ORIGINAL ARTICLE

END-TIDAL CARBON DIOXIDE MONITORING DURING FLEXIBLE FIBEROPTIC BRONCHOSCOPY

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Abstract

Background-In recent years, flexible fiberoptic bronchoscopy (FFB) has been applied for diagnostic and therapeutic purposes. Premedication along with the passage of FFB into the airway, even in the presence of supplemental oxygen, may cause hypoventilation leading to hypoxia and desaturation. Arterial oxygen saturation is usually monitored with pulse oximetry (Spo_2) during FFB; end-tidal Pco_2 (ET-Pco_2) monitoring is not routinely used.

Methods-Two-hundred patients, ages 53±19 years (mean±SD), underwent FFB and received supplemental oxygen during various stages of FFB: 1-before and during instillation of lidocaine on the vocal cords, 2-during passage of instrument into the trachea, RMB, IMB, 3-during bronchoalveolar lavage, bronchial biopsy, transbronchial biopsy (TBB), and 4-at the final stages of FFB. ET-Pco_2 changes were studied with a capnograph and Spo_2 using a pulse oximeter simultaneously and the results were recorded.

Results-Mean ET-Pco_2 significantly decreased from 28.7±4.5 mmHg before FFB to 28±5.7 mmHg, 27.9±5.5 mmHg, 27.5±5.6 mmHg, 27.1±4.5 mmHg, 27.9±5.3 mmHg during bronchoscopy of the right main bronchus (RMB), left main bronchus (LMB), bronchial washing, bronchial biopsy and transbronchial biopsy (TBB), and at the termination of FFB, respectively ($p<0.05$). In 118 patients (59%), the decrease of ET-Pco_2 was equal to or greater than 4 mmHg; in 105 patients (52.5%) the amount of decrease in Spo_2 was 5% and in 32 patients (16%), Spo_2 decreased 10%. No correlation was found between decreasing ET-Pco_2 and Spo_2 during the procedure.

Conclusion- ET-Pco_2 and Spo_2 decreased during bronchoscopy. We also speculate that this reflects airway obstruction by the instrument. Further studies and more experimental analysis in this field is recommended.

Keywords • End-tidal Pco_2 • fiberoptic bronchoscopy • Spo_2

Introduction

Since its introduction in the late 1970's, flexible fiberoptic bronchoscopy (FFB) has been increasingly utilized for both diagnostic and therapeutic purposes.[1] The indications for performing this procedure are hemoptysis[2], atelectasis[3], diffuse parenchymal disease[4,5], chest X-ray consistent with neoplasia[6,7], chronic cough[8] and positive cultures.[9-11] Although routine FFB is a safe procedure, possibility of some complications such as vasovagal reactions[12]and laryngospasm[12,13] should be kept in mind. Pulse oximetry is a reliable, non- invasive method used in assessing arterial oxygen saturation (Spo_2) and it is routinely used to monitor patients during FFB.[15,16] A decrease in oxygen saturation during FFB is most frequently found when the instrument is positioned at the carina where consequent hypoventilation, hypoxemia and the need for supplemental oxygen may be expected.[17] These patients receive oxygen during the procedure via a nasal canula. Under these circumstances, Spo_2 can be normalized while the hypoventilation remains unrecognized.

End-tidal Pco_2 (ET-Pco_2) monitors measure peak carbon dioxide in the airway at the end of exhalation and is frequently utilized in intensive care units or emergency rooms. This type of monitoring is an accepted technique for the assessment of the adequency of ventilation and airway patency.[18-22]

The measurement of ET-Pco_2 may become a

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useful modality in monitoring the ventilatory status of patients undergoing FFB, particularly those receiving supplemental oxygen.

In order to determine the utility of capnographic monitoring during this procedure, we prospectively measured the levels of ET-Pco_2 and Spo_2 in patients subjected to FFB while receiving supplemental oxygen.

Patients and Methods

Two-hundred patients requiring FFB were included in this prospective study. Post-treatment diagnoses are shown in Table 1. The American College of Chest Physicians (ACCP) survey was used to perform the procedure.[23] The patients were admitted into the bronchoscopy room after 6-8 hours of fasting. Premedication and sedatives were used for bronchoscopy[23] including 0.5 mg atropine and 10 mg diazepam, administered IM and IV, respectively. Topical anesthesia with 2% lidocaine was utilized at the nostrils and vocal cords. Oxygen was administered at 5 lit/min via nasal prongs. Olympus type XT20 bronchoscopes (Olympus Corporation, Japan) were utilized for the procedure.

Inspection of the upper and lower airways and bronchial washing and biopsy were performed when indicated. All patients underwent full bronchoscopic inspection, regardless of the upper airway findings.

