Clinical Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2018, Vol. 46(8) 3200–3208

DOI: 10.1177/0300060518774138
journals.sagepub.com/home/imr
SAGE

Utility of a novel elastic traction system in endoscopic thyroidectomy via breast approach: initial experience with 34 patients

Yi-Jun Lyu[1,2,*], Fang Shen[3,*], Hai Zhang[1,2] and Gao-Xiang Chen[1,2]

Abstract

Objective: To summarize our experiences in using an elastic traction, space-making technique for endoscopic thyroidectomy via breast approach in the treatment of early-stage differentiated papillary thyroid carcinoma.

Methods: A retrospective analysis was performed on patients who underwent endoscopic thyroidectomy via breast approach for thyroid carcinoma in our department. We used our self-developed "mini elastic traction space-maker" in a group of 34 patients; another 45 patients who underwent the procedure with the conventional CO_2 insufflation method were enlisted as the control group.

Results: All patients had successful unilateral lobectomy and central lymph node dissection (CLND) surgeries. The adoption of the intraoperative elastic traction system increased the height of the subcutaneous working space (by 1 cm) and significantly decreased the times required for lobectomy and CLND compared with the controls (46.7 ± 4.7 min *vs.* 50.7 ± 4.9 min). However, there was no significant difference between the two groups in the set-up time to create the working space.

Conclusions: The elastic traction, space-making technique is a safe and feasible technique for endoscopic thyroidectomy via breast approach.

[1]Department of Thyroid and Breast Surgery, Ningbo Medical Center Lihuili Eastern Hospital, Ningbo, Zhejiang, China
[2]Department of Thyroid and Breast Surgery, Taipei Medical University Ningbo Medical Center, Ningbo, Zhejiang, China
[3]Department of Orthopaedic Surgery, Spine Division, The Affiliated Hospital of Medical School of Ningbo University, Ningbo, Zhejiang, China

*These authors contributed equally to this work.

Corresponding author:
Gao-Xiang Chen, Ningbo Medical Center Lihuili Eastern Hospital, No.1111 Jiangnan Road, Ningbo, Zhejiang, 315040, China.
Email: xtkxcgx@126.com

Keywords
Endoscopic thyroidectomy, breast approach, elastic traction, CO_2 insufflation, anterior neck surgery, cosmesis

Date received: 8 December 2017; accepted: 10 April 2018

Introduction

The incidence of the most common endocrine system malignancy, thyroid cancer, has been increasing in recent years. Treatments for thyroid carcinoma include radioactive iodine therapy, targeted therapies with tyrosine kinase inhibitors, and total thyroidectomy.[1] Traditionally, total thyroidectomy is carried out via an open transcervical incision (3–6 cm), which will leave a prominent scar on the anterior neck.[2,3] Therefore, some patients, especially young women, are reluctant to undergo such surgeries because of esthetic concerns.[3]

Endoscopic thyroidectomy, introduced about two decades ago, has a cosmetic appeal to patients because of its smaller skin scar. With the advancements in endoscopic technology and increased demands for better cosmetic outcomes, endoscopic thyroidectomy has become popular and is a common procedure in many hospitals. Various modifications of endoscopic thyroidectomy techniques, either in the surgical approach or the method for establishing working space, have been introduced. For example, the breast approach, endoscopic/robotic bilateral axillo-breast approach, endoscopic/robotic transaxillary approach, and endoscopic/robotic facelift approach have been developed and shown satisfactory results.[4–10]

Conventional endoscopic thyroidectomy requires CO_2 insufflation in the subcutaneous space.[5,9,11] However, the working space maintained by CO_2 air pressure is often insufficient and unstable. Other groups showed the feasibilities of creating an endoscopic working space in the anterior neck skin by mechanical lifting, such as by inserting two Kirschner needles[12] or with a gasless anterior neck skin lifting method via an approach from the chest wall.[4] The neck skin could also be mechanically lifted by two Kirschner wires to form an L-shaped pole in trans-oral video-assisted neck surgery.[13] Similarly, in the unilateral axillo-breast approach for endoscopic thyroid surgery without gas insufflation, the working space is established by insertion of an external retractor through the skin incision in the axilla and suspension by a lifting device.[14] The authors have invented a "mini elastic traction space-maker" (patent number: 201520962366.7), that is used together with low-pressure CO_2 insufflation (0–3 mmHg) to establish the working space for endoscopic thyroidectomy. Our goal was to compare the safety and efficacy of this system with the conventional CO_2 insufflation technique.

