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Application of Thyroid Cartilage Recording Electrode for Intraoperative Neuromonitoring During Giant Retrosternal Goiter Surgery

Zhang M[1#], Shao G[2,#], Sun B[3#], Shi M[2#], Wang X[2], Song Y[2], Zhang G[2] and Li G[2]*

[1]*The First Clinical Medical College, Shandong University of Traditional Chinese Medicine, China*

[2]*Department of Thyroid and Breast Diagnosis and Treatment Center, Weifang Hospital of Traditional Chinese Medicine, Shandong Second Medical University, China*

[3]*Department of Ophthalmology, Affiliated Hospital of Shandong Second Medical University, China*

[#]*These authors have contributed equally to this work and share first authorship*

Abstract

Background: At present, the vocal cord surface contact electrode attached to the endotracheal tube is the mainstream device at the receiving end of the intraoperative neuromonitoring system. However, the application is often limited in patients with difficult airway caused by the oppression of a huge goiter.

Methods: A 66-year-old man from China came to our department because of the compression, displacement and deformation of trachea caused by huge retrosternal goiter. Our preoperative evaluation found that it was difficult to insert a traditional endotracheal tube with surface electrodes in his condition. Thus, we selected the thyroid cartilage recording electrodes to monitor the neural signals and reduce the probability of recurrent laryngeal nerve injury during the surgery.

Results: The lesion in this patient was completely excised, along with complete protection of the recurrent laryngeal nerve and vagus nerve. There were no complications, such as hoarseness, coughing upon drinking water, and dyspnea after the operation, the patient recovered well.

Conclusion: The intraoperative neuromonitoring system technique using thyroid cartilage recording electrodes was an effective method for reducing recurrent laryngeal nerve injury during giant retrosternal goiter surgery.

Keywords: Giant retrosternal goiter; Intraoperative neuromonitoring; Thyroid cartilage recording electrode; Recurrent laryngeal nerve injury

Abbreviations

RLN: Recurrent Laryngeal Nerve; IONM: Intraoperative Neuromonitoring; VN: Vagus Nerve

Introduction

Giant retrosternal goiter resection is a high-risk thyroidectomy, because the tumor is large and located behind the sternum, it is often accompanied by the compression, displacement and deformation of trachea, esophagus and recurrent laryngeal nerve, in which the probability of Recurrent Laryngeal Nerve (RLN) injury during operation is higher [1,2]. The protection of RLN during surgery has been a hot spot for thyroid surgeons. The Intraoperative Neuromonitoring (IONM) system, an effective auxiliary tool for the monitoring and protection of laryngeal nerve function, has been widely used in thyroid surgery. In it, the vocal cord surface contact electrode attached to the endotracheal tube is widely used because of the ease of operation, non-invasiveness and larger contact range with the vocal cord, making it the mainstream device at the receiving end of the IONM system [3]. However, the monitoring catheter surface electrodes do not meet the needs of special patients having tracheal lesions or requiring special endotracheal intubation. Herein, we report the diagnosis and treatment experience in monitoring nerve signals using thyroid cartilage recording electrodes during the compression of tracheal shift and narrowing by a substernal giant goiter, thereby aiming to provide a new method of nerve monitoring during giant retrosternal goiter surgery.

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***Correspondence:**
Guangdong Shao, Department of Thyroid and Breast Diagnosis and Treatment Center, Weifang Hospital of Traditional Chinese Medicine, Shandong Second Medical University, No. 1055 Weizhou road, Kuiwen district, Weifang city 261000, Shandong Province, China, Tel: +86 15762509159; Fax: +86 0536-8060213;

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Methods and Results

A 66-year-old man presented with a giant retrosternal goiter discovered during an examination in 2017. The goiter was untreated and its mass gradually increased. On 2020-08-05, he developed dyspnea and dysphagic symptoms accompanied by overnight food taste persistently in the mouth. Physical examination on admission revealed that: A 5 cm × 4 cm firm mass in the left neck was palpated, which moved up and down with swallowing; the lower edge of the mass was untouched; a 3 cm × 2 cm soft mass with an unclear border was palpated in the right neck, the trachea was compressed and it moved to the right, with tortuous dilation of superficial veins of the anterior neck (Figure 1A).

