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Effect of droperidol combined with twice the ED_{95} rocuronium on intraoperative nerve monitoring during thyroid surgery

JI Tingting, XU Zhenhua, SUN Ren, ZHU Jie

Department of Anesthesiology, Zhangjiagang First People's Hospital, Zhangjiagang Hospital Affiliated to Soochow University, Zhangjiagang, Jiangsu 215600, China

Corresponding author: ZHU Jie, E-mail: drzhujie@126.com

Abstract: Objective To investigate the effects of droperidol combined with twice the 95% effective dose (ED_{95}) of rocuronium (0.6 mg/kg) on electromyography (EMG), intraoperative nerve monitoring (IONM), and vital sign indicators in patients during thyroid surgery. **Methods** A total of 100 patients undergoing scheduled thyroid surgery at Zhangjiagang First People's Hospital between January 2023 and December 2024 were selected as the study subjects. According to the random number table method, the patients were divided into a control group and a combination group, with 50 patients in each group. The control group received rocuronium (0.6 mg/kg), while the combination group received rocuronium (0.6 mg/kg) plus droperidol (2 mg). The tracheal intubation conditions (Cooper's score), IONM signals, vital sign indicators, EMG amplitude and neural monitoring situation, surgeon satisfaction, respiratory complications, and antagonism were compared between the two groups. **Results** The Cooper's score of the patients in the combination group was higher than that in the control group (8.95 ± 0.95 *vs* 5.32 ± 0.54, t=23.489, P<0.01). Compared with the control group, the combination group exhibited higher maximum [(758.90±8.59) μV *vs* (442.53±9.60) μV, t=173.658, P<0.01] and minimum [(544.06 ± 4.51) μV *vs* (394.64 ± 4.59) μV, t=164.191, P<0.01] amplitude values in IONM signals. In comparison with the control group, the combination group had lower propofol maintenance dosage, remifentanil maintenance dosage, proportion of cases with delayed recurrent laryngeal nerve detection, and waiting time required for delayed detection cases, with the differences being statistically significant (P<0.05). At 60, 90, and 120 minutes, the EMG amplitude gradually increased in both groups, and the EMG amplitude of the combination group at each time point was lower than that of the control group (P<0.05). Compared with the control group after intubation, the combination group showed lower heart rate and blood pressure levels (P<0.05). Before and after anesthesia induction, there was no statistically significant differences in end-tidal carbon dioxide partial pressure ($P_{ET}CO_2$), peak airway pressure, or saturation of peripheral oxygen (SpO_2) levels between the two groups (P>0.05). There was no statistically significant difference between the two groups in the incidence of intraoperative body movement, respiratory complications, or antagonism (P>0.05). And there was no statistically significant difference in surgeon satisfaction between the two groups (P>0.05). **Conclusion** The combination of droperidol with twice the ED_{95} of rocuronium can effectively improve the accuracy of IONM in thyroid surgery and help maintain the stability of vital sign indicators of patients.

Keywords: Anesthesia; Droperidol; Rocuronium; Thyroid gland; Intraoperative nerve monitoring

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Thyroid surgery is the most common surgical procedure for the treatment of thyroid tumors, hyperthyroidism, simple goiter and other diseases. Patients may develop various complications after surgery, among which recurrent laryngeal nerve injury is a relatively serious complication that seriously affects patients' quality of life. Unilateral recurrent laryngeal nerve injury may lead to hoarseness, while bilateral recurrent laryngeal nerve injury may cause symptoms such as dyspnea and endanger patients' lives [1]. In recent years, intraoperative nerve monitoring (IONM) technology can accurately locate the recurrent laryngeal nerve, thereby preventing nerve injury caused by excessive dissection during surgery [2]. To prevent laryngeal injury, it is necessary to find a suitable site for intubation, which requires rational use of drugs during anesthesia induction, and IONM also imposes high requirements on anesthesia. Muscle relaxants are key factors in the IONM process. Rocuronium bromide at 2 times the 95% effective dose (ED_{95}) (0.6 mg/kg) not only has a fast onset and minor cardiovascular side effects, but also prolongs the maintenance time of clinical muscle relaxation [3]. Monitoring the concentration of rocuronium bromide is also particularly important for evaluating the muscle relaxation effect in clinical anesthesia [3-4]. Reducing respiratory depression, stress response during extubation and the incidence of complications has a good effect on postoperative analgesia, and droperidol is widely used in clinical practice at present [5]. At present, there are few clinical studies on the effect of droperidol combined with 2 times ED_{95} rocuronium bromide on IONM in thyroid surgery. Therefore, this study aims to analyze the effect of droperidol combined with 2 times ED_{95} rocuronium bromide on IONM during thyroid surgery.

1 Materials and Methods

1.1 General Information

The study subjects were patients who underwent thyroid surgery admitted to Zhangjiagang First People's Hospital from January 2023 to December 2024. A total of 100 patients were enrolled, and they were divided into the control group (50 cases) and the combination group (50 cases) using the random number table method.

Inclusion criteria: (1) Aged 18 to 65 years old, with stable vital signs, normal cognitive function, and normal functions of the heart, liver, kidney and other organs; (2) All patients were confirmed by imaging examinations; (3) American Society of Anesthesiologists (ASA) classification grade I to III [6]; (4) No other analgesic measures or analgesic drugs were used in the past 3 months; (5) Meeting the indications for thyroid surgery; (6) Patients and their families were informed and signed the informed consent form.