Patients and methods

Patient groups

This research was approved by the institutional ethical committee of Ningbo Medical Center Lihuili Eastern Hospital and Taipei Medical University Ningbo Medical Center (Ethical approval No. DYLL2016001), and informed consent was obtained from all participants. Over the period from January 2016 to May 2017, patients

diagnosed with unilateral thyroid carcinoma with planned unilateral lobectomy and central lymph node dissection (CLND) were enrolled. Inclusion criteria included: (1) primary thyroid carcinoma with no prior surgical history; (2) pre-operative ultrasound and CT assessments showing no obvious lymphatic metastasis (cN0), (3) pre-operative thyroid lesion fine needle aspiration and intra-operative frozen biopsies confirmed papillary thyroid carcinoma. Exclusion criteria included patients with (1) serious cardiovascular and pulmonary dysfunction and (2) chest wall deformity. Consecutive patients were assigned to either the elastic traction technique group or the conventional CO_2 space-making technique group based on their personal preferences.

Surgical methods

All patients underwent endoscopic thyroidectomy via the breast approach. Briefly, a 1–1.5-cm incision was made 1–2 cm to the left or right of the central cleavage. Then 0.5-cm incisions were made in the mammary areola for the placement of trocars and CO_2 was insufflated with a pressure maintained at 6–8 mmHg (conventional CO_2 space-making technique). After introduction of the endoscopic lens, the subcutaneous loose connective tissue was separated using the ultrasonic scalpel to the level of the upper edge of the thyroid cartilage and the medial margin of the sternocleidomastoids on both sides. Then unilateral lobectomy and CLND were performed.

In the elastic traction group, a self-developed elastic traction suspension system was used. This system was a "mini elastic traction space-maker" (the hook end of the straight "s-shaped" retractor was connected to a spring component) and a right-angle support rod, which was connected to the operating table (Figure 1A). During the operation, the skin flap was vertically punctured with this mini elastic traction space-maker, retracted towards the head, and secured to the retractor. The deeper surface of the skin flap was lifted vertically to maintain its initial stiffness and, with an elastic connector, connected to the support rod (Figures 1B and 1C). The CO_2 insufflating pressure was then adjusted to 0–3 mmHg and the lobectomy was performed. Different sizes of s-shaped retractors were available according to individual requirements. A subcutaneous space measuring needle, modified from a lumbar puncture needle with indication scale (0–6 cm), was inserted at the level of the suprasternal fossa to measure the height of the subcutaneous working space before and after the suspension (Figures 2A and 2B).

Data such as operation stay, postoperative hospitalization stay, postoperative drainage volume, postoperative complications, and pathological diagnosis were recorded for all patients. To ensure consistency in the procedure, the operations were performed by the same surgical team.

Postoperative follow-up

The first follow-up was performed 1 month after the procedure and after that, follow-up was conducted by the outpatient department or by phone calls every 3 months. Postoperative follow-up data included thyroid function, ultrasound screening for lymph node metastasis, and complications.

Statistics

Data are expressed as mean ± standard deviation. The chi-square test and Fisher's exact test were used to compare dichotomous variables. Student's t-test and the Mann–Whitney U-test were used to compare continuous variables between groups where appropriate. Pearson's correlation method was used to assess the relationship

