Evaluation of Endotracheal Intubation with a Flexible Fiberoptic Bronchoscope in Lateral Patient Positioning: A Prospective Randomized Controlled Trial

Hui Li¹, Wu Wang², Ya-Ping Lu¹, Yan Wang¹, Li-Hua Chen³, Li-Pei Lei², Xiang-Ming Fang¹

¹Department of Anesthesiology, School of Medicine, The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang 310003, China
²Department of Anesthesiology, Lishui Central Hospital of Zhejiang Province, Lishui, Zhejiang 323000, China
³Department of Anesthesiology, Jiaxing First Hospital of Zhejiang Province, Jiaxing, Zhejiang 314001, China
⁴Department of Gastroenterology, School of Medicine, The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang 310003, China

Hui Li and Wu Wang contributed equally to this work.

Background: There is an unmet need for a reliable method of airway management for patients in the lateral position. This prospective randomized controlled two-center study was designed to evaluate the feasibility of intubation using a flexible fiberoptic bronchoscope in the lateral position during surgery.

Methods: Seventy-two patients scheduled for elective nonobstetric surgery in the lateral decubitus position requiring tracheal intubation under general anesthesia at Lishui Central Hospital of Zhejiang Province and Jiaxing First Hospital of Zhejiang Province from April 1, 2015, to September 30, 2015, were enrolled in this study. Patients were randomly assigned to the supine position group (Group S, \( n = 38 \)) and the lateral position group (Group L, \( n = 34 \)). Experienced anesthetists performed tracheal intubation with a fiberoptic bronchoscope after general anesthesia. The time required for intubation, intubation success rates, and hemodynamic changes was recorded. Between-group differences were assessed using the Student’s t-test, Mann–Whitney U-test, or Chi-square test.

Results: The median total time to tracheal intubation was significantly longer in Group S (140.0 [135.8, 150.0] s) compared to Group L (33.0 [24.0, 38.8] s) (\( P < 0.01 \)). The first-attempt intubation success rate was significantly higher in Group L (97%) compared to Group S (16%). Hemodynamic changes immediately after intubation were more exaggerated in Group S compared to Group L (\( P = 0.02 \)).

Conclusion: Endotracheal intubation with a flexible fiberoptic bronchoscope may be an effective and timesaving technique for patients in the lateral position.

Trial Registration: Chinese Clinical Trial Register, ChiCTR-IIR-16007814; http://www.chictr.org.cn/showproj.aspx?proj=13183.

Key words: Airway Management; Bronchoscope; Intubation; Patient Positioning

INTRODUCTION

Anesthesiologists may encounter situations in which a accidental loss of airway patency occurs in patients in a lateral patient position during surgery. Intubation is required in the lateral position in cases of oropharyngeal bleeding to reduce the risk of aspiration, or in airway management in some patients with limited posture.¹,² Previous studies have revealed that intubation with direct laryngoscopy is more difficult and time-consuming in patients in the lateral position compared to the supine position, especially when there is a sudden loss of airway patency.³,⁴ These observations suggest that there is an unmet need for a reliable method of airway management for patients in the lateral position.

Address for correspondence: Prof. Xiang-Ming Fang, Department of Anesthesiology, School of Medicine, The First Affiliated Hospital, Zhejiang University, Hangzhou, Zhejiang 310003, China
E-Mail: xiangming_fang@163.com

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

© 2016 Chinese Medical Journal | Produced by Wolters Kluwer - Medknow

Received: 02-06-2016 Edited by: Yuan-Yuan Ji
How to cite this article: Li H, Wang W, Lu YP, Wang Y, Chen LH, Lei LP, Fang XM. Evaluation of Endotracheal Intubation with a Flexible Fiberoptic Bronchoscope in Lateral Patient Positioning: A Prospective Randomized Controlled Trial. Chin Med J 2016;129:2045-9.
Fiberoptic intubation (FOI) was first described in the late 1960s and has since become an effective and well-established technique for airway management in awake, sedated, and anesthetized patients. FOI is especially useful in patients with known or suspected difficult airways such as those with an elevated risk for aspiration, cervical spine injury, limited mouth opening, reduced neck mobility, or obesity.[19] The benefits of FOI also include fewer complications such as tooth injury and oropharyngeal bleeding; and the opportunity for optimal positioning of double-lumen tubes in patients undergoing thoracic surgery. Accordingly, we propose that FOI has clinical application in patients constrained in the lateral decubitus position. Therefore, we evaluated the efficacy and safety of endotracheal intubation using a flexible fiberoptic bronchoscope in patients in the lateral position.

