Risk Factors for Residual Neuromuscular Blockade after General Anesthesia

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Objective: *To determine the risk factors for residual neuromuscular blockade (rNMB).*
Material and Method: *This prospective observational study enrolled 209 patients with general anesthesia receiving neuromuscular blocking agents (NMBAs). Upon arrival at the post-anesthesia care unit (PACU), the train-of-four (TOF) ratios were recorded using a TOF watch®. In addition, the respiratory peak flow rates were assessed, and the demographic and perioperative data were recorded. We defined rNMB as a TOF ratio less than 0.9.*
Results: *The incidence of rNMB was 53.1%. A univariate analysis identified the following as predictors of rNMB: increasing age, American Society of Anesthesiologist physical status classification II, low risk surgical procedures, high MAC of inhalation agent, an interval of <30 minutes between the last dose of NMBAs, and hypothermia on arrival at the PACU. Using a multivariate analysis: increasing age every 10 years (OR 1.31, 95% CI 1.04 to 1.65), inhalation agent more than 1 MAC (OR 1.95, 95% CI 1.02 to 3.71), an interval before relaxant reversal of <30 minutes (OR 2.27; 95% CI 1.17 to 4.40), and hypothermia at PACU (OR 3.31, 95% CI 1.35 to 8.09) remained significant risk factors.*
Conclusion: *Residual neuromuscular blockade after general anesthesia is common. Increasing age, MAC of inhalation agent >1, hypothermia at PACU and an interval between the last application of the NMBAs and reversal less than 30 minutes seem to be particular risk factors.*

Keywords: *Residual neuromuscular blockade, Train of four, Risk factors, Incidence, General anesthesia*

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Neuromuscular blocking agents (NMBAs), which are also called relaxants, are used in general anesthesia to facilitate intubation and controlled ventilation during surgery. However, using NMBAs may lead to postoperative residual neuromuscular blockade (rNMB), which may be followed by respiratory insufficiency, upper airway obstruction and aspiration[1]. For patient's safety, the administration of an NMBA to induce muscle paralysis must be carried out with caution; the level of paralyzation of the patient should be monitored via the so called 'train of four' (TOF), which is the muscular response to four, sequentially-applied, electrical stimuli[2].

Train of four is usually expressed as "ratio". Complete paralysis would be TOF 0, whereas a complete reversal would be TOF 1.0. Over time, the definition of residual neuromuscular blockade has changed from a TOF ratio of <0.7 to <0.9. Previous study showed that TOF less than 0.9 was often still accompanied by significant muscle weakness such as impair pharyngeal and upper airway muscle and increase risk of aspiration[3]. Therefore, we find varying data for rNMB within literature, with a prevalence as high as 88% before extubation and 32% on PACU admission[4]. The risk factors defined by several research groups including age, female gender, American Society of Anesthesiologists (ASA) physical status classification, body mass index (BMI), surgical risk, anesthetic time, anesthesia technique, inhalation agent, types of NMBAs and dosage, opioid drugs and dosage, and anticholinesterase[5-7].

The primary objective of this study was to identify the risk factors for residual paralysis, defined as a TOF ratio less than 0.9. In addition, the incidence of residual neuromuscular blockade and the peak respiratory flow rate after extubation were recorded.

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Material and Method

After Institutional Review Board approval, this prospective observational study was conducted.

Two hundred and nine patients were included after written, informed consent was obtained. Inclusion criteria were patients who aged 18 years old or over and ASA classification I-III scheduled for otorhinolaryngology, breast, open abdominal, laparoscopic abdominal or extremities surgeries and received general anesthesia with using neuromuscular blockade. Exclusion criteria were the presence of a neuromuscular disease such as myasthenia gravis, myotonia, muscular dystrophy and upper motor neuron lesion. We also excluded patients using neuromuscular drugs, such as anticonvulsants or magnesium sulfate, and with a body temperature prior to surgery of <36.0°C or >37.8°C.

