MEDICAL SCIENCES

EFFECTIVENESS OF LIDOCAINE INFUSION ON THE FUNCTIONALITY OF INTRAOPERATIVE MONITORING OF THE RECURRENT LARYNGEAL NERVE DURING THYROID GLAND SURGERY

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Abstract

Intraoperative nerve monitoring (INM) to assess for recurrent laryngeal nerve dysfunction during thyroid surgery is becoming the standard of care in many institutions. Successful provision of data analysis with the help of IONM requires complete relaxation of the larynx and suppression of the reflex. We investigated the role of intravenous lidocaine in providing such working conditions to ensure the least impact on hemodynamic changes and obtain better conditions for working with IONM.

The study aims to evaluate the effect of lidocaine, administered intravenously in estimated doses, on the IONM and laryngotracheal reflexes during surgical interventions on the thyroid and parathyroid glands.

Methods: Forty-six patients were randomly assigned to Group 1 where lidocaine was administered and Group 2 where no lidocaine was administered. All patients were anaesthetized with a narcotic analgesic and inhalation anaesthetic. The loading dose of lidocaine was administered at the rate of 1 mg/kg intravenously, and the maintenance dose was calculated at 1.5 mg/kg/hour. For IONM, a Dragonfly single-channel laryngeal surface electrode (C2 NerveMonitor; 8 channel system for intraoperative Neurophysiological Monitoring, GERMANY) attached to a cuffed ETT #7 (MEDICARE, China) was used during surgery the same to the manufacturer's instructions.

Results: The number of patients who required StMC strength at 0.5 mA (the manufacturer's recommended strength is 1.5 mA) was significantly higher in the lidocaine group (P=0.001) than in the no lidocaine group (P=0, 00006). The same number of patients with < 50% DAIL at the end of surgery was significantly higher in group 1 than in group 2. In addition, the proportion of patients with hypotensive episodes and blood pressure medication requirements more than twice during surgery was significantly lower in group 1 than in group 2 ($P < 0.05$).

Conclusions: Patients who were prescribed lidocaine intravenously were more resistant to laryngotracheal irritation during surgery, and this made it possible to maintain such a condition of the larynx, which was necessary to ensure increased relaxation of the larynx and suppression of reflexes when using IONM. Our ability to elicit a positive signal with StMC 0.5 mA intraoperatively and provide a DAIL < 50% before the end of surgery was statistically significant in the IV lidocaine group (group 1).

Keywords: Lidocaine , recurrent laryngeal nerve, IONM.

Introduction

Laryngeal paresis due to damage to the recurrent laryngeal nerves (RLN) is one of the most dangerous mistakes that can reduce the patient's quality of life after surgery on the thyroid or parathyroid glands. Since the problem of patient safety during such operations remains one of the most relevant today, technologies are increasingly being developed to reduce the risk of such injuries. In particular, according to some authors, the use of electromyography and neuromonitoring (EMG-NM) during operations on the thyroid and parathyroid glands can reduce the risk of damage to the thyroid gland.

The surgeon and the anesthesiologist can evaluate and predict the function of the nerves already during the operation, which affects the tactics of both the operation itself and the postoperative management of patients. [] A prerequisite for this is the absence of muscle relaxants during surgery, which creates for the anesthesiologist the problem of preserving reflexes from the respiratory tract and vocal folds, as well as the need for deep anesthesia to suppress them [1-2,10].

The use of intraoperative nerve monitoring (IONM) in combination with visual recurrent laryngeal nerve (RLN) identification results in significant lower postoperative RLN palsy rates than RLN identification without IONM . The alerting of the surgeon early to potential RLN problems is a pre-requisite for the decrease of RLN injury and should result in lower RLN palsy rates and an improved quality of life for patients. A reduction in the time of identification of RLN when using IOMN during thyroid surgery has been documented in the literature. Because of the simplicity of design and cost effectiveness, recording of electromyography of the vocal cords using surface electrodes integrated or attached to the endotracheal tube (ETT) is perhaps the most widely used technique of the IONM [2]. The full functionality of IOMN depends on almost complete relaxation and suppression of the reflex without the use of neuromuscular blockers. The depth of anesthesia required to meet these criteria often results in hemodynamic instability. Intravenous (IV) lidocaine is widely used in anesthesia to suppress laryngotracheal reflexes,

intubation-induced bronchospasm, and to blunt the adverse cardiovascular response during intubation.