**METHODS**

**Trial design**

A prospective randomized controlled two-center study of intubation in the supine or lateral position was conducted in two tertiary hospitals (Lishui Central Hospital of Zhejiang Province and Jiaxing First Hospital of Zhejiang Province) from April 1, 2015, to September 30, 2015 (Chinese Clinical Trial Register, ChiCTR-IIR-16007814). The study was approved by the Ethics Committee of the First Affiliated Hospital of Zhejiang University. Written informed consent was provided by all patients or their immediate relatives. To ensure the consistency, all the three anesthesiologists were simultaneously trained and one of them (Hui Li) took a supervisory role during the intubation of every patient at the two centers.

**Patients**

A total of 103 patients were assessed for eligibility. Exclusion criteria included: patients with a history of poor cardiopulmonary function, coronary artery disease, asthma, or cerebrovascular disorders; American Society of Anesthesiologists (ASA) ≥III; and patients undergoing lung surgery using a double-lumen endobronchial tube. The patients were randomly assigned to the supine position group (Group S) and the lateral position group (Group L) according to a random number table provided by an independent statistician. General anesthesia was administered by the specified anesthesiologist at each hospital.

**Procedure**

All patients underwent a ≥8 h preoperative fast. Preoperative medication was not administered. Patients were subjected to standard heart rate (HR), noninvasive blood pressure, and pulse oximetry monitoring in the operating room. Then, they were positioned in the lateral or supine position according to their group designation. This position was maintained during induction of anesthesia and intubation. Following adequate preoxygenation using 100% oxygen via a face mask for 3 min, general anesthesia was administered via an intravenous injection of 2 mg midazolam, 1–2 mg/kg propofol, 0.4–0.6 μg/kg sufentanil, and neuromuscular blockade with 0.2 mg/kg cisatracurium besylate. After confirming ease of mask ventilation, the patients’ heads and necks were maintained in the neutral or relatively extended position supported by a pillow. A suction tube was used to clear patients’ oropharyngeal secretions, and a bite-block was positioned on one of the premolars. An experienced anesthetist, who stood at the head of operating table, performed intubation using a flexible fiberoptic bronchoscope (TIC-SC-II, UE Medical, Taizhou, Zhejiang, China) following standard procedures [Supplementary Video Material 1], without manipulating the mandibular angle or assistance from other health-care professionals or tools. Patients’ head and neck positions were adjusted as needed. To maximize patient safety, attempts at intubation that took >120 s were considered failures. After the first unsuccessful intubation attempt, an assistant immediately manipulated the mandibular angle to facilitate reintubation. If the attempt at reintubation failed, the patient was immediately placed in the supine position and intubated by conventional laryngoscopy. If oxygen saturation (SpO₂) dropped to 95%, intubation was suspended, and patients were immediately oxygenated by face mask.

**Study outcomes**

The primary outcomes were intubation time and intubation success rate. Secondary outcomes included mean arterial blood pressure (MAP), pulse oximetry saturation (SpO₂), and HR at different time points. Patient demographic and clinical characteristics were documented. Intubation time was measured using a stopwatch; each failed intubation attempt was recorded as 120 s. Hemodynamic stability was assessed based on MAP, SpO₂, and HR, which were measured at the following time intervals: before induction of anesthesia at baseline (BA), after induction of anesthesia but before tracheal intubation (T1), and immediately after successful intubation (T2). Patients were followed up for 24 h after surgery. Perioperative side effects and complications were noted.

**Statistical analysis**

Based on our previous experience of a 26.7% intubation success rate in the supine position and 100% intubation success rate in the lateral position, a sample size of 16 participants (8 per group) would be required to have 90% power, assuming a Type 1 error of 5%. Assuming 10% of participants would drop out, a minimum sample size of 18 participants was established. To achieve clinical significance and generalizability, we conducted this trial at each hospital for 3 months.

