Predictors of Oxygen Desaturation in Patients Undergoing Diagnostic Bronchoscopy

Wen-Feng Fang[1], MD; Yung-Che Chen[1], MD; Yu-Hsiu Chung[1], MD;
Wei-Tong Woon[1], MD; Chia-Chen Tseng[1], MD; Hsueh-Wen Chang[2], PhD;
Meng-Chih Lin[1,3], MD

Background: Oxygen desaturation is not uncommon during bronchoscopy. We sought to identify factors predictive of desaturation during flexible bronchoscopy.

Methods: Over eight months, we enrolled 137 randomly selected patients who were undergoing fiberoptic bronchoscopy at our medical center. The patients' oxygen saturation was monitored on their arrival and during the procedure by finger pulse oximetry. Desaturation was defined as an overall saturation nadir of < 90% or an episode of decreased saturation of 5% from the baseline regardless of whether the patient was receiving supplemental oxygen.

Results: The need for oxygen supplementation before the procedure was predictive of a higher rate of desaturation episodes (73.9% vs. 50%, $p = 0.036$). Although all interventional procedures or their complications can cause desaturation, the specific type of procedure was the most important predictor of desaturation (lavage, 88.9%; washing, 43.8%; brushing, 15.2%; biopsy, 10%). A low peak expiratory flow rate before the procedure seemed to be predictive of a high desaturation rate in patients undergoing lavage or washing during bronchoscopy.

Conclusion: Our study suggested that age, sex and baseline oxygen saturation were not predictors of desaturation. We should be reminded of the possibility of desaturation during every procedure, especially in patients who need supplemental oxygen before bronchoscopy.

(Chang Gung Med J 2006;29:306-12)

Key words: bronchoscopy, oxygen desaturation, peak expiratory flow rate. pulse oximetry.

Bronchoscopy is a procedure commonly performed for a variety of purposes. During bronchoscopy, oxygen desaturation is not unusual[(1)] because respiratory depressants are often used as premedication and the bronchoscope partially occludes the airway. Patients in a poor general condition and those with impaired pulmonary function are at high risk of hypoxemia.[(2)] This risk prompts physicians to determine whether the possibility of desaturation before performing bronchoscopy can be predicted.

We hypothesized that some interventions, such as bronchoalveolar lavage (BAL) and biopsy, or some medical complications, such as hemorrhage

From the [1]Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Chang Gung Memorial Hospital, Kaohsiung; [2]Department of Biological Sciences, National Sun Yat-Sen University; [3]Department of Respiratory Care, Chang Gung Institute of Technology, Chia-Yi.
Received: Aug. 4, 2005; Accepted: Jan. 24, 2006
Correspondence to: Dr. Meng-Chih Lin, Pulmonary and Critical Care Division, Chang Gung Memorial Hospital. 123, Dabi Road, Niaosung Shiang, Kaohsiung, Taiwan 833, R.O.C. Tel: 886-7-7317123 ext. 8199; Fax: 886-7-7322402; E-mail: mengchih@adm.cgmh.org.tw

and bronchospasm, can induce hypoxemia. However, the severity of the resultant hypoxemia is not predictable. In addition to testing this hypothesis, we were also interested in the characteristics of desaturation and its relationship to other factors, such as the patient's sex, underlying disease, baseline oxygen saturation (SpO_2), preprocedural peak expiratory flow rate (PEFR) or use of supplemental oxygen. Therefore, we prospectively investigated factors predictive of changes in SpO_2 during flexible bronchoscopy with the use of pulse oximetry.

METHODS

Patients

Between December 2003 and July 2004, patients undergoing fiberoptic bronchoscopy (FOB) in the Bronchoscopy Unit, for a variety of reasons, were enrolled. These patients were eligible for bronchoscopic examination. Oxygen supplementation, if used within three days before bronchoscopy, was adjusted to achieve SpO_2 of 90%. The local ethics committee approved this study. Consent was obtained from all patients or their guardians before the patients' enrollment.