The interpretation of intraoperative nerve monitoring data during surgery depends on almost perfect placement of laryngeal electrodes and almost complete inhibition of laryngeal reflexes. In this prospective, randomized, double-blind, placebo-controlled trial, we investigated the role of intravenous lidocaine infusion in improving the functionality of intraoperative nerve monitoring during thyroid and parathyroid surgery. [3-4]

The purpose of the study is to evaluate the effect of lidocaine, administered intravenously in estimated doses, on the IONM and laryngotracheal reflexes during surgical interventions on the thyroid and parathyroid glands.

Materials and methods

It was conducted in compliance with the ethical standards of our institution on human subjects as well as with the Helsinki Declaration. Patient recruitment was initiated during the preoperative visit to the surgical clinic. We included 46 male and female patients aged 18 to 75 years scheduled for thyroid and parathyroid surgery, including reoperation, according to American Society of Anesthesiologists (ASA) physical status classification I to III.

Forty-six patients were randomly assigned to the lidocaine group (group 1) or the placebo group (group 2).

- 1 group (LG) of general combined anesthesia, patients who were administered intravenous lidocaine, n=24;

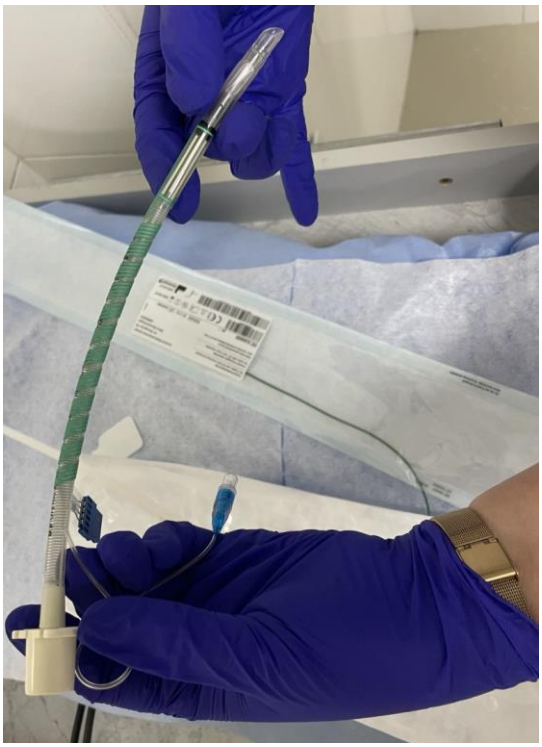
- 2nd group (PG) of general combined anesthesia without lidocaine, n=22.

All patients of both groups were given the same type of anesthesia.

Lidocaine was given as an intravenous bolus at a dose of 1.5 mg/kg, followed by an infusion of 1 mg/min to maintain therapeutic plasma lidocaine levels.

The IONM setup was prepared by applying a Dragonfly® single-channel laryngeal surface electrode (C2 NerveMonitor; 8 channel system for intraoperative Neurophysiological Monitoring, GERMANY) to a №7 cuffed ETT (MEDICARE, China) according to the manufacturer's instructions.

For intraoperative neuromonitoring during surgery, a Dragonfly single-channel laryngeal surface electrode (C2 NerveMonitor; 8 channel system for intraoperative Neurophysiological Monitoring, GERMANY) attached to ETT №7 with a cuff (MEDICARE, China) was used ccording to the manufacturer's instructions (Fig. 1).



Rice. 1. Installation of a disposable electrode for electromyographic neuromonitoring ETT №7.

