Cardiopulmonary Responses to the Tracheobronchial Suction with a Fiberoptic Bronchoscope during and after Anesthesia

Toshiyuki ARAI, Yoshio HATANO, Masayuki IMAMURA*
and Kenjiro MORI

The cardiopulmonary responses to endobronchial suction with a fiberoptic bronchoscope (FOB suction) during and after anesthesia were compared in 12 patients underwent elective surgeries. FOB suction for 1 min was performed during enflurane anesthesia (1.5% enflurane in oxygen) with muscle relaxant (anesthetized stage) and after anesthesia during spontaneously breathing of oxygen (awake stage). FOB suction lowered Pa_{O_2} to a greater extent in the awake than in the anesthetized stage. Mean Pa_{O_2} decreased from 414 to 111 torr in the awake and from 447 to 333 in the anesthetized stage. During suction, Pa_{CO_2} slightly increased in both stages. In response to FOB suction, heart rate increased significantly in the awake stage ($P < 0.001$), while mean blood pressure increased significantly in the anesthetized stage ($P < 0.01$). These findings indicate that the cardiopulmonary responses to FOB suction for 1 min during and after anesthesia differed. The procedure might be less dangerous during anesthesia. (Key words: Tracheobronchial suction, fiberoptic bronchoscope, cardiopulmonary response)

(Arai T, Hatano Y, Imamura M et al.: Cardiopulmonary responses to the tracheobronchial suction with a fiberoptic bronchoscope during and after anesthesia. J Anesth 3: 183–187, 1989)

It is essential to rid airway of secretions prior to extubation for preventing atelectasis and postoperative pulmonary complications, but the removal of secretions from the peripheral airway is occasionaly difficult with a blindly inserted suction catheter, even with a curved tip catheter[1]. The fiberoptic bronchoscope (FOB), which is recently used more often in a wide variety of clinical stuations, can overcome this problem by direct vision. There have been a few studies on the effects of fiberoptic bronchoscopy lasting for more than 30 min on the cardiopulmonary system in patients breathing air under topical anesthesia[2,3], indicating that hypoxemia, hypertension, and tachycardia were the most prominant during the suctioning procedures[3]. However, no information concerning the cardiopulmonary changes induced by the suctioning with an FOB (FOB suction) during general anesthesia is available. In anesthetized, preoxygenated, and paralyzed patients, the cardiopulmonary responses to FOB suction may differ from those in awake patients. The present study was thus undertaken to elucidate the cardiopulmonary responses to FOB suction for 1 min in anesthetized and paralyzed patients. The responses to the suction was also studied after anesthesia, when the pa-

Department of Anesthesia and Surgery, Kyoto University Hospital, Kyoto, 606 Japan*

Address reprint requests to Dr. Arai: Department of Anesthesia, Kyoto University Hospital, 54 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto, 606 Japan

Table 1. Cardiopulmonary changes by 1 min suction with a fiberoptic bronchoscope

		Control	Just after suction	1 min after suction	3 min after suction	5 min after suction
Pa_{O_2} (torr)	Anesthetized stage	447 ± 106	333 ± 83 *	428 ± 111	440 ± 106	442 ± 105
	Awake stage	414 ± 101	111 ± 28 ***	341 ± 83	403 ± 84	420 ± 92
Pa_{CO_2} (torr)	Anesthetized stage	31 ± 7	38 ± 6 *	31 ± 8	29 ± 7	30 ± 7
	Awake stage	40 ± 7	43 ± 7	43 ± 9	43 ± 9	41 ± 9
mean BP (mmHg)	Anesthetized stage	85 ± 17	109 ± 16 **	99 ± 16	92 ± 13	86 ± 12
	Awake stage	95 ± 14	104 ± 19	102 ± 13	98 ± 14	97 ± 15
HR (beat/min)	Anesthetized stage	81 ± 20	96 ± 21	93 ± 23	83 ± 16	79 ± 16
	Awake stage	81 ± 15	124 ± 28 ***	105 ± 24 *	84 ± 20	82 ± 18

Data are shown as mean ± SD. *,**, and *** show $P < 0.05$, 0.01, and 0.001, respectively, compared to control.

tient gained consciousness and spontaneous breathing, to compare the responses to FOB suction in patients anesthetized and those awake.