General anesthesia (GA) was provided by the attending anesthesiologist, who was not involved in this study; he/she decided the kind and dose of drugs, including any NMBAs that were administered intraoperatively. Oxygen was routinely administered after extubation, including the period during transport to and the stay at the PACU.

Upon arrival at the PACU, one of the authors, who was not involved in conducting anesthesia, applied and recorded train of four ratio (via a TOF watch®) by stimulating the ulnar nerve. The amperage was 10 mA, and the frequency was 2 Hz. The residual neuromuscular blockade was set as TOF ratio less than 0.9.

The peak expiratory flow in L/min was measured on three occasions using a Mini Wright peak flow meter: once preoperatively before relaxant administration, and again 5 and then 60 minutes after the PACU admission. The measurement was taken three on each of the three occasions. Patients with postoperative rNMB received close monitoring until no clinical sign of postoperative residual neuromuscular blockade was observed, and they were promptly treated when any complications occurred.

The following data were recorded: age, gender, body weight, height, ASA classification, surgical risk (low, intermediate, high risk)[8] the type and duration of general anesthesia, the maximum level of the inhalation agent, the type and amount of opioid drugs and NMBAs used, and the timing of the anticholinergic drugs (the interval between the last relaxant and reversal).

Statistical analysis

The calculation of the sample size (209 patients) was based on the incidence of rNMB 62% from previous study[9], eleven risk factors related to rNMB and 20% dropout.

Data were analyzed using PASW Statistics for Windows, Version 18.0 Chicago: SPSS, Inc. Continuous data were presented as mean ± standard deviation (SD). Categorical data were presented as number and percentage. To assess the relationship between each clinical risk factor and rNMB, a univariate analysis was performed using an unpaired t-test and a Chi-square test, along with an odds ratio and its 95% confidence interval (95% CI). For higher accuracy regarding the impact of single risk factor, a multiple logistic regression analysis was also performed.

Results

During the period from December 2014 to February 2015, 209 patients were enrolled. The incidence of rNMB was 53.1%. Most of the patients were female and ASA physical status II. The perioperative data are presented at Table 1. Intraoperatively, most of the patients (67.3%) only received fentanyl. Seven of the 209 patients (3.3%) did not receive anticholinesterase drug.

From the univariate analysis, the significant risk factors that increasing risk of residual blockade (rNMB) were determined to be increasing age every year (OR 1.03, 95% CI 1.01 to 1.05); patients with ASA II compared to those with ASA I (OR 2.31, 95% CI 1.17 to 3.88); a duration from the last dose of the NMBA to relaxant reversal less than 30 minutes (OR 2.12, 95% CI 1.11 to 3.89); and a body temperature at PACU admission less than 36°C (OR 2.83, 95% CI 1.29 to 6.20) (Table 2). Inhalation agents more than 1 MAC during anesthesia was also a nearly significant risk factor for rNMB (OR 1.29, 95% CI 1.01 to 1.66). But the patients who underwent intermediate risk surgery had significant lower risk of rNMB compared to those who underwent low risk surgery (OR 0.52, 95% CI 0.29 to 0.96). In contrast, the type and amount of the NMBAs used together with the type and amount of opioids were without significant effect on residual neuromuscular blockade. When a multiple logistic regression analysis was applied, increasing age10 year (OR 1.31, 95% CI 1.04 to 1.65), the time interval between the last NMBAs and the antagonist less than 30 minutes (OR 2.27, 95% CI 1.17 to 4.40) and hypothermia (OR 3.01, 95% CI 1.35 to 8.09) were associated with residual paralysis. However, the ASA physical status and surgical risk was not a correlate.