Inclusion criteria: age over 18 years; surgery on the neck organs. Exclusion criteria: contraindications to the introduction of lidocaine, initial heart rate less than 50 per minute, initial damage of the IHV or n. vagus.

Operative interventions were performed for thyroid neoplasms and hyperparathyroidism.

The distribution of nosology patients is shown in Table 1.

Table 1

Main diagnosis	Group 1 (n=24)	Group 2 (n=22)
Thyroid adenoma	19	17
Thyroid carcinoma	4	4
Parathyroid adenoma	1	1

In the evening the day before surgery, patients received per os hydazepam 0.02 mg. Induction was carried out with propofol 1.5-2.5 mg per 1 kg of body weight and fentanyl 2-3 μg per 1 kg of body weight, for myoplegia succinylcholine 1 mg per 1 kg of body weight was prescribed during intubation. An intubation tube with a cuff was used to protect the airway, a surface electrode was pre-installed on the airway, attached to the endotracheal tube.

Anaesthesia was maintained with air, oxygen, and sevoflurane at the desired minimum levels of alveolar concentration, titrated for effect.

Prior to intubation and during direct laryngoscopy, no local anesthetics were used to irrigate the oropharynx and ETT. To manage patients in both groups of the study, a C2 neuromonitor (Inomed Medizintechnik GmbH, Germany) with ETT electrodes ranging in size from 7 to 9 mm. Bispectral index measurement using (BIS) Vista (Aspect Medical Systems, USA). After tracheal intubation, the circuit was filled with sevoran, and BIS values were maintained in the range of 40 to 50 by changing its concentration. With the help of a pressure gauge, the pressure was set 30 cm of water. in the ETT cuff. The correctness of the sensor position at the level of the vocal folds was assessed visually during direct laryngoscopy, as well as after controlling the impedance of the electrode channels according to the data of the neuromonitor (Fig. 2).

Rice. 2. Automatic impedance detection from four electrode channels.

Artificial lung ventilation was carried out along a semi-closed circuit with the Getinge Flow-c device in VCV mode, normative ventilation was maintained by focusing on capnography. Before the skin incision, fentanyl was additionally injected at a rate of 3-4 μg per 1 kg of body weight. With clinical signs of insufficient depth of anesthesia, the appearance of laryngotracheal reflexes, fentanyl 0.1 mg and propofol 30 mg were additionally administered. At the stage of subcutaneous suture, the sevoran was turned off, the breathing circuit was purged with 100% oxygen. The time from the end of surgery to tracheal extubation was recorded.

Measuring Results

The main outcome measure was the suppression of laryngotracheal reflexes during thyroid and parathyroid surgery, as well as the time frame from the beginning of surgery to its end. We evaluated laryngotracheal activity as a function of maintaining contact between laryngeal electrodes and vocal cords, documenting the lowest stimulus current (StMC) level that causes a positive signal and a < 50% drop in cumulative impedance level (DAIL) after surgery is completed. Intraoperative monitoring of laryngotracheal activity was objectively recorded and evaluated according to IONM data (StMC and DAIL).

The number of patients who required StMC strength at 0.5 mA (manufacturer's recommended strength to 2.0 mA) was significantly higher in the lidocaine group (P=0.001) than in the non-lidocaine group (P=0.00006). Tha same, the proportion of patients with DAIL at < 50% at the end of surgery was significantly higher in group 1 than in group 2 (Figure 3).