Subjects and Methods

The subjects consisted of 8 male and 4 female adult patients undergoing elective surgeries, i.e., 10 upper abdominal and 2 thoracic surgeries. The patients were 34.2 ± 16.1 (mean ± SD) years old, weighed 59.3 ± 7.5 kg and were 166.3 ± 11.0 cm tall. Preoperative examinations revealed that all of these patients had normal respiratory and cardiac functions. The informed consent of each patient was obtained before this study.

Following the administration of 5 mg/kg thiopental and 0.1 mg/kg pancuronium, the patients were intubated and manually ventilated with 1.5% enflurane in oxygen. The radial artery was cannulated for continuous blood pressure (BP) monitoring and blood sampling. After the patients' BP and heart rate (HR) had stabilized, the tracheobronchial suction with an FOB (BF type 4B2, OD 4.8 mm, Olympus, Tokyo, Japan) was performed with the endotracheal tube open to room air (anesthetized stage). The suction time was rigidly limited to 1 min, and the amount of gas removed by suction was measured using a flow sensor (Magtrak, Ferraris Development & Engineering Co., London, UK). After the 1 min suctioning, the patients were immediately ventilated manually with the same gas as used before suctioning. The sampling of arterial blood for gas analysis and the measurements of mean BP and HR were performed before, at the end of, 1, 3 and 5 min after the suction. Throughout the procedure, ECG (Lead II) was continuously monitored.

FOB suction was performed in the immediate postoperative period after consciousness and muscle tone had been restored. After the patients breathed 100% oxygen spontaneously for more than 10 min, FOB suction for 1 min was carried out just as in their anesthetized stage. Then, the patient was allowed to breath 100% oxygen spontaneously. The procedures of the blood

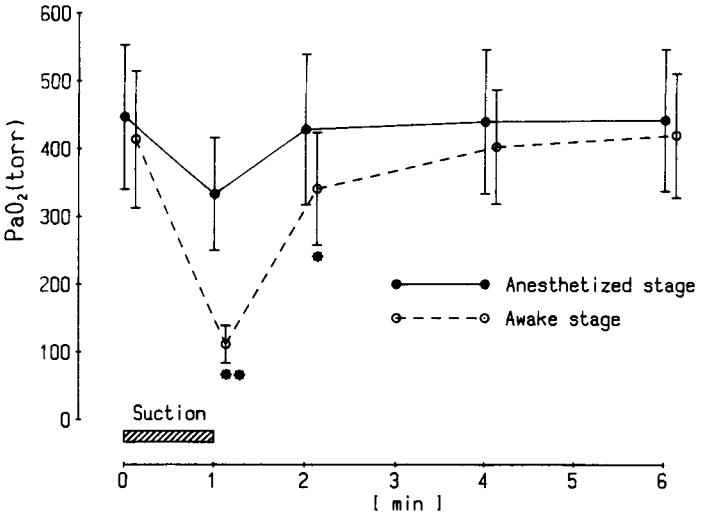

Fig. 1. Comparison of suction-induced Pa_{O_2} changes in the anesthetized and awake stages. Data are shown as the mean ± SD.
*$P < 0.05$, **$P < 0.01$, compared to the values of the anesthetized stages.

sampling, and the measurements of suction volume were the same as in the anesthetized stage.

Data were expressed as the mean ± SD, and were analyzed statistically by the paired t-test for the comparison of suction volume, and the two way analysis of variance followed by the Newman-Keuls multiple comparison for the other parameters.

Results

Table 1 shows the respiratory and circulatory responses to FOB suction. FOB suction for 1 min caused a marked and significant decrease in Pa_{O_2} in the awake stage ($P < 0.001$, the lowest Pa_{O_2} value was 65 torr), and slight but significant decrease in Pa_{O_2} in the anesthetized stage ($P < 0.05$, the lowest value was 210 torr); the difference between the two stages being significant at the end of the suction and 1 min after the cessation of the suction ($P < 0.01$ and $P < 0.05$, respectively, fig. 1). Pa_{O_2} in the awake stage returned to the pre-suction level apparently 1 min and completely 3 to 5 min after cessation of the suction. Pa_{CO_2} significantly increased during the 1 min suction in the anesthetized stage ($P < 0.05$) while there was no significant change in Pa_{CO_2} in the awake stage. Suction volume during the 1 min suctioning in the anesthetized and awake stages were 16.4 ± 2.0 l/min and 16.5 ± 1.8 l/min, respectively, not showing any significant difference.

Mean BP and HR increased in response to FOB suction with a maximum at the end of suction (table 1); there was a significant increase in mean BP in the anesthetized stage ($P < 0.01$) and a significant increase in HR in the awake stage ($P < 0.001$).

