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Research Article

Reliability of Flexible Fiberoptic Bronchoscopy in Patients with Low Oxygen Saturation

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Abstract

Background: Flexible fiberoptic bronchoscopy (FOB) is used to diagnose and plan various respiratory diseases. During FOB, the peripheral oxygen value can decrease, increasing the risk of respiratory failure. Our aimed to evaluate the main indications and safety of FOB applied to patients with low, moderate, and high SO_2 in our clinic.

Methods: In this single-centre retrospective study conducted in our clinic between 2016 and 2022, a power analysis was performed on 1512 patients who underwent FOB. As a result of the analysis, three groups of 67 people, each with low, medium, and high SO_2, were formed. FOB was performed on 201 patients with low oxygen saturation (SO_2<87%), medium oxygen saturation (87%<SO_2<93%), and high oxygen saturation (SO_2>92). The indications for the FOB procedure and the changing SO_2 values before and after the procedure were uploaded to the SPSS program (Statistical Package for Social Sciences for Windows version 25 software). Since the patients' values did not show normal distribution, the data of the three groups were compared in pairs by applying the Mann-Whitney U Test.

Results: The mean age of the patients was 67 years ± 12.4 years. Patients underwent bronchoscopy for multiple reasons, such as mass 37.3%), parenchymal infiltration (26.4%), atelectasis (10.4%), chronic cough (5%), resistant bronchospasm (7.5%), tuberculosis (3%), haemoptysis (2.5%), and sarcoidosis (1.5%), and lymphoma (1.5%).

Complications had been seen in our patients after bronchoscopy are as follows; 1% massive haemoptysis, 5.97% arrhythmia, 3.48% pneumonia, 1% pneumothorax, 7.96% mucosal haemorrhage, 2.49% hypertension, 0.5% hypotension, and 7.96% epistaxis.

Mann-Whitney U Test was applied to all three groups, and no significant difference was found between smoking in pairs ($p > 0.05$). When comparing the SO_2 differences of the groups with no difference in smoking, significant differences were found between Groups: I and II, Groups II and III, and Groups I and III ($p < 0.05$).

Conclusion: Regardless of the level of SO_2, although there are problems that may develop in patients undergoing bronchoscopy, the risks that may develop before and after the procedure can be easily controlled with simple, predictable interventions by monitoring.

Keywords: Flexible Fiberoptic Bronchoscopy; Blood Oxygen Saturation; Hypoxia

Introduction

Since its introduction in 1967, the flexible fiberoptic bronchoscopy has been a critical tool for thoracic surgeons for diagnostic and therapeutic interventions by evaluating both respiratory diseases and lung pathology [1]. Flexible fiberoptic bronchoscopy (FOB), which has developed rapidly in the last 30 years, is an invasive procedure used for diagnosis and treatment [2].

Bronchoscopy indications may vary between regions. FOB plays an important role in determining the cause and side of haemoptysis, isolating the source of pneumonia, and diagnosing various conditions such as parenchymal or endobronchial lung disease and mediastinal lymphadenopathy. In addition, removal of the substance that causes foreign body aspiration with FOB, debulking of endobronchial masses with argon, cautery or laser, the opening of airway stenosis, closure of emphysema areas by using coils or valves, ensuring the survival of the patient, and targeted treatment by taking bronchial lavage (BAL) can be provided Bronchoscopy in adults in a tertiary care centre: indications and complications [3,4].

The harmony of the team is essential for the results to be obtained from the FOB process to be successful and to cope with the problems that may develop quickly [5]. Various complications and side effects may occur during the FOB intervention, from the patient's previous diseases to the drugs used during the procedure [6].

In general, the FOB procedure is safe for all respiratory disease patients. To support this, we aimed to show the indications of bronchoscopy procedures in the diagnosis of various respiratory tract diseases and their reliability even at low saturation.

Materials and Methods

Before being referred to our clinic, all patients were evaluated by Computed Thoracic Tomography (CTT) clinics. The radiology clinic performs this thorax tomography; It was reported as a pulmonary nodule, suspicious mass, consolidation, infiltration, fibrotic band, and lymph nodes.

