CLINICAL RESEARCH / KLİNİK ÇALIŞMA

COMPARISON OF NEUROMUSCULAR MONITORING MEASUREMENTS WITH ROCURONIUM-SUGAMMADEX AND SUCCINYLCHOLINE IN PEDIATRIC SHORT PROCEDURES: A RETROSPECTIVE STUDY

PEDİYATRİK KISA SÜRELİ CERRAHİLERDE ROKÜRONYUM-SUGAMMADEKS VE SÜKSİNİLKOLİNİN NÖROMÜSKÜLER MONİTÖRİZASYON DEĞERLERİNİN KARŞILAŞTIRILMASI

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SUMMARY

Objective: *The use of succinylcholine is not encouraged for pediatric patients due to possible life-threatening side effects such as hyperkalemia and malignant hyperthermia. In recent years, rocuronium-sugammadex has been used in adult patients as an alternative to succinylcholine both in short procedures requiring muscle relaxant and in rapid serial intubation. However, data on the use of rocuronium and sugammadex in pediatric patients are limited. In this retrospective study, we compared neuromuscular blockade duration between succinylcholine and rocuronium reversed with sugammadex in pediatric short procedures.*

Method: *The anesthesia records of 50 patients who underwent rigid bronchoscopy and esophagoscopy with neuromuscular monitoring between 2014 and 2016 years were reviewed retrospectively.*

Results: *There was no significant difference between two agents in terms of the muscle relaxant reversing time after the end of the procedure, although there were significant differences in terms of time to T90, T100 and extubation time. Mean time to a train-of-four ratio of 0.9 was 1.52±0.60 min for rocuronium-sugammadex.*

Conclusion: *There is no significant difference between the two agents in terms of post-procedure muscle relaxant reversal time. However, considering the rates of side effects observed, the use of rocuronium-sugammadex may be eligible than succinylcholine.*

KEY WORDS: *Neuromuscular monitoring, Pediatric anesthesia, Sugammadex, Succinylcholine*

ÖZET

Amaç: *Pediatrik hastalarda süksinilkolin kullanımı hiperkalemi ve malign hipertermi gibi yan etkileri nedeniyle çekince yaratmaktadır. Son yıllarda erişkin hastalarda roküronyum ve sugammadeks, hem kas gevşetici kullanımının gerektiği kısa sureli vakalarda hem de hızlı seri entübasyonda süksinilkoline alternatif olarak kullanılmaktadır. Buna rağmen pediatrik hastalarda roküronyum ve sugammadeks kullanımı ile ilgili veriler kısıtlıdır.*

Yöntem: *Bu retrospektif çalışmada, pediatrik kısa süreli cerrahi prosedürlerde süksinilkolin ile roküronyum ve sugammadeksin blok süresi karşılaştırılmıştır. 2014-2016 yılları arasında rijid bronkoskopi ve özefagoskopi uygulanmış olan 50 hastanın anestezi kayıtları retrospektif olarak incelenmiştir.*

Sonuçlar: *İki grup karşılaştırıldığında süksinilkolin kullanılan hastalarda T90, T100 ve ekstübasyon süresi anlamlı olarak kısa ölçülmesine rağmen cerrahi prosedürün tamamlanması sonrasında kas gevşeticilerin etkisinin ortadan kalkması için geçen süre değrlendirildiğinde anlamlı fark bulunmadı. Roküronyum sugammadeks grubunda TOF değerinin %90'a ulaşılması için geçen süre ortalama 1.52±0.60 dakika idi.*

Sonuç: *Cerrahinin bitiş zamanı dikkate alındığında her iki grupta kas gevşeticilerin etki sonlanma süreleri arasında fark bulunmadı. Buna rağmen, görülen yan etkiler dikkate alındığında roküronyum sugammadeks kullanımının süksinilkolin kullanımından daha güvenli olabileceği düşünüldü.*

ANAHTAR KELİMELER: *Nöromüsküler monitörizasyon, Pediyatrik anestezi, Sugammadeks, Süksinilkolin*

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INTRODUCTION

Pediatric airway foreign body aspiration is associated with a high rate of airway morbidity and mortality (1). Retrieval of these aspirated foreign bodies is crucial due to the risk of atelectasis, bronchiectasis, chronic pneumonia, and granulation tissue formation (2). Drinking an acidic or alkaline substance is more common later in childhood and could cause serious clinical problems such as esophageal stricture and perforation. Profound sedation is necessary in these cases, but the use of neuromuscular blocker (NMB) agent depends on the anesthetist's preference (3,4).

NMBs are commonly used in anesthesia practice due to various benefits such as facilitating endotracheal intubation and application of mechanical ventilation and improving surgery conditions. One of the issues that should be considered during short procedures requiring intubation is the duration of effect of NMBs. In the past, succinylcholine was often preferred because of its short duration of effect; however, rocuronium with the use of sugammadex has been introduced recently as an alternative.

