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 (Spo2) during FFB; end-tidal Pco2 (ET-Pco2) 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-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 transbronchial 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.

Keywords • End-tidal Pco2 • fiberoptic bronchoscopy • Spo2

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 hemoptysis2, atelectasis3, diffuse parenchymal disease4,5, chest X-ray consistent with neoplasia6,7, chronic cough8 and positive cultures.9-11 Although routine FFB is a safe procedure, possibility of some complications such as vasovagal reactions12 and laryngospasm12,13 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.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, 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 1. The American College of Chest Physicians (ACCP) survey was used to perform the procedure. The patients were admitted into the bronchoscopy room after 6-8 hours of fasting. Premedication and sedatives were used for bronchoscopy 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. 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.

**Table 1.** Summary data (mean±SD) of Spo₂ and ET-Pco₂ and its significant decrease during different stages of FFB. († TBB: Transbronchial biopsy)

<table>
<thead>
<tr>
<th>Steps of bronchoscopy (n)</th>
<th>Spo₂ (mmHg)</th>
<th>Pre FFB (mmHg)</th>
<th>ET-Pco₂ (mmHg)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre FFB (200)</td>
<td>95.22±4.22</td>
<td>28.74±4.50</td>
<td>28.74±4.50</td>
<td>-</td>
</tr>
<tr>
<td>Lidocaine instillation (193)</td>
<td>95.75±3.27</td>
<td>28.78±4.38</td>
<td>28.84±5.05</td>
<td>0.85</td>
</tr>
<tr>
<td>Tracheal passage (186)</td>
<td>95.4±3.44</td>
<td>28.76±4.06</td>
<td>28.20±5.51</td>
<td>0.08</td>
</tr>
<tr>
<td>Right main bronchus (194)</td>
<td>94.46±4.06</td>
<td>28.82±4.5</td>
<td>28.01±5.70</td>
<td>0.01</td>
</tr>
<tr>
<td>Left main bronchus (195)</td>
<td>94.70±3.76</td>
<td>28.80±4.44</td>
<td>27.91±5.54</td>
<td>0.009</td>
</tr>
<tr>
<td>Bronchoalveolar lavage (190)</td>
<td>94.31±4.04</td>
<td>28.73±4.55</td>
<td>27.47±5.55</td>
<td>0.001</td>
</tr>
<tr>
<td>Bronchial biopsy of TBB† (118)</td>
<td>92.12±4.99</td>
<td>28.03±4.23</td>
<td>27.12±4.99</td>
<td>0.02</td>
</tr>
<tr>
<td>End FFB (184)</td>
<td>93.06±4.43</td>
<td>28.72±4.60</td>
<td>27.95±5.27</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Results of the mean Spo2 and ET-Pco2 measurements during various stages of FFB are presented in Table 1. 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 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 1 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 by the relative distribution of ventilation and perfusion (V/Q) within the lungs.27

Possible hemodynamic alterations could also be involved in the ET-Pco2 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-Pco2. A decline in blood pressure, if severe enough, also causes an increase in the physiologic dead space and a reduction in the end-expired CO2 levels.

Figure 1. 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).
Capnography with FFB has been used to assess the effects of lobectomy on regional lung function, to monitor high-frequency jet ventilation and to evaluate hypoventilation in sedated pediatric patients during FFB. 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-Pco2 during FFB. In contrast to Franchi and colleagues, and the present study, other investigators have reported increases in ET-Pco2 in high-risk patients in childhood during rigid bronchoscopy under general anesthesia.

Measurement of ET-Pco2 has been recommended for the noninvasive estimation of Paco2. Documenting fluctuations or trends of ET-Pco2 values, however, may provide more useful clinical information than monitoring isolated values.

In conclusion, the data in this study indicate a decrease in SpO2 and ET-Pco2 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-Pco2 monitoring during FFB is useful in detecting significant airway obstruction. No correlation was found between ET-Pco2 changes with SpO2 during the procedure.

References