Written informed consent was obtained from each patient or their relatives before the procedure. The patient's vital signs, who were fasted for at least two hours, were monitored before, during, and after the procedure, and their data were recorded, mostly for three to four hours.

Oral-nasal oxygen was administered to the patients to ensure adequate oxygen saturation and prevent oxygen loss from the endotracheal area by aspirating during the procedure. The nasal cavities and pharynx of all patients were anesthetized with lidocaine spray. During the procedure, additional 2% lidocaine was diluted with physiological saline and administered through the bronchoscopy canal above the vocal codes and to the trachea-bronchial mucosa. No sedative or hypnotic was given to any of the patients.

All bronchoscopic procedures were performed with Olympus^{R} trademarked and Fuji^{R} branded fiberoptic bronchoscopy (Olympus the EVIS X1 BF-H1100 bronchoscopy and Fuji Film Bronchoscope video endoscope 3.8 mm EB-530P) with the patient in a 15-degree head-up position and standing on the head while lying on the back. Bronchial lavage was obtained from all patients. In addition, bronchial brushing and transbronchial needle aspiration (TBNA) by its indicated.

The records of 11 patients with missing records despite normal SO_2 values and two patients who were removed from the table because of panic attacks were excluded from the study. We reviewed the findings before and after the FOB procedure performed on 201 patients in our clinic. Age, gender, comorbidity, bronchoscopy indications, and SO_2 values before and after bronchoscopy were collected. In this article, we investigated the safe feasibility of the procedure in two low saturation groups, SO_2 <92 (Hypoxic patient SO_2 <87%, hypercapnia risk 88-92%) and SO_2>92, which are generally considered to be at relative risk because the procedure takes longer than 1 minute [7].

Statistical analysis

The Process of Determining the Number of Samples.

According to the calculation made using the G*power 3.1 program (Table 1) of the sample number of this study, The sample size was determined to be at least 201 (each group 67), with an effect size of 0.28, a margin of error of 0.05, a confidence level of 0.95, and a population representation of 0.95. Cohen states that the

F tests - ANOVA: Fixed effects, omnibus, one-way	
Analysis	A priori: Compute required sample size
Input	Effect size f = 0.28 α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 3
Output	Noncentrality parameter λ = 15.7584000 Critical F = 3.0415182 Numerator df = 2 Denominator df = 198 Total sample size = 201 Actual power = 0.9509846

Table 1: G power analysis coefficients and output in determining the number of sample.

sample size in which power values ranging between 0.90-0.99 are calculated should be reached [8,9].

Statistical analysis of data

According to G power analysis, a total of n = 201 patients were included in the study. The patients were divided into three groups according to their saturation, and an equal number of n = 67 patients were included in each of the three groups.

All data were entered into SPSS 25.0 (Statistical Program in Social Sciences). Descriptive statistics of bronchoscopic diagnostic procedures were calculated to identify study variables. Normal distribution conformity tests of the data were performed. Kolmogorov-Smirnov and Shapiro-Wilk test results were calculated as p = 0.00. The Kurtosis value was calculated as 2.915. In the data that did not provide normal distribution, Kruskal Wallis Test was used, and pairwise comparisons were made with the Mann Whitney U test to determine which groups caused the statistical difference in the groups with a difference ($p<0.05$). Bonferroni corrected p-value was calculated automatically by SPSS 25.0 (0.05/ pairwise comparison) since the p-value would increase depending on the increase in the number of comparisons at this analysis stage.

Results

A total of 201 FOB patients were included in the study process. The mean age of these patients was 66.24 ± 12.62 years, with the youngest being 21 years old and the oldest 96 years old (Table 2). Most of the patients were male (75.1%), while 24.9% were female (Table 3).

	N	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Age	201	21	96	66,24	12,620	1,246	,341

Table 2: Analysis of patients by age.

	Frequency	Percent
Man	151	75,1
Woman	50	24,9
Total	201	100,0

Table 3: Gender distribution of patients.

