; if distribution was not normal, the non-parametric Kruskal-Wallis/ Mann-Whitney U test was used. The non-parametric Pearson chi square test and where applicable Fischer exact test was used. For all statistical tests, a significance threshold of p=0.05 was applied.

Statistical analysis

The changes in arterial oxygen tension during FOB were assessed and their effects on central hemodynamics, electrocardiographically and pulmonary function tests were found. The results were considered statistically significant if p<0.05.

Sample size calculation

Sample size was calculated at alpha error 0.05 and study power 90% using the below formula for difference in paired mean in a single sample.

$$N = \frac{2 \times (Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2 \times \sigma^2}{d^2} + (Z_{1-\frac{\alpha}{2}})$$

$N=(1.96+1.28)^2\times(8.53)^2\div(8)^2+2=25.86$

Where;

N=Sample size

$(Z_{1-\frac{\alpha}{2}})$ =Standard normal deviate for type 1 error (taken as 1.96 for 95% confidence interval)

$Z_{1-\beta}$=Standard normal deviate for type 2 error (taken as 1.28 for 90% study power).

σ^2=pooled standard deviation of arterial oxygen tension (taken as 8.53 as per reference article).

d=minimum expected significant difference in mean arterial oxygen tension by two methods (taken as 8.00 as per reference article).

Sample size was calculated to be minimum of 26 subjects. Sample size was enhanced and rounded to 100 subjects.

RESULTS

The study was undertaken in one hundred patients of various pathologies of chest with fiberoptic bronchoscopy as a diagnostic procedure. To evaluate its safety and complications like hypoxia, following points were assessed: To evaluate decrease in arterial oxygen tension in blood after the procedure, if present, to evaluate the pulmonary function abnormality after bronchoscopy, if any, to evaluate the effects of hypoxaemia in patients by clinical examination and by ECG.

No patient had hypoxaemia before the procedure. All patients developed a fall in PaO_2 but hypoxaemia was noted only in 18 cases. Bronchial washing, punch biopsy and brush biopsy did contribute to hypoxaemia significantly.

No significant changes in $PaCO_2$ and pH were observed.

There was a uniform rise in heart rate in all the patients after bronchoscopy and this change was statistically significant. There was slight sinus tachycardia in most of cases but fiberoptic bronchoscopy does not enhance ectopy.

ECG recorded before and after bronchoscopy indicated no major arrhythmias.

Fiberoptic bronchoscopy itself does not endanger the patients with the any significant or serious complications.

Pulmonary function tests were done prior to and after bronchoscopy. In pulmonary functions tests, forced expiratory volume in one second, vital capacity, peak expiratory flow rate and forced vital capacity were recorded. It was observed that there was no significant difference in pulmonary function test results before and after bronchoscopic examination. Although there was decrease in FEV_1, FVC, VC and PEFR, these changes were of no statistical significance by 'paired t' test.

Table 1: Patient characteristics.

Variables		Values
No. of patients		100
Age (Years)	Years	22-84
	Mean ± SD	59.3±11.83
Sex	Males	89%
	Females	11%
Height		60.00-69.00
	Mean ± SD	65.05±2.6

Table 2: Distribution of patients according to diagnosis with PaO_2.

Diagnosis	Total	PaO_2 (mmHg)			
		<60		>60	
		BFF	AF	BFF	AF
Bronchiectasis	03	-	-	03	03
Fibro-cavitatory lesion	03	-	-	03	03
CA lung	59	-	11	59	48
CAP	03	-	02	03	01
COPD	15	-	02	15	13
Empyema	01	-	-	01	01
Haemoptysis	01	-	-	01	01
Lung abscess	04	-	01	04	03
NTM	01	-	01	01	-
Pleural effusion	07	-	01	07	06
Pneumonia	01	-	-	01	01
PTB	02	-	-	02	02

Table 3: Change in heart rate, blood pressure (SBP and DBP), pH, $PaCO_2$, PaO_2 during FOB.

Parameters	Before bronchoscopy	After bronchoscopy	P value	Sig.
Heart rate (rate/min.)	85.55±8.92	96.10±8.64	0.01	S
SBP (mmHg)	119.84±13.03	122.96±12.29	0.01	S
DBP (mmHg)	78.76±9.10	80.04±8.84	0.01	S
PaO_2 (mmHg)	80.73±11.37	69.77±11.07	0.01	S
pH	7.33±0.05	7.42±0.32	0.21	NS
$PaCO_2$ (mmHg)	37.86±6.38	38.72±5.89	0.14	NS

Table 4: Distribution of cases according to PaO_2 (mmHg).

