Rev Bras Anestesiol. 2017;67(6):592–599

REVISTA BRASILEIRA DE ANESTESIOLOGIA

Publicação Oficial da Sociedade Brasileira de Anestesiologia
www.sba.com.br

SCIENTIFIC ARTICLE

Use of protocol and evaluation of postoperative residual curarization incidence in the absence of intraoperative acceleromyography – Randomized clinical trial

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Received 20 October 2016; accepted 9 February 2017
Available online 7 June 2017

KEYWORDS
Neuromuscular blockers;
Rocuronium;
Neostigmine;
Postoperative residual curarization;
Quantitative neuromuscular monitoring;
Acceleromyography

Abstract
Objective: Evaluate the incidence of postoperative residual curarization (PORC) in the post-anesthesia care unit (PACU) after the use of protocol and absence of intraoperative acceleromyography (AMG).
Methods: Randomized clinical trial with 122 patients allocated into two groups (protocol and control). Protocol group received initial and additional doses of rocuronium (0.6 mg·kg^{-1} and 10 mg, respectively); the use of rocuronium was avoided in the final 45 min; blockade reversal with neostigmine (50 μg·kg^{-1}); time ≥15 min between reversion and extubation. Control: initial and additional doses of rocuronium, blockade reversal, neostigmine dose, and extubation time, all at the discretion of the anesthesiologist. AMG was used in the PACU and PORC considered at T4/T1 ratio <1.0.
Results: The incidence of PORC was lower in protocol group than in control group (25% vs. 45.2%, $p = 0.02$). In control group, total dose of rocuronium was higher in patients with PORC than without PORC (0.43 vs. 0.35 mg·kg^{-1}·h^{-1}, $p = 0.03$) and the time interval between the last administration of rocuronium and neostigmine was lower (75.0 vs. 101.0 min, $p < 0.01$). In protocol group, there was no difference regarding the analyzed parameters (with PORC vs. without PORC). Considering the entire study population and the presence or absence of PORC, total dose of rocuronium was higher in patients with PORC (0.42 vs. 0.31 mg·kg^{-1}·h^{-1}, $p = 0.01$),

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http://dx.doi.org/10.1016/j.bjane.2017.02.003

while the time interval between the last administration of rocuronium and neostigmine was lower (72.5 vs. 99.0 min, $p \leq 0.01$).
Conclusion: The proposed systematization reduced PORC incidence in PACU in the absence of intraoperative AMG.

PALAVRAS-CHAVE
Bloqueadores neuromusculares;
Rocurônio;
Neostigmina;
Curarização residual pós-operatória;
Monitoração neuromuscular quantitativa;
Aceleromiografia

Aplicação de protocolo e avaliação da incidência de curarização residual pós-operatória na ausência de aceleromiografia intraoperatória – Ensaio clínico randomizado

Resumo
Objetivo: Avaliou-se a incidência de curarização residual pós-operatória (CRPO) na sala de recuperação pós-anestésica (SRPA) após emprego de protocolo e ausência de aceleromiografia (AMG) intraoperatória.
Métodos: Ensaio clínico, aleatório, com 122 pacientes, distribuídas em dois grupos: protocolo e controle. Protocolo: dose inicial e adicionais de rocurônio foram de 0,6 mg.kg^{-1} e 10 mg, respectivamente; evitou-se o uso de rocurônio nos 45 minutos finais; reversão do bloqueio com neostigmina (50 μg.kg^{-1}); tempo ≥ 15 minutos entre reversão e extubação. Controle: doses inicial e adicional de rocurônio, reversão do bloqueio, dose de neostigmina e momento da extubação decididos pelo anestesiologista. Foi usada AMG na SRPA e considerado CRPO razão T4/T1 < 1,0.
Resultados: A incidência de CRPO foi menor no grupo protocolo em relação ao controle (25% vs. 45,2%; $p = 0,02$). No grupo controle, a dose total de rocurônio foi maior em pacientes com CRPO em relação àqueles sem CRPO (0,43 vs. 0,35 mg.kg^{-1}.h^{-1}; $p = 0,03$) e o intervalo entre a última administração de rocurônio e a neostigmina foi menor (75,0 vs. 101,0 min; $p < 0,01$). No grupo protocolo não houve diferença dos parâmetros analisados (com CRPO vs. sem CRPO). Considerando toda a população de estudo e a presença ou não de CRPO, a dose total de rocurônio foi maior em pacientes com CRPO (0,42 vs. 0,31 mg.kg^{-1}.h^{-1}; $p = 0,01$), enquanto o intervalo entre a última administração de rocurônio e a neostigmina foi menor (72,5 vs. 99,0 min; $p \leq 0,01$).
Conclusão: A sistematização proposta reduziu a incidência de CRPO na SRPA na ausência de AMG intraoperatória.

