Fabrication of a Custom Electrode Endotracheal Tube

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INTRODUCTION

Direct intraoperative nerve stimulation is commonly used in head and neck surgery. Recently, commercial endotracheal tubes fitted with electrodes have been introduced which can transtracheally stimulate the recurrent laryngeal nerve (RLN). An easily fabricated custom electrode endotracheal tube capable of reliably stimulating the RLN has been developed at UCLA.

Documenting the integrity and function of the RLN is important in a variety of neck and laryngeal procedures. Direct electrical stimulation of the RLN has been used for many years by surgeons during thyroid surgery.[1,2] In other situations, such as phonosurgery, electrical nerve stimulation may be desirable but neck exploration is not indicated.

Two methods of stimulation that do not require exposure of the RLN have been previously reported in animal models. In 1987, Berke, *et al.* reported a modified endotracheal tube designed to allow intraoperative RLN stimulation during in vivo canine research.[3] The tube was fabricated from a standard endotracheal tube with foil electrodes attached to the balloon. In the canine model, the glottographic features of transtracheally stimulated phonation were identical to those from direct RLN stimulation.[3] Sanders, *et al.*[4] reported the use of transcutaneous stimulation of the RLN in monkeys. A stimulating rod was placed in the tracheoesophageal groove and a 2.5-mA current applied. The vocal cord excursion was similar for transcutaneous and direct stimulation.

The technique of fabricating an electrode endotracheal tube is the subject of this brief report. The modified tube is simple and inexpensive to produce, and relies upon materials readily available to surgeons. Unlike similar commercial endotracheal tube electrodes, it can be adapted to any size endotracheal tube.

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TECHNIQUE

A standard endotracheal tube was modified as follows. Foil tape (3M, Minneapolis, Minn.), commonly used for the protection of endotracheal tubes during laser surgery, was cut into 20-cm long strips 6 to 8 mm wide and attached length-wise to the endotracheal tube. Over the balloon, the foil was placed at the 4- and 8-o'clock (12 o'clock = anterior) positions to correspond to the location of the RLN. The foil tape was secured to the length of the endotracheal tube. Electrical tape was used to insulate the exposed foil (Figs. 1, 2). The proximal ends of the foil strips were attached to alligator clips from a constant-current nerve stimulator (WR Medical Electronics, St. Paul, Minn., Model S2LH).

Because of the distance from the electrode to nerve and the presence of intervening cartilage and soft tissue, the current necessary for transtracheal RLN stimulation was 10-fold higher than that required for open nerve stimulation. Approximately 10 to 20 mA direct current was required. During surgery, the endotracheal tube would generally be passed through a tracheostomy. The larynx should be suspended and visualized to verify the ability of the electrodes to stimulate laryngeal muscle contraction.

DISCUSSION

There are several potential uses for the method of transtracheal recurrent nerve stimulation described in this report. When the integrity of the RLN is in doubt, this technique could be used for intraoperative verification of the electrical continuity of the RLN. Two clinical examples are *1.* in the case of a severely scarred post-traumatic larynx and *2.* in a patient with cricothyroid arthritis and an immobile true vocal cord. The electrode could also be used during thyroid surgery for immediate feedback regarding nerve function. In patients with a tracheostomy, the electrode is passed through the neck, allowing complete visualization of the larynx. In addition, the electrode endotracheal tube shows promise for potential use in laryngeal-evoked electromyography.