A "bucking" was noticed in all patients during suction in the awake stage. There was no ECG evidence of arrhythmia nor other complications during the procedure in either stage.

Discussion

Endotracheal suctioning with a conventional suction catheter is commonly performed at the end of general anesthesia. In this period, the removal of secretion by a blindly entered catheter can be facilitated by coughing which causes mobilization of secretions from peripheral airway[4]. Although the duration of the suction should be limited 15 sec in order to minimize the cardiopulmonaly changes[5], the procedure is often repeated to obtain complete removal, which causes tracheobronchial damage[6], and discomfort in the patient awake. The direct vision with an FOB allows the selective and complete removal of secretions without mobilization of secretions by coughing. This suggests that FOB suction can be effectively performed in

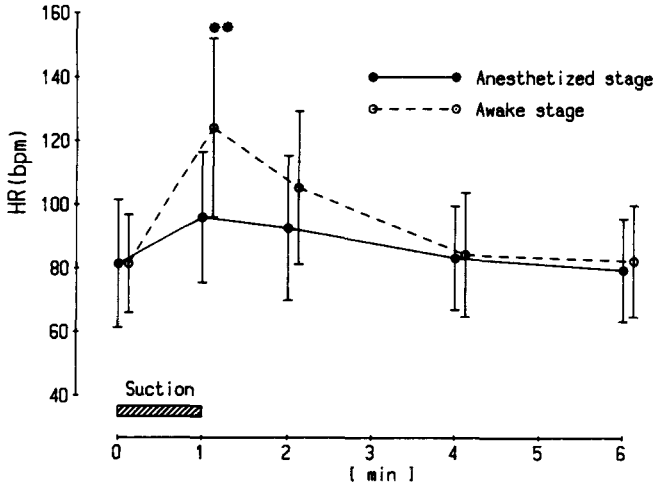

Fig. 2. Comparison of suction-induced heart rate (HR) changes in the anesthetized and awake stages. Data are shown as the mean ± SD.
$^{**}P < 0.01$, compared to the values of the anesthetized stage.

anesthetized and paralyzed patients.

During a 1 min suction in the anesthetized stage, Pa_{CO_2} increased slightly but significantly because of the absence of ventilation; the mean Pa_{CO_2} increased from 31 to 38 torr. Eger and Severinghaus have demonstrated that, apnea for 1 min elevated the alveolar CO_2 tension ($P_{A_{CO_2}}$) an average of 13.4 torr in moderately hyperventilated patients under general anesthesia[7]. Therefore, hypercapnea can be avoided by limiting the duration of FOB suction to 1 min. The small change in the Pa_{CO_2} during the awake stage with spontaneous breathing indicate that adequate ventilation was maintainted even during insertion of an FOB, although an FOB with a large diameter relative to that of endotracheal tube can cause CO_2 retention[8].

In our patients breathing oxygen, Pa_{O_2} dereased significantly during suction in both stages. The derease in Pa_{O_2} can be explained by the replacement of oxygen-enriched gas with ambient air[9], small-airway and alveolar collapse[10], local ventilation/perfusion mismatching[11], or to a lesser extent, bronchoconstriction caused by the airway stimulation. In the present study, Pa_{O_2} during FOB suction for 1 min decreased to a greater extent in the awake stage than in the anesthetized stage, while the changes in suction volume in both stages did not significantly differ. These results are indicating that a different degree of reduction in alveolar oxygen tension ($P_{A_{O_2}}$) existed between the two stages. In the awake stage, the entrained air was inhaled and thus reached the alveolar level, thereby causing a marked reduction of $P_{A_{O_2}}$. The non-significant rise in Pa_{CO_2} indicates the persistence of alveolar ventilation in this stage. By contrast, in the anesthetized stage, the entrained air reached the level of the airways but did not penetrate completely to the gas exchanging zone, allowing $P_{A_{O_2}}$ to be maintained at a higher level than the awake stage.

Increases in HR and elevation of mean BP were observed in response to FOB suction for 1 min. The mechanical stimulation of the airway by a foreign body such as tracheal intubation is known to induce an increase in sympathetic discharge[12]. Although hypoxemia or hypercapnea can also cause sympathetic discharge[13], these may be excluded by the observation that Pa_{O_2} and Pa_{CO_2} remained within tolerable ranges even at the end of the suction.