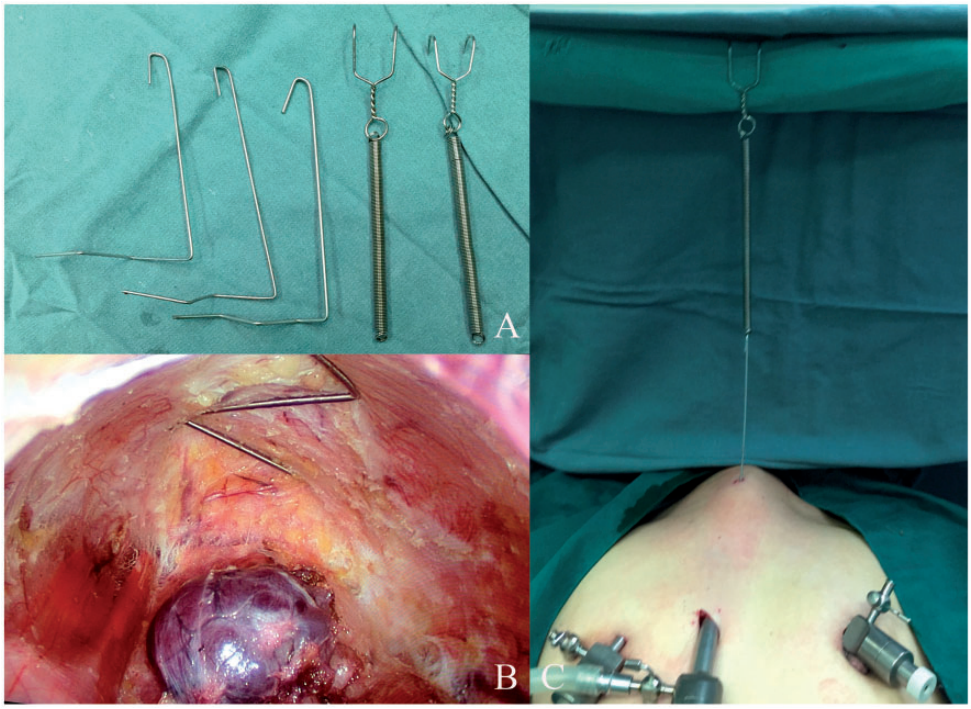

Figure 1. "Mini elastic traction space-maker" and its intraoperative application. A: Elastic traction system composed of a mini elastic space-maker (hook end of straight "s-shaped" retractor connected to a spring component) and a right-angle support rod to connect to operating table. B: Inside view during operation shows vertically punctured skin flap, and deeper surface of flap was vertically lifted to maintain initial stiffness. C: Outside view during operation showed skin flap was vertically pulled by retractor connected to support rod.

between two continuous variables. $P < 0.05$ was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 34 patients (mean age, 36 ± 5 years; range 23–48 years) were enrolled in the elastic traction group; all of them were females. Another group of 45 patients (45 women; mean age, 37 ± 7 years) underwent the conventional CO_2 insufflation space-making technique. The demographic data were comparable between the two groups (Table 1). Endoscopic unilateral lobectomy with CLND was completed successfully in patients of the two groups, and none of them required conversion to open thyroidectomy. The postoperative pathology confirmed early-stage differentiated papillary thyroid carcinoma in all patients.

For the elastic traction group, the height of the subcutaneous space measured during operation increased 1 cm after the elastic traction. The mean overall operation time for the elastic traction group was similar to that of the conventional CO_2 group. However, the mean time for unilateral lobectomy and CLND was significantly shorter than that of the conventional CO_2 group (46.7 ± 4.7 min *vs.* 50.7 ± 4.9 min, $P < 0.01$). The elastic traction technique