Exclusion criteria: (1) History of hyperthyroidism or thyroid surgery; (2) Complicated with severe heart disease, hepatic or renal insufficiency; (3) Complicated with asthma, neuromuscular diseases, or endocrine diseases; (4) History of allergy to local anesthetics; (5) No complete behavioral capacity, or complicated with mental illness; (6) Predictable intraoperative airway dyspnea, or patients with morbid obesity; (7) Contraindications to the drugs used in the study.

Dropout and exclusion criteria: (1) Drug allergy or other serious adverse reactions occurred during the treatment process; (2) Incomplete data during the trial, which affects the judgment of efficacy and safety; (3) Voluntarily requested to withdraw from this clinical trial for personal reasons. There was no statistically significant difference in general data between the two groups of patients ($P > 0.05$), as shown in **Table 1**. This study was approved by the Medical Ethics Committee of Zhangjiagang First People's Hospital (No.: KYLX-007).

Tab.1 Comparison of general data between two groups (n=50)

Group	Age (years, $\bar{x} \pm s$)	Gender (male/female, case)	Body mass (kg, $\bar{x} \pm s$)	Surgical method (total thyroidectomy/subtotal thyroidectomy, case)
Control group	42.33±9.65	18/32	65.38±6.75	15/35
Combination group	45.50±10.77	21/29	67.68±7.60	12/38
***t*/χ^2 value**	1.550	0.378	1.600	0.457
***P* value**	0.124	0.539	0.113	0.499

1.2 Research Methods

After entering the operating room, peripheral venous access was established, and basic vital signs [peripheral oxygen saturation (SpO_2), respiration, blood pressure, electrocardiogram, and heart rate], as well as partial pressure of end-tidal carbon dioxide ($P_{ET}CO_2$) and airway pressure before and after anesthesia induction were monitored, and mask oxygen inhalation (6 L/min) was administered. Anesthesia induction: Sufentanil (Yichang Humanwell Pharmaceutical, National Medical Product Administration Approval No. H20054171, 1 mL∶50 μg) 0.5 μg/kg and propofol (Xi'an Libang Pharmaceutical, National Medical Product Administration Approval No. H19990282, 20 mL∶0.2 g) 2 mg/kg were sequentially injected intravenously. After the disappearance of eyelid reflex and muscle relaxation, tracheal intubation was performed. Respiratory parameters were set as follows: tidal volume 6-8 mL/kg, respiratory rate 11-14 breaths/min; the depth of anesthesia was maintained at bispectral index (BIS) 40-60. Intraoperative anesthesia maintenance: remifentanil (Yichang Humanwell Pharmaceutical, National Medical Product Administration Approval No. H20030197) 0.5 μg/(kg·min) and propofol 0.10-0.15 mg/(kg·min) were continuously infused intravenously. BIS, SpO_2, heart rate, electromyogram (EMG), IONM and blood pressure were continuously monitored. During the operation, BIS was maintained at 40-60, SpO_2 was maintained above 95%, and blood pressure fluctuation did not exceed 30% of the baseline blood pressure. If the full dose of analgesic measures had been administered, and the patient's heart rate fluctuation amplitude and blood pressure value still exceeded 30% of the baseline value, corresponding vasoactive drugs should be administered. When the heart rate was > 100 beats/min, esmolol (Qilu Pharmaceutical, National Medical Product Administration Approval No. H20066758, 2 mL∶0.2 g) 10 mg was injected intravenously. When the heart rate was < 60 beats/min, atropine (Shanghai Hefeng Pharmaceutical, National Medical Product Administration Approval No. H31021172, 1 mL∶0.5 mg) 0.3 mg was injected intravenously. Control group: Patients were administered 2 times ED_{95} rocuronium bromide (Guangdong Xinghao Pharmaceutical, National Medical Product Administration Approval No. H20103495, 5 mL∶50 mg) (0.6 mg/kg). Combination group: Rocuronium bromide + droperidol (Shanghai Xudong Haipu Pharmaceutical, National Medical Product Administration Approval No. H31020895, 2 mL∶5 mg) were administered. The dose of rocuronium bromide was the same as that in the control group, and droperidol injection 2 mg diluted with 0.9% sodium chloride was slowly injected during intraoperative intubation.

1.3 Observation Indicators

1.3.1 Tracheal Intubation Condition Score

Tracheal intubation was performed by experienced anesthesiologists. Changes in heart rate and blood pressure of patients during intubation were recorded, and Cooper's score was used to evaluate tracheal intubation conditions: 0 point indicates closed glottis, coughing during intubation, and impossible laryngoscopy; 1 point

indicates mild coughing during intubation, approximated glottis, and difficult laryngoscopy; 2 points indicates mobile glottis, mild diaphragmatic movement during intubation, and acceptable laryngoscopy; 3 points indicates no response during intubation, open glottis, and easy laryngoscopy. Higher scores indicate better conditions. The intubation condition is graded as poor (0-2 points), fair (3-5 points), good (6-7 points), and excellent (8-9 points) [7].

1.3.2 Vital Sign Monitoring

Changes in blood pressure and heart rate of the two groups of patients 90 s after drug administration and 90 s after intubation were observed and recorded [8]. $P_{ET}CO_2$, peak airway pressure, and SpO_2 before and after anesthesia induction were recorded.

1.3.3 EMG Level Measurement

During thyroid surgery, the threshold for inducing EMG amplitude was set at 100 μV to obtain stable sound prompts and biphasic EMG, with the current set at 2 mA. A disposable nerve stimulation probe (Medtronic Xomed, USA) was used to stimulate and induce neuromuscular potentials, and potentials exceeding the set threshold were regarded as valid myoelectric signals. The intraoperative EMG amplitude levels of the two groups were observed and recorded. The recording time ranged from 30 to 120 min after intravenous injection of 2 times ED_{95} rocuronium bromide (0.6 mg/kg), and changes in EMG amplitude were recorded every 10 min. The EMG amplitude levels at 60, 90, and 120 min (i.e., EMG60, EMG90, EMG120) of the two groups were analyzed.