Measurements

We recorded the patient's demographic characteristics, purpose for bronchoscopy and preprocedural PEFR. The PEFR is the maximum rate of airflow that can be achieved during a sudden forced expiration from a position of full inspiration. We measured patients' PEFR with an Invacare Peak Flow Meter (Mini-Bell Peak Flow Meter manufactured by Trimedica) just before and after performing the bronchoscopy. The patients' SpO_2 and pulse rate were monitored on their arrival and during the procedure by finger pulse oximetry (FingerPrint, BCI International, Wisconsin, USA). Desaturation was defined as an overall saturation nadir of < 90% or an episode of decreased saturation with a change of 5% from baseline regardless of whether the patient was receiving supplemental oxygen. For the patients' safety, oxygen was provided via a nasal cannula during bronchoscopy if desaturation lasted longer than 20 seconds. Oxygen flow was started at a rate of 2 L/min if it was not initially used and increased by increments of 2 L/min to achieve SpO_2 of 90% during the procedure.

Atropine was not used for premedication because the use of anticholinergic agents prior to bronchoscopy did not affect performance of bronchoscopy or complication rates.[3] No patient was offered sedatives because of proven safety of outpatient FOB without sedation,[4] although there were no grounds for abandoning sedation.[5,6] Bronchoscopy (Olympus EVIS PF P260, Japan) was performed transnasally. Nasal anesthesia was achieved by administering lidocaine (Xylocaine) gel after a lidocaine liquid spray was given; aliquots of 2 mL (2% solution) were used to achieve local analgesia of the vocal cords and the bronchial tree.

We recorded all episodes (*e.g.* alterations in oxygen flow, changes in SpO_2, performance of any procedure) and the time at which they occurred (by using a stopwatch). After bronchoscopy, the PEFR of each patient was measured again and recorded.

Bronchoalveolar lavage

The bronchoscope was advanced and wedged in a subsegmental bronchus of the affected area. Four 50-mL aliquots of sterile saline solution were instilled through the bronchoscope and aspirated via a hand-held syringe. Before each procedure, the lavage fluid was warmed to 37°C.

Statistical analysis

Analysis was performed with the statistical software SAS (version 8.02, SAS Institute, Cary, NC, USA). The Student t test or Wilcoxon rank sum test was used to compare continuous variables, and the χ^2 test or Fisher exact test was used for categorical variables. A p value of < 0.05 was considered statistically significant.

RESULTS

A total of 137 patients were included in the data analysis. Among them, 88 (64.2%) neither required nor received oxygen supplementation during flexible bronchoscopy (Table 1). Patients with desaturation seemed to have lower preprocedural and postprocedural PEFRs than those of the other patients, although the difference was not statistically significant. Table 1 shows that patients who do not need oxygen supplement may still suffer from transient desaturation.

Before the procedure, 114 patients did not

Table 1. Demographic and Clinical Data in Patients Not Receiving Oxygen Supplementation

	Desaturation (n = 42)	No desaturation (n = 46)	*p* value
Age (years)	57.5 ± 17.7	58.9 ± 13.4	0.741
Male to female ratio	25:17	31:15	0.444
SpO_2 %			
Baseline	97.3 ± 1.4	96.8 ± 1.7	0.212
Lowest	88.0 ± 14.2	94.9 ± 2.4	< 0.001
Change*	7.1 ± 2.7	2.0 ± 1.4	< 0.001
PEFR L/min			
Preprocedural	273.1 ± 102.8	313.1 ± 139.5	0.181
Postprocedural	241.5 ± 92.3	279.3 ± 111.7	0.105

Abbreviations: SpO_2: baseline oxygen saturation; PEFR: peak expiratory flow rate
Data are mean ± standard deviation or frequency
*Baseline SpO_2 minus lowest SpO_2

receive oxygen supplementation and 23 did receive it (Table 2). The median oxygen flow was 5 L/min. No patient had hypoxemia severe enough to require use of an oxygen mask. Patients who did not receive oxygen supplementation before the procedure had preprocedural and postprocedural PEFRs better than those of patients who did receive oxygen. However,