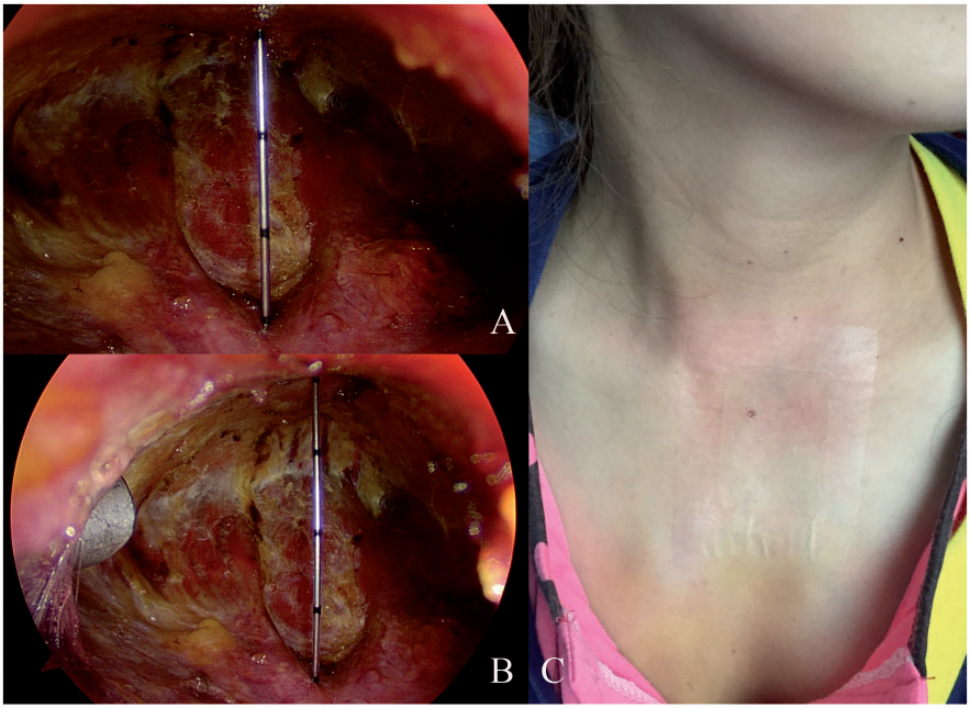

Figure 2. Measurement of subcutaneous height of working space. A: Before elastic traction, a subcutaneous space-measuring needle was inserted at level of suprasternal fossa to measure height. B: After elastic traction, height of subcutaneous working space was increased about 1 cm. C: Postoperative view of neck skin showed no scar at site of fine-needle puncture 3 days after procedure.

Table 1. Endoscopic unilateral thyroidectomy via breast approach with our "mini elastic traction spacemaker" compared with conventional CO_2 insufflation

	Elastic Traction Group	CO_2 Insufflation Group	*P*-Value
Patients (n)	34	45	–
Women (n)	34	45	–
Age, years	36 ± 5	37 ± 7	0.591
Largest tumor diameter, mm	5.9 ± 2.0	6.0 ± 1.9	0.651
Surgery duration, min			
Overall	78.1 ± 6.6	80.4 ± 7.0	0.069
Lobectomy + CLND	46.7 ± 4.7	50.7 ± 4.9	0.000
Space establishment	16.2 ± 3.0	16.0 ± 2.6	0.727
Dissected lymph node count	5 ± 2	6 ± 3	0.796
Drainage, mL	52.2 ± 11.3	53.6 ± 12.7	0.623
Postsurgery stay, days	3.8 ± 0.6	3.9 ± 0.7	0.538

Data are presented as mean ± standard deviation unless otherwise specified.
CLND, central lymph node dissection.

did not prolong the time required for setting up the working space. One patient experienced transient vocal cord palsy, but she had full recovery 2 months after the procedure. Although the elastic traction technique involved puncture of the suprasternal fossa with a fine needle, there was no scar left at the site of puncture 1 month after the surgery, and the patients were satisfied with the overall cosmetic effect (Figure 2C).

There was no significant difference in clinical outcomes between the two groups in terms of average post-operative drainage volume, average post-operative duration of hospitalization, and dissected lymph node counts (Table 1). In both groups, patients had a full recovery in neck movement after the operation and there was no scar, wound pain, numbness, skin ecchymosis, burn, necrosis, hematoma, effusion, or infection in the anterior neck skin flap. No patient experienced hypocalcemic convulsions after the operation.

The patients were followed over a period ranging from 4 months to 20 months, with a median follow-up time of 10 months. Post-operative ultrasound revealed no cancer relapse or metastasis.

Discussion

Endoscopic thyroidectomy via the breast approach is appealing to patients for its improved cosmetic results as compared with the other variations of endoscopic thyroidectomy.[15,16] As for all endoscopic operations, the fundamental requirement for endoscopic surgery is to create and maintain a stable working space that is spacious enough to achieve the surgical goals. In this study, instead of the conventional CO_2 insufflation technique, we applied a self-developed elastic traction system and achieved satisfactory clinical results.

Endoscopy has most commonly been used in the peritoneal, thoracic, and other natural body cavities with the serosa acting as a natural barrier and CO_2 insufflation was used to establish the working space. However, because there is no natural cavity in the neck, it is necessary to create space in the loose connective tissue to establish the working space for endoscopic operation in that area. Many modified space-making techniques for endoscopic thyroidectomy have been proposed, including adjusting the CO_2 insufflation pressure to 6–8 mmHg.[5,9,17] Another potential benefit of using the combination of traction system plus low pressures is that it might help avoiding the complications related to higher CO_2 insufflation pressures; for example, mediastinal emphysema, cardiac dysrhythmias, and even death.[12,18–21] We believed the key to the success of endoscopic thyroidectomy via the breast approach is not only the establishment of working space but also its maintenance. Therefore, we developed a two-step space-making strategy that employed both low-pressure CO_2 insufflation and an elastic traction system for space maintenance. During the breast approach, the subcutaneous working space created by the separation of the tissues in the chest and neck is relatively limited. However, if mechanical traction was applied at that time, the subcutaneous working space would still be insufficient, and the space would not be uniform. Furthermore, the technique carries increased risks for tracheal injury and subcutaneous bleeding. Therefore, CO_2 insufflation (6–8 mmHg) was chosen to create more space in the loose connective tissues and simplify the skin flap separation process. To maintain the space, the skin flap was then lifted vertically with our mini elastic traction space-maker, followed by insufflation of low-pressure CO_2 to support the mechanical force. Because this insufflation and space-making process only accounted for a relatively small proportion of the whole operation time, the risk of

