Intraoperative electromyogram monitoring of the recurrent laryngeal nerve: experience with an intralaryngeal surface electrode

A method to reduce the risk of recurrent laryngeal nerve injury during thyroid surgery

Abstract  Introduction: A clinical method to localize the recurrent laryngeal nerve intraoperatively in order to minimize the risk of accidental injury is presented. Methods and results: By means of an electrode, the nerve was stimulated by a pulsed contact current. The resulting muscle potential was detected using an electrode placed in the larynx. We applied this technique during the time period between 1 January 1997 and 31 December 1998. In 96 cases of primary thyroid resection, the recurrent nerve was identified 167 times. The patients were operated on for nodular thyroid (n=85), Grave’s disease (n=9) and malignant papillary goiter (n=2). Retrospectively, the rate of intraoperative nerve injury, equivalent to the rate of postoperative transient and permanent nerve palsy, was 1.04% in the 96 patients and 0.60% with respect to the 167 nerves at risk. The rate of failure of the method was 7.29%.

Key words  Lesion of the recurrent laryngeal nerve · EMG monitoring · Intralaryngeal electrode

Introduction

The danger of intraoperative injury of the recurrent laryngeal nerve is especially high when dissecting near the dorsal capsules of the left and right lobes of the thyroid gland. This is not only the case when performing a radical thyroidectomy for treatment of malignant thyroid disease, but even when performing surgery for benign goiter. The nodules cannot only penetrate the dorsal capsule of the thyroid gland but even envelope the nerve (so-called circular growth). In these cases, a total thyroidectomy with resection of all nodules is recommended, because the chance of disease recurrence originating from those nodules is high. The risk of accidental injury to the recurrent laryngeal nerve (RLN) is certainly increased with this approach. In this manuscript, a method is presented that reduces the risk of RLN lesion and identifies the RLN using careful preparation and electrophysiological monitoring.

Material and methods

Principle of nerve stimulation and signal reception

Using a sterile electrode, the nerve or the tissue surrounding the nerve was stimulated with a pulsed contact current variable in amplitude. The resulting muscle potential was detected by an electrode placed in the larynx. The instrument transforms the muscular activity into a crackling or humming tone, depending on the stimulation frequency used (3 Hz or 30 Hz). We only used the frequency of 30 Hz.

Equipment

We used a standard electromyogram (EMG) machine (Neurosign 100®) with an integrated nerve stimulator. A disposable electrode was used as a larynx electrode. The electrode consists of a flexible plastic body. One side of the plastic body features a printed circuit that is in electrical contact with the vocal cords. The other side of the electrode body carries an adhesive pad, making it possible to attach the electrode 10 mm above the cuff of a regular disposable endotracheal tube. After ordinary intubation, the cuff of the tube was typically positioned in the trachea below the larynx, and the electrode was automatically placed between the vocal cords.

By monitoring the electrode impedance, it is easy to check any dislocation of the electrode or defective wiring. The intralaryngeal
electrode detects the EMG signal of the larynx muscles as a difference of electrical potentials against a ground of from 30 µV up to 20 mV and conducts this signal to the preamplifier.

This preamplifier serves as a differential amplifier and guarantees potential separation to the EMG apparatus. The EMG machine provides a further amplification of the signal and a representation of the signal peaks (Fig. 1).

The integrated impulse generator serves to stimulate the nerve. This impulse generator produces a constant rectangular signal of 200 µs in length with a frequency of 3 Hz or 30 Hz. The constant current can be varied from 0.05 mA to 5 mA. To apply the stimulation current to the nerve, two different probes were used. A probe with a monopolar radial electric field was used to approximately locate the nerve, while a bipolar, fork-shaped probe enabled selective identification.

Operative technique

Using a short-acting depolarizing agent, the anesthesiologist used standard techniques to intubate the patient with the endotracheal tube to which the electrode was attached. Further muscle relaxation was not induced for the duration of the operation. Recovery of muscular activity was checked by relaxometry.

The operation began with cleaving of the thyroid isthmus and preparation of the thyroid poles, including the identification of the parathyroid glands. The respective thyroid portion (left or right) was ventralized and retracted medially. To check the system, we stimulated the nerve close to the thyroid cartilage’s inferior horn with the monopolar probe and a high stimulatory current (1.2 mA).

Since the depth of penetration of the monopolar electrical field depends on the intensity of the current, the nerve can be stimulated even through surrounding tissue, such as the dorsal capsule (Fig. 2). The detected EMG signal shows the functional integrity of the EMG apparatus and proves that the intralaryngeal electrode is able to receive EMG signals from the larynx.

Second, we applied tension to the tissue of the dorsal capsule of the thyroid gland in the area where we expected to find the recurrent nerve on its way from the mediastinum to the larynx. The dorsal capsule was split open sharply in a longitudinal direction. With the monopolar probe and high stimulatory current (1.2 mA, 30 Hz), the recurrent nerve was approximately localized. Next, the nerve was carefully dissected to the point of visibility, still covered by a layer of connective tissue. The NLR was positively identified through its capability of stimulation. The stimulating current was reduced to a minimum of about 0.5 mA so that the surrounding anatomical structures would not produce an EMG signal. Using the bipolar, forked electrode, which must be applied lengthwise to the nerve, the surface of the nerve was depolarized locally. In this way, the side effects of the widespread monopolar electric field were eliminated. After resection of the thyroid gland, a final stimulation of the nerve was performed to prove its functional integrity.