For measurement of ET-Pco_2 and Spo_2, capnometer (CC-104 CCI-104, DATEX Instramentarium Corp) and pulse oximeter (Model 520 A, NOVAMETRIX, Medical Systems Inc.) were utilized, respectively. Continuous sampling of tidal breaths was obtained by connecting a 8 Fr feeding tube to the capnometer and placing it 1-2 cm inside the nostril, which was not used for bronchoscopic evaluation. The accuracy of this method for capnographic monitoring of the respiratory status of non-intubated patients has been previously reported.[24] The Spo_2 probe was attached to a finger.

Simultaneous measurements of Spo_2 and ET-Pco_2 were obtained in various stages of bronchoscopy as mentioned before. Special care was taken to obtain adequate waveforms from capnometer. Trends of Spo_2 and ET-Pco_2 were also recorded before, during, and after FFB.

The Kolmogorov-Smirnov test was used to show the distribution of quantitative variables. Mean± standard deviation values of Spo_2 and ET-Pco_2 measurements before and during the procedure were compared using paired student's *t-test*. Comparison between groups with decrease in ET-$Pco_2 \geq 4$ mmHg and decrease in $Spo_2 \geq 5$ mmHg was made by chi-squared test. A p value of less than 0.05 was considered to be statistically significant. Statistical analysis was performed by the means of a statistical software package (SPSS for windows, Version 6.1)

Results

Two-hundred patients (119 males and 81 females) were included in this study, most of whom were diagnosed with lung cancer (38.5%), tuberculosis (15%) and bronchiectasis (12%). Other patients suffered from pneumonia, hydatid cysts and other less prevalent lung diseases. The average age of the patients was 53±15 years, ranging from 13 to 90 years. Oxygen saturation was 95.2±4.2% and ET-Pco_2 was 28.14 mmHg±4.5 before FFB.

Table 1. Summary data (mean±SD) of Spo_2 and ET-Pco_2 and its significant decrease during different stages of FFB. († TBB: Transbronchial biopsy)

Steps of bronchoscopy (n)	Spo_2 (mmHg)	Pre FFB (mmHg)	ET-Pco_2 (mmHg)	P value
Pre FFB (200)	95.22±4.22	28.74±4.50	28.74±4.50	-
Lidocaine instillation (193)	95.75±3.27	28.78±4.38	28.84±5.05	0.85
Tracheal passage (186)	95.4±3.44	28.76±4.06	28.20±5.51	0.08
Right main bronchus (194)	94.46±4.06	28.82±4.5	28.01±5.70	0.01
Left main bronchus (195)	94.70±3.76	28.80±4.44	27.91±5.54	0.009
Bronchoalveolar lavage (190)	94.31±4.04	28.73±4.55	27.47±5.55	0.001
Bronchial biopsy of TBB† (118)	92.12±4.99	28.03±4.23	27.12±4.99	0.02
End FFB (184)	93.06±4.43	28.72±4.60	27.95±5.27	0.01

Results of the mean Spo_2 and ET-Pco_2 measurements during various stages of FFB are presented in Table 1. Decreases noted in ET-Pco_2 during the passage of the instrument from the right and left main bronchi, bronchial biopsy, bronchial washing and at the end of the FFB were statistically significant with $p<0.05$, possibly reflecting a change in the amount of exhaled Co_2 reaching the capnometer. In 118 of the 200 patients (59%), the decline in ET-Pco_2 was greater than 4 mmHg. The mean±SD of ET-Pco_2 decline in various stages of FFB was 5.04±3.21 mmHg. In 105 patients (32.5%) and in 32 patients (16%), the amount of decline in Spo_2 was greater than 5% ($Spo_2 \geq 5\%$) and 10% ($Spo_2 \geq 10\%$), respectively. No correlation could be established between the changes in Spo_2 and ET-Pco_2 during FFB.

Figure 1 shows the trends of Spo_2 and ET-Pco_2 before and during various stages of bronchoscopy as well as a tendency of ET-Pco_2 to decrease during different stages of FFB. ET-Pco_2 remained low throughout the procedure, returning to baseline values after the instrument was withdrawn from the airway. Chi-square statistical groups with decrease in ET-$Pco_2 \geq 4$ mmHg among patients with decrease in $Spo_2 \geq 5\%$ was not significant (Yates correction=0.1046).