complications caused by CO_2 insufflation could also be decreased.

Previous studies also suggested using the mechanical suspension insufflation method to create the endoscopic working space, commonly by inserting two Kirschner needles in the platysma at the level of the thyroid cartilage and one third of the medial clavicle, and then using mechanical suspension to lift the anterior neck skin slap to form a cube-shaped operating space.[3,12] In contrast to previous techniques, after suspension of the skin flap, our mini elastic traction space-maker could create a funnel-shaped working space. This space is similar to the dome-shaped working space created by the traditional insufflation method, and thus better fulfills the requirements of endoscopic surgery. When the continuous negative pressure was applied for suction, the retraction system and skin flap would be pulled downward by the negative pressure in the work cavity. However, the elastic components would resist the stretching force and maintain most of the working space (Figure 3). When the suction was stopped, however, the elastic component would rapidly return to its original state, and the working space would be restored to the initial level. Another advantage of this elastic traction is that it could avoid secondary injury to the anterior neck skin flap caused by the tension after negative pressure suction. Therefore, this elastic traction system would make the endoscopic procedure simpler and less invasive.

In addition to the 34 patients who underwent unilateral thyroidectomy, we also successfully used this elastic traction system for endoscopic resection of large thyroid tumors (tumor diameter > 5 cm) in five patients (data not shown). Our results suggested, as compared to the conventional CO_2 insufflation method, in the elastic traction system CO_2 is no longer the only factor to maintain the "stability" of the working space. Besides, gas leaks because of bleeding or smoke suction during the operation will not lead to interruption or delays in the procedure. The combination of the low-pressure CO_2 insufflation and the elastic traction system maintained a stable visual field during the whole procedure, therefore ensuring the safety of the operation. We also tried to turn off the gas flow during the operation and the mechanical lifting

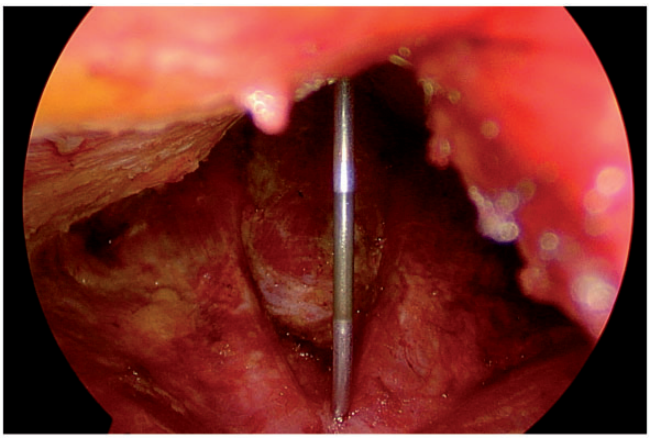

Figure 3. Intraoperative view of working space when applying continuous negative pressure for suction. Elastic components could adapt to stretching force; there was still considerable working space left after suction.

by our mini elastic traction space-maker alone had satisfactorily maintained the working space. Because of the relatively limited working space in the neck, it was hard to ventilate the smoke generated by coagulation with the ultrasound scalpel. However, the combination of elastic traction and high flow of low pressure (0–3 mmHg) CO_2 insufflation for space-making could effectively remove the smoke and contribute to a clear vision of the working space, which was important during the CLND. These advantages might help to explain why the time required for performing unilateral lobectomy with CLND was shortened in the elastic traction group. Moreover, there was no significant difference between the two groups in the time required to separate the skin flap.