Table 2. Demographic Data of Total Patient Population

	No preprocedural oxygen supplementation (n = 114)	Preprocedural oxygen supplementation (n = 23)	*p* value
Age (years)	58.4 ± 15.9	64.5 ± 13.0	0.093
Male to female ratio	76:38	16:7	0.788
SpO_2 %			
Baseline	96.8 ± 1.8	95.9 ± 2.6*	0.183
Lowest	91.4 ± 9.4	92.8 ± 4.5	0.224
Change	4.7 ± 3.8	3.1 ± 4.4	0.009
PEFR L/min			
Preprocedural	289.3 ± 123.0	203.7 ± 101.8	0.0005
Postprocedural	254.9 ± 103.1	201.0 ± 122.0	0.014
Desaturation			
Patients n	57 (50)	17 (73.9)	0.036
Not prevented†	2 (1.8)	3 (13.0)	0.033

Abbreviations: SpO_2: baseline oxygen saturation; PEFR: peak expiratory flow rate.
Data are mean ± standard deviation or frequency (percentage).
* SpO_2 detected with oxygen supplementation.
† The patient suffered from a first episode of desaturation and was given oxygen supplementation or the flow of oxygen supplementation was increased but further desaturation was not prevented.

when compared with oxygen supplementation in the latter group, the mean baseline SpO_2 did not differ significantly. Although the differences between baseline and nadir saturations were less in patients receiving oxygen supplementation before the procedure than in the others, they had a higher risk of desaturation. In most patients, judicious use of oxygen overcame the desaturation, especially in the group without oxygen supplementation before the procedure.

To eliminate the interference of multiple interventions and oxygen supplementation on SpO_2, we divided patients who were breathing room air before and during bronchoscopy into four groups according to the first interventional procedure performed (Table 3). Patients receiving oxygen supplementation or those not undergoing any interventional procedure were excluded. We observed no statistical difference among the four groups (*i.e.* lavage, biopsy, brushing, washing) in terms of patient age or baseline SpO_2. When we compared each subgroup (*i.e.* desaturation and no desaturation), we also found no statistical difference in age. However, preprocedural PEFRs significantly differed between the desaturation and nondesaturation subgroups undergoing lavage or washing.

The rates of desaturation for the interventional procedures were as follows: lavage, 88.9% (95% confidence interval: 51.8 - 99.7%); washing, 43.8% (95% confidence interval: 19.4 - 70.1%); brushing, 15.2% (95% confidence interval: 21.1 - 50.9%); and biopsy, 10% (95% confidence interval: 0.3 - 44.5%).

DISCUSSION

Desaturation may have many causes, some of which are obscure, and failure to respond promptly may place the patient at risk. Bronchoscopy may be required where desaturation is persistent and/or when no apparent causes for lung lesions can be found.[7] However, transient, minor desaturation is common during bronchoscopy. Desaturation may occur at any value of forced expiratory volume in one second, even without sedation. Most patients do not require routine oxygen supplementation, especially those with relatively good preprocedural pulmonary function.[8] In our study, 42 (48%) of the 88 patients had an episode of transient desaturation due to various etiologies. Certain interventions, such as BAL, can

Table 3. Clinical Data of Patients Receiving Specific Procedure during Bronchoscopy