Discussion

Our study confirms previous reports of a decrease in Spo_2 during various stages of FFB and indicates that this can occur even when the patient is receiving supplemental oxygen.[14, 17] It also demonstrates that a significant decrease in ET-Pco_2 can be seen during this procedure. The measurement of ET-Pco_2 is now widely used to monitor the ventilatory status of patients, since it is well correlated with arterial CO_2 pressure and is not significantly affected by oxygen flow rate.[25]

In the presence of supplemental oxygen, ET-Pco_2 monitoring may be a more sensitive way to detect airway obstruction than Spo_2. A decrease in Spo_2 during FFB has been previously reported.[17] The changes in ET-Pco_2 values observed during FFB could be derived from (a) tachypnea and increased minute ventilation secondary to airway stimulation, (b) hypoventilation due to airway obstruction and/or sedation, or (c) significant changes in pulmonary perfusion arising from increased airway resistance.[26] Abnormally low end-tidal values (below 35 mmHg), most often reflect hyperventilation but may also be caused by an increase in dead space with normal $Paco_2$. The value of ET-Pco_2 depends on the alveolar dead space, which is in turn mainly influenced by the relative distribution of ventilation and perfusion (V/Q) within the lungs.[27]

Possible hemodynamic alterations could also be involved in the ET-Pco_2 variations observed during bronchoscopy. Changes in minute ventilation, V_D/V_T and cardiac output may occur in patients receiving cardioactive drugs such as atropine, which was administered to all. Any of these changes may affect ET-Pco_2. A decline in blood pressure, if severe enough, also causes an increase in the physiologic dead space and a reduction in the end-expired CO_2 levels.

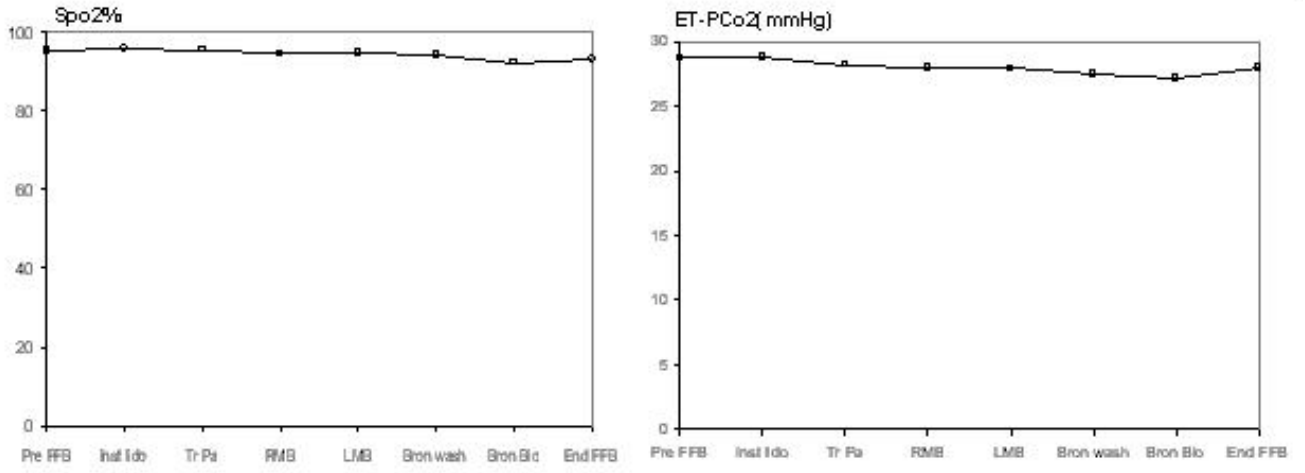

Figure 1. Trends of mean Spo_2 (a) and ET-Pco_2(b) in different stages of FFB. (Inst. Lido.: Instillation of lidocaine on vocal cords, Tr.Pa.: Tracheal passage, RMB: Right Main Bronchus, LMB: Left Main Bronchus, Bron.wash.: Bronchial washing, Bron.Bio.: Bronchial biopsy or transbronchial biopsy).

Capnography with FFB has been used to assess the effects of lobectomy on regional lung function[28], to monitor high-frequency jet ventilation[29] and to evaluate hypoventilation in sedated pediatric patients during FFB.[30] Franchi and colleagues postulated that patients suffering from partial airway obstruction during FFB variations in alveolar ventilation, with or without a concomitant change in alveolar dead space, could have been responsible for the decrease in ET-Pco_2 during FFB.[30] In contrast to Franchi and colleagues[30], and the present study, other investigators have reported increases in ET-Pco_2 in high-risk patients in childhood during rigid bronchoscopy under general anesthesia.[31]

Measurement of ET-Pco_2 has been recommended for the noninvasive estimation of $Paco_2$.[25,32,33] Documenting fluctuations or trends of ET-Pco_2 values, however, may provide more useful clinical information than monitoring isolated values.

In conclusion, the data in this study indicate a decrease in Spo_2 and ET-Pco_2 levels during FFB with oxygen supplementation. We believe that these changes are due to the obstruction of the tracheal and bronchial airway produced by the bronchoscope, and there was no correlation between these changes. Further studies are needed to determine if continuous ET-Pco_2 monitoring during FFB is useful in detecting significant airway obstruction. No correlation was found between ET-Pco_2 changes with Spo2 during the procedure.

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