Introduction

Numerous published studies linking the use of non-depolarizing neuromuscular blockers (NMB) to the occurrence of postoperative residual curarization (PORC) has increased the recognition and understanding of this event by anesthesiologists.[1] There is evidence that PORC is associated with several complications (particularly respiratory) and prolonged post-anesthesia care unit (PACU) stay.[2] Its incidence varies from 3.5% to 83%[1]; values close to 50% are frequently reported, including in the presence of intraoperative monitoring.[1,3–6]

The use of objective intraoperative neuromuscular monitoring is essential at the time of neuromuscular blockade reversal and may contribute to reduce the incidence of PORC. It was seen that the use of intraoperative acceleromyography (AMG) reduced the incidence of PORC from 50% to 14.5%, possibly reducing the use of additional doses of non-depolarizing NMB, from 18.9% to 6.6% in 45 min.[7] However, most anesthesiologists still consider the analysis of subjective clinical data to assess the neuromuscular blockade reversal.[2,6,8] The difficulty of routinely employing intraoperative neuromuscular monitoring is a worldwide problem that has persisted over the years.[2,6,8,9]

It is also known that most European and American anesthesiologists do not routinely use anticholinesterase at the end of surgery.[9] In a Brazilian study, only 36% of the patients received a reversing agent in the absence of intraoperative monitoring.[6] The reversal time is also fundamental. It is necessary to wait for a TOF count > 2 for neostigmine administration and for a period longer than 10 min for extubation in propofol venous anesthesia. In sevoflurane anesthesia, these variables must be a TOF = 4 and 15 min, respectively.[10]

The importance of a routine use of intraoperative monitoring and performing an adequate reversal whenever necessary is undeniable, as well as the need for studies

focused on the reduction of PORC and its complications. Thus, we hypothesized that a protocol for systematizing the use of rocuronium and neostigmine could be of relevant importance to reduce the incidence of PORC in PACU in health centers that do not use neuromuscular monitors, which provides better patient care and, possibly, cost reduction.

The aim of this study was to comparatively evaluate the incidence of residual blockage after the application or not of the protocol for the systematic use of rocuronium and neuromuscular blockade reversal with neostigmine in PACU patients who underwent general anesthesia.

Method

This study was performed after obtaining the institutional Medical Ethics and Research Committee approval and written informed consent. It was a randomized, parallel-type clinical trial with an allocation ratio of 1:1 between groups, in which female patients, aged 18–60 years, BMI $\leq 30\,kg{\cdot}m^{-2}$, physical status ASA I or II, submitted to elective surgeries under general anesthesia with expected duration of more than 60 min were consecutively allocated. Exclusion criteria were patients with neuromuscular, pulmonary, renal or hepatic diseases, heart failure, hydroelectrolytic and acid–base changes, history of gastroesophageal reflux, taken drugs that interact with neuromuscular blockers, presence of signs indicative of difficult laryngoscopy maneuvers and intubation, impossibility of neuromuscular function monitoring in PACU, and patients who were not extubated in the operating room.