67 (33.3%) of the patients were non-smokers. The most common primary indication for diagnostic bronchoscopy was the mass, 37.3% (n = 75). Parenchymal infiltrates 26.4% (n = 53) and atelectasis 20.89% (n = 42) were other common primary indications. A total of 404 pre-diagnosis procedures were performed on 201 patients with first pre-diagnosis, second pre-diagnosis and third pre-diagnosis (Table 4).

Mass	111
Parenchymal infiltration	105
Atelectasis	69
Resistant bronchospasm	25
Haemoptysis	12
Chronic cough	12
Effusion	10
Tuberculosis	10
Bronchial asthma	9
Bronchiectasis	8
Lymphoma	8
Sarcoidosis	6
Operated Laryngeal ca	4
Rhythm disorder	3
Diabetes Mellitus	2
Hemopneumothorax	2
Chronic kidney failure	2
Obstructive sleep apnea	2
Pneumothorax	2
Rib fracture	1
Breast ca	1
Total	404

Table 4: Bronchoscopy Indications.

While the most common pathology we encountered radiologically with the mass was parenchymal infiltrates and atelectasis seen in the distal of the mass, bronchial asthma, chronic cough, pleural effusion and bronchiectasis were pre-diagnosed in resistant bronchospasm. It was evaluated in terms of secretion clearance and metastasis to the trachea in operated laryngeal cancer. Tuberculosis was primarily investigated in patients with renal failure. Again, in patients with mediastinal lymph nodes, tuberculosis, lymphoma and sarcoidosis were among our preliminary diagnoses. Patients with chest trauma, rib fractures, and smokers are usually scheduled for bronchoscopy for secretion retention. Diabetes mellitus, chronic renal failure and rhythm disturbance were among our additional diagnoses in patients with pleural effusion. 6 tracheal stenosis were detected in the FOB performed with the preliminary diagnosis of resistant bronchospasm and asthma. One of them was resection, one was T-tube and four of them were stenotic silicone stent (Table 4).

It took an average of 10.8 ± 5.17 minutes to perform the FOB procedure after the preparations for the patient. While 97.52% of the procedure was done nasally, 2.48% was done orally. Procedures performed on these patients; bronchial lavage 100% (n = 201), bronchial brush biopsy 67.66% (n = 136), needle aspiration biopsy 20.39% (n = 41), and biopsy 26.36% (n = 136).

Significant differences were found between the age groups between the groups ($p < 0.05$). It was observed that the age was slightly higher in Group I compared to the other groups. The older patients tolerate the procedure well, while at the same time the improvement in SO_2 is greater (Figure 1).

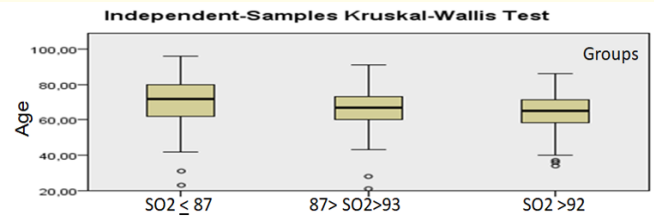

Figure 1: Comparison of Age and Groups.

When all groups were compared, a statistically significant p = 0.00 value was obtained. Regardless of the group of patients, if there was an indication, the procedure was a significant result (Table 5).

Samples	Test Statistic	Std. Error	Std.Test Statistic	Sig.	Adj. Sig.
Group I-II	42,522	10,027	4,241	,000	,000
Group I-III	100,022	10,027	9,975	,000	,000
Group II-III	57,500	10,027	5,734	,000	,000

Table 5: Pairwise Comparisons of Groups for SO_2 differences.

A significant difference was obtained in terms of saturation changes of Groups I and II (p = 0.00) (Table 6).

Group I - II	N	Mean Rank	Sum of Ranks	U	P
$SO_2 \leq 87$	67	86,25	5778,50		
$87 > SO_2 > 93$	67	48,75	3266,50		
Total	134			988,500	0,00

Table 6: Two independent samples tests with Mann-Whitney U test for Group I and II.