The average peak expiratory flow was in the normal range for all study patients before surgery. Postoperatively, the percentages of mean change of

Table 1. Demographic and perioperative data

Variables	Total (n = 209)
Age (yr)	51.2±15.9 (18-88)
Gender: Male	79 (37.8)
BMI	23.1±4.7 (11.7-40.6)
ASA	
I	69 (33.0)
II	122 (58.4)
III	18 (8.6)
Types of operation	
Low risk	64 (30.6)
Intermediate risk	145 (69.4)
Anesthetic time (min)	168.3±85.5 (35-495)
Operation time (min)	122.5±77.9 (10-420)
Choice of Anesthesia	
General anesthesia with endotracheal tube	141 (67.5)
General anesthesia with supraglottic device	38 (18.2)
Combined general and regional anesthesia	30 (14.4)
Inhalation (MAC)	
≤1	135 (64.9)
>1	74 (35.1)
Types of neuromuscular blocking agents	
Atracurium	182 (87.1)
Cisatracurium	22 (10.5)
Others	5 (2.4)
Doses of neuromuscular blocking agents (mcg/kg/min)	
Atracurium	6.2±2.3 (1.5-17.6)
Cisatracurium	1.3±0.5 (0.5-2.9)
Rocuronium	5.6±3.5 (2.6-9.9)
Types of opioids	
Fentanyl	140 (67.3)
Morphine	43 (20.6)
Meperidine	6 (2.9)
Combined	19 (9.1)
Morphine equivalent dose (mcg/kg/min)	1.2±0.7 (0.2-4.8)
Receiving anticholinesterase before extubation	202 (96.7)
Duration between last dose from NMBA and reversal agents (min)	
≤30	67 (32.1)
>30	135 (64.6)
Body temperature upon arrival at post-anesthesia care unit (°C)	
<36	37 (17.7)
≥36	172 (82.3)

Data presented as mean ± SD (min, max) and number (%)
ASA = American Society of Anesthesiologist physical status; BMI = Body Mass Index; MAC = Minimum Alveolar Concentration

respiratory peak flow rate (PFR) at 60 minutes compared with preoperative PFR in patients with and without rNMB were 31.1±25.0% and 30.4±20.9%, respectively which showed no statistically significant difference. None of the patients with a residual block (TOF <0.9) had clinical signs of respiratory insufficiency or required any treatment.

Discussion

Nowadays, a residual neuromuscular block or paralysis is defined as a TOF ratio of <0.9[5]. The incidence of residual neuromuscular block (rNMB) in our study was 53.4%, Compared with other literature, the incidence of rNMB in our study is in range. Donati[10] in his 2013 review found rates of 4 to 57%.

Table 2. Correlation between patient- and anesthesia/surgery-related characteristics and residual neuromuscular blockade (TOF <0.9)

Features	Residual paralysis		Crude OR		Adjust OR	
	No (n = 98)	Yes (n = 111)	(95%CI)	*p*-value[1]	(95%CI)	*p*-value[2]
Age (yr)	47.2±16.2	54.5±14.8	-	-	-	-
Increasing age (10 yr)	-	-	1.03 (1.01,1.05)	<0.01	1.38 (1.10,1.74)	<0.01
Gender						
Male	37 (46.8)	42 (53.2)	1.00 (0.57,1.76)	0.99		
Female	61 (46.9)	69 (53.1)	1			
ASA						
I	40 (58.0)	29 (42.0)	1			
II	48 (39.3)	74 (60.7)	2.31 (1.17,3.88)	0.01	1.64 (0.76,3.54)	0.21
III	10 (55.6)	8 (44.4)	1.10 (0.39,3.14)	0.44	0.98 (0.24,4.25)	0.96
BMI (kg/m^2)	23.2±4.8	23.0±4.5	0.99 (0.94,1.05)	0.75	-	-
Types of operation						
Low risk	23 (35.9)	41 (64.1)	1		0.53 (0.27,1.07)	0.08
Intermediate risk	75 (51.7)	70 (48.3)	0.52 (0.29,0.96)	0.04		
Group of anesthetic time (hr)						
≤2	34 (48.6)	36 (51.4)	1			
2-3	31 (48.4)	33 (51.6)	1.01 (0.51,1.98)	0.99		
≥3	33 (44.0)	42 (56.0)	1.02 (0.63,2.31)	0.58		
Anesthesia technique						
General anesthesia with tracheal tube	70 (49.6)	71 (50.4)	1			
General anesthesia with supraglottic device	15 (39.5)	23 (60.5)	1.51 (0.73,3.14)	0.27		
Combine general and regional anesthesia	13 (43.3)	17 (56.7)	1.29 (0.58,2.85)	0.53		
Inhalation (MAC)						
≤1	70 (51.9)	65 (48.1)	1			
>1	28 (37.8)	46 (62.2)	1.77 (0.99,3.16)	0.05	1.95 (1.02,3.71)	0.04
Types of neuromuscular agents						
Atracurium	85 (46.7)	97 (53.3)	1		-	-
Cisatracurium	11 (50.0)	11 (50.0)	0.88 (0.36,2.12)	0.77	-	-
Others	2 (40.0)	3 (60.0)	1.31 (0.22,8.05)	0.77	-	-