All analyses were conducted using the SPSS 17.0 for Windows (SPSS, Inc., Chicago, IL, USA). Data are presented as mean ± standard deviation (SD), median (Q₁, Q₃), or the percentage. Between-group differences were evaluated using the t-test for normally distributed continuous variables, the Mann–Whitney U-test for nonnormal continuous variables,
and the Chi-square test for categorical variables. \( P < 0.05 \) was considered statistically significant.

**RESULTS**

Of the 103 patients, 31 patients (2 for asthma, 18 for ASA ≥III, 11 for undergoing lung surgery using a double-lumen endobronchial tube) were excluded. Finally, 72 patients (male, \( n = 24 \); female, \( n = 48 \); age, 23–77 years) (ASA Grade I and II) scheduled for elective nonobstetric surgery in the lateral decubitus position requiring tracheal intubation under general anesthesia were enrolled in this study.

Demographic and clinical characteristics including age, gender distribution, body weight, and height were similar between Group S (\( n = 38 \) patients; male, \( n = 12 \); female, \( n = 26 \)) and Group L (\( n = 34 \) patients; male, \( n = 12 \); female, \( n = 22 \)) [Table 1]. All patients received mask ventilation with no complications.

Median total time to tracheal intubation was significantly longer in Group S (140.0 [135.8, 150.0] s) compared to Group L (33.0 [24.0, 38.8] s) \( (P < 0.01) \). The median intubation time on the first attempt was significantly longer in Group S (120.0 [120.0, 120.0] s) compared to Group L (33.0 [24.0, 38.8] s) \( (P < 0.01) \). The median intubation time on the second attempt was also significantly longer in Group S (20.0 [15.8, 30.0] s) compared to Group L (0 [0, 0] s) \( P < 0.01 \) [Table 2].

The shorter time to intubate with the flexible fiberoptic bronchoscope with lateral patient positioning compared to supine patient positioning. In addition, this approach is simple and does not require displacing the mandibular angle or assistance from other health-care professionals. In contrast, direct larygoscopy is challenging with lateral patient positioning. Tracheal intubation in the lateral position is necessary and desirable under certain circumstances. Endotracheal intubation with a flexible fiberoptic bronchoscope may be a simple, safe, and timesaving technique in surgical patients in the lateral position.

The first-attempt intubation success rate was 97% in Group L and 16% in Group S. Nearly 84% of patients in Group S required reintubation after an unsuccessful first attempt, while only one patient required reintubation in Group L. When an assistant manipulated the mandibular angle, all patients were successfully intubated [Table 2].

MAP and HR gradually declined from BA to T1 and increased rapidly from T1 to T2 in all patients [Table 3]. There were no significant differences in MAP or HR between patients in Group S and Group L at BA and T1 \( (P > 0.05) \); however, MAP and HR were significantly higher in Group S than in Group L at T2 \( (P = 0.02) \) [Table 3].

\( \text{SpO}_2 \) remained >95% during induction of anesthesia and intubation in all patients. No patients experienced complications such as oral mucosal bleeding, dental injuries, or lacerations.

**DISCUSSION**

This prospective randomized controlled trial showed that tracheal intubation with a flexible fiberoptic bronchoscope resulted in a shorter time to intubate and a higher first-attempt intubation success rate, as well as hemodynamic stability during intubation, with lateral patient positioning compared to supine patient positioning. In addition, this approach is simple and does not require displacing the mandibular angle or assistance from other health-care professionals. In contrast, direct larygoscopy is challenging with lateral patient positioning. Tracheal intubation in the lateral position is necessary and desirable under certain circumstances. Endotracheal intubation with a flexible fiberoptic bronchoscope may be a simple, safe, and timesaving technique in surgical patients in the lateral position.

The improvement in the intubation success rate reported in the

---

### Table 1: Basic characteristics of patients undergoing endotracheal intubation in supine or lateral position

| Items                  | Group S (\( n = 38 \)) | Group L (\( n = 34 \)) | Statistics       | \( P \) |
|------------------------|------------------------|------------------------|------------------|--------|
| Female/male            | 26/12                  | 22/12                  | 0.11*            | 0.81   |
| Age (years)            | 52.6 ± 12.3            | 50.5 ± 12.3            | 0.72†            | 0.47   |
| Height (cm)            | 160.7 ± 7.6            | 160.5 ± 6.5            | 0.11†            | 0.91   |
| Weight (kg)            | 60.8 ± 9.8             | 63.2 ± 10.7            | -0.99†           | 0.33   |

*\( \chi^2 \) values; † \( t \) values. Data were shown as \( n \) or mean ± SD. Group S: Intubation with flexible fiberoptic bronchoscope in the supine position; Group L: Intubation with flexible fiberoptic bronchoscope in the lateral position; SD: Standard deviation.