Neck and chest CT showed that the left lobe of the thyroid gland was significantly enlarged and it projected downward into the mediastinum, with its lower edge reaching the level of T6; the size was approximately 12.8 cm × 10.3 cm × 9.2 cm. The lump had heterogeneous attenuation, showing patchy low-density shadow inside, and punctate and "cluster" high-density shadow inside and at the edges. The compressed trachea was displaced to the right, approximately 4.9 mm at the narrowest part, and 6.5 cm from the narrowest part to the vocal cord (Figure 1B). A patchy low-density shadow was visible in the right side of the right lobe of the thyroid with the gas density shadow of dimensions, 3.2 cm × 3.1 cm × 4.3 cm inside (Figure 1C). The tracheomalacia test showed that the anterior superior mediastinum occupied and the middle and lower part of the trachea were compressed and flattened, and the tracheomalacia test was positive (Figure 1D). Esophageal barium meal test showed intrathoracic goiter with esophageal compression, and an esophageal diverticulum in the seventh thoracic segment of the right cervical margin at the upper end of the esophagus (Figure 1E). Preoperative fibro laryngoscopy showed normal bilateral vocal cord movement. No abnormality was detected for thyroid function, or parathyroid hormone, calcitonin and carcinoembryonic antigen levels.

As the narrowest part of his compressed trachea was approximately 4.9 mm and the tracheomalacia test was positive, the risk of postoperative tracheal collapse was extremely high. To prevent the occurrence of dyspnea due to tracheal collapse after extubation, the balloon of the endotracheal tube should be passed through the narrowest part of the trachea during preoperative anesthesia and intubation. For the clinically used conventional endotracheal tube with surface electrodes, the distance from the upper end of the balloon to the upper end of the surface electrode is approximately 5 cm (Figure 2A), while in this case, the distance from the narrowest part of the trachea to the vocal cord was 6.5 cm (Figure 1B). Herein, if the vocal cord surface contact electrode was used for IONM, as the surface electrode cannot contact the vocal cord, no myoelectric signal would have been received. Given this, the enhanced endotracheal intubation without surface electrode was inserted with the aid of trachea scope during anesthesia intubation in this case.