Data are presented as mean ± SD or number (%).
ASA = American Society of Anesthesiologist physical status; BMI = body mass index; MAC = minimum alveolar concentration; NMBA = Neuromuscular blocking agent; PACU = post anesthetic care unit.
p-value[1] = univariate analysis; *p*-value[2] = multiple logistic regression analysis

Table 2. (Cont.)

Features	Residual paralysis		Crude OR		Adjust OR	
	No (n = 98)	Yes (n = 111)	(95% CI)	*p*-value[1]	(95% CI)	*p*-value[2]
Relaxant dosage (mcg/kg/min)						
Atracurium	6.0±2.4	6.3±2.2	-	-	-	-
Cisatracurium	1.4±0.6	1.2±0.4	-	-	-	-
Rocuronium	4.7±3.1	6.5±4.8	-	-	-	-
Morphine equivalent dose (mcg/kg/min)	9.1±3.4	9.0±3.2	-	-	-	-
Reversal agents						
Yes	94 (46.5)	108 (53.5)	1	0.58	-	-
No	4 (57.1)	3 (42.9)	0.65 (0.14, 2.99)		-	-
Time from last relaxant administration to reversal agents (min)						
≤30	23 (34.3)	44 (65.7)	2.12 (1.11, 3.89)	0.02	2.27 (1.17, 4.40)	0.02
>30	71 (52.6)	64 (47.4)	1			
Body temperature upon arrival at PACU(°C)						
<36	10 (27.0)	27 (73.0)	2.83 (1.29, 6.20)	<0.01	3.01 (1.35, 8.09)	<0.01
≥36	88 (51.2)	84 (48.8)	1			

Data are presented as mean ± SD or number (%).
ASA = American Society of Anesthesiologist physical status; BMI = body mass index; MAC = minimum alveolar concentration; NMBA = Neuromuscular blocking agent; PACU = post anesthetic care unit.
p-value[1] = univariate analysis; *p*-value[2] = multiple logistic regression analysis

While the other study the incidence of rNMB was 62%[3]. This may be partly due to the absence of any intraoperative TOF monitoring of our patients. Compared to the preoperative period, the respiratory peak flow decreased by up to 39% postoperatively, but it was not correlated to rNMB, neither at the 5-minute nor the 60-minute point after arrival at the PACU, nor to any clinical signs of respiratory insufficiency. The risk factors for rNMB determined by the multivariate analysis were increasing age, the temperature upon arrival at the PACU, and the interval between the application of the last relaxant and the reversal medication.

The risk factors found in our study are partly in accordance with literature. Yu et al[7] demonstrated the significant risk factors to be an age of ≥45 years, the combined use of different NMBAs, an interval between the last relaxant application and extubation of <60 minutes, and an interval between the neostigmine administration and extubation of <10 minutes.