1.3.4 Dosage of Sedative and Analgesic Drugs for Maintenance

The dosages of sedative and analgesic drugs (sufentanil and propofol) used at the beginning of the surgery were recorded.

1.3.5 IONM

After intubation with an IONM-specific tracheal tube (Shanghai Better Medical Instruments, 8G), the central part of the blue area was precisely positioned at the vocal cord level. Different sizes of nerve monitoring tracheal tubes were selected according to the patient's gender (6 mm for females, 7 mm for males). The reference electrode was inserted into the scapular muscle, and connected sequentially to the nerve monitor (NIM-Response 3.0, Medtronic Xomed, USA). Surgery was initiated and nerve function was monitored, including the number of cases with delayed detection of recurrent laryngeal nerve (judged by the same group of surgeons within 40 min after administration of muscle relaxants), waiting time (the time required from 40 min after administration to the re-detection of recurrent laryngeal nerve), and the number of cases with intraoperative body movement. The maximum and minimum values of intraoperative IONM amplitude were recorded and analyzed.

1.3.6 Surgeon Satisfaction, Respiratory Complications, and Antagonism Status

The two groups were recorded for surgeon satisfaction with anesthesia (mild swallowing during surgery requiring deepening of anesthesia), respiratory complications (laryngospasm, choking, glossoptosis), and antagonism status (administration of muscle relaxant antagonists).

1.4 Statistical Methods

Data were processed using SPSS 26.0 software. Measurement data conforming to normal distribution were described as $\bar{x} \pm s$ independent samples t-test was used for comparison between the two groups, paired samples t-test was used for intra-group comparison, repeated measures analysis of variance (ANOVA) was used for multi-time point comparison, and LSD-*t* test was used for pairwise comparison. Count data were expressed as case (%), and χ^2 test or corrected χ^2 test was used for comparison between the two groups. A P value < 0.05 was considered statistically significant.

2 Results

2.1 Comparison of Intraoperative Indicators Between the Two Groups

Compared with the control group, the Cooper's score, the maximum amplitude and minimum amplitude of IONM signals in the combination group were higher, (P < 0.05), as shown in **Table 2**.

2.2 Comparison of EMG Amplitude Levels Between the Two Groups

The EMG amplitudes of both groups increased gradually at 60, 90 and 120 min; the EMG_{60}, EMG_{90} and EMG_{120} in the combination group were lower than those in the control group, (P < 0.05), as shown in **Table 3**.

2.3 Comparison of Heart Rate and Blood Pressure Between the Two Groups Before and After Treatment

Compared with the control group, the heart rate and blood pressure of the combination group after intubation were significantly lower (P < 0.05), as shown in **Table 4**.

Tab.2 Comparison of intraoperative indicators between two groups (n=50, $\bar{x}\pm s$)

Group	Cooper's score (point)	Maximum amplitude of IONM signal (μV)	Minimum amplitude of IONM signal (μV)
Control group	5.32±0.54	442.53±9.60	394.64±4.59
Combination group	8.95±0.95	758.90±8.59	544.06±4.51
t value	23.489	173.658	164.191
P value	<0.001	<0.001	<0.001

Tab.3 Comparison of EMG levels between two groups (n=50, $\bar{x}\pm s$)

Group	EMG_{60} (μV)	EMG_{90} (μV)	EMG_{120} (μV)
Control group	821.09±26.25	1016.09±53.97[a]	1312.53±68.77[b]
Combination group	156.87±79.60	577.80±68.28[a]	844.30±83.45[b]
***t* value**	56.036	35.609	30.618
***P* value**	<0.001	<0.001	<0.001

Note: Compared with EMG_{60}, [a]P<0.05; compared with EMG_{90}, [b]P<0.05.

2.4 Comparison of $P_{ET}CO_2$, Peak Airway Pressure and SpO_2 Levels Between the Two Groups Before and After Anesthesia Induction

There were no statistically significant differences in $P_{ET}CO_2$, peak airway pressure and SpO_2 levels between the two groups before and after anesthesia induction (P > 0.05), as shown in **Table 5**.

Tab.4 Comparison of heart rate and blood pressure before and after treatment between two groups (n=50, $\bar{x}\pm s$)

Group	Systolic blood pressure (mmHg)		Diastolic blood pressure (mmHg)		Heart rate (times/min)	
	After administration	After intubation	After administration	After intubation	After administration	After intubation
Control group	103.41±14.92	143.62±14.23[a]	62.73±8.91	88.21±9.32[a]	66.92±7.51	93.51±12.24[a]
Combination group	102.71±16.82	120.41±15.33[a]	63.24±8.22	72.52±7.54[a]	66.06±7.35	74.92±10.26[a]
***t* value**	0.220	7.846	0.297	9.255	0.579	8.230
***P* value**	0.826	<0.001	0.767	<0.001	0.564	<0.001

Note: Compared with after administration, [a]P<0.05.