Sample size calculation was based on results from previous studies,[4–7] in which the incidence of residual block in PACU was about 50%. Considering that the proposed protocol application could reduce the incidence of PORC in PACU by half and assuming a significance level of 5% and a test power of 80% to detect a difference of 0.25 (25%) in the incidence between groups, the minimum required sample size was calculated as $n = 58$ patients per group. A computer-generated list was used to randomly assign patients (simple 1:1) into two groups (protocol × control). Patients were blind to the allocation group. The anesthesiologists responsible for administering the anesthesia were not blinded to the patient's allocation group at the time of her admission to the operating room.

The anesthetic technique was standardized for both groups: balanced general anesthesia (intravenous and inhaled), without neuraxial blockade; induction with sufentanil ($0.5–1.0\,\mu g{\cdot}kg^{-1}$), propofol ($1–2.5\,mg{\cdot}kg^{-1}$), and rocuronium as non-depolarizing NMB; maintenance with an expired fraction of sevoflurane (1.5–2.5%) in a mixture of nitrous oxide/oxygen (50%/50%); neostigmine was used as a reversing agent. Cardioscopy on DII and V5 leads, pulse oximeter, capnography, and noninvasive blood pressure monitor were used as continuous monitoring. Intraoperatively, no neuromuscular, qualitative or quantitative monitoring method was used. In the operating room, a peripheral vein was catheterized for hydration and drug administration.

Protocol group

The initial dose of rocuronium was $0.6\,mg{\cdot}kg^{-1}$, with additional doses of 10 mg during surgery if necessary; whenever possible, avoid the use of non-depolarizing NMB in the final 45 min of surgery; reversal of neuromuscular blockade must be made at the end of the procedure with atropine ($10–20\,\mu g{\cdot}kg^{-1}$) and neostigmine ($50\,\mu g{\cdot}kg^{-1}$), the anesthesiologist was responsible for deciding the best appropriated reversal time; wait at least 15 min after reversal to proceed with extubation.

Control group

The initial and additional doses of rocuronium, blockade reversal or not, atropine and neostigmine doses, and extubation time were at the discretion of the anesthesiologist responsible for the anesthesia.

Neuromuscular blockade assessment in PACU

All patients were extubated, transferred to the PACU, and equally monitored by accelerometer (TOF GUARD®, Organon, Teknika) by one of the main investigators, regardless of the group. After skin cleansing and preparation, two surface electrodes were placed on the wrist in the path of the ulnar nerve (3 cm apart). The acceleration (piezoelectric) transducer was attached to the thumb distal phalanx and a temperature sensor on the skin in the thenar region. The other fingers and arm of the patient were fixed in order to avoid possible monitoring interferences. An uncalibrated and non-normalized train-of-four (TOF) with 0.2 ms duration, frequency of 2 Hz, and current of 60 mA was applied. Two sequential measurements with 15 s interval between them were obtained. If there was a difference greater than 10% in the values, new measurements were made until such difference was less than 10%. Then, the mean value of the T4/T1 ratio was recorded.

Assessed variables and statistical analysis

Incidence of residual blockage in PACU: a TOF ratio (AMG < 1.0) was considered as a diagnostic criterion for residual blockade. This result was presented as a percentage and analyzed using the chi-square test.

Other variables were the initial ($mg{\cdot}kg^{-1}$) and total ($mg{\cdot}kg^{-1}{\cdot}h^{-1}$) dose of rocuronium; dose of neostigmine ($\mu g{\cdot}kg^{-1}$); duration of anesthesia (min); interval between initial dose of rocuronium and extubation; interval between the last dose of rocuronium and the time of neuromuscular blockade reversal; interval between the time of neuromuscular blockade reversal and extubation; and interval between extubation and neuromuscular monitoring in PACU.

Continuous data with normal distribution are presented as means and standard deviations and analyzed using Student's *t*-test. Continuous data with non-normal distribution are presented as median and interquartile range (q1–q3) and analyzed with Mann–Whitney *U* test or

Table 1 Characteristics of patients.