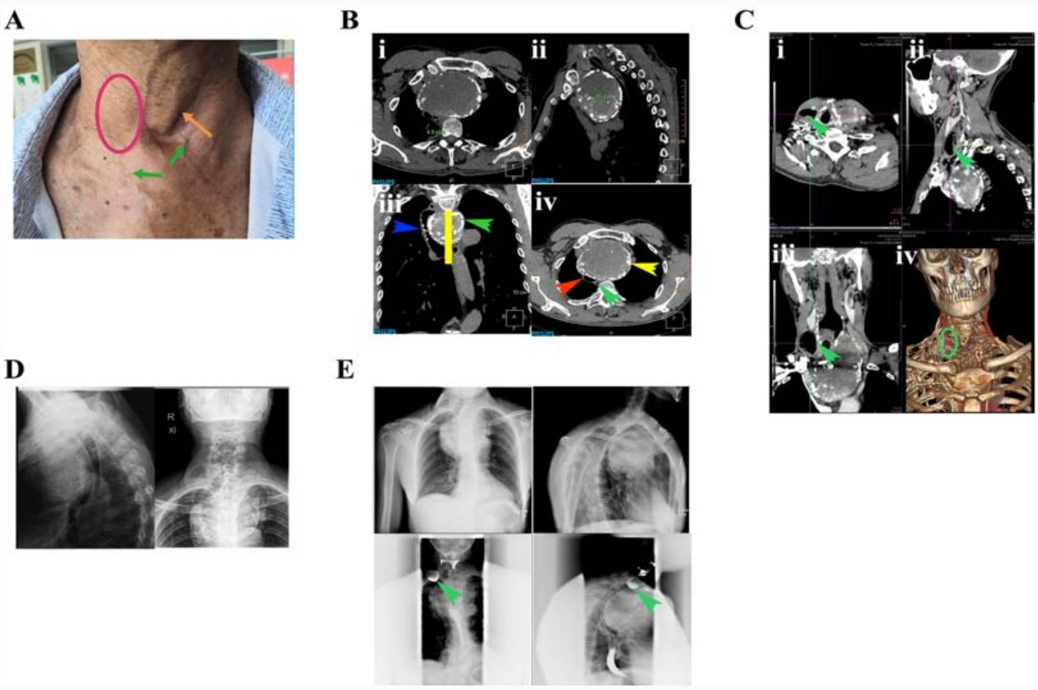

Figure 1: Preoperative Data.
Figure 1A: Physical examination of the neck: The position shown by the red circle is the position of a soft mass in the right cervical mass. Orange arrow indicates that the trachea is compressed and displaced to the right. The green arrow indicates a tortuous dilated superficial vein in the anterior neck.
Figure 1B: CT scan evaluation of the goiter: (a) The cross-section shows that the diameter of the narrowest part of the trachea under compression is approximately 4.9 mm. (b) The sagittal plane shows that the distance from the narrowest point of tracheal compression to the vocal cord is 6.5 cm. (c) On the coronal plane, the blue arrow indicates the rightward movement of the trachea due to compression, the green arrow indicates the substernal goiter, and the yellow solid line indicates the putative position of the trachea in the normal uncompressed state. (d) In the cross-section, the yellow arrow indicates substernal goiter, with patchy low-density shadow, and scattered high-density shadow inside. The red arrow indicates the rightward movement of the trachea due to compression. The green arrow shows the esophageal pressure moving to the right.
Figure 1C: CT scan evaluation of the right cervical soft mass: (i) Cross-sectional view; (ii) sagittal view, and (iii) coronal view of the soft right cervical mass. (iv) No obvious solid mass is found on the three-dimensional reconstruction map of the right cervical soft mass.
Figure 1D: Positive tracheal softening test.
Figure 1E: Esophageal barium meal map: The green arrow indicates esophageal diverticulum.

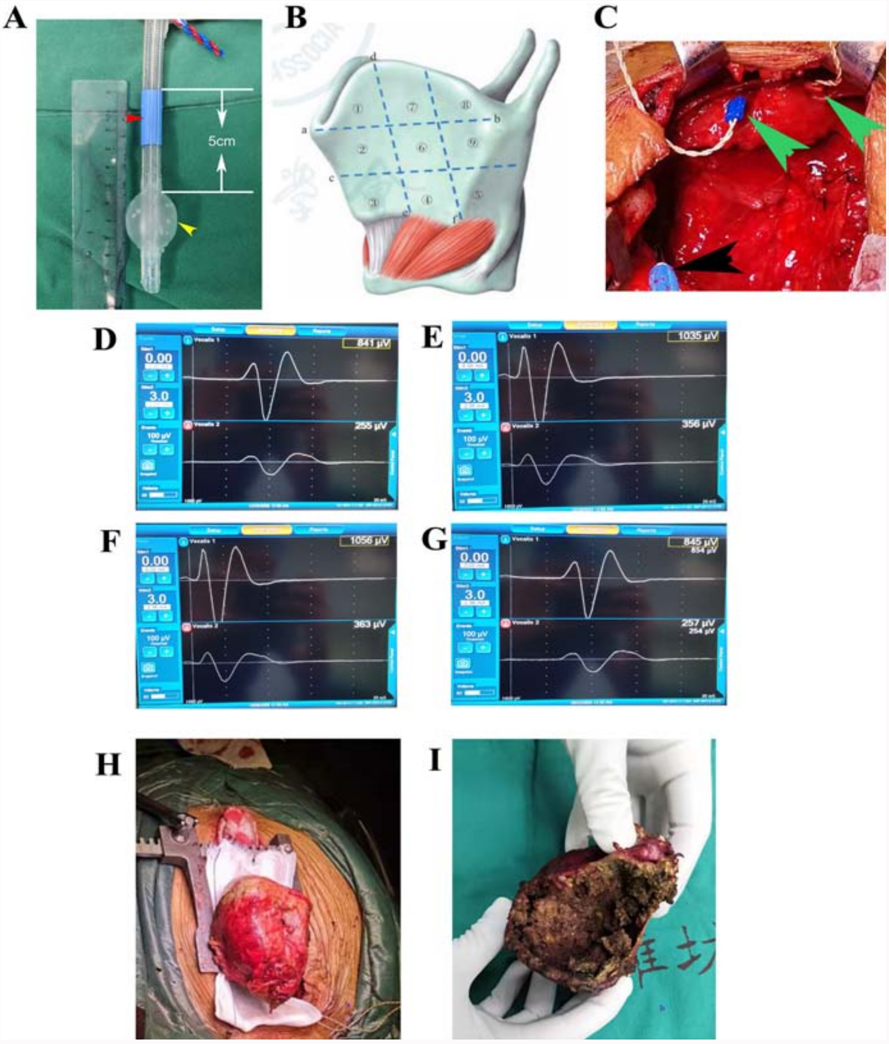

Figure 2: Intraoperative Data.