	Total	Desaturation	No desaturation	*p* value*
Lavage				
Patients n	9	8	1	
Age (years)	46.78 ± 12.90	45.63 ± 13.29	56	
SpO_2 %				
Baseline	97.56 ± 1.33	97.38 ± 1.30	99	
Change after procedure	4.89 ± 2.37	5.25 ± 2.25	2	
Change during procedure	6.56 ± 4.33	7.38 ± 3.81	0	
Preprocedural PEFR L/min	314.44 ± 133.15	282.50 ± 98.81	570	
Biopsy				
Patients n	10	1	9	
Age (years)	63.70 ± 12.03	70	63.00 ± 12.54	
SpO_2 %				
Baseline	96.40 ± 1.35	97	96.33 ± 1.41	
Change after procedure	2.20 ± 1.93	5	1.89 ± 1.76	
Change during procedure	1.40 ± 1.43	0	1.56 ± 1.42	
Preprocedural PEFR L/min	250.50 ± 122.53	250	250.56 ± 129.96	
Brushing				
Patients n	33	5	28	
Age (years)	60.52 ± 18.58	56.60 ± 35.20	61.21 ± 14.91	0.786
SpO_2 %				
Baseline	96.70 ± 2.42	95.40 ± 4.56	96.93 ± 1.86	0.499
Change after procedure	1.58 ± 2.87	5.40 ± 3.36	0.89 ± 2.22	0.0005
Change during procedure	1.91 ± 3.26	7.40 ± 2.30	0.93 ± 2.29	< 0.0001
Preprocedural PEFR L/min	278.06 ± 110.79	198.00 ± 63.80	297.36 ± 112.00	0.079
Washing				
Patients n	16	7	9	
Age (years)	56.06 ± 15.25	51.43 ± 16.78	59.67 ± 13.83	0.299
SpO_2 %				
Baseline	96.88 ± 1.31	97.14 ± 0.90	96.67 ± 1.58	0.490
Change after procedure	3.50 ± 4.32	5.71 ± 5.82	1.78 ± 1.39	0.127
Change during procedure	4.06 ± 4.45	7.71 ± 4.68	1.22 ± 1.20	0.010
Preprocedural PEFR L/min	298.75 ± 123.23	222.86 ± 59.92	357.78 ± 129.69	0.024

Note.-Desaturation indicates desaturation due to the first procedure performed. Patients had not received supplemental oxygen during bronchoscopy. Change after procedure refers to baseline SpO_2 minus SpO_2 at the end of the first procedure, and change during procedure refers to baseline SpO_2 minus SpO_2 during the first procedure.
Note.-No statistical testing for *p* value in *lavage* and *biopsy* group due to case number = 1.
* Wilcoxon rank sum test.

aggravate hypoxemia during flexible bronchoscopy.[9] We observed that all interventional procedures or complications could cause desaturation.

The addition of supplemental oxygen during flexible bronchoscopy and the recovery period can prevent bronchoscopy-induced hypoxemia.[10-12] Indeed, it can prevent further desaturation episodes, especially in patients who do not receive preprocedural oxygen supplementation, as shown in our series. Many articles have investigated the influence of body position on gas exchange in patients with lung diseases.[13-15]

The study by Mirci showed that patients with baseline hypoxemia had more desaturation during bronchoscopy in the supine position than in other positions.[16] The study by Golpe and Mateos was not able to demonstrate a significant influence of body position on SpO_2 after BAL.[17] We did not explore the effect of position on desaturation, and all of our patients were supine during bronchoscopy.

Montravers et al.[9] revealed that the decrease in SpO_2 is no greater in patients with the lowest initial values than in other patients. Our results agreed with this observation.

Chhajed and his coworkers noted that lung transplant recipients undergoing FOB who had been treated previously with nasopharyngeal tube insertion had further episodes of oxygen desaturation (< 90%), despite supplemental oxygen therapy. Prophylactic nasopharyngeal tube insertion prevented acute hypoxemia in the majority of lung transplant recipients, with previously documented FOB-related oxygen desaturation secondary to upper airway obstruction.[18] The main (but not the only) factor related to desaturation is the existence of an obstructive ventilatory defect.[19] So we are interested in evaluating whether a pulmonary function test before undergoing bronchoscopy can be a predictor of desaturation. We recorded the patients' PEFR before and after the procedure to define possible individual predictive factors, since this measure is economical and easy to record, and it detects moderate or severe disease. Many patients scheduled to undergo diagnostic bronchoscopy cannot tolerate other pulmonary function tests such as forced expiratory volume in one second (FEV_1). The simplicity of the PEFR method is its main advantage; however it is less accurate than FEV_1 in predicting severity in patients with chronic obstructive pulmonary disease. Our findings suggested that measuring PEFR before the procedure may be a noninvasive and easy method for predicting desaturation in patients undergoing lavage or washing. However, based on a small number of cases, the clinical value of preprocedual PEFR to predict desaturation remains to be determined. Moreover, bronchoconstriction is not likely to be related to a propensity for oxyhemoglobin desaturation in patients undergoing biopsy or brushing during bronchoscopy. The study would have been stronger had we also measured the functional residual capacity or the FEV_1.