	Control group ($n = 62$)	Protocol group ($n = 60$)	p
Age (years)[a]	46.0 (40.0–51.0)	45.5 (38.5–50.5)	0.74
Weight (kg)[b]	63.6 ± 9.6	65.9 ± 10.0	0.19
BMI ($kg \cdot m^{-2}$)[a]	25.0 (22.5–27.5)	26.0 (22.7–28.0)	0.50
Height (cm)[b]	159.6 ± 6.8	161.2 ± 6.4	0.18
ASA[c]			
I	19 (30.6%)	20 (33.3%)	0.75
II	43 (69.4%)	40 (66.7%)	

Non-parametric data presented as median (interquartile range Q1–Q3); parametric data presented as means ± standard deviations; number of patients (%).
[a] Mann–Whitney *U* test.
[b] Student's *t*-test.
[c] Chi-square test.

Wilcoxon test. Categorical variables were assessed using chi-square test. A p-value < 0.05 was considered statistically significant.

Results

A total of 122 patients were included in the study. There was no significant difference between groups regarding patients' characteristics (Table 1). The initial dose of rocuronium was different between groups, it was significantly lower ($p < 0.01$) in protocol group. Neostigmine dose ($\mu g \cdot kg^{-1}$) and time between blockade reversal and extubation were significantly lower in control group ($p < 0.01$). There was no significant difference between groups regarding total dose of rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$), duration of anesthesia,interval between the last dose of rocuronium and neostigmine or between extubation and time of TOF assessment in PACU (Table 2).

The number of patients with PORC was significantly lower ($p = 0.02$) in protocol group compared with control group (25% vs. 45.2%, respectively). Regarding the presence or absence of PORC in each group, we found that the total dose of rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$) was higher in control group ($p = 0.03$), and the interval between the last administration of rocuronium and neostigmine was shorter ($p < 0.01$) in patients with PORC compared to those without. In protocol group, considering patients with or without PORC (TOF < or ≥ 1.0), there was no significant difference in the use of rocuronium (initial dose and total dose), neostigmine dose, duration of anesthesia or other intervals evaluated (Table 3).

Table 2 Data regarding rocuronium, neostigmine, and ranges according to group and TOF.

	Control group ($n = 62$)	Protocol group ($n = 60$)	p	TOF < 1.0 ($n = 43$)	TOF ≥ 1.0 ($n = 79$)	p
Initial dose rocuronium ($mg \cdot kg^{-1}$)	0.63 (0.58–0.67)	0.60 (0.60–0.60)	<0.01	0.60 (0.60–0.64)	0.60 (0.60–0.63)	0.32
Total dose rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$)	0.39 (0.26–0.50)	0.29 (0.23–0.51)	0.29	0.42 (0.27–0.58)	0.31 (0.23–0.47)	0.01
Neostigmine dose ($\mu g \cdot kg^{-1}$)	31.7 (29.0–35.1)	50.0 (49.8–50.0)	<0.01	40.0 (31.3–50.0)	49.3 (31.7–50.0)	0.16
Duration of anesthesia (min)	129.5 (90.0–185.0)	147.5 (91.5–202.5)	0.41	119.0 (81.0–172.0)	147.0 (94.0–206.0)	0.08
Interval between the last administration of rocuronium and neostigmine (min)	83.0 (60.0–113.0)	95.5 (67.0–132.0)	0.35	72.5 (54.0–95.0)	99.0 (70.0–139.0)	<0.01
Interval between neostigmine and extubation (min)	13.0 (10.0–18.0)	18.0 (16.0–22.0)	<0.01	15.0 (12.0–21.0)	16.0 (14.0–19.0)	0.39
Interval between extubation and TOF assessment (min)	7.5 (5.0–12.0)	8.0 (5.0–10.5)	0.88	7.0 (5.0–12.0)	8.0 (5.0–11.0)	>0.99

Non-parametric data presented as median (interquartile range Q1–Q3).
Mann–Whitney *U* test.