Tab.5 Comparison of $P_{ET}CO_2$, peak airway pressure, and SpO_2 levels at different time points between two groups (n=50, $\bar{x}\pm s$)

Group	SpO_2 (%)		$P_{et}CO_2$ (mmHg)		Peak airway pressure (cmH_2O)	
	Before induction	After induction	Before induction	After induction	Before induction	After induction
Control group	98.63±0.98	97.05±0.87	36.93±2.88	36.45±2.08	20.92±1.77	17.77±1.40
Combination group	98.96±0.87	96.77±0.85	37.05±2.79	36.33±2.05	21.10±1.82	18.02±1.46
***t* value**	1.781	1.628	0.212	0.291	0.501	0.874
***P* value**	0.078	0.107	0.833	0.772	0.617	0.384

2.5 Comparison of Intraoperative Drug Dosage Between the Two Groups

The maintenance dosage of propofol in the combination group was (17.50 ± 3.15) mL/h, which was significantly lower than that in the control group (18.97 ± 3.61) mL/h, with a statistically significant difference (t = 2.170, P=0.033). The maintenance dosage of remifentanil in the combination group was also significantly lower than that in the control group [(16.53 ± 3.62) mL/h *vs* (18.70 ± 3.94) mL/h, t = 2.868, P = 0.005].

2.6 Comparison of Nerve Monitoring Conditions Between the Two Groups

There was no statistically significant difference in the incidence of intraoperative body movement between the two groups (P > 0.05). The proportion of patients with delayed detection of recurrent laryngeal nerve in the combination group was 24% (12/50), which was significantly lower than that in the control group [44% (22/50)], (χ^2 = 4.456, P = 0.035). The waiting time for patients with delayed detection in the combination group was shorter than that in the control group [(4.06 ± 3.28) min *vs* (6.25 ± 4.30) min, t = 2.868, P = 0.005].

2.7 Comparison of Surgeon Satisfaction, Respiratory Complications and Antagonism Status Between the Two Groups

There was no statistically significant difference in surgeon satisfaction between the control group and the combination group [70.00% (35/50) *vs* 84.00% (42/50), χ^2 = 2.767, P = 0.096]. There were 6 cases of respiratory complications in the control group and 2 cases in the combination group; 8 cases of antagonism occurred in the control group and 3 cases in the combination group. There were no statistically significant differences in the incidence of respiratory complications and antagonism between the two groups (χ^2 = 1.223, P = 0.269; χ^2 = 2.554, P = 0.110, respectively).

3 Discussion

Thyroid surgery may disrupt the homeostasis of lymphocyte immunity in the body, leading to decreased levels of related indicators, postoperative pain, increased incidence of complications, and poorer postoperative recovery outcomes [9-10]. Thyroid surgical procedures include total thyroidectomy and partial resection (subtotal thyroidectomy). Total thyroidectomy has higher surgical requirements, while subtotal thyroidectomy has relatively lower technical demands. The drugs and strategies applied during surgery are also critical. Surgeons believe that the application of IONM in thyroid surgery can help surgeons identify and locate the recurrent laryngeal nerve as early as possible, reducing laryngeal injury [11-12]. IONM includes tracheal intubation monitoring and needle electrode monitoring. For needle electrode monitoring, a double-needle electrode is placed in the submucosa of the inferior vocal fold and inserted toward the head through the cricothyroid membrane to obtain EMG signals

[13-14]. In thyroid surgery, IONM mainly has two modes: intermittent monitoring and continuous monitoring [15]. This study showed that the EMG amplitude levels in the combination group were lower than those in the control group, indicating that droperidol combined with 2 times the ED_{95} of rocuronium has a significant effect on IONM in thyroid surgery. The analysis suggests that the emergence of continuous IONM effectively overcomes the shortcomings of intermittent monitoring. Meanwhile, IONM has multiple advantages, such as avoiding permanent nerve injury, detecting recurrent laryngeal nerve injury in time, and identifying EMG patterns associated with early nerve injury [16-17].

The results of this study demonstrated that compared with the control group, the combination group had higher Cooper's scores, maximum and minimum IONM signal amplitudes, and surgeon satisfaction. Meanwhile, the heart rate, blood pressure after intubation, and intraoperative drug dosage in the combination group were lower than those in the control group. These findings indicate that droperidol combined with $2\times ED_{95}$ rocuronium can provide favorable conditions for IONM in thyroid surgery. The underlying reason may be that droperidol exerts both antipsychotic and antiemetic effects, which can effectively alleviate nausea and vomiting, and relieve mental stress by regulating dopamine receptors in the brain. Due to its rapid onset of action, droperidol is commonly used to relieve anxiety in surgical patients [18-19]. Rocuronium is a non-depolarizing muscle relaxant with effects including skeletal muscle relaxation, sedation, and improvement of airway patency. The $2\times ED_{95}$ dose of rocuronium has the advantages of minimal impact on hemodynamics and few adverse reactions. Rocuronium is mainly excreted via the liver, can provide good intubation conditions within 1 minute after intravenous injection, and its effect can be reversed by anticholinesterase agents [20].

In conclusion, compared with rocuronium alone, droperidol combined with $2\times ED_{95}$ rocuronium is more beneficial for IONM in thyroid surgery with high safety. However, this study still has certain limitations, including short observation period, small sample size, and lack of tests to explore its influencing factors and corresponding records. In the future, the sample size can be further expanded, and multicenter studies can be carried out for verification.