Age

In their pharmacological review of changing metabolism in old age, Lee et al[11] described a decreased clearance capacity of the old organism where the definition of elderly moved from >65 to >75 years. Their message was, the older the patient, the longer may be the effects of the muscle relaxants and other drugs. Murphy et al[12] had demonstrated that the incidences of rNMB in elderly patients (70 to 90 years) and younger patients (18 to 50 years) were 57.7% and 30.0%, respectively. They also found that older patients required supplemental oxygen and had a higher incidence of SpO_2 ≤94% during transportation, a longer PACU and hospital stay, and more complications. This study is in accordance with the literature, indicating wariness in the elderly.

Hypothermia (body temperature at PACU admission of <36℃)

In our study, hypothermia was identified as a significant risk factor for postoperative residual neuromuscular blockade (OR 3.59, 95% CI 1.51 to 8.54). Heier et al[13] described the impact of hypothermia on muscle strength. A reduction of body temperature of two degrees Celsius may double the duration of the neuromuscular blockade. In experimental and clinical studies, two studies[14,15] demonstrated the impact of a reducing body temperature on the pharmacokinetics of rocuronium and vecuronium. In their study with volunteers, Leslie et al[16] demonstrated that mild hypothermia increases the duration of the action of atracurium. In our study, rocuronium, atracurium and cisatracurium were used; however, the respective relaxant had no impact on residual paralysis.In conclusion, hypothermia prolongs the action of muscle relaxants, thus increasing the risk of postoperative residual neuromuscular blockade, which is in accordance with our findings. In general, these findings stress the importance of body temperature for patients' outcome.

Interval between last dose of relaxant and anticholinestrase

In our study, an interval less than 30 minutes between the last relaxant-application and the administration of the anticholinestrase was revealed as a significant risk factor for postoperative residual neuromuscular blockade (OR 2.31, 95% CI 1.12 to 4.07). These findings become comprehensible in the light of the study conducted by Song et al[17]. They demonstrated that the recovery time for cisatracurium was significantly shorter when reversal was delayed. Their study also suggested that anticholinestrase should only be applied when there are no clinical signs of residual paralysis and the TOF ratio is ≥0.9. Therefore, to avoid residual paralysis, it is essential both to monitor the timing from the last dose of the NMBAs to the end of surgery, and to apply the anticholinestrase only when TOF is ≥0.9.

Relaxometry

Neuromuscular monitoring was first applied by Christie and Churchill-Davidson[18] in 1958; however, it can be assumed to be still not standard in most hospitals[2]. In Thailand, TOF monitoring is not common. In 1979, Viby-Mogensen[19] was the first to alert anesthesiologists to the high incidence of residual paralysis after relaxant use. At that time, residual paralysis was considered to be a TOF ratio less than 0.7. Since then, not much has happened, mainly because there are conflicting data about the incidence of outcome deterioration caused by residual paralysis, and as a consequence, therapists do not seem to care much. In his 2013 literature review, Donati[10] found a reported rNMB incidence of 4 to 57%, whereas surveys revealed that the guesses of the respective anesthesiologists were 1% or even less.

The effect of routine TOF monitoring on residual paralysis is also a matter of debate. The French group of Baillard et al[3] reported that subsequent TOF monitoring led to a decrease in the incidence of residual

neuromuscular block from 62 to 3%. Their data clearly indicate the routine use of neuromuscular monitoring. Our data regarding rNMB would certainly have been better if TOF monitoring had been applied intraoperatively. As much as neuromuscular monitoring is recommended, it does not completely prevent residual paralysis and its detrimental effects. As stated by Brull and Murphy[20] that monitoring may not be accurate when TOF ratios are between 0.6 and 1.0. No meta-analysis or systematic review of using neuromuscular monitoring to prevent residual paralysisare available.

Residual neuromuscular block and outcome

It is still debatable whether neuromuscular monitoring can significantly reduce residual paralysis and whether it has a relevant impact on patients' outcome, though there are impressive data indicating the use of relaxants increases postoperative morbidity. This study, focusing on the incidence of and risk factors for residual blockade, cannot contribute to the outcome discussion; this is due to the lack of adequate data as we only checked one simple parameter, the peak expiratory flow, but nothing else.