The reason for adding a reduction in SpO_2 of 5% from baseline to the definition of desaturation is that it may offer a good measure of the dynamic changes in saturation, such as that usually used in polysomnographic scoring.[20] When we defined desaturation as an overall saturation nadir of < 90%, we had fewer patients in the desaturation group. However, regardless of the definition of desaturation, none of the patients had major complications attributable to hypoxia during or immediately after the procedure.

Sedation can cause hypoventilation during bronchoscopy, secondary to central respiratory depression. Flexible bronchoscopy can aggravate this condition when the bronchoscope is introduced into a major airway, reducing its cross-sectional area and increasing the resistance to airflow. In our Bronchoscopy Unit, most patients are not given conscious sedation and they tolerate the bronchoscopy procedures well. In our series, breath holding because of anxiety was one of the causes of desaturation. By encouraging the patient to breathe normally, a transient decrease in SpO_2 was easily overcome.

Our findings suggest that, during flexible bronchoscopy, the need for oxygen supplementation before the procedure may be predictive of desaturation episodes (73.9% vs. 50%). The poorer underlying pulmonary function of those patients versus the others (preprocedural PEFR 203.7 vs. 289.3) should play an important role. A further point needs to be clarified. During flexible bronchoscopy, more than one interventional procedure may be performed. For example, a patient might receive bronchial brushing followed by bronchial lavage if clinically indicated. Therefore, all previous interventional procedures may interfere with saturations recorded thereafter. In addition, if oxygen supplementation during bronchoscopy is not uniform, it can influence the oxygen dissociation curve and the SpO_2 recorded. To eliminate these interferences, we selected the patients shown in Table 3 for analysis. The type of procedure performed was the most important predictor of desaturation ($p < 0.0001$, Fisher exact test).

Bronchoscopy is acknowledged to induce desaturation. However, the results of our prospective study showed that age, sex and baseline SpO_2 were not predictive factors. We concluded that the type of procedure performed was the most important predictor of desaturation. We should be reminded of the possibility of desaturation during every procedure, especially in patients who need oxygen supplementation before bronchoscopy. Judicious use of oxygen supplementation can prevent possible desaturation.