### Table 2: Time to intubate and intubation success rate in patients undergoing endotracheal intubation in supine or lateral position

| Items                        | Group S (\( n = 38 \)) | Group L (\( n = 34 \)) | Statistics       | \( P \) |
|------------------------------|------------------------|------------------------|------------------|--------|
| Intubation time (s)          |                        |                        |                  |        |
| All attempts                 | 140.0 (135.8, 150.0)    | 33.0 (24.0, 38.8)      | -6.44*           | <0.01  |
| The first attempt            | 120.0 (120.0, 120.0)    | 33.0 (24.0, 38.8)      | -6.79*           | <0.01  |
| The second attempt           | 20.0 (15.8, 30.0)       | 0 (0, 0)               | -6.29*           | <0.01  |
| Success rate, % (\( n/N \)) |                        |                        |                  |        |
| All attempts                 | 100 (38/38)            | 100 (34/34)            | -                | -      |
| The first attempt            | 16 (6/38)              | 97 (33/34)             | 47.74†           | <0.01  |
| The second attempt           | 100 (32/32)            | 100 (1/1)              | -                | -      |

*\( Z \) values; † \( \chi^2 \) values. Data were shown as median (\( Q_1, Q_3 \)) or percentage. Group S: Intubation with flexible fiberoptic bronchoscope in the supine position; Group L: Intubation with flexible fiberoptic bronchoscope in the lateral position; -: Not applicable.
In contrast, the flexible fiberoptic laryngeal mask airway, and 2.5%, 7.5%, and 7.5% of cases undergoing endotracheal intubation via the intubating lightwand-guided intubation or intubating laryngeal mask showed that esophageal intubation occurs in 5% of cases is a risk associated with esophageal intubation. Studies in an emergency situation of sudden accidental loss of airway in patients in the lateral position, as well as hemodynamic stability during changes are well tolerated by patients with ASA Grade I and II. Sudden changes in body position during anesthesia can cause injury, substantial decreases in blood pressure and HR, and can be life-threatening, especially in elderly and obese patients.\[10,11\] FOI in the lateral position minimizes the need to reposition patients during surgery.

Evidence suggests that endotracheal intubation via lightwand-guided intubation or intubating laryngeal mask airway is the reliable approaches for airway management in an emergency situation of sudden accidental loss of airway in patients in the lateral position,\[12-14\] but there is a risk associated with esophageal intubation. Studies showed that esophageal intubation occurs in 5% of cases undergoing endotracheal intubation via the intubating laryngeal mask airway, and 2.5%, 7.5%, and 7.5% of cases undergoing endotracheal intubation via lightwand-guided intubation in a supine, left lateral, and right lateral position, respectively.\[12,13,16\] In contrast, the flexible fiberoptic bronchoscope provided an excellent view of the glottis and the trachea, and had a low probability of esophageal intubation.

The superiority of this technique is reflected in two separate aspects: First, patients who must remain in the lateral position during surgery following anesthesia do not have to change position and have less significant hemodynamic fluctuations when undergoing endotracheal intubation. Second, in case that anesthesia administration is changed or there is a accidental loss of airway patency, this technique can immediately rescue the airway without changing the patient’s position and compromising the surgical field.

This study has several limitations. First, the results represent findings from a relatively small sample size. Clinical studies with a larger number of patients are required to confirm the observations reported here. Second, selected time points for hemodynamic monitoring might not be enough. Third, blinding was not possible as the intubation position was not randomizable.

Overall, the current study showed a stable hemodynamic response during FOI in the lateral position. These findings are in contrast to a previous report that showed an exaggerated hemodynamic response to laryngoscopy and intubation in the lateral position.\[4\] This discrepancy may be attributed to the benefit of performing FOI in the lateral position does not require manipulation of the mandibular angle, and the manipulation of the mandibular angle is a bigger stimulation. A transient increase in hemodynamic response was observed in this study, reflected by changes in HR and MAP. These changes are well tolerated by patients with ASA Grade I and II. Sudden changes in body position during anesthesia can cause injury, substantial decreases in blood pressure and HR, and can be life-threatening, especially in elderly and obese patients.\[10,11\] FOI in the lateral position minimizes the need to reposition patients during surgery.