Table 3 Characteristics of the use of rocuronium, neostigmine, and ranges according to group and PORC.

	Control group ($n = 62$)		p	Protocol group ($n = 60$)		p
	TOF < 1.0	TOF ≥ 1.0		TOF < 1.0	TOF ≥ 1.0	
Initial dose rocuronium ($mg \cdot kg^{-1}$)	0.63 (0.60–0.65)	0.63 (0.56–0.69)	0.92	0.60 (0.60–0.60)	0.60 (0.60–0.60)	0.54
Total dose rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$)	0.43 (0.30–0.55)	0.35 (0.24–0.45)	0.03	0.39 (0.24–0.66)	0.28 (0.23–0.50)	0.35
Neostigmine dose ($\mu g \cdot kg^{-1}$)	33.0 (30.8–39.2)	31.3 (27.8–34.50	0.05	50.0 (49.1–50.0)	50.0 (49.9–50.0)	0.57
Duration of anesthesia (min)	124.0 (84.0–163.0)	136.0 (92.0–206.0)	0.17	107.0 (81.0–204.0)	148.0 (98.0–201.0)	0.41
Interval between the last administration of rocuronium and neostigmine (min)	75.0 (55.0–87.0)	101.0 (68.0–146.0)	<0.01	71.0 (53.0–139.0)	99.0 (72.0–131.0)	0.24
Interval between neostigmine and extubation (min)	13.0 (9.0–17.0)	13.5 (11.0–18.0)	0.59	21.0 (15.0–30.0)	17.0 (16.0–21.0)	0.26
Interval between extubation and TOF assessment (min)	6.0 (4.5–12.5)	9.0 (5.0–12.0)	0.70	9.0 (6.0–11.0)	7.0 (5.0–10.0)	0.46

Non-parametric data presented as median (interquartile range Q1–Q3).
Wilcoxon's test.

In the analysis of the study population ($n = 122$), independent of the group and classifying it according to the presence or absence of PORC, the total dose of rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$) was higher and the interval between the last dose of rocuronium and neostigmine was lower in patients with PORC (TOF < 1.0), with significant difference ($p \leq 0.01$) compared to those without PORC (TOF ≥ 1.0). There was no difference between patients with and without PORC regarding other parameters (Table 2).

Discussion

This study shows that the incidence of PORC in PACU is high in the absence of intraoperative acceleromyography and that the proposed protocol reduced the incidence of PORC by approximately 50%. This is of great relevance in view of the innumerable complications associated with PORC and the fact that the proposed protocol does not lead to increased costs or need for new equipment. Moreover, many institutions do not have neuromuscular and neostigmine monitoring options, which makes this topic of paramount importance and current topic of discussion among specialists.[11–13]

According to some estimates, 112,000 patients per year in the US are at risk for adverse events associated with undetected residual blocks.[9] These include changes in pharyngeal function, upper airway muscle weakness, and reduction of ventilatory response to hypoxemia.[1] There is an increased risk of aspiration, atelectasis, hypercarbia, hypoxemia, airway obstruction, need for reintubation, and other pulmonary complications.[11,14] PORC also increases the perception of symptoms of muscle weakness and worsens the postoperative sensation of well-being,[7] in addition to increase PACU length of stay.[15]

In order to exclude the presence of PORC, it is proposed that complete neuromuscular recovery be based on T4:T1 ratio (RTOF) ≥ 0.9 evaluated through mechanomiography, the current gold standard for objective neuromuscular monitoring.[2] However, when assessed through acceleromiography (AMG), even after RTOF = 1.0 the majority of acetylcholine receptors may still be occupied by NMB, which makes the patient potentially susceptible to PORC.[16] Furthermore, there is a large difference in the required dose of anticholinesterase to achieve a RTOF = 0.9 or 1.0 assessed by AMG.[17] Thus, many authors currently consider that an RTOF = 1.0 on AMG is necessary to ensure complete recovery from blockade.[18-21]