A significant difference was obtained in terms of saturation changes of Groups I and III (p = 0.00) (Table 7).

Group I - III	N	Mean Rank	Sum of Ranks	U	P
$SO_2 \leq 87$	67	96,3	6450		
SO2>92	67	38,7	2595		
Total	134			317,000	0,00

Table 7: Two independent samples tests with Mann-Whitney U test for Group I and III.

A significant difference was obtained in terms of saturation changes of Groups II and III (p = 0.00) (Table 8).

Group II - III	N	Mean Rank	Sum of Ranks	U	P
$87 > SO_2 > 93$	67	91,24	6113,00		
$SO_2 > 92$	67	43,76	2932,00		
Total	134			654,000	0,00

Table 8: Two independent samples tests with Mann-Whitney U test for Group II and III.

Again, when the smoking rates of the three groups were compared, no significant difference was observed. All groups smoked at the same rate ($p > 0.05$).

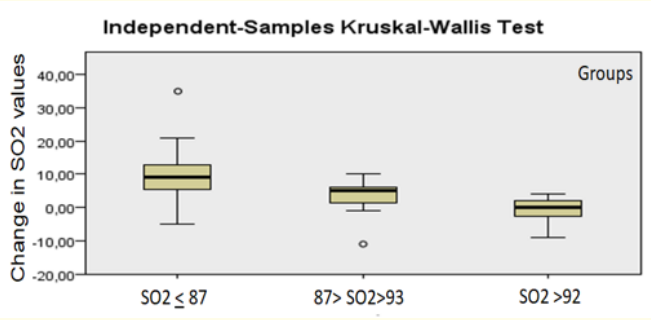

Figure 2: Comparison of change in SO_2 values and Groups.

As seen in the Kruskal-Wallis test, while the change in oxygen saturation in Group I was more positive, it was less positive in Group II. Group III with normal SO_2 had more stable or negative results (Figure 2).

Developing complications

After postbronchoscopy, massive hemoptysis in 1%, arrhythmia in 5.97%, pneumonia in 3.48%, pneumotorax in 1%, mucosal bleeding in 7.96%, 2.49% of patients 0.5% developed hypotension and 7.96% developed epistaxis (Table 9).

	N	%
Massive hemoptysis	2	1,00
Arrhythmia	12	5,97
Pneumonia	7	3,48
Pneumothorax	2	1,00
Mucosal bleeding	16	7,96
Hypertension	5	2,49
Hypotension-hypoxia	1	0,50
Epistaxis	16	7,96
Total = 201	61	30,35

Table 9

While complications were generally observed during needle and punch biopsy, only brush biopsy was taken from one of the patients who developed pneumothorax (Table 9). Patients who developed pneumonia returned to the emergency department with fever and pneumonic infiltration on chest X-ray approximately 8 hours after bronchial lavage. They were hospitalized and treated.

Discussion

Before the procedure, the patient's respiratory tract should be evaluated. Depending on the preference of the bronchoscopist, the procedure can be performed under general anaesthesia, accompanied by sedation and regional anaesthesia, or by giving a combined anaesthetic. The physician who will perform the bronchoscopy and his team should be ready to intubate at any time [10]. Bronchoscopy was performed on the patients of our clinic after frontal massage and anaesthesia of the nasal-oral tracts with anaesthetic spray.

Despite more-invasive sampling methods and less sedation during bronchoscopy, elderly patients tolerate bronchoscopy as well as younger patients. There is increased risk for adverse events with increasing age, but the absolute frequency is low, suggesting that chronological age should not be a contraindication for bronchoscopy in older persons [11]. Our patients over the age of 60 were able to tolerate bronchoscopy more than those under the age of 60. Between men and women, however, women tolerated bronchoscopy better than men.