Variables	Mean PaO_2 (mmHg)	Range of PaO_2	Mean fall in PaO_2	Range of fall in PaO_2
Before bronchoscopy	80.73±11.37	61-100	10.96	7.82-14.09
After bronchoscopy	69.77±11.07	50.9-99.4		

SE=0.94, T=1.1, p=0.001 (S).

Table 5: Change in oxygen saturation level in relation to the special procedure during FOB.

Parameters	Groups	Procedure		
		B. washing, (n=45)	B. biopsy, (n=20)	P. biopsy, (n=35)
PaO_2 (mmHg)	Before	79.69±11.34	82.89±11.16	80.84±11.69
	After	69.35±11.78	70.14±10.13	70.10±10.93
P value		<0.0001	<0.0001	<0.0001
$PaCO_2$ (mmHg)	Before	38.01±5.78	39.75±8.41	36.60±5.67
	After	39.70±5.16	37.38±5.34	37.79±6.54
P value		0.148	0.214	0.206
pH	Before	7.45±0.05	7.43±0.05	7.44±0.04
	After	7.36±0.45	7.45±0.05	7.47±0.20
P value		0.213	0.200	0.399

In our study, all 100 patients, showed a decline in arterial PaO_2 after fiberoptic bronchoscopy ranging from 7.82-14.09 mmHg. In the 100 patients studied during room air breathing, the decline in arterial PaO_2 from 80.73 (SD±11.37) to 69.77 (SD±11.07) mmHg was highly significant ($p<0.05$). One case showed maximum fall of PaO_2 level i.e., 26 mmHg from 78.5 to 52.5 mmHg. No case showed an increase in PaO_2 level following bronchoscopy.

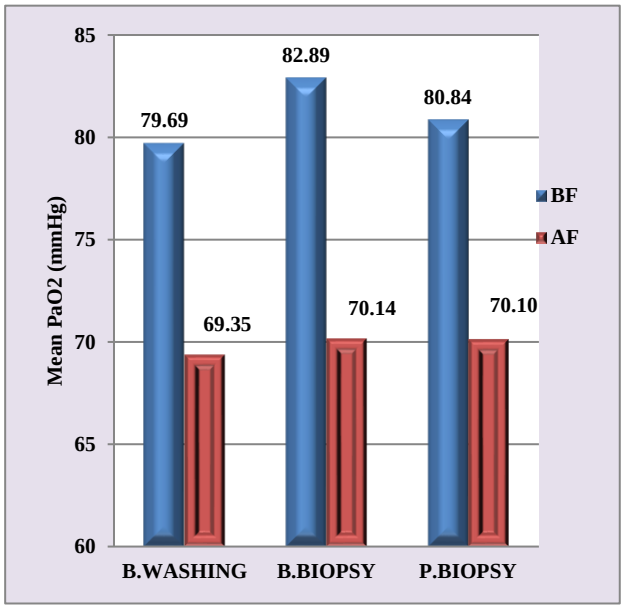

Figure 1: Change in PaO_2 level in relation to the special procedure during FOB.

Table 6: Pearson correlation coefficient PaO_2 with PFT parameters.

Variables	PaO_2			P value
	Before (r)	P value	After (r)	
VC (L)	0.089	0.378	0.017	0.867
FVC (L)	0.011	0.910	0.018	0.856
PEV1 (L)	-0.089	0.378	0.067	0.506
PEFR (L)	-0.071	0.485	0.011	0.242

Table 7: Distribution of patients according to diagnosis with PaO_2.

Diagnosis	PaO_2 (mmHg)				P
	<60		>60		
	Before	After	Before	After	
B. washing	00	08	45	37	0.005
B. biopsy	00	04	20	16	0.106
P. biopsy	00	06	35	29	0.024
Total	00	18 (18%)	100	82 (82%)	