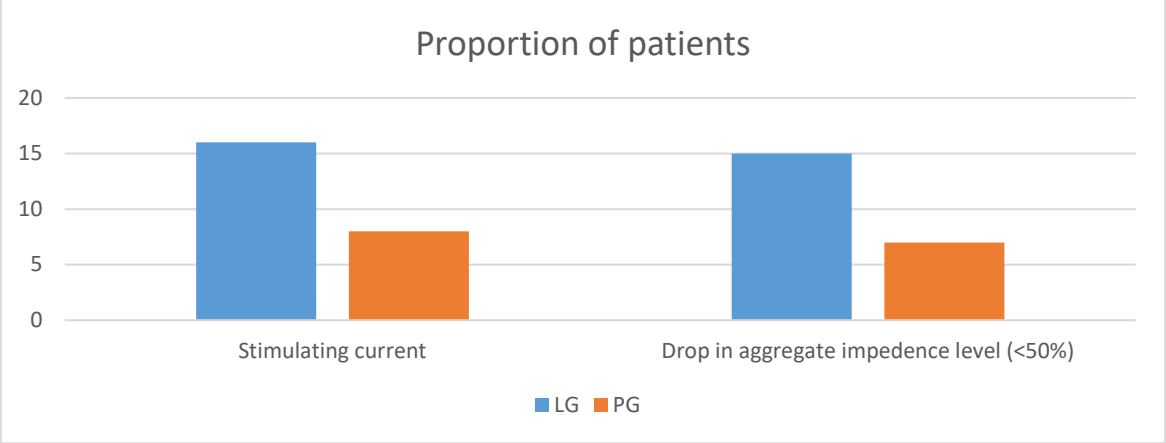


Fig.3 Intraoperative monitoring of laryngotracheal activity

Secondary outcome measures included the amount of anesthesia drugs used, postoperative pain control, pain medication needed, nausea, and overall patient comfort. The total number of anesthetic drugs used and the necessary postoperative analgesics was recorded in absolute numbers. The period of postoperative monitoring began from the moment of admission to the Department of Anesthesiology and Intensive Care and ended 24 hours after surgery. Control of postoperative pain, postoperative nausea, and overall patient comfort were recorded on a VAS of Paine scale of 1 to 10.

Research Results

Although this was not originally planned as part of the study, there were a few additional outcomes that were significantly favorable for Group 1 patients that we felt should have been reported (Table 2). For example, diastolic blood pressure at extubation was significantly lower in patients in group 1 (M = 79.2, SD = 8.2) compared to patients in group 2 (M = 84.6, SD = 8,4) (P = 0,04). The total duration of surgery was also significantly reduced among patients in group 1 compared to patients in group 2. While more than three-quarters of patients in group 1 were operated on ≤ 120 minutes, in contrast to group 2, where only less than half of patients in group 2 were operated ≤ 120 minutes (P = 0.009). The proportion of patients who required additional administration of atracurium besylate from group 1 was significantly lower than in group 2 (P = 0.002). Similarly, the proportion of hypotension episodes requiring emergency medication more than twice during surgery was significantly lower in group 1 than in group 2 (P = 0.02)

Table 2

Research Result	**Study group**	
	Group 1, N (%)	**Group 2, N (%)**
Just	24 (100,0)	22 (100,0)
Diastolic blood pressure (mmHg) [b]		
Medium	79.2	84.6
Standard deviation	8.2	8.4
Duration of the procedure (min.)		
≤ 120	16 (66,67)	8 (36,36)
> 120	8 (79,17)	14 (63,4)
Atracurium besylate		
yes	5(20,83)	18 (81,82)
no	19 (65,6)	4 (18,18)
Episodes of hypotension [d]		
yes	2 (8,33)	6 (27,27)
no	22 (93,67)	16 (72,73)

Analysis of the parameters of the reverse laryngeal nerve myogram did not show statistically significant intergroup differences: the average value of its amplitude in group 1 was 1.86±0.79 mV, group 2 — 2.08±0.13 mV (p=0.25), latency — 2.16±0.6 ms and 2.28±0.49 ms, respectively (p=0.95). The obtained parameters in patients of both groups allow for successful EMG-NM, and the use of lidocaine in our study did not affect the monitored parameters.

During the operations, it was necessary to note situations when an adequate depth of anesthesia and complete anesthesia did not always suppress laryngotracheal reflexes, which led to coughing, an increase in peak pressure in the respiratory tract, and sometimes a manifestation of motor activity on the part of the patient. In these cases, the problem was solved by bolus administration of fentanyl and propofol.

