

END-TIDAL CARBON DIOXIDE MONITORING DURING FLEXIBLE FIBEROPTIC BRONCHOSCOPY

Mohammed A. Taher¹, Fawaz A. Kamash², Jafar A. Al-Momani³

ABSTRACT

Background: In recent years, Flexible Fiberoptic Bronchoscopy (FFB) has been applied for diagnostic and some therapeutic purposes. During FFB and even in the presence of supplemental oxygen, hypoventilation leading to hypoxia and desaturation may occur; this is aggravated by the use of suction. Arterial oxygen saturation is usually monitored with pulse oximetry (SpO₂) during FFB; End-Tidal Pco₂ (ET-Pco₂) monitoring is not routinely used.

Methods: Two-hundred patients were studied between May 1998 till April 2003, at the divisions of chest surgery and Pulmonology at King Hussein Medical Center, (KHMC). Their ages 53±19 years (mean±SD), underwent FFB and received supplemental oxygen during various stages of FFB: 1-before and during installation of lidocaine on the vocal cords, 2-during passage of instrument into the trachea, RMB, LMB, 3-during bronchoalveolar lavage, bronchial biopsy, Trans Bronchial Biopsy (TBB), and 4-at the final stages of FFB. ET-Pco₂ changes were studied with a capnograph and SpO₂ using a pulse oximeter simultaneously and the results were recorded.

Results: Mean ET-Pco₂ 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 Trans Bronchial Biopsy (TBB), and at the termination of FFB, respectively (p<0.05). In 118 patients (59%), the decrease of ET-Pco₂ was equal to or greater than 4 mmHg; in 105 patients (52.5%) the amount of decrease in SpO₂ was = 5% and in 32 patients (16%), SpO₂ decreased = 10%. No correlation was found between decreasing ET-Pco₂ and SpO₂ during the procedure.

Conclusion: ET-Pco₂ and SpO₂ 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.

KEY WORDS: End-Tidal Pco₂, fiberoptic bronchoscopy, SpO₂.

Pak J Med Sci April - June 2006 Vol. 22 No. 2 149 - 153

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 cough⁸ and positive cultures.⁹⁻¹¹ Although routine FFB is a safe procedure, possibility of some complications such as vasovagal reactions¹² and laryngospasm^{12,13} should be kept in mind. Pulse oximetry is a reliable, non-invasive method used in assessing arterial oxygen saturation (SpO₂) and it is routinely used to monitor patients during FFB.¹⁴⁻¹⁶ 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,

1. Dr. Mohammed A. Taher
2. Dr. Fawaz A. Kamash
3. Dr. Jafar A. Al-Momani

1-3: Division of Thoracic Surgery,
King Hussein Medical Center (KHMC),
Amman, Jordan.

Correspondence:

Dr. Jafar Al-Momani
P.O. Box: 142993,
Amman-11814,
JORDAN.
E-Mail: jafarmom@yahoo.com

* Received for Publication: April 7, 2005

Accepted: November 1, 2005

Spo₂ can be normalized while the hypoventilation remains unrecognized.

End-Tidal Pco₂ (ET-Pco₂) 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 adequacy of ventilation and airway patency.¹⁸⁻²² The measurement of ET-Pco₂ may become a 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-Pco₂ and Spo₂ 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-I. 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 bronchoscopy²³ 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-Pco₂ and Spo₂, capnometer (CC-104 CCI-104, DATEX Instrumentarium 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 Spo₂ probe was attached to a finger.

Simultaneous measurements of Spo₂ and ET-Pco₂ were obtained in various stages of bronchoscopy as mentioned before. Special care was taken to obtain adequate waveforms from capnometer. Trends of Spo₂ and ET-Pco₂ 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 Spo₂ and ET-Pco₂ measurements before and during the procedure were compared using paired student's *t*-test. Comparison between groups with decrease in ET-Pco₂=4 mmHg and decrease in Spo₂=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-Pco₂ was 28.14 mmHg±4.5 before FFB.

