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Does the Use of Rocuronium-Sugammadex Instead of Succinylcholine in Electroconvulsive Therapy Affect Seizure Duration?

Ceyhan Oflezer[1] ✉, Özge Atay[2], Zümrüt Ela Kaşdoğan[1], Gülay Özakay[1], Derya İpekçioğlu[2], and Hakan Bahadır[3]

[1]Department of Anesthesiology, University of Health Sciences, Bakirkoy Training and Research Hospital for Psychiatry, Neurology and Neurosurgery, Istanbul, Turkey
[2]Department of Psychiatry, University of Health Sciences, Bakirkoy Training and Research Hospital for Psychiatry, Neurology and Neurosurgery, Istanbul, Turkey
[3]Department of Radiology, Private Practice, Betatom Medical Imaging Center, Istanbul, Turkey

Objective We compared retrospectively the seizure variables of electroconvulsive therapy (ECT) patients after administration of rocuronium-sugammadex or succinylcholine as a muscle relaxant with propofol anesthesia.

Methods The sample comprised 134 ECT patients. The mean age was 33.6±10.48 years. Anesthesia induction was provided with propofol one mg kg-intravenously (IV) followed by succinylcholine 0.5 mg kg^{-1} IV (n=68) (Group S) or rocuronium 0.3 mg kg^{-1} IV (n=66) (Group R). For patients who were given rocuronium, reversal of the residual neuromuscular block was accomplished with sugammadex (1.5 mg kg^{-1} IV). First session seizure variables were compared between the two groups. We also presented the clinical outcome with Clinical Global Impression-Improvement (CGI-I) and overall adverse effects.

Results EEG seizure durations in Group R (55.09±36.11 s) and Group S (47.00±26.33 s) were comparable and were not significantly different (p=0.432). The clinical efficacy of ECT measured by CGI-I in both groups was comparable (p=0.075). There were no major complications or death during or after ECT.

Conclusion The results of this study show that the use of rocuronium-sugammadex as a neuromuscular blocker instead of succinylcholine during ECT with propofol anesthesia produces similar results in terms of seizure variables and clinical outcomes.

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Keywords Electroconvulsive therapy; Rocuronium; Sugammadex; Succinylcholine; Seizure.

INTRODUCTION

Despite advances in pharmacotherapy, electroconvulsive therapy (ECT) remains the main treatment option in psychiatry. It can be used primarily when urgent treatment is needed for severe psychiatric diseases or secondarily after failure or intolerance to pharmacotherapy.[1] This modality is based on electrical stimulation of brain tissues and creating an epileptic seizure. The quality and duration of the seizure triggered by ECT were associated with the effectiveness of the procedure. Although seizure duration is accepted as a standard to determine therapeutic efficacy, and a motor seizure typically lasting a minimum of 20−25 seconds was suggested;[2] recent guidelines or articles suggest that a minimum of 15 seconds seizure duration is enough or that seizure duration is not as important as the quality of the seizure.[3]

The 'unmodified' ECT technique was initially applied with a high incidence of musculoskeletal complications. Various modifications, including general anesthesia and muscle relaxation, are used to increase the safety and acceptability of ECT by the patient. Neuromuscular blockade is required to control excessive muscle contractions during ECT.[4] The aims of their use are reduction of motor activity to avoid injuries, minimal interference with seizure activity, and prompt recovery of spontaneous ventilation without residual paralysis.[5] Succinylcholine is used to be the classic agent for ECT, due to its rapid onset and short duration of action. However, its use may also be accompanied by serious adverse effects due to its metabo-

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✉