Succinylcholine, which has a depolarizing block mechanism, has rapid onset and short duration of effect. The use of succinylcholine is avoided in pediatric patients due to its possible side effects. Hyperkalemia and malignant hyperthermia are among the serious life-threatening side effects. Many anesthetists, however, are still using succinylcholine in adult patients due to certain clinical advantages such as short duration of effect and good intubation conditions (5).

Sugammadex is a special molecule modified with γ-cyclodextrin that acts as an antagonist to rocuronium and can reverse the neuromuscular effects of rocuronium and vecuronium. Although there are different doses for different levels of neuromuscular blockade in adults, only a dose of 2 mg kg^{-1} has been approved for children in moderate neuromuscular blockade. Sugammadex can be used as an alternative to neostigmine for reversal of neuromuscular block induced by vecuronium and rocuronium. Moreover, it can also be used as an alternative to succinylcholine for rapid intubation with rocuronium. Sugammadex can provide a rapid reversal response in procedures which are short but necessitating profound neuromuscular blockade in adults. That use of rocuronium with sugammadex and succinylcholine has been researched in adults, but not yet in pediatric patients (6).

In this retrospective study, we aimed to compare neuromuscular monitoring measurements in pediatric patients anesthetized with rocuronium-sugammadex and succinylcholine. We hypothetized that, end of the effect of rocuronium reversed with sugammadex could be shorter than hydrolysis of succinylcholine by cholinesterase and have shorter duration from the end of the procedure to extubation in addition to recovery of 90% of single twitch.

MATERIAL AND METHOD

The anesthesia records of patients who underwent rigid bronchoscopy and esophagoscopy in our clinic between 2014 and 2016 were reviewed retrospectively. For this purpose, the routinely used neuromuscular monitoring form and anesthesia form were analyzed in 64 patients whose procedures were conducted with neuromuscular monitoring; 14 patients with missing information were excluded from the study. All patients were monitored with TOF Watch SX (Organon, The Netherlands) and calibrated using the CAL2 function before administering NMBs.. Patient demographics, procedure type, NMB onset time, intubation time, time until recovery of 90% of first twitch (T90), time until recovery of 100% of first twitch (T100), time until recovery of 100% of train-of-four (TOFR90) measurement during extubation for rocuronium, extubation time, and adverse events were recorded. Time differences from the end of the procedure to T90 and from the end of the procedure to extubation were calculated. All patients were extubated after returning to spontaneous ventilation. MedCalc® 10.3 package program was used for statistical analyses. Numerical variables were shown as mean and standard deviation. Student's t test was used in intergroup comparisons. The significance level was accepted to be a p value of 0.05.

Neuromuscular recording forms have been used routinely in our department since 2014 in cases with neuromuscular monitoring.

RESULTS

Thiopenthal 5 mg kg^{-1}, fentanyl 0.5 µg kg^{-1} were administered intravenously for induction and sevoflurane 0.5-2% with 4 L fresh gas (50-100% oxygen with nitrous oxide) were used for maintain of anesthesia. 1 mg kg^{-1} succinylcholine was administered to the 26 of patients and 0.6 mg kg^{-1} rocuronium with 2 mg kg^{-1} sugammadex were administered to the 24 of patients. Demographic and procedural data were summarized in Table I.

There were significant differences between the succinylcholine and rocuronium-sugammadex groups in terms of NMB onset time (34.07±12.89 vs 58.70±43.02 s, respectively), intubation time (58.11±35.77 vs 122.12±35.82 s), T90 (6.32±1.44 vs 2.10±1.02 min), T100 (7.32±2.22 vs 3.18±1.32 min), and extubation time (8.19±3.18 vs 4.13±1.33 min) ($p<0.01$) (Table II).

When the differences measured by considering the end of the operation are evaluated, there were no significant

Table I. Patients' demographic and procedure data

	Group S (N:26)	Group RS (N:24)
Age (years)	3.48±1.40	3.68±1.34
Gender (male/female)	12/14	11/13
Weight (kg)	16.77±5.85	18.71±5.68
Procedure type		
Esophagoscophy	9	13
Rigid bronchoscophy	17	11
Mean procedure time (min)	8.23±7.16	10.21±7.17
Mean anesthesia time (min)	12.36±7.31	14.00±6.41
Complications		
Bradycardia	6 (24%)	-
Hypoxemia	1 (4%)	-