Evidence suggests that endotracheal intubation via lightwand-guided intubation or intubating laryngeal mask airway is the reliable approaches for airway management in an emergency situation of sudden accidental loss of airway in patients in the lateral position,\[12-14\] but there is a risk associated with esophageal intubation. Studies showed that esophageal intubation occurs in 5% of cases undergoing endotracheal intubation via the intubating laryngeal mask airway, and 2.5%, 7.5%, and 7.5% of cases undergoing endotracheal intubation via lightwand-guided intubation in a supine, left lateral, and right lateral position, respectively.\[12,13,16\] In contrast, the flexible fiberoptic bronchoscope provided an excellent view of the glottis and the trachea, and had a low probability of esophageal intubation.

The superiority of this technique is reflected in two separate aspects: First, patients who must remain in the lateral position during surgery following anesthesia do not have to change position and have less significant hemodynamic fluctuations when undergoing endotracheal intubation. Second, in case that anesthesia administration is changed or there is a accidental loss of airway patency, this technique can immediately rescue the airway without changing the patient’s position and compromising the surgical field.

This study has several limitations. First, the results represent findings from a relatively small sample size. Clinical studies with a larger number of patients are required to confirm the observations reported here. Second, selected time points for hemodynamic monitoring might not be enough. Third, blinding was not possible as the intubation position was clearly visible.

In summary, tracheal intubation with a flexible fiberoptic bronchoscope showed a shorter time to intubate and a higher first-attempt intubation success rate with lateral patient positioning compared to supine patient positioning, as well as hemodynamic stability during intubation. Endotracheal intubation with a flexible fiberoptic bronchoscope may be an effective and timesaving technique for patients in the lateral position.

**Table 3: MAP, HR, and SpO₂ during induction of anesthesia and intubation in patients undergoing endotracheal intubation in supine or lateral position**

| Items                          | Group S (n = 38) | Group L (n = 34) | Statistics | P       |
|-------------------------------|-----------------|-----------------|------------|---------|
| **MAP (mmHg)**                |                 |                 |            |         |
| BA                            | 97.7 ± 15.2     | 100.0 ± 14.5    | −0.66*     | 0.51    |
| T1                            | 81.6 ± 17.4     | 76.0 ± 18.8     | 1.32*      | 0.19    |
| T2                            | 100.4 ± 23.4    | 88.5 ± 17.7     | 2.45*      | 0.02    |
| △T                            | 18.8 ± 21.4     | 12.5 ± 2.5      | 1.36*      | 0.18    |
| **HR (beats/min)**            |                 |                 |            |         |
| BA                            | 75.8 ± 10.2     | 80.4 ± 13.1     | −1.65*     | 0.11    |
| T1                            | 74.2 ± 15.6     | 69.6 ± 15.2     | 1.27*      | 0.21    |
| T2                            | 89.0 ± 13.1     | 81.3 ± 14.4     | 2.37*      | 0.02    |
| △T                            | 14.8 ± 15.1     | 11.7 ± 4.8      | 0.88*      | 0.38    |
| **SpO₂ (%)**                  |                 |                 |            |         |
| BA                            | 99.5 (98.0, 100.0) | 99.0 (97.0, 100.0) | −0.86†      | 0.39    |
| T1                            | 100.0 (100.0, 100.0) | 100.0 (100.0, 100.0) | −0.63†      | 0.53    |
| T2                            | 100.0 (99.0, 100.0) | 100.0 (99.8, 100.0) | −1.53†      | 0.13    |
| △T                            | 0.0 (0.0)       | 0.0 (0.0)       | −1.63†      | 0.10    |

*Z values; †Z values. Data were shown as mean ± SD or median (Q₁, Q₃). Group S: Intubation with flexible fiberoptic bronchoscope in the supine position; Group L: Intubation with flexible fiberoptic bronchoscope in the lateral position; BA: Before induction of anesthesia at baseline; T1: After induction of anesthesia but before tracheal intubation; T2: Immediately after successful intubation; △T: the changes between T2 and T1. SD: Standard deviation; MAP: Mean arterial blood pressure; HR: Heart rate; SpO₂: Oxygen saturation.