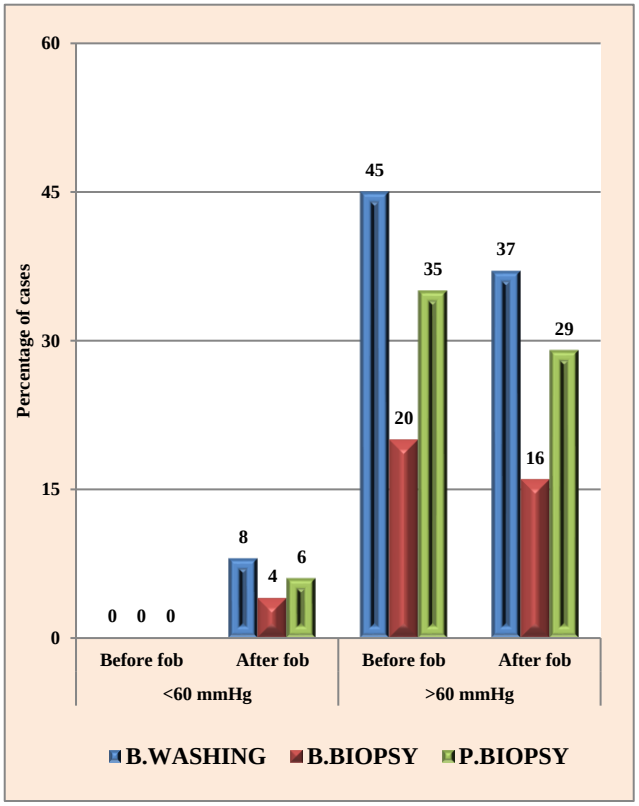

Figure 2: Distribution of patients according to diagnosis with PaO_2.

Table 8: Procedure done with PFT parameters.

PFT parameters	Groups	Procedure		
		B. washing, (n=45)	B. biopsy, (n=20)	P. biopsy, (n=35)
VC	BF	71.73±14.70	77.65±9.08	71.80±12.86
	AF	72.20±15.32	72.70±10.60	73.48±11.44
P value		0.885	0.153	0.500
FVC (L)	BF	71.35±11.86	71.80±9.76	71.60±10.46
	AF	70.97±11.56	70.85±13.55	71.08±12.49
P value		0.866	0.821	0.833
FEV1(L)	BF	69.17±14.56	64.55±10.01	68.17±11.78
	AF	68.42±14.82	63.45±10.23	64.25±10.15
P value		0.784	0.696	0.136
PEFR (L)	BF	70.64±12.12	76.35±12.76	71.11±12.87
	AF	71.15±11.64	75.50±13.37	70.74±13.12
P value		0.812	0.802	0.899

DISCUSSION

The patients included in the study were distributed mainly in the age group of 20 to 70 years, out of which 89 were males and 11 were females. Bronchoscopic procedures like punch biopsy, bronchial washing and brush biopsy were performed.

There was a uniform increase in the heart rate in patients undergoing fiberoptic bronchoscopy procedure. Before bronchoscopy the range of heart rate was 71-116 beats per minute with the mean heart rate being 85.39 while after the fiberoptic bronchoscopic procedure the range of heart rate was 70-99 beats per minute with the mean heart rate being 88.49. On statistical comparison between pre and post bronchoscopy procedure $p<0.05$ i.e., significant. Anxiety and catecholamine stimulation during the procedure may well contribute to ensuing tachycardia. The tachycardia was self-limiting.

Shrader and Laxminarayan observed that ischaemic heart disease and COPD are the main risk factors which may influence the cardiac rhythm and oxygen status during fiberoptic bronchoscopic procedure.[2]

Nearly uniform sinus tachycardia was also observed by Credle et al.[3]

Luck et al recorded most of the ectopic beats in patients of coronary heart disease.[4] No hemodynamic changes were observed and the patients did not develop angina during the procedure. Minor arrhythmias were frequent in cases with carcinoma lung in the form of sinus tachycardia which was reported only in 6 cases in present study. That can be explained by the degree of hypoxaemia because of the loss of lung volume due to malignancy. All the cases in present study were well selected and none had unstable angina or hypoxaemia at rest and this may well account for the no incidence of cardiac arrhythmias developing during the procedure of bronchoscopy as compared to the series of Barrett.[5] Lundgren et al observed that when bronchoscopy passed through larynx, it induced marked increase in heart rate and cardiac index with significant decrease in PaO_2.[6]

Sharma et al observed that out of 50 patients, the pH, $PaCO_2$, HCO_3 parameters were found to change insignificantly during the procedure.[7] The increase in heart rate was observed in 97% of cases. The maximum increase in heart rate was observed during the procedure (27 beats/min) during which a significant fall in PaO_2 was also noted. Frequency of sinus tachycardia was 94%, bradycardia was 2% while no arrythmia and blocks were present in the study.