Figure 2A: Endotracheal tube with surface electrodes: The red arrow indicates a surface electrode. The yellow arrow shows the balloon of the endotracheal tube. Two white lines indicate that the distance from the upper end of the balloon to the upper end of the surface electrode is approximately 5 cm.

Figure 2B: Schematic diagram of zone 9 of thyroid cartilage:

(a) Adam's apple of thyroid cartilage. (b) Thyroid supra-cartilage nodule. (c) The anterior horn of thyroid cartilage is about 1/2 level. (d) Superior horn of thyroid cartilage. (e) Straight ventral front of cricothyroid muscle. (f) Oblique ventral front of cricoid muscle.

Figure 2C-2G: Intraoperative thyroid cartilage records electrode nerve monitoring figure:

(C) The figure during the indwelling operation of the thyroid cartilage recording electrode. The green arrow points to the location of the thyroid cartilage recording electrode, and the black arrow points to the probe. (D) Left vagus nerve myoelectric signal, V1. (E) Left recurrent laryngeal nerve myoelectric signal, R1. (F) Left recurrent laryngeal nerve myoelectric signal, R2. (G) Left vagus nerve myoelectric signal, V2.

Figure 2H, 2I: Surgical specimen of substernal goiter:

(H) A holistic view of the mass. (I) Glial and calcified material filling is observed after the mass is sectioned.

During the operation, we found a hard mass with intact capsule of about 12 cm × 10 cm in the anterior superior mediastinum. Since the upper end of the mass is located in the neck, Kocher's incision of 8 cm along the upper edge of the sternal incision was made. Routine operation was performed until the thyroid gland was exposed, and the fascia connective tissue on the surface of thyroid cartilage was fully free. Referring to Professor Sun Hui's [3] previous research, we placed the thyroid cartilage acupuncture electrode in Area 6 (Figure 2B, 2C, 2H). IONM was followed according to the standard procedure of V1-R1-R2-V2 signals. First, the left Vagus Nerve (VN) was stimulated using a probe at the left cervical sheath to gain myoelectric signal, V1 (Figure 2D), and the left RLN myoelectric signal, R1 (Figure 2E), was obtained by the detection of the tracheoesophageal sulcus. The running region of the RLN was locked, and the left RLN was found by dissecting through the site, wherein the myoelectric signal was strongest. During the dissociation of RLN, the monitoring was continuous, and the changes in myoelectric signals from the RLN were noted. After the RLN was dissected and freed from Berry's ligament, the myoelectric signal, R2 (Figure 2F), was obtained by stimulating the nearest exposed part. The R2 signal was continuous and stable, without attenuation than before [4]. The mass was completely removed under the support of IONM and sent for intraoperative rapid pathology showing a nodular goiter (Figure 3C, 3D). After the resection of the goiter, during the operation, the esophagus and trachea were found to return to the normal anatomical position, no soft mass was seen on the right side of the right thyroid lobe, and no obvious softening area was seen on touching the trachea. After the operator communicated with the cardiothoracic surgeon,