Conflict of Interest None

Reference

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·临床麻醉专题·论著·

氟哌利多复合2倍ED_{95}罗库溴铵对甲状腺手术中神经监测的影响

姬婷婷，徐振华，孙韧，朱洁

苏州大学附属张家港医院 张家港市第一人民医院麻醉科，江苏 苏州 215600

摘要：目的　探究氟哌利多复合2倍95%有效剂量(ED_{95})罗库溴铵(0.6 mg/kg)对甲状腺手术过程中患者肌电图(EMG)、术中神经监测(IONM)及体征指标的影响。**方法**　选取2023年1月至2024年12月于张家港市第一人民医院择期行甲状腺手术的100例患者为研究对象，依据随机数字表法将患者分为对照组和联合组，每组各50例。其中对照组给予患者罗库溴铵(0.6 mg/kg)，联合组给予患者罗库溴铵(0.6 mg/kg)+氟哌利多(2 mg)。对比两组患者气管插管条件评分(Cooper's评分)、IONM信号、体征指标、EMG波幅与神经监测情况、术者满意度、呼吸系统并发症及拮抗情况等。**结果**　联合组患者的Cooper's评分高于对照组(8.95±0.95 *vs* 5.32±0.54，t=23.489，P<0.01)。与对照组相比，联合组IONM信号最大波幅值更高[(758.90±8.59)μV *vs* (442.53±9.60)μV，t=173.658，P<0.01]和最小波幅值[(544.06±4.51)μV *vs* (394.64±4.59)μV，t=164.191，P<0.01]。与对照组相比，联合组患者维持丙泊酚用量、维持瑞芬太尼用量、未及时检测到喉返神经患者比例、未及时检测到的病例需等待时间均较低(P<0.05)。两组第60、90、120 min，EMG振幅逐渐升高，且各时点联合组EMG振幅均低于对照组(P<0.05)。较对照组，联合组插管后心率、血压水平降低(P<0.05)。在麻醉诱导前后，两组呼气末二氧化碳分压($P_{ET}CO_2$)、气道峰压、外周血氧饱和度(SpO_2)水平相比，差异无统计学意义(P>0.05)。两组患者术中出现体动发生率、呼吸系统并发症、拮抗情况差异无统计学意义(P>0.05)。两组术者满意度差异无统计学意义(P>0.05)。**结论**　氟哌利多复合2倍ED_{95}罗库溴铵能够有效提升甲状腺手术中IONM准确度，且可维持患者体征指标的稳定。

关键词：麻醉；氟哌利多；罗库溴铵；甲状腺；术中神经监测

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Effect of droperidol combined with twice the ED_{95} rocuronium on intraoperative nerve monitoring during thyroid surgery

JI Tingting, XU Zhenhua, SUN Ren, ZHU Jie

Department of Anesthesiology, Zhangjiagang First People's Hospital, Zhangjiagang Hospital Affiliated to Soochow University, Zhangjiagang, Jiangsu 215600, China

Corresponding author: ZHU Jie, E-mail: drzhujie@126.com

Abstract: Objective　To investigate the effects of droperidol combined with twice the 95% effective dose (ED_{95}) of rocuronium (0.6 mg/kg) on electromyography (EMG), intraoperative nerve monitoring (IONM), and vital sign indicators in patients during thyroid surgery. **Methods**　A total of 100 patients undergoing scheduled thyroid surgery at Zhangjiagang First People's Hospital between January 2023 and December 2024 were selected as the study subjects. According to the random number table method, the patients were divided into a control group and a combination group, with 50 patients in each group. The control group received rocuronium (0.6 mg/kg), while the combination group received rocuronium (0.6 mg/kg) plus droperidol (2 mg). The tracheal intubation conditions (Cooper's score), IONM signals, vital sign indicators, EMG amplitude and neural monitoring situation, surgeon satisfaction, respiratory

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通信作者：朱洁，E-mail：drzhujie@126.com

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complications, and antagonism were compared between the two groups. **Results** The Cooper's score of the patients in the combination group was higher than that in the control group (8.95±0.95 *vs* 5.32±0.54, t=23.489, P<0.01). Compared with the control group, the combination group exhibited higher maximum [(758.90±8.59)μV *vs* (442.53±9.60)μV, t=173.658, P<0.01] and minimum [(544.06±4.51)μV *vs* (394.64±4.59)μV, t=164.191, P<0.01] amplitude values in IONM signals. In comparison with the control group, the combination group had lower propofol maintenance dosage, remifentanil maintenance dosage, proportion of cases with delayed recurrent laryngeal nerve detection, and waiting time required for delayed detection cases, with the differences being statistically significant (P<0.05). At 60, 90, and 120 minutes, the EMG amplitude gradually increased in both groups, and the EMG amplitude of the combination group at each time point was lower than that of the control group (P<0.05). Compared with the control group after intubation, the combination group showed lower heart rate and blood pressure levels (P<0.05). Before and after anesthesia induction, there was no statistically significant differences in end-tidal carbon dioxide partial pressure ($P_{ET}CO_2$), peak airway pressure, or saturation of peripheral oxygen (SpO_2) levels between the two groups (P>0.05). There was no statistically significant difference between the two groups in the incidence of intraoperative body movement, respiratory complications, or antagonism (P>0.05). And there was no statistically significant difference in surgeon satisfaction between the two groups (P>0.05). **Conclusion** The combination of droperidol with twice the ED_{95} of rocuronium can effectively improve the accuracy of IONM in thyroid surgery and help maintain the stability of vital sign indicators of patients.