Table II. Neuromuscular monitoring measurements

	Group S (N:26)	Group RS (N:24)
NMB Onset time (s)	34.07±12.89$^{\alpha}$	58.70±43.02
Intubation time (s)	58.11±35.77$^{\alpha}$	122.12±35.82
T90 (min)	6.32±1.44$^{\alpha}$	2.10±1.02
T100 (min)	7.32±2.22$^{\alpha}$	3.18±1.32
Extubation time (min)	8.19±3.18$^{\alpha}$	4.13±1.33
Time from end of procedure to T90 (s)	178.19±92.27	156.79±54.30
Time from end of procedure to extubation (s)	252.35±118.60	232.21±70.87

$^{\alpha}$: $p< 0.01$

differences between the two agents in time to T90 (178.19 ± 92.27 s for succinylcholine, 156.79 ± 54.30 s for rocuronium-sugammadex) or time to extubation (the difference between the end of operation and the extubation time; 252.35±118.60 s for succinylcholine, 232.21±70.87 s for rocuronium-sugammadex) (Table II). TOF measurement values for rocuronium-sugammadex group are summarized in Table III.

Of the patients who administered succinylcholine, bradycardia occurred in 6 patients and was treated with atropine, and hypoxia (SpO_2 <93) was noted during the procedure in one patient. Persistent hypoxemia was not observed. No complications were observed in the group that received rocuronium and sugammadex (Table I).

DISCUSSION

In cases of foreign body removal from the airway or esophagus and caustic substance ingestion in children, bronchoscopy and esophagoscopy procedures require proper airway management due to life-threatening risks such as hypoxia. Our comparison of procedures performed using succinylcholine and those using rocuronium-sugammadex revealed significant differences in terms of time to T90, T100 and intubation time, though there was no significant difference in NMB reversal time when the termination of the operation time was considered. Our observation of serious side effects such as bradycardia in succinylcholine-administered patients suggests that rocuronium-sugammadex is the safer option.

The use of succinylcholine has a long history in anesthesia practice. Cook et al. reported time to T90 as 4.8±1.1 min in eight children administered 1 mg kg^{-1} succinylcholine (7). We found T90 as 6.32±1.44 min for succinylcholine and 2.10±1.02 min for rocuronium-sugammadex. Plaud et al. reported the TOFR90 as 1.2 min after using 0.6 mg kg^{-1} rocuronium and 2 mg kg^{-1}

Table III. Train-of-four (TOF) measurements in patients administered rocuronium-sugammadex

Number of patients according to twitch count when administered sugammadex (T1/T2/T3/T4) (n:24)	6/10/5/3
Mean time to TOFR90 (min) (n:24)	1.52±0.60
Mean time to TOFR90 (administrated sugammadex after T2 reappeared) (min) (n:18)	1.39±0.60

TOFR90: Train-of-four ratio of 0.9

sugammadex when administered after reappearance of T2 twitch response in four children (8). In the current study, this interval was 1.52±0.60 min. This difference may be due to the fact that we administrated sugammadex in some patients without a T2 response (Table 3). In another study, time to TOFR90 was reported as 1.97±2.14 min for rocuronium reversed with neostigmine and 0.46±0.70 min with reversal by sugammadex in pediatric patients, but sugammadex was administered after T4 reappeared (9).

Hypoxemic episodes are a common issue during bronchoscopy. A study showed that desaturation could be observed 20 seconds earlier with succinylcholine compared to rocuronium due to fasciculations during intubation (10). Furthermore, desaturation may occur when the effect of succinylcholine ends and spontaneous ventilation efforts begin during the procedure. It was reported that bucking, coughing, shallow breathing, apnea and breath-holding could lead to desaturation episodes during bronchoscopy with spontaneous ventilation (11). We found desaturation events in one patient who was administrated succinylcholine and it could be associated with the off-set of succinylcholine effect during the procedure.

Due to its rapid onset and short duration of effect, succinylcholine may be advantageous in rapid sequence intubation, difficult airway management, and short procedures. On the other hand, it also has many side effects including bradycardia, muscle pain, hyperkalemia, increased intracranial and intraocular pressure, malignant hyperthermia and prolonged effect with phase II block (12). It has also been reported that many cases of cardiac arrest and death could be related to hyperkalemia (13,14). Bradycardia occurred in 6 patients who were administered succinylcholine and treated with atropine in our study.

Rocuronium and NMB reversal agents also have side effects. Transient hypotension, hypertension, allergic reaction and pain at injection site may occur after administering rocuronium. The potential side effects of sugammadex include hypotension, allergic reaction and abnormal levels of N-acetylglucosaminidase in the urine (16,17). Sugammadex-related allergic reactions are more common at higher clinical doses (16–96 mg kg^{-1}) (17,18).

In conclusion, time to T90, T100 and extubation were shorter for rocuronium-sugammadex when compared with succinylcholine, but the two agents were comparable in terms of NMB reversing time according to end of the procedure. Considering the lower incidence of side effects, rocuronium-sugammadex seems eligible than succinylcholine in these procedures.

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