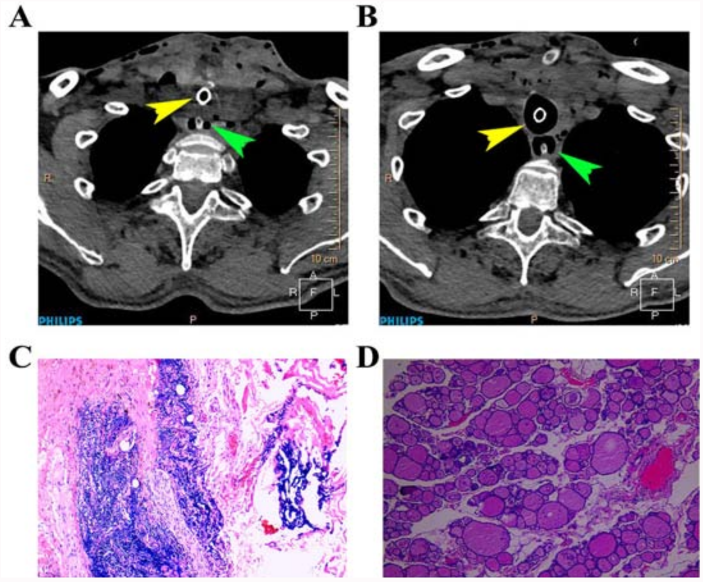

Figure 3: Postoperative Data.
Figure 3A, 3B: Chest CT scan, 48 h after surgery:
As shown, there is no obvious hematoma in the operated area, and the trachea and esophagus returned to their normal anatomical positions. No tracheomalacia or collapse was seen. The yellow arrow points to the trachea, the inner white circle points to the endotracheal tube, and the green arrow points to the esophagus.
Figure 3C, 3D: Typical morphological characteristics of the substernal goiter (×100 amplification).
(C) The cyst wall of the tumor body shows fibrotic changes. (D) Glial deposits are observed in the body composition of the tumor, which is consistent with the manifestation of nodular goiter.

the occurrence of the esophageal diverticulum cannot be ruled out due to the tumor squeezing the esophagus. To reduce the risk of the postoperative thoracic infection, no esophageal diverticulum resection was performed after informing the family members during the operation. The VN signal V2 (Figure 2G) was detected at the left neck sheath again, and there was no attenuation compared to the previous one (V1), and the surgical incision was closed.

To prevent postoperative tracheal collapse and suffocation, we decided to appropriately extend the intubation time after surgery and transferred the patient to ICU for observation. A reexamination by chest CT was performed 48 h after surgery (Figure 3A, 3B), which revealed good bilateral lung dilatation with no evidence of tracheal collapse. After the patient's spontaneous breathing function was fully restored, the intubation tube was pulled out and the patient was transferred to the general ward after confirming a good ventilation function. Postoperative routine pathology revealed the tumor wall showed fibrotic changes (Figure 3C). The intertumoral composition showed gliosis, which was consistent with the manifestation of nodular goiter (Figure 3D). The patient recovered well after the operation and was discharged.

Discussion

Relevant studies have found that the application of IONM in thyroid surgery can significantly reduce the probability of nerve injury, and the operation of substernal giant goiter is the absolute indication for the application of IONM [5-7].

For the currently clinically applied endotracheal tube with surface electrodes, the distance from the upper end of the balloon to the upper end of the surface electrode is about 5 cm, while in this case, the distance from the narrowest part of the patient's airway to the vocal cord is about 6.5 cm. In this case, if the surface electrode of endotracheal tube is used for IONM, since the surface electrode cannot contact with the vocal cord, the myoelectric signal will not be received, resulting in no intraoperative nerve monitoring.

In order to overcome this difficulty, we found that thyroid cartilage recording electrode is an effective substitute. During the operation, the nerve monitoring technology with thyroid cartilage recording electrode is that motor nerves are stimulated by electricity to form nerve impulses which are transmitted to the laryngeal muscles to produce myoelectric signals.

Referring to Zhao et al. [8] concerning the application of thyroid cartilage recording electrode in neuromonitoring during thyroidectomy, in this case, we also adopted the acupuncture indwelling method at the superficial layer of chondral membrane from inside to outside. The postoperative patient had no complications related to recurrent laryngeal nerve injury.

However, there were still some shortcomings in our study, for example, in order to reduce the examination pain of patients and avoid the waste of medical resources, no further laryngoscopy was conducted to confirm the vocal cord movement and esophageal barium meal was conducted to confirm the disappearance degree of esophageal diverticulum after surgery when the patients did not show relevant clinical symptoms.

Conclusion

When a giant retrosternal goiter compresses and narrows the trachea and displaces it so that the surface electrodes of the endotracheal tube cannot be applied, the IONM technique with thyroid cartilage recording electrode is an effective alternative.

Funding

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