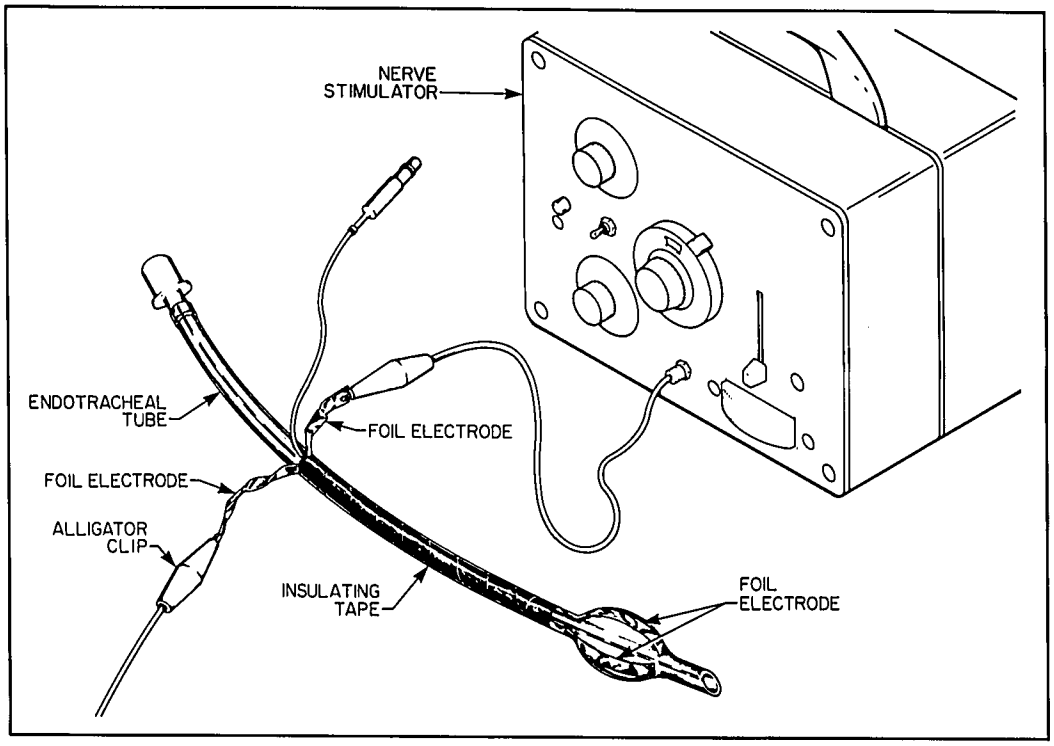

Fig. 1. Diagram of the custom endotracheal tube and recurrent laryngeal nerve stimulator.

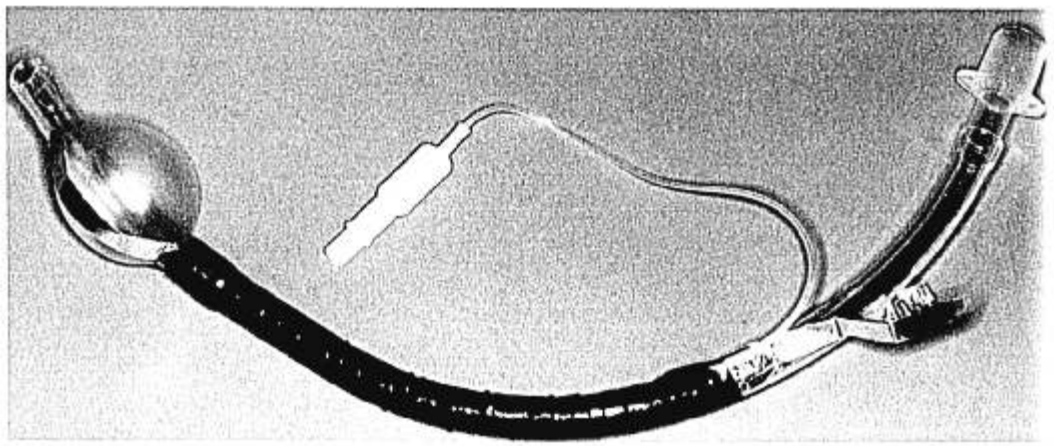

Fig. 2. Photograph of endotracheal tube after modification for use as nerve stimulator.

At UCLA, this system has been used in four patients under general anesthesia. In each case, the RLN was stimulated without difficulty using the described currents of 10 to 20 mA. No complications resulted. Because of the delivery of a possibly painful stimulus, we have used the electrode only under general anesthesia.

Phonation can be stimulated by flowing pressurized air caudally through the tracheostomy and bilaterally stimulating the RLN. A train of stimulating pulses at a frequency of 60 to 70 Hz best simulates phonation in our experience. This method allows videostroboscopic documentation of laryngeal vibration despite general anesthesia. The "phonation" produced in the in vivo canine model with the electrode has led the UCLA laryngeal laboratory staff to refer to the electrode endotracheal tube as "the howler."

The major advantage of this device is the ability to stimulate the RLN without neck exploration. Compared to percutaneous methods, it is less likely to stimulate neighboring nerves, because of the close proximity of the RLN to the tracheal wall. Also, once the tube is properly positioned, the RLN can be stimulated at any time without further manipulation. The purchase of more expensive prefabricated electrode endotracheal tubes is not necessary.

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