The most common uses of flexible bronchoscopy include the diagnosis of many interstitial lung diseases, diagnosis of potential airway injury or obstructions such as foreign body or tumour, a biopsy of airway masses for diagnosis, tracheal stenosis, specific guided endobronchial washes for diagnosis of micro-bacterial evaluation, or pulmonary lobe pulmonary hygiene for collapse. Sterile saline 0,9% is flushed through the working port to break up thick secretions. Culture samples should be sent to treat bacterial pneumonia properly [12-14]. In our study, bronchial lavage culture obtained bronchoscopically was rare in patients with pneumonia and secretion retention. It was thought that this was due to the fact that the procedure was performed under antibiotic pressure rather than the failure of the procedure. After culture, we provided easy aspiration of secretions by administering sterile saline or additionally pure acetyl cysteine.

Masses within the tracheobronchial tree can cause airway obstruction and lobar parenchymal collapse. Tumours are

evaluated by visual examination for the degree of involvement, and a biopsy should be performed for pathological diagnosis. In patients with suspected lung cancer, the diagnostic yield of flexible bronchoscopy alone is high (74%) when there is a visible endobronchial component and a forceps biopsy is performed. Efficiency is increased with the addition of endoscopic brushing too [15,16]. We did not see an endobronchial mass in all of our 111-bronchoscopy performed for cancer or mass. We took punch and brush biopsies from suspicious areas. When the patient was diagnosed with cancer with tests such as needle biopsy, these previous samples played an important role in the surgical approach of the patient.

Airway injuries may not be detected on imaging such as a chest X-ray or CT scan. Using bronchoscopy in blunt or penetrating trauma helps diagnose occult airway injuries; this is important because early detection improves patient outcomes [17]. We also found vocal cord injury in one and tracheal injury in one of 12 bronchoscopies performed for hemoptysis.

The risks and potential benefits of FOB must be assessed in those patients with bronchial hyperreactivity. If these patients are adequately premedicated, the risk of FOB can be significantly reduced [18]. FOB and BAL have been reported to be safe in patients with asthma with no or mild symptoms and having an FEV1 of greater than 60%. Inhaled and IV steroids, bronchodilators, diuretics, Glyceryl Trinitrate (GTN), and Nifedipine were given to the patients with asthma or resistant respiratory distress included in our study.

It fills approximately 10% of the diameter of the trachea and 15% of the cricoid ring level. As a result, an increase in airflow resistance develops in the patient's airways, thereby increasing the work of breathing. When suction is applied, the end-expiratory lung volume decreases, resulting in alveolar recruitment, increased shunt, and venous mixing. As mentioned, these respiratory changes return after FOB, but in severe parenchymal lung diseases, their return can take anywhere from 15 minutes to several hours. Oxygen support [19,20], usually with conventional therapy or non-invasive ventilation, is required during and after FOB to avoid desaturation episodes. However, a recent study in the UK reported that only 48% of bronchoscopy units had a policy of delivering oxygen to all patients [21,22]. Before, during the procedure, stopping or continuing the procedure changes depending on the experience of the bronchoscopist. In high-risk patients with severe hypoxemia where FOB is believed to have an acceptable risk-benefit ratio [23]. It is essential to determine whether the patient has a disease that may cause hypercapnic respiratory failure or not in determining the initial need for O_2 support in the hypoxia patient. In diseases with hypercapnia risk, O_2 support is initially 1-4lt/min, while in patients without hypercapnia risk, it can be started from 5-10lt/min [7]. We gave O_2 and other drug treatments to patients with chronic hypercapnia starting from 1-4lt/min before the procedure. When the patient's saturation decreased during the procedure, the oxygen amount was increased to 5-10lt/min. In addition, we prefer to wait by pulling the FOB to the trachea. We stopped the aspiration and waited for a while in the trachea. The process was completed as quickly as possible.

In some patients, hypoxemia can be severe and persist for several hours after the completion of the procedure [24]. During nasal FOB, McCain at al. could not discern a difference between oxygen delivery by nasal cannula using either a nasal or oral route [25]. It was performed in our clinic using the nasal passage as the bronchoscopy route. O_2 supplementation was provided orally. In order to understand whether the amount of O_2 to be given to the patients was sufficient, after the SO_2 value of the patient to be processed was measured, nasal or oral O_2 was administered for about 10 minutes.