One of the largest studies regarding neuromuscular blockade and outcomes was published in 2012 by Grosse-Sundrup et al[21]. They compared two propensity-matched groups, with 18,579 patients in each, and with and without intraoperative muscle relaxation. Those patients administered neuromuscular blocking agents had a significantly higher risk of a postoperative desaturation of <90% and of re-intubation requiring an unplanned ICU stay. The application of not only neuromuscular monitoring but also the routine application of relaxant-antagonists did not prevent these complications, which is in contrast to the previously-mentioned results of Baillard[3] and Norton et al[22] having investigated 202 adult patients, found that a TOF less than 0.9 was statistically associated with critical respiratory events, such as airway obstruction, hypoxemia and an inability to breathe deeply. Similar results have been published by the other[5]. Thus residual paralysis after general anesthesia contributes to postoperative respiratory morbidity; accurate data about the quantitative dimension, however, are not yet available.

Indication for muscle relaxation

Several authors have questioned the usual practice of dealing with muscle blocking agents. Debaene et al[23] reported on 520 patients who had received vecuronium, rocuronium or atracurium to facilitate tracheal intubation, without a repetition dose. The TOF ratio upon arrival at the PACU was less than 0.7 and less than 0.9 for 16% and 45% of the patients (n = 230), respectively. Even two hours after extubation, The TOF ratio at the PACU less than 0.7 and less than 0.9 was still found in 10% and 37% of patients, respectively. King et al[24], in a blinded, placebo-controlled, randomized study, investigated the operating conditions for 120 patients undergoing retropubic prostatectomy; one group was administered vecuronium, and the other, saline. Though there were significantly more patients with 'unacceptable' conditions in the placebo (no relaxants) group, two-thirds of them demonstrated good conditions for surgery. The authors concluded, "Thus, the routine use of muscle relaxants in adequately anesthetized patients may not be indicated". Donati and Brull[25], by sharing these conclusions, are additionally concerned that the availability of sugammadex may lead to an increasing carelessness by anesthesiologists when it is about muscle relaxation.

Residual neuromuscular blockade is common. Anesthesiologists are frequently un aware of the problem and its consequences, though relaxants are potentially harmful drugs. Measures to prevent rNMB include utilizing neuromuscular monitoring, achieving a TOF less than 0.9 at extubation, reversing the relaxants at the proper time, keeping patients warm, and using relaxants sparingly. Anesthesiologists should bear in mind that neostigmine is no guarantee for 100% reversal, and it cannot reverse profound blockade due to its ceiling effect. There are many surgical procedures (e.g. in orthopedic surgery or urology) where relaxation after intubation is not necessary at all. By no means should muscle blocking agents be administered 'by the clock', but instead, cautiously - and then, only when truly indicated.

Conclusion

Residual neuromuscular blockade after general anesthesia is common. Increasing age, hypothermia, MAC of inhalation and an interval between the last application of the NMBAs and the administration of the anticholinestrase less than 30 minutes are statistic significant risk factors.

Limitations

Our study has some limitations; the TOF ratio was monitored only once, at the PACU, but not intraoperatively. Some of the patients may have had a

baseline TOF ratio of <1.0 (before the induction of the anesthesia), whereas the intraoperative TOF could have varied between patients. The respiratory peak flow was only assessed preoperatively and at the PACU, but not later.

What is already known on this topic?

Residual neuromuscular blockade (rNMB) is frequently found; nevertheless, its impact on postoperative morbidity, such as airway obstruction and aspiration, has not been adequately investigated yet. Neuromuscular monitoring is still not generally accepted.

What this study adds?

The incidence of rNMB in patients without routine neuromuscular monitoring is high, at more than 50%. Four risk factors could be identified: increasing age, MAC of inhalation agent, hypothermia at PACU admission, and an interval between the last dose of the NMBA and the anticholinestrase less than 30 minutes.