Keywords: Anesthesia; Droperidol; Rocuronium; Thyroid gland; Intraoperative nerve monitoring

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甲状腺外科手术是最常见的用于治疗甲状腺肿瘤、甲状腺功能亢进(甲亢)、单纯性甲状腺肿等疾病的外科手术,术后患者可能会出现各种合并症,其中喉返神经损伤是较为严重的合并症,严重影响患者的生活质量,单侧喉返神经损伤可能会导致患者声音出现嘶哑,而双侧喉返神经损伤会导致患者出现呼吸困难等症状,危及患者生命安全[1]。近年来,术中神经监测(intraoperative nerve monitoring, IONM)技术能对喉返神经进行准确定位,从而防止了手术过程中因解剖过度而引起的神经损伤[2],防止喉部损伤则需要找到适宜插管的部位,这要求麻醉诱导中合理使用药物,同时IONM也对麻醉提出了高要求。肌肉松弛药(肌松药)是IONM过程中关键的因素。2倍95%有效剂量(95% effective dose, ED_{95})的罗库溴铵(0.6 mg/kg)不仅起效快、对心血管副作用小,还使临床肌肉松弛维持时间延长[3]。监测罗库溴铵浓度对于评估临床麻醉中肌肉松弛效果也尤其重要[3-4]。降低呼吸抑制、拔管时机体的应激反应以及并发症发生率对于术后镇痛有着良好效果,临床目前使用氟哌利多较多[5]。目前临床上关于氟哌利多复合2倍ED_{95}罗库溴铵对甲状腺手术IONM的影响研究较少。因此本研究旨在分析氟哌利多复合2倍ED_{95}罗库溴铵对甲状腺手术中IONM的影响。

1　资料与方法

1.1　一般资料　研究对象为2023年1月至2024年12月张家港市第一人民医院收治的行甲状腺手术的患者,共纳入100例,采用随机数字表法将患者分为对照组50例和联合组50例。纳入标准:(1)年龄18~65岁,生命体征平稳,认知能力正常,心脏、肝脏、肾脏等功能正常;(2)均经影像学检查确诊;(3)美国麻醉医师协会(American Society of Anesthesiologists, ASA)分级Ⅰ~Ⅲ级[6];(4)近3个月未使用过其他镇痛措施或镇痛药物;(5)符合甲状腺手术指征;(6)患者及家属均知晓并签署知情同意书。排除标准:(1)甲亢或甲状腺手术史;(2)合并严重心脏病、肝或肾功能不全;(3)合并哮喘、神经肌肉疾病、内分泌疾病;(4)存在局部麻醉药过敏史;(5)无完全行为能力,或合并精神疾病;(6)可预计术中气道呼吸困难,或病态肥胖患者;(7)对于使用的药物存在禁忌证。脱落及剔除标准:(1)在治疗过程中出现药物过敏或其他严重不良反应;(2)试验过程中资料不全,影响疗效判断和安全性判断;(3)因个人原因主动要求退出本临床试验。两组患者一般资料差异无统计学意义(P>0.05)。见表1。本研究经张家港市第一人民医院医学伦理委员会批准通过(编号:KYLX-007)。

表 1　两组一般资料比较　（n=50）

Tab.1　Comparison of general data between two groups　（n=50）

组别	年龄（岁，$\bar{x}\pm s$）	性别（男/女，例）	体质量（kg，$\bar{x}\pm s$）	手术方式（全切/次全切，例）
对照组	42.33±9.65	18/32	65.38±6.75	15/35
联合组	45.50±10.77	21/29	67.68±7.60	12/38
t/χ^2值	1.550	0.378	1.600	0.457
P值	0.124	0.539	0.113	0.499

1.2　*研究方法*　入室后建立外周静脉通路，监测基本生命体征[外周血氧饱和度（saturation of peripheral oxygen，SpO_2）、呼吸、血压、心电图、心率]，以及麻醉诱导前后的呼气末二氧化碳分压（partial pressure of end-tidal carbon dioxide，$P_{ET}CO_2$）、气道压力，并给予面罩吸氧（6 L/min）。麻醉诱导：依次静脉注射舒芬太尼（宜昌人福药业，国药准字 H20054171，1 mL∶50 μg）0.5 μg/kg、丙泊酚（西安力邦制药，国药准字 H19990282，20 mL∶0.2 g）2 mg/kg。待眼睑反射消失，肌肉松弛后行气管插管，呼吸参数：潮气量 6~8 mL/kg，呼吸频率 11~14 次/min；维持麻醉深度在脑电双频指数（bispectral index，BIS）40~60。维持术中麻醉：瑞芬太尼（宜昌人福药业，国药准字 H20030197）0.5 μg/（kg·min）及丙泊酚 0.10~0.15 mg/（kg·min），持续静脉泵入，持续监测 BIS、SpO_2、心率、肌电图（electromyogram，EMG）、IONM、血压。术中维持 BIS 在 40~60，SpO_2 维持 95%以上，血压变化不超过基础血压的 30%。若镇痛措施已给予足量，患者心率波动幅度以及血压数值仍超过基础值 30%，则需给予相应血管活性药；当心率>100 次/min 时，给予艾司洛尔（齐鲁制药，国药准字 H20066758，2 ml∶0.2 g）10 mg 静脉推注；当心率<60 次/min 时，给予阿托品（上海禾丰制药，国药准字 H31021172，1 mL∶0.5 mg）静脉推注 0.3 mg。对照组：给予患者 2 倍 ED_{95} 罗库溴铵（广东星昊药业，国药准字 H20103495，5 mL∶50 mg）（0.6 mg/kg）。联合组：罗库溴铵 + 氟哌利多（上海旭东海普药业，国药准字 H31020895，2 mL∶5 mg），罗库溴铵剂量同对照组，并给予氟哌利多注射液 2 mg+0.9%氯化钠稀释后在术中插管时缓慢注射。