REFERENCES

1. Albertini RE, Harrell JH 2nd, Kurihara N, Moser KM.

Arterial hypoxemia induced by fiberoptic bronchoscopy. JAMA 1974;230:1666-7.
2. Kristensen MS, Milman N, Jarnvig IL. Pulse oximetry at fibre-optic bronchoscopy in local anaesthesia: indication for postbronchoscopy oxygen supplementation? Respir Med 1998;92:432-7.
3. Cowl CT, Prakash UB, Kruger BR.The role of anticholinergics in bronchoscopy. A randomized clinical trial. Chest 2000;118:188-92.
4. Colt HG, Morris JF. Fiberoptic bronchoscopy without premedication. A retrospective study. Chest 1990;98:1327-30.
5. Hatton MQ, Allen MB, Vathenen AS, Mellor E, Cooke NJ. Does sedation help in fibreoptic bronchoscopy? BMJ 1994;309:1206-7.
6. Putinati S, Ballerin L, Corbetta L, Trevisani L, Potena A.Patient satisfaction with conscious sedation for bronchoscopy. Chest 1999;115:1437-40.
7. Szekely SM, Runciman WB, Webb RK, Ludbrook GL. Crisis management during anaesthesia: desaturation. Qual Saf Health Care 2005;14:e6.
8. Jones AM, O'Driscoll R. Do all patients require supplemental oxygen during flexible bronchoscopy? Chest 2001;119:1906-9.
9. Montravers P, Gauzit R, Dombret MC, Blanchet F, Desmonts JM. Cardiopulmonary effects of bronchoalveolar lavage in critically ill patients. Chest 1993;104:1541-7.
10. Dubrawsky C, Awe RJ, Jenkins DE. The effect of bronchofiberscopic examination on oxygenation status. Chest 1975;67:137-40.
11. Hendy MS, Bateman JR. Stableforth DE. The influence of transbronchial lung biopsy and bronchoalveolar lavage on arterial blood gas changes occurring in patients with diffuse interstitial lung disease. Br J Dis Chest 1984;78:363-8.
12. Afsar S, Choudhri AN, Talib A, Farooqi T, Pasha MJ. Oxygen desaturation during fiberoptic bronchoscopy. J Pak Med Assoc 1992;42:263-5.
13. Romero S, Martin C, Hernandez L, Arriero JM, Benito N, Gil J. Effect of body position on gas exchange in patients with unilateral pleural effusion: influence of effusion volume. Respir Med 1995;89:297-301.
14. Gillespie DJ, Rehder K. Body position and ventilation-perfusion relationships in unilateral pulmonary disease. Chest 1987;91:75-9.
15. Prokocimer P, Garbino J, Wolff M, Regnier B. Influence of posture on gas exchange in artificially ventilated patients with focal lung disease. Intensive Care Med 1983;9:69-72.
16. Mirci AN. Patients with baseline hypoxemia demonstrate more desaturation during bronchoscopy at supine position. Respir Med 2002;96:287.
17. Golpe R, Mateos A. Effect of body position on gas exchange after bronchoalveolar lavage. Respir Med 2005;99:1061-3.
18. Chhajed PN, Aboyoun C, Malouf MA, Hopkins PM, Plit M, Grunstein RR, Glanville AR. Prophylactic nasopharyngeal tube insertion prevents acute hypoxaemia due to upper-airway obstruction during flexible bronchoscopy. Intern Med 2003;33:317-8.
19. Golpe R, Mateos A. Supplemental oxygen during flexible bronchoscopy. Chest 2002;121:663-4.
20. Vazquez JC, Tsai WH, Flemons WW, Masuda A, Brant R, Hajduk E, Whitelaw WA, Remmers JE. Automated analysis of digital oximetry in the diagnosis of obstructive sleep apnoea. Thorax 2000;55:302-7.

執行支氣管鏡術時引發低血氧飽和度之分析

方文豐[1] 陳永哲[1] 鍾聿修[1] 溫偉東[1] 曾嘉成[1] 張學文[2] 林孟志[1,3]

背 景：因執行支氣管鏡術而造成低血氧飽和度並不罕見，我們試圖找出其誘發因子。

方 法：在爲期八個月之研究中，我們將所有至本院執行支氣管鏡術之病人隨機取樣，共有137 人納入研究。這些病人除了全程使用脈搏血氧飽和度儀監測血氧外，術前術後亦測量其吐氣尖峰流速及記錄病人相關資料。在術中，我們將所有過程及其相對應之血氧飽和度予以紀錄。

結 果：我們發現在術前需使用氧氣之病人有較高之機會發生低血氧 (73.9% vs 50%)。雖然在執行任何侵入性步驟都有可能誘發低血氧，然而最主要之危險因子爲所執行之侵入性檢查類別 (lavage, 88.9%; washing, 43.8%; brushing, 15.2%; and biopsy, 10%)。例如灌洗術及沖洗術較會引發低血氧飽和度。而且這兩類病人若術前吐氣尖峰流速較低者有更高之機率發生低血氧飽和度。

結 論：在本研究中，我們發現年紀性別及術前血氧飽和度與術中血氧飽和度並無相關。執行任何侵入性步驟都有可能誘發低血氧，尤其在術前需使用氧氣之病人。
(長庚醫誌 2006;29:306-12)

關鍵詞：支氣管鏡術，低血氧飽和度，吐氣尖峰流速，脈搏血氧飽和度儀。

[1]長庚紀念醫院 高雄院區 胸腔內科；[2]國立中山大學生物科學系 [3]長庚技術學院 嘉義分部 呼吸照護系
受文日期：民國94年8月4日；接受刊載：民國95年1月24日
通訊作者：林孟志醫師，長庚紀念醫院 胸腔內科。高雄縣833鳥松鄉大埤路 123 號。Tel.: (07)7317123轉8199; Fax: (07)7322402; E-mail: mengchih@adm.cgmh.org.tw