There was a significant increase in mean BP above the pre-suction level in the anesthetized stage (table 1). This results indicate that the anesthesia with 1.5% enflurane in oxygen was too light to attenuate the BP response to the repeated stimulation of the airway by an FOB, since deep inhalation anesthesia attenuates the BP response[14]. On the other hand, there was a marked increase

in HR (53%) in the awake stage, compared to that in the anesthetized stage (19%) (fig. 2). The greater response of HR to the suction in the awake stage may have been rather due to the emotional stimulation of the procedure and the "bucking" observed during the suction. The forceful coughing of itself can induce intense tachycardia without stimulation of the airway[15].

In summary, FOB suction for 1 min induced a decrease in Pa_{O_2} and an increase in HR to a greater extent in the awake stage than in the anesthetized stage. These cardiopulmonary changes induced by FOB suction should be more hazardous in patients with impaired cardiopulmonary functions. Severe complications such as hypotension[16], hypoxemia[17], myocardial ischemia[3], and even death[18] have been reported in association with fiberoptic bronchoscopy performed under topical anesthesia. Thus, when FOB suction is required in patients undergoing surgery, the procedure, if the duration is limited to within 1 min, might be more harmless before the patients gain consciousness and muscle tone.

(Received Jan. 6, 1989, accepted for publication Feb. 27, 1989)

References

1. Kubota Y, Magaribuchi T, Ohara M, Fujita M, Toyoda Y, Asada A, Harioka T: Evaluation of selective brochial suctioning in the adult. Crit Care Med 8:748–749, 1980
2. Randazzo GP, Wilson AF: Cardiopulmonary changes during flexible fiberoptic bronchoscopy.
3. Lundgren R, Haggmark S, Reiz S: Hemodynamic effects of flexible fiberoptic bronchoscopy performed under topical anesthesia. Chest 3:295–299, 1982
4. Damers RR, Saklad M: Mechanical aspiration: a reappraisal of its hazard. Respir Care 20:661–666, 1975
5. Smith RA: Respiratory Care: mechanical, Anesthesia. 2nd ed. Edited by Miller RD. New York. Churchill Livingstone, 1986, pp2182
6. Sacker MA, Landa JF, Greeneltch M, Robinson MJ: Pathogenesis and prevention of trachobronchial damage with suction procedure. Chest 64:284–290, 1973
7. Eger EI, Severinghaus JW: The rate of rise of $P_{A_{CO_2}}$ in the apneic anesthetized patient. Anesthesiology 22:419–425, 1961
8. Lindholm C-E, Ollman B, Snyder JV, Millen EG, Grenvik A: Cardiorespiratory effects of flexible fiberoptic bronchoscopy in critically ill patients. Chest 74:362–368, 1978
9. Shapiro BA, Harrison RA Kacmarek RM, Cane RD: Clinical application of respiratory care. 3rd ed. Chicago, Year book Medical Publishers Inc, 1985, pp 248
10. Urban BJ, Weitzner SW: Avoidance of hypoxemia during endotracheal suction. Anesthesiology 31:473–475, 1969
11. Brach BB, Escano GG, Harrell JH, Moser KM: Ventilation perfusion alteration induced by fiberoptic bronchoscopy. Chest 69:335–337, 1976
12. Tomori H, Widdicombe JG: Muscular, bronchomotor and cardiovascular reflexes elicited by mechanical stimulation of the respiratory tract. J Physiol (Lond) 200:35–49, 1969
13. Breivik H, Grenvik A, Millen E, Safar P: Normalizing low arterial CO_2 tension during mechanical ventilation. Chest 63:525–531, 1973
14. King BD, Harris JC Jr, Greifenstein FE, Elder JD Jr, Dripps RD: Reflex circulatory responses to direct laryngoscopy and tracheal intubation performed during general anesthesia. Anesthesiology 12:556–566, 1951
15. Takeshima R, Dohi S: Circulatory responses to baroreflexes, valsalva maneuver, coughing, swallowing, and nasal stimulation during acute cardiac sympathectomy by epidural blockade in awake humans. Anesthesiology 63:500–508, 1985
16. Credle WF, Smiddy JF, Elliott RC: Complications of fiberoptic bronchoscopy. Am Rev Respir Dis 111:62–68, 1975
17. Albertini RE, Harrell JH II, Kurihara N, Moser KM: Arterial hypoxemia induced by fiberoptic bronchoscopy. JAMA 230:1666–1667, 1974
18. Suratt PM, Smiddy JF, Gruber B: Deaths and complications associated with fiberoptic bronchoscopy. Chest 69:747–751, 1976