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Trial registration

Clinicaltrials.gov; NCT 02146859.

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Potential conflicts of interest

None.

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การศึกษาเรื่องปัจจัยที่มีผลต่อการเกิดภาวะหย่อนกล้ามเนื้อหลงเหลือหลังผ่าตัดในการระงับความรู้สึกแบบทั่วร่างกาย

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วัตถุประสงค์: เพื่อศึกษาปัจจัยเสี่ยงของการเกิดภาวะยาหย่อนกล้ามเนื้อเหลือ

วัสดุและวิธีการ: การศึกษานี้เป็นการศึกษาเชิงสังเกตชนิดเก็บข้อมูลไปข้างหน้า โดยรวบรวมผู้ป่วย 209 ราย ที่ได้รับการระงับความรู้สึกแบบทั่วไปร่วมกับยาหย่อนกล้ามเนื้อเมื่อผู้ป่วยมาถึงห้องพักฟื้นจะได้รับการบันทึกอัตราส่วนของ train of four (TOF ratio) ตัวด้วยเครื่องกระตุ้นเส้นประสาทด้วยไฟฟ้า TOF watch ทำการบันทึก peak flow rate ข้อมูลผู้ป่วยและข้อมูลระยะ perioperative ผู้วิจัยกำหนดให้วินิจฉัยภาวะยาหย่อนกล้ามเนื้อเหลือเมื่ออัตราส่วนของ train of four น้อยกว่า 0.9

ผลการศึกษา: พบอุบัติการณ์การเกิดภาวะยาหย่อนกล้ามเนื้อเหลือร้อยละ 53.1 จากการวิเคราะห์แบบ univariate analysis พบปัจจัยเสี่ยงในการเกิดภาวะยาหย่อนกล้ามเนื้อเหลือ ได้แก่อายุที่มากขึ้นความเสี่ยงตามแนวทางการประเมินความเสี่ยงของสมาคมวิสัญญีแพทย์ของประเทศสหรัฐอเมริกา Class II, การผ่าตัดที่มีความเสี่ยงต่ำ ได้รับยาดมสลบ ชนิดไอระเหยความเข้มข้นสูงระยะเวลาระหว่างการให้ยาหย่อนกล้ามเนื้อครั้งสุดท้าย และยาแก้ฤทธิ์ยาหย่อนกล้ามเนื้อน้อยกว่า 30 นาที และอุณหภูมิกายต่ำขณะแรกรับที่ห้องพักฟื้นเมื่อวิเคราะห์แบบ multivariate analysis พบว่าปัจจัยเสี่ยงในการเกิดภาวะยาหย่อนกล้ามเนื้อเหลือ ได้แก่อายุที่เพิ่มขึ้นทุก 10 ปี (OR 1.31, 95% CI 1.04 ถึง 1.65), MAC ของยาดมสลบชนิดไดระเหยมากกว่า 1 (OR 1.95, 95% CI 1.02 ถึง 3.71) ระยะเวลาระหว่างการให้ยาหย่อนกล้ามเนื้อครั้งสุดท้าย และยาแก้ฤทธิ์ยาหย่อนกล้ามเนื้อน้อยกว่า 30 นาที (OR 2.27, 95% CI 1.17 ถึง 4.40) และอุณหภูมิกายต่ำ (OR 3.31, 95% CI 1.35 ถึง 8.09)

สรุป: ภาวะยาหย่อนกล้ามเนื้อเหลือหลังการระงับความรู้สึกแบบทั่วไปเป็นภาวะที่พบได้บ่อยอายุที่มากขึ้นค่า MAC ของยาดมสลบชนิดไอระเหยมากกว่า 1, อุณหภูมิกายต่ำและระยะเวลาระหว่างการให้ยาหย่อนกล้ามเนื้อครั้งสุดท้าย และยาแก้ฤทธิ์น้อยกว่า 30 นาทีเป็นปัจจัยเสี่ยงที่มีนัยสำคัญทางสถิติ