The dose of fentanyl in group 1 patients was 4.24 (2.44-4.45) μg·per 1 kg of body weight per hour, the control dose was 4.88 (3.05-5.88) μg· per 1 kg of body weight. per hour (p=0.92). The time from completion of surgery to extubation also showed no statistically significant differences and was 5.5 (3.5 to 7.0) minutes in patients in the intervention group compared to 7.5 (5.5 to 9.5) minutes in patients in the control group. The length of stay in the waiting room after anesthesia was the same (all patients were monitored for 1 hour).

Analysis of postoperative complications and adverse effects revealed no statistically significant differences. The vast majority of patients of both groups were discharged on the first day after surgery (20 patients of group 1 and 17 patients of group 2). Analysis of complications showed that the most frequent events were nausea and vomiting (in 2 patients of group 1 and in group 5-2).

Discussion

The peculiarities of surgical interventions on the thyroid and parathyroid glands using neuromonitoring pose a difficult task for the anesthesiologist. General anesthesia in the absence (or minimal) of muscle relaxation increases the risk of developing laryngeal reflexes and coughing during surgery. Coughing in response to ETT irritation during recovery from anesthesia has been recognized as a risk factor for respiratory and cardiovascular complications [7]. On the other hand, anesthesia that is too deep slows down recovery after surgery and also increases the risk of complications and long-term mortality.

The most dreaded complication after surgery on the thyroid gland and, to a lesser extent, on the parathyroid gland is the paralysis of the GLN. Experienced surgeons can also injure the nerve, resulting in persistent nerve paralysis in 1-2% of patients [5]. Despite the progress made over the years in neuromonitoring, atraumatic dissection and visual identification remain the gold standard in the preservation of SGB. The nerve is very sensitive, and even a slight tension can lead to temporary paresis. In addition to atraumatic dissection of the SGN, intraoperative neuromonitoring is preferable to surgical exposure (of the nerve) because not only morphological but also functional integrity can be demonstrated [6].

When administered intravenously, lidocaine is not equally effective in blunting the haemodynamic response to intubation. IV lidocaine decreases the intracellular concentration of Ca^{2+} in the smooth muscle of the respiratory tract, decreases the sensitivity of the Ca^{2+} myofilament, and has been shown to suppress cough and prevent reflex bronchial constriction. Laryngoscopy, with or without intubation, elicits a sympathoadrenal response. These events are clearly harmful to individuals who have limited myocardial reserve due to age or disease. Administration of intravenous lidocaine 1.5 mg/kg attenuates the hyperdynamic response to laryngoscopy and intubation [8].

Inhibition of laryngotracheal reflexes during thyroid and parathyroid surgery is mainly controlled by clinical signs such as coughing, or swallowing during anesthesia. IOMN causes severe contractions of the vocal cords and can cause changes in the larynx [9]. Such laryngeal changes may not be clinically noticeable, but contribute to a small dislocation of the ETT held between the vocal cords.

Conclusions

The results obtained during the studies showed that patients who were prescribed intravenous lidocaine were more resistant to laryngotracheal irritation during surgery, and this made it possible to maintain such a state of the larynx when using IONM, which was necessary to ensure increased relaxation of the larynx and inhibition of reflexes. This, in turn, ensured that contact between the electrodes and the vocal cords was maintained more optimally and for a long time, despite intralaryngeal changes in the IONM and extralaryngeal manipulations during surgery. Our ability to elicit a positive signal with a 0.5 mA StMC during surgery and to provide a DAIL < 50% prior to surgery completion was statistically significant in the intravenous lidocaine group (group 1).

Although none of our secondary outcome evaluations reach the level of statistical significance, we are encouraged that our exploratory results have offered us positive data for a future clinical trial. The total duration of surgery, additional doses of atracurium besylate required during surgery, diastolic pressure at extubation, and episodes of hypotension requiring emergency medication more than twice during surgery were lower in group 1. We believe that IONM contributed to these results and propose further targeted research.

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