1.3　观察指标

1.3.1　气管插管条件评分　由经验丰富的麻醉医生对患者完成气管插管，记录插管过程中患者心率、血压变化情况，并采用 Cooper's 评分对器官插管条件进行评估：0 分为声门处于紧闭状态、插管时咳嗽、喉镜无法检查；1 分为插管时轻微咳嗽、声门靠拢、喉镜检查困难；2 分为声门活动、插管时膈肌轻微活动、喉镜检查尚可；3 分为插管无反应、声门开放、喉镜容易检查。评分越高状态越好。差 0~2 分，一般 3~5 分，良 6~7 分，优 8~9 分[7]。

1.3.2　体征指标监测　观察并记录两组患者给药 90 s 后以及插管 90 s 后血压及心率的变化[8]。记录麻醉诱导前后的 $P_{ET}CO_2$、气道峰压、SpO_2。

1.3.3　EMG 水平测定　在甲状腺手术过程中，将诱发 EMG 波幅的阈值设定为 100 V，以获得稳定的声音提示和双相 EMG 为准，电流设置为 2 mA，使用一次性使用神经刺激探头（美国美敦力施美敦公司）刺激诱发神经肌电位，超过设定阈值即为有发出肌电信号。观察两组患者术中 EMG 波幅水平并记录，记录时间应从静脉推注 2 倍 ED_{95} 罗库溴铵（0.6 mg/kg）后 30~120 min，每隔 10 min 记录 1 次 EMG 波幅水平变化，分析两组患者第 60、90、120 min 的 EMG 波幅水平（即 EMG_{60}、EMG_{90}、EMG_{120}）。

1.3.4　维持镇静镇痛药物用量　记录在手术开始时使用的镇静、镇痛药物（舒芬太尼和丙泊酚）的用量。

1.3.5　IONM　用气管导管（上海贝特医疗器械，8G）插管完毕后，将蓝色区域的中央部位精确定位于声带位置，根据患者性别选用不同神经监测气管（女性 6 mm，男性 7 mm），将参照电极插入肩胛肌，顺序与神经监测仪（NIM-Response 3.0，美国美敦力施美敦）等相连。开始手术并检测神经功能，包括喉返神经未及时监测到的例数（给予肌松药后 40 min 内，由同一组外科医师评判）、等待时间（40 min 后至再监测到喉返神经时需要等待的时间）和术中出现体动例数等。记录并分析患者术中 IONM 波幅的最大值和最小值。

1.3.6　术者满意度、呼吸系统并发症、拮抗情况　记录两组术者麻醉满意度（术中出现轻微吞咽、需要加深麻醉）、呼吸系统并发症（喉痉挛、呛咳、舌后坠）、拮抗情况（给予肌松剂拮抗剂）。

1.4　*统计学方法*　采用 SPSS 26.0 软件处理数据。计量资料中符合正态分布的以 $\bar{x}\pm s$ 描述，两组间比较行独立样本 t 检验，组内比较行配对样本 t 检验，多时点比较采用重复测量资料方差分析，两两比较采用 LSD-t 检验。计数资料以例（%）表示，两组间比较行 χ^2 检验或校正 χ^2 检验。P<0.05 为差异有统计学意义。

2　结　果

2.1　*两组患者术中指标比较*　与对照组相比，联合组患者 Cooper's 评分和 IONM 信号最大波幅值、最小波幅值高于对照组，差异有统计学意义（P<0.05）。见表 2。

2.2 两组患者EMG振幅水平比较 两组第60、90、120 min，EMG波幅逐渐升高；且联合组EMG_{60}、EMG_{90}、EMG_{120}均低于对照组，差异有统计学意义（$P<0.05$）。见表3。

2.3 两组患者治疗前后的心率、血压比较 与对照组比较，联合组插管后心率、血压明显下降，差异有统计学意义（$P<0.05$）。见表4。

表2 两组患者术中指标比较 （$n=50$，$\bar{x}\pm s$）

Tab.2 Comparison of intraoperative indicators between two groups （$n=50$，$\bar{x}\pm s$）

组别	Cooper's评分（分）	IONM信号最大波幅值（μV）	IONM信号最小波幅值（μV）
对照组	5.32±0.54	442.53±9.60	394.64±4.59
联合组	8.95±0.95	758.90±8.59	544.06±4.51
t值	23.489	173.658	164.191
P值	<0.001	<0.001	<0.001

表3 两组患者EMG振幅水平比较 （$n=50$，$\bar{x}\pm s$）

Tab.3 Comparison of EMG levels between two groups （$n=50$，$\bar{x}\pm s$）

组别	EMG_{60}（μV）	EMG_{90}（μV）	EMG_{120}（μV）
对照组	821.09±26.25	1 016.09±53.97[a]	1 312.53±68.77[ab]
联合组	156.87±79.60	577.80±68.28[a]	844.30±83.45[ab]
t值	56.036	35.609	30.618
P值	<0.001	<0.001	<0.001

注：与EMG_{60}相比，[a]$P<0.05$；与EMG_{90}相比，[b]$P<0.05$。

2.4 两组患者麻醉诱导前后$P_{ET}CO_2$、气道峰压、SpO_2水平的比较 在麻醉诱导前后两组$P_{ET}CO_2$、气道峰压、SpO_2水平相比，差异无统计学意义（$P>0.05$）。见表5。

2.5 两组患者术中药物用量比较 联合组维持丙泊酚用量为（17.50±3.15）mL/h，显著低于联合组的（18.97±3.61）mL/h，差异有统计学意义（$t=2.170$，$P=0.033$）。维持瑞芬太尼的用量联合组显著低于对照组[（16.53±3.62）mL/h *vs*（18.70±3.94）mL/h，$t=2.868$，$P=0.005$]。