Results of the mean Spo₂ and ET-Pco₂ measurements during various stages of FFB are presented in Table-I. Decreases noted in ET-Pco₂ 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 Co₂ reaching the

TABLE-I

Steps of bronchoscopy (n)	Spo ₂ (mmHG)	Pre FFB (mmHG)	ET-Pco ₂ (mmHG)	p value
Pre FFB (200)	95.22±4.22	28.7±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
Rt 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

capnometer. In 118 of the 200 patients (59%), the decline in ET-Pco₂ was greater than 4 mmHg. The mean±SD of ET-Pco₂ 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 Spo₂ was greater than 5% (Spo₂=5%) and 10% (Spo₂=10%), respectively. No correlation could be established between the changes in Spo₂ and ET-Pco₂ during FFB.

Figure-I shows the trends of Spo₂ and ET-Pco₂ before and during various stages of bronchoscopy as well as a tendency of ET-Pco₂ to decrease during different stages of FFB. ET-Pco₂ 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-Pco₂=4 mmHg among patients with decrease in Spo₂=5% was not significant (Yates correction=0.1046).

DISCUSSION

Our study confirms previous reports of a decrease in Spo₂ 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-Pco₂ can be seen during this procedure. The measurement of ET-Pco₂ is now widely used to monitor the ventilatory status of patients, since it is well correlated with arterial CO₂ pressure and is not significantly affected by oxygen flow rate.²⁵

In the presence of supplemental oxygen, ET-Pco₂ monitoring may be a more sensitive way to detect airway obstruction than Spo₂. A decrease in Spo₂ during FFB has been previously reported.¹⁷ The changes in ET-Pco₂ 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 Paco₂. The value of ET-Pco₂ depends on the alveolar dead space, which is in turn mainly influenced

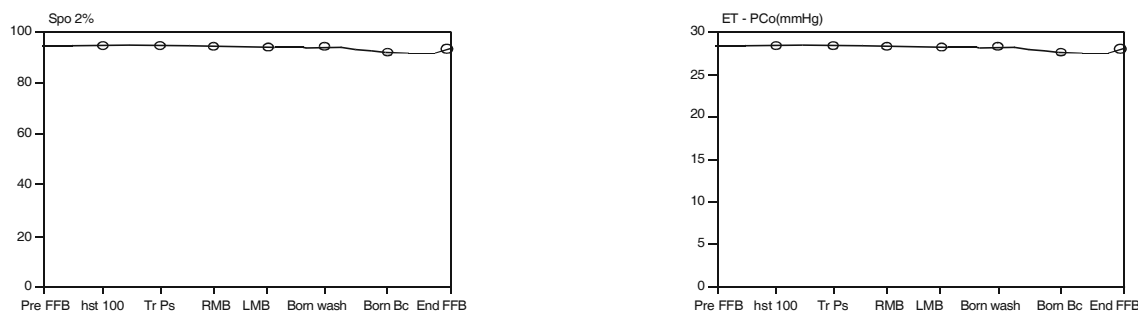


Figure-I: Trends of mean Spo₂ (a) and ET-Pco₂ (b) in different stages of FFB. (Inst. Lido.: Instillation of lidocaine on vocal cords, Tr.Pa.: Tracheal passage, RMB: Right Main Bronchus, LMB: Left Main Bronchus, Bron.wash.: Bronchial washing, Bron.Bio.: Bronchial biopsy or transbronchial biopsy).

by the relative distribution of ventilation and perfusion (V/Q) within the lungs.²⁷

Possible hemodynamic alterations could also be involved in the ET- P_{CO_2} variations observed during bronchoscopy. Changes in minute ventilation, VD/VT 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- P_{CO_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.

Capnography with FFB has been used to assess the effects of lobectomy on regional lung function,²⁸ to monitor high-frequency jet ventilation²⁹ 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- P_{CO_2} during FFB.³⁰ In contrast to Franchi and colleagues,³⁰ and the present study, other investigators have reported increases in ET- P_{CO_2} in high-risk patients in childhood during rigid bronchoscopy under general anesthesia.³¹

Measurement of ET- P_{CO_2} has been recommended for the noninvasive estimation of P_{aCO_2} .^{25,32-33} Documenting fluctuations or trends of ET- P_{CO_2} values, however, may provide more useful clinical information than monitoring isolated values.

CONCLUSION

The data in this study indicate a decrease in Spo_2 and ET- P_{CO_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- P_{CO_2} monitoring during FFB is useful in detecting significant airway obstruction. No cor-

relation was found between ET- P_{CO_2} changes with Spo_2 during the procedure.

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