For endoscopic surgeries of thyroid tumors, especially the large ones, suspension of the neck skin flap with the mini elastic traction space-maker not only could ensure the stability of the working space, but also could create additional vertical working space. These advantages could therefore reduce the difficulty of the procedure and expand the indications for endoscopic surgery in the treatment of benign thyroid diseases.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Nguyen QT, Lee EJ, Huang MG, et al. Diagnosis and treatment of patients with thyroid cancer. *Am Health Drug Benefits* 2015; 8: 30–40.
2. Byeon HK, Holsinger FC, Tufano RP, et al. Robotic total thyroidectomy with modified radical neck dissection via unilateral retroauricular approach. *Ann Surg Oncol* 2014; 21: 3872–3875.
3. Chen D, Ding K, Guo K, et al. Gasless single incision endoscopic thyroidectomy. *JSLS* 2012; 16: 60–64.
4. Shimizu K, Akira S, Jasmi AY, et al. Video-assisted neck surgery: endoscopic resection of thyroid tumors with a very minimal neck wound. *J Am Coll Surg* 1999; 188: 697–703.
5. Ohgami M, Ishii S, Arisawa Y, et al. Scarless endoscopic thyroidectomy: breast approach for better cosmesis. *Surg Laparosc Endosc Percutan Tech* 2000; 10: 1–4.
6. Yoon JH, Park CH and Chung WY. Gasless endoscopic thyroidectomy via an axillary approach: experience of 30 cases. *Surg Laparosc Endosc Percutan Tech* 2006; 16: 226–231.
7. Choe JH, Kim SW, Chung KW, et al. Endoscopic thyroidectomy using a new bilateral axillo-breast approach. *World J Surg* 2007; 31: 601–606.
8. Shimazu K, Shiba E, Tamaki Y, et al. Endoscopic thyroid surgery through the axillo-bilateral-breast approach. *Surg Laparosc Endosc Percutan Tech* 2003; 13: 196–201.
9. Ikeda Y, Takami H, Sasaki Y, et al. Endoscopic resection of thyroid tumors by the axillary approach. *J Cardiovasc Surg (Torino)* 2000; 41: 791–792.
10. Jeryong K, Jinsun L, Hyegyong K, et al. Total endoscopic thyroidectomy with bilateral breast areola and ipsilateral axillary (BBIA) approach. *World J Surg* 2008; 32: 2488–2493.
11. Hüscher CS, Chiodini S, Napolitano C, et al. Endoscopic right thyroid lobectomy. *Surg Endosc* 1997; 11: 877.
12. Usui Y, Sasaki T, Kimura K, et al. Gasless endoscopic thyroid and parathyroid surgery using a new retractor. *Surg Today* 2001; 31: 939–941.
13. Nakajo A, Arima H, Hirata M, et al. Trans-Oral Video-Assisted Neck Surgery (TOVANS). A new transoral technique of endoscopic thyroidectomy with gasless

premandible approach. *Surg Endosc* 2013; 27: 1105–1110.
14. Koh YW, Kim JW, Lee SW, et al. Endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation for unilateral benign thyroid lesions. *Surg Endosc* 2009; 23: 2053–2060.
15. Puntambekar SP, Palep RJ, Patil AM, et al. Endoscopic thyroidectomy: Our technique. *J Minim Access Surg* 2007; 3: 91–97.
16. Ikeda Y, Takami H, Sasaki Y, et al. Comparative study of thyroidectomies. Endoscopic surgery versus conventional open surgery. *Surg Endosc* 2002; 16: 1741–1745.
17. Bellantone R, Lombardi CP, Rubino F, et al. Arterial PCO2 and cardiovascular function during endoscopic neck surgery with carbon dioxide insufflation. *Arch Surg* 2001; 136: 822–827.
18. Gottlieb A, Sprung J, Zheng XM, et al. Massive subcutaneous emphysema and severe hypercarbia in a patient during endoscopic transcervical parathyroidectomy using carbon dioxide insufflation. *Anesth Analg* 1997; 84: 1154–1156.
19. Kitano H, Fujimura M, Kinoshita T, et al. Endoscopic thyroid resection using cutaneous elevation in lieu of insufflation. *Surg Endosc* 2002; 16: 88–91.
20. Shimizu K and Tanaka S. Asian perspective on endoscopic thyroidectomy – a review of 193 cases. *Asian J Surg* 2003; 26: 92–100.
21. Kim JS, Kim KH, Ahn CH, et al. A clinical analysis of gasless endoscopic thyroidectomy. *Surg Laparosc Endosc Percutan Tech* 2001; 11: 268–272.