Supplementary information is linked to the online version of the paper on the Chinese Medical Journal website.
Financial support and sponsorship
This study was supported by a grant of National Key Technology Research and Development Program of China during the “12th Five-Year Plan”, China (No. 2012BAI11B05).

Conflicts of interest
There are no conflicts of interest.

References
1. Prasad MK, Sinha AK, Bhadani UK, Chabra B, Rani K, Srivastava B. Management of difficult airway in penetrating cervical spine injury. Indian J Anaesth 2010;54:59-61. doi: 10.4103/0019-5049.60501.
2. Goldik Z, Mezc Y, Bornstein J, Lurie A, Heifetz M. LMA insertion after accidental extubation. Can J Anaesth 1995;42:1065. doi: 10.1007/BF03011088.
3. McCaul CL, Harney D, Ryan M, Moran C, Kavanagh BP, Boylan JF. Airway management in the lateral position: A randomized controlled trial. Anesth Analg 2005;101:1221-5. doi: 10.1213/01.ane.0000171712.44746.bb.
4. Khan MF, Khan FA, Minai FN. Airway management and hemodynamic response to laryngoscopy and intubation in supine and left lateral positions. Middle East J Anaesthesiol 2010;20:795-802.
5. Collins SR, Blank RS. Fiberoptic intubation: An overview and update. Respir Care 2014;59:865-78. doi: 10.4187/respcare.03012.
6. Nathanson MH, Gajraj NM, Newson CD. Tracheal intubation in a manikin: Comparison of supine and left lateral positions. Br J Anaesth 1994;73:690-1. doi: 10.1093/bja/73.5.690.
7. Joo HS, Rose DK. The intubating laryngeal mask airway with and without fiberoptic guidance. Anesth Analg 1999;88:662-6.
8. Yamamoto K, Tsubokawa T, Ohnura S, Itoh H, Kobayashi T. Left-molar approach improves the laryngeal view in patients with difficult laryngoscopy. Anesthesiology 2000;92:70-4. doi: 10.1097/00000542-200001000-00016.
9. GillN, Purohit S, Kalra P, Lal T, Khare A. Comparison of hemodynamic responses to intubation: Flexible fiberoptic bronchoscope versus McCoy laryngoscope in presence of rigid cervical collar simulating cervical immobilization for traumatic cervical spine. Anesth Essays Res 2015;9:337-42. doi: 10.4103/0259-1162.158013.
10. Cheng KJ, Chu KS, Chau SW, Ying SL, Hsu HT, Chang YL, et al. Lightwand-assisted intubation of patients in the lateral decubitus position. Anesth Analg 2004;99:279-83. doi: 10.1097/00000539-20040000-00068.
11. Dimitriou V, Voyagis GS. Use of the intubating laryngeal mask for airway management and light-guided tracheal intubation in the lateral position. Eur J Anaesthesiol 2000;17:395-7. doi: 10.1076/0003643-200006000-00010.
12. Panwar M, Bharadwaj A, Chauhan G, Kalita D. Intubating laryngeal mask airway as an independent ventilatory and intubation device. A comparison between supine, right lateral and left lateral. Korean J Anesthesiol 2013;65:306-11. doi: 10.4097/kjae.2013.65.4.306.
13. Caponas G. Intubating laryngeal mask airway. Anesth Intensive Care 2002;30:551-69.
14. Dimitriou V, Voyagis GS. Blind intubation via the ILMA: What about accidental oesophageal intubation? Br J Anaesth 1999;82:478-9. doi: 10.1093/bja/82.3.478.
15. Catheline JM, Capelluto E, Gaillard JL, Turner R, Champault G. Thromboembolism prophylaxis and incidence of thromboembolic complications after laparoscopic surgery. Int J Surg Invest 2002;2:41-7.
16. Kamolpornwijit W, Iamrirat P, Phupong V. Cardiac and hemodynamic changes during carbon dioxide pneumoperitoneum for laparoscopic gynecologic surgery in Rajavithi Hospital. J Med Assoc Thai 2008;91:603-7.