Bleeding occurs frequently following transbronchial lung biopsy [26]. Patients with airway bleeding may develop blood clots that cause bronchial obstruction. Severe bleeding following transbronchial lung biopsy may cause a ventilation-perfusion mismatch, leading to hypoxemia. It is crucial to fully control the bleeding before the FOB is removed from the airway [26-28]. In our clinic, the patient is first turned to the side of the bleeding bronchus. With flexible bronchoscopy over the carina, it is expected to prevent filling of the contralateral airway. Bleeding is drained. +4C saline, tranexamic acid and adrenaline are given. Oxygen supplementation is continued during and after the procedure. None of the patients we intervened in this way required rigid bronchoscopy. Rigid Bronchoscopy is usually used after the patient is taken to the operating room with double lumen intubation [26].

In addition, FOB indirectly causes also significant hemodynamic changes. An increase in airway resistance and work of breathing leads to changes in intra-thoracic pressure, which may also affect venous return and afterload while reducing cardiac output. However, it has been reported that cardiac output increases by 50% secondary to sympathetic stimulation during FOB, and it returns to baseline 15 min after its completion. During FOB induces significant hemodynamic changes that the mean arterial pressure can increase by 30%, heart rate by 43%, cardiac index by 28%, and mean pulmonary artery occlusion pressure by 26%, compared with pre-bronchoscopic measured values [21,29]. The clinician chooses the more appropriate oxygenation own strategy from a physiological point of view. Hypoxemia during bronchoscopy has been linked to an increased risk of arrhythmia. Bronchoscopy can produce ischemic changes, especially in those over sixty. Tachycardia may be the first sign of impending hypoxia [20]. If tachyarrhythmia is detected in the patient's ECG during the bronchoscopy preparation period, we start anti-arrhythmic treatment or change the treatment and perform the procedure the next days. Bradycardia is always a signal for the bronchoscopy specialist to immediately remove the bronchoscope from the airway and support ventilation [19]. Oxygen supplementation during and post FOB in the recovery period has been recommended to achieve an SO_2 of at least 90% and to reduce the risk of significant arrhythmias.

Sometimes hypoxia can persist for a significant time after FOB is complete, and therefore, oxygen support should be continued in the recovery room after the procedure [30]. This supplement is particularly beneficial in people with impaired lung function. Patients should be weaned off oxygen in the recovery room using pulse oximetry monitoring [31]. We encountered a patient with refractory hypoxic disease once, who had asthma and tracheal stenosis that did not respond to treatment. We had to intubate him for 2 days.

Mechanical stimulation of the airways in patients with reactive airway disease may result in bronchospasm [30]. Those cases usually respond well to nebulized salbutamol given immediately after the procedure. Patients with known reactive airway disease should receive bronchodilators immediately before FOB The cause of pneumonia after bronchoscopy may be pushing the existing infection focus in the trachea to the periphery and the aspiration of the given normal serum saline 0,9% in sufficient amounts.

Flexible fiberoptic bronchoscopy is very well tolerated. Although there is minimal risk, tissue sampling in bronchopulmonary diseases is done safely and effectively [12]. As with any medical intervention, the bronchoscopic procedure has minor and major complications. These are respiratory tract bleeding (0.12%), fever (2.5%), pneumonitis (0.4%), weakness (2%), bronchospasm (0.7%), hypoxia, pneumothorax (0.1-0.16%), and mortality (0-0.02) [15,32,33]. Similar complications were found at a higher rate in our study. Our rate of epistaxis and mucosal bleeding was close to 8% (Table 9). The reason for this was thought to be that bronchoscopy was performed through the nasal passage or that the nasal structure of the people of our country was damaged and cigarette consumption was high.

Conclusion

Although several studies show benefits from different oxygenation strategies during FOB, more guidelines still need to be made available [7-23]. Our study; Oxygen support is given to patients who need FOB before, during, and after the procedure. If the measured values of the patient are getting better with the given O2 support, the procedure should be continued. This way, the FOB procedure can be performed safely in patients with chronic hypoxemia, hypertension, and arrhythmia. Support should be continued for at least two hours after the procedure.

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