In our study mean of SBP before bronchoscopy was 119.84 and after bronchoscopy the mean value was 122, $p<0.05$ was statistically significant and mean of DBP before bronchoscopy 78.76 and after bronchoscopy the mean value was 80.04, $p<0.05$ was statistically significant.

Lundgren et al in 1982 observed that when bronchoscopy passed through larynx, it induced marked increase in mean arterial pressure, mean pulmonary arteriolar occlusion pressure and cardiac index with significant decrease in PaO_2.[6]

Mohan et al studied 88 patients referred for FOB by measuring the supine blood pressure, heart rate, oxygen saturation, and respiratory rate at 0 min, 5 min, and 10 min counted from scope insertion and found that the heart rate, systolic blood pressure, and diastolic blood pressure significantly increased while oxygen saturation declined.[8]

Xue et al studied blood pressure and heart rate changes during nasotracheal intubation under general anaesthesia in 100 patients.[9] These patients were randomly allocated to either the direct laryngoscopy group or the fibreoptic bronchoscope group. Blood pressure at intubation and the maximum values during the observation were significantly higher in the fibreoptic bronchoscope group than in the direct laryngoscopy group. Heart rate at

intubation was also significantly greater in the fibreoptic bronchoscope group than in the direct laryngoscopy group.

In our study all hundred patients showed a decline in arterial PaO_2 after fiberoptic bronchoscopy ranging from 7.82-14.09 mmHg. All patients studied during room air breathing, the decline in arterial PaO_2 from 80.73 (SD±11.37) to 69.77 (SD±11.07) mm Hg was highly significant ($p<0.05$). The mean fall in PaO_2 levels in this study was 10.96 mmHg. One case showed maximum fall of PaO_2 level i.e., 26 mm Hg from 78.5 to 52.5 mmHg. No case showed an increase in PaO_2 level following bronchoscopy.

In 45 patients where bronchoscopy was performed along with bronchial washings, changes of fall in PaO_2 before and after bronchoscopy procedure were noted with minimum 0.2 mmHg, maximum 35.7 mmHg with the mean value 10.56 mm of Hg (SD±8.88), statistically it was found significant ($p<0.05$). In 20 patients the brush biopsy was performed along with bronchoscopy. The changes of fall in PaO_2 were noted with minimum 2.2 mmHg, maximum 23.1 mmHg, mean values of 12.75 mmHg (SD±6.35) and it was statistically significant ($p<0.05$). In 35 cases where punch biopsy was performed with fiberoptic bronchoscopy, the change in PaO_2 level after bronchoscopy procedure were noted with minimum value of 0.7, maximum value of 32 and mean value 10.73 mmHg (SD±7.98), statistically it was found significant ($p<0.05$).

Hendy et al observed in 26 patients during fiberoptic bronchoscopy that hypoxaemia was seen in patients having lung biopsy during routine fiberoptic bronchoscopy.[10]

Sharma et al selected twenty-one patients for bronchoscopic study and arterial blood gas study were also done.[11] They concluded that arterial hypoxaemia during fiberoptic bronchoscopy can be of substantial degree and persists for a variable period of time after completion of the procedure. Bronchoalveolar lavage has also been associated with hypoxaemia which can not only be distressing to the patient but may also precipitate cardiac arrhythmias and cardiac arrest. Furthermore, it is anticipated that patients with bilateral diffuse interstitial lung disease by virtue of diffuse lung involvement would have either low basal PaO_2 which may be attributed to reflex mechanisms causing laryngospasm and bronchospasm, altered ventilation-perfusion ratio caused by aspiration of sputum, local anaesthetic, and stimulation of subepithelial receptors in the carina causing bronchoconstriction.

Sharma et al studied 50 patients in whom a significant fall in PaO_2 was seen (mean fall 8±2.45 mmHg).[7] The lowest values were recorded at the completion of the procedure. In all patients studied during room air breathing, the decline in arterial PaO_2 from 63.69±6.43 to 56.65±5.47 was highly significant ($p<0.05$) The mechanisms responsible for the arterial PaO_2 decline during fiberoptic bronchoscopy were not defined by this procedure but may be due to intrapulmonary shunt and zones of low ventilation-perfusion ratio, obstruction of the trachea and large bronchi, laryngospasm and bronchospasm.

Jones et al studied forty-four patients in whom oxygen saturation was monitored during the procedure with pulse oximetry (PO) and arterial blood gas levels were measured before and after FOB.[12] No difference in saturation values was found between arterial blood gas levels and PO analysis both before and after FOB. Saturation values (mean ± SD) were significantly decreased after FOB (from 96.5±1.0% to 91.6±3.6%, $p<0.05$), and desaturation (arterial oxygen saturation<90%) was detected in 22 of the patients (50%) during the procedure.