A non-calibrated and non-normalized AMG is known to overestimate RTOF; therefore, patients with PORC may erroneously be considered as having a complete recovery from blockade.[21] However, despite understanding the importance of calibration and normalization, the aim of this study was to try to get as close as possible to the reality of places that do not routinely use neuromuscular monitoring. The monitoring often seen in research settings differ from that employed in daily clinical practice.[21] Difficulty and delay in setting up the monitor prior to the administration of non-depolarizing NMB are factors that may contribute to many anesthesiologists stop using monitoring. In view of these aspects, we chose to assess neuromuscular function at a single time, at PACU admission, and consider an RTOF < 1.0 as a diagnostic criterion for PORC.

There was no difference between protocol and control groups regarding total dose of rocuronium ($mg \cdot kg^{-1} \cdot h^{-1}$). However, taking into account body weight and duration of the procedure, the use of rocuronium according to the protocol proposed in this study made total dose ($mg \cdot kg^{-1} \cdot h^{-1}$) no longer a significant factor in the incidence of PORC, different from that observed in the group that was not exposed to the protocol. The dose suggested and used in the protocol follows that recommended by other authors for laryngoscopy maneuvers and tracheal intubation, as well as to ensure adequate muscle relaxation during surgery, with an initial dose of $2ED_{95}$ ($0.6\,mg \cdot kg^{-1}$) and additional doses of 10 mg, respectively.[19,22] In addition, we proposed to avoid the use of non-depolarizing NMB in the final 45 min of surgery, which may be important for more superficial levels of neuromuscular blockade to be present at the time of blockade reversal. Intraoperative acceleromyography is known to decrease the incidence of PORC, as it allows to reduce the use of non-depolarizing NMB in the final 45–60 min of surgery.[7] Recently, other authors have found a similar result when observing a correlation between the occurrence of PORC at the time of extubation and shorter intervals than 60 min between the last administration of non-depolarizing NMB and extubation.[3]

Although the protocol has significantly reduced the incidence of PORC in PACU, a PORC rate of 25% is still high. This shows that although we have reduced the contribution of some factors in the occurrence of PORC, its etiology is multifactorial and other aspects not evaluated in this study may have contributed. This may be due to several factors, such as hypothermia, use of neostigmine in patients with spontaneous and complete recovery of neuromuscular transmission, interaction between anesthetic drugs and NMB, among others. It is known that even with the use of qualitative monitors during the intraoperative period, the incidence of PORC remains high in PACU. Therefore, the only effective way to minimize this incidence is through the use of intraoperative quantitative monitors or specific reversal agents, such as sugammadex.

In a case–control study, the anesthetic technique impact on mortality during the first 24 h of early postoperative period was evaluated and a 10-fold increase in the risk of death was seen when neuromuscular blockade was not reversed at the end of anesthesia.[23] The incidence of PORC assessed in PACU after 2 h or more of a non-depolarizing NMB single dose administration is 37% when the neuromuscular blockade is not reversed.[4] Thus, in situations without neuromuscular monitoring, a routine pharmacological reversal is currently recommended after spontaneous return of muscle activity.[2]

The neostigmine dose used for neuromuscular blockade reversal ranges from 20 to 70 $\mu g \cdot kg^{-1}$ and 50 $\mu g \cdot kg^{-1}$ are frequently used and recommended.[2,7,10,15,17,24] However, its use in patients who already have a complete blockade recovery is not safe, as it may lead to upper airway collapse and respiratory muscle dysfunction.[1,11,14] Furthermore, neostigmine increases the time to PACU discharge and length of hospital stay, regardless of residual blockage on admission to PACU.[11] When administered at high doses (>60 $\mu g \cdot kg^{-1}$), it also increases the chances of postoperative complications and triples the chance of atelectasis.[11,14] These effects appear to be related to a depolarizing blockade caused by neostigmine, desensitization of acetylcholine receptors, or open-channel blockade of acetylcholine receptors.[11]