2.6 两组患者神经监测情况比较 两组患者术中出现体动发生率比较，差异无统计学意义（$P>0.05$）；联合组未及时检测到喉返神经的患者占24%（12/50），显著低于对照组的44%（22/50）（$\chi^2=4.456$，$P=0.035$）。联合组未及时检测到的病例需等待时间短于对照组[（4.06±3.28）min *vs*（6.25±4.30）min，$t=2.868$，$P=0.005$]。

2.7 两组术者满意度及患者呼吸系统并发症、拮抗情况比较 对照组和联合组的术者满意度差异无统计学意义[70.00%（35/50） *vs* 84.00%（42/50），$\chi^2=2.767$，$P=0.096$]。呼吸系统并发症对照组6例，联合组2例；拮抗情况对照组发生8例，联合组发生3例。两组呼吸系统并发症和拮抗发生率比较差异均无统计学意义（$\chi^2=1.223$，$P=0.269$；$\chi^2=2.554$，$P=0.110$）。

表4 两组患者治疗前后心率及血压比较 （$n=50$，$\bar{x}\pm s$）

Tab.4 Comparison of heart rate and blood pressure before and after treatment between two groups （$n=50$，$\bar{x}\pm s$）

组别	收缩压（mmHg）		舒张压（mmHg）		心率（次/min）	
	给药后	插管后	给药后	插管后	给药后	插管后
对照组	103.41±14.92	143.62±14.23[a]	62.73±8.91	88.21±9.32[a]	66.92±7.51	93.51±12.24[a]
联合组	102.71±16.82	120.41±15.33[a]	63.24±8.22	72.52±7.54[a]	66.06±7.35	74.92±10.26[a]
t值	0.220	7.846	0.297	9.255	0.579	8.230
P值	0.826	<0.001	0.767	<0.001	0.564	<0.001

注：与给药后相比，[a]$P<0.05$。

表5 两组患者麻醉诱导前后$P_{ET}CO_2$、气道峰压及SpO_2水平比较 （$n=50$，$\bar{x}\pm s$）

Tab.5 Comparison of $P_{ET}CO_2$, peak airway pressure, and SpO_2 levels at different time points between two groups （$n=50$，$\bar{x}\pm s$）

组别	SpO_2（%）		$P_{ET}CO_2$（mmHg）		气道峰压（cmH_2O）	
	诱导前	诱导后	诱导前	诱导后	诱导前	诱导后
对照组	98.63±0.98	97.05±0.87	36.93±2.88	36.45±2.08	20.92±1.77	17.77±1.40
联合组	98.96±0.87	96.77±0.85	37.05±2.79	36.33±2.05	21.10±1.82	18.02±1.46
t值	1.781	1.628	0.212	0.291	0.501	0.874
P值	0.078	0.107	0.833	0.772	0.617	0.384

3 讨 论

甲状腺手术可能会破坏机体淋巴细胞免疫平衡，导致相关指标水平降低，同时也会导致患者术后产生疼痛，并发症的发生增多以及术后恢复情况变差[9-10]。甲状腺手术有全切术和部分切除（次全切）术，全切术对手术的要求更高，而次全切术对手术的要求较低。术中采取的药物与方式也很关键，外科医生认为在甲状腺手术中应用IONM技术可以帮助医生尽早辨认并定位喉返神经，减少喉部损伤[11-12]。IONM包含气管插管监测和针刺电极监测，针刺电极监测是将双针式电极置于声带下黏膜下层然后通

过环甲膜向头部方向插入，获得肌电信号[13-14]。在甲状腺手术中，IONM 主要有间断性监测和连续性监测两种模式[15]。本研究表明，相较于对照组，联合组患者 EMG 振幅水低于对照组，表明氟哌利多复合 2 倍 ED_{95} 罗库溴铵对甲状腺手术 IONM 的影响很大。分析其原因可能为连续 IONM 的出现，有效克服了间断监测的不足。同时 IONM 具备很多优点，如可避免出现永久性神经损伤，及时发现喉返神经损伤，识别与早期神经损伤相关的肌电信号图等优点[16-17]。

本研究显示，相比对照组，联合组 Cooper's 评分、IONM 信号最大波幅值及最小波幅值和术者满意度均较高，且相较于对照组，联合组插管后心率、血压及术中药物用量均较低，这表明了氟哌利多复合 2 倍 ED_{95} 罗库溴铵可对甲状腺手术 IONM 提供较好的条件，原因可能为氟哌利多在起抗精神病作用的同时有止吐作用，可以有效缓解恶心呕吐，还可以通过调节大脑中的多巴胺受体，从而缓解精神紧张，由于其快速起效的特点，氟哌利多常被用来缓解手术患者的紧张情绪[18-19]。罗库溴铵是一种非去极化肌松药，有骨骼肌松弛、镇静、促进呼吸道通畅的效果，而 2 倍 ED_{95} 罗库溴铵具有对血流动力学影响小、不良反应少等优点，并且罗库溴铵的排泄主要经肝脏，在 1 min 静脉注射后即可提供良好的插管条件，能被抗胆碱酯酶药抵抗[20]。

综上所述，相比单用罗库溴铵，氟哌利多复合 2 倍 ED_{95} 罗库溴铵更有利于甲状腺手术 IONM，安全性高。但本次研究仍存在一定局限性，观察时间短、样本量小且没有应用测试探索其效果因素及记录。未来可进一步扩大样本量，开展多中心研究验证。

利益冲突　无

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