Hassan et al observed that during bronchoscopy done on 56 hospitalized patients, statistically highly significant ($p<0.001$) fall of SaO_2 was observed progressively while bronchial tree was being examined and various procedures like forceps biopsy, brush biopsy and bronchoalveolar lavage were performed.[13] The difference in the degree of fall in PaO_2 in various groups of patients like bronchial washing and brush biopsy, brush biopsy and punch biopsy and punch biopsy and bronchial washing along with fiberoptic bronchoscopy, was found to be statistically insignificant ($p>0.05$).

In our study mean $PaCO_2$ was 37.86 (SD±6.38) with range of 23.6 to 46.2 mmHg before bronchoscopy and mean $PaCO_2$ became 38.72 (SD±5.89) with range of 26.5 to 48.9 mm Hg after bronchoscopy. Mean change in $PaCO_2$ was 0.85 mm Hg and range of change (rise or fall) in $PaCO_2$ was 0.29 to 2.09 mmHg. On statistically comparison this change in $PaCO_2$ was not found to be insignificant ($p>0.05$).

So, we conclude in our study that there was no significant change in $PaCO_2$ level, before and after bronchoscopy.

Albertini et al studied in eighteen patients and concluded that there was no significant change in $PaCO_2$ level after bronchoscopic examination except in 6 patients, a transient rise in $PaCO_2$ level was from 80 to 90 mmHg.[14] Albertini et al studied in twenty patients and concluded that alterations in $PaCO_2$ associated with fiberoptic bronchoscopy were uncommon in these patients, no significant mean $PaCO_2$ changes were noted in this study.[14] They had encountered several patients who had developed acute bronchospasm during fiberoptic bronchoscopy, which was associated with acute hypercapnic acidosis. All patients were of asthma and/or bronchitis, and their current approach also called for intensive bronchodilator therapy for such patients the day prior to fiberoptic bronchoscopy.

Sharma et al and Sharma et al also did not observe any significant change in $PaCO_2$ at any stage.[11,7] Maintenance of $PaCO_2$ during and after the procedure suggests that alveolar ventilation was not impaired by fiberoptic bronchoscopy and / or bronchoalveolar lavage.

pH observed in one hundred patients selected for study also did not show any significant change. Before bronchoscopy mean pH was 7.33 (SD±0.03) with range of 7.33 to 7.57 and after bronchoscopy mean pH was 7.42 (SD±with range of 7.42 to 7.60. On statistically comparison, it was found to be insignificant ($p>0.05$).

Albertini et al observed in 40 patients and concluded that alterations in pH associated with fiberoptic bronchoscopy were uncommon in these patients, no significant mean pH changes were noted in this study.[14]

Sharma et al observed in 50 patients that there was not any significant change in pH in their study.[7]

The pulmonary functions which include change in vital capacity, forced vital capacity, forced expiratory volume in one second and peak expiratory flow rate were performed before and after bronchoscopic procedure and on statistically comparison no statistical difference could be observed. Similar type of findings were observed by Lin et al that there was no significant change in FEV_1, PEF, FEV_1/ FVC, vital capacity except for a decreased PaO_2 level after bronchoscopic examination.[15]

Matsushima et al measured pulmonary functions in patients who were undergoing routine diagnostic flexible fiberoptic bronchoscopy either through an 8 mm endotracheal tube or tranasally.[16] In these patients with moderate airway obstruction, functional residual capacity increased significantly after inserting the endotracheal tube. Removal of flexible fiberoptic bronchoscopy and endotracheal tube caused functional residual capacity to return toward the control value.

Limitations

Our study had some limitations. Only short-term post FOB measurements could be taken because patients were discharged from the hospital within 2-3 h after the procedure. We did not measure the total volume of topical lignocaine given to all patients. These could have affected the degree of bronchoconstriction during FOB.

CONCLUSION

All patients showed a decline in arterial PaO_2 after FOB which was highly significant. There was slight sinus tachycardia in most of cases. FOB itself does not endanger the patients with any significant or serious complications.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kumar P, Purohit G, Choudhary CR, Borana H, Shyam R. An observational study to find out changes in arterial oxygen tension during fiberoptic bronchoscopy. Int J Adv Med 2022;9:278-85.