Thus, it is clear that the neostigmine dose should be based on data obtained via objective intraoperative monitoring. Therefore, the routine and fixed-dose use of neostigmine as proposed in the protocol studied is far from ideal, but it is in line with the best clinical practice in situations in which neuromuscular monitoring or neostigmine is not available.[2] Furthermore, the recommended dose (50 $\mu g \cdot kg^{-1}$) is lower than those capable of causing undesired respiratory effects (>60 $\mu g \cdot kg^{-1}$).[11,14] We believe that reducing the incidence of PORC with the protocol use outweighs the possible undesirable effects of using neostigmine in the absence of adequate monitoring. However, new studies are needed to confirm this hypothesis.

Kim et al.[10] identified the time of 15 min after the use of neostigmine for blockade reversal and safe extubation in patients undergoing general anesthesia with sevoflurane, monitored and with four TOF responses. A recent study showed that in the presence of intraoperative monitoring the mean time between neostigmine administration and extubation was 15.6 min, significantly higher than that observed in unmonitored patients.[11]

These values are similar to those found in our control group. Although in the group exposed to the protocol the interval between neostigmine and extubation was significantly higher compared to the non-exposed group, but this time was not significantly different between patients with and without PORC. A possible explanation for this result would be the fact that most patients, even in control group, had an interval >10 min. Yu et al.[3] found that extubation less than 10 min after neostigmine administration may be associated with increased PORC incidence at the extubation time.

Absence of adequate neuromuscular monitoring increases the risks of pulmonary edema and reintubation; it is essential to guide the adequate reversal of neuromuscular blockade in clinical practice.[2,11] However, even in those settings where the equipment is available, one out of five patients receiving non-depolarizing NMB does not have a single TOF recorded.[11] This behavior is not restricted to a single institution, it is observed in several centers.[6,9] The reasons are many: lack of knowledge dissemination, lack of physicians' interest or motivation, difficulty in using the monitors, long time to reach a reliable response, sensitivity to external factors, results of difficult interpretation, and the need for training and routine use. All these factors make the inclusion of neuromuscular monitoring in daily practice unlikely, a fact evidenced in worldwide surveys.[2,25] Faced with this reality, this study proposes an option to reduce the incidence of PORC in non-ideal situations.

Limitations

This study was performed in a single center, a Brazilian tertiary university hospital. Therefore, we are unable to affirm that the protocol application in other institutions will have the same impact, as PORC is a multifactorial condition.However, the protocol modified factors identified as responsible for the increase of PORC in larger studies at other centers.[3,7]

Another aspect to be considered is the use of rocuronium alone as a non-depolarizing NMB. Although generalization of these results to clinical practice involving the use of other non-depolarizing NMB is difficult, this choice was essential to standardize the protocol elaboration and facilitate data analysis. The choice of rocuronium is due to the fact that it is the non-depolarizing NMB most used in most institutions,[9,26] particularly after the introduction of sugammadex in the market.

As discussed earlier, our choice was for an uncalibrated and non-standardized AMG, which may have led to less reliable and more biased results. However, we tried to minimize this factor by considering an RTOF threshold < 1.0 for PORC diagnosis.

Conclusion

The proposed systematization for neuromuscular blockade reversal in patients undergoing general anesthesia who received rocuronium proved to be effective, significantly reduced the incidence of residual blockage in PACU in the absence of intraoperative neuromuscular monitoring. Patients exposed to the protocol had a lower incidence of residual blockade, possibly because factors such as total dose of rocuronium and the interval between the last dose of this drug and the reversal time were no longer relevant for the occurrence of this complication. Therefore, one can infer that the occurrence of residual curarization is multifactorial.

Conflicts of interest

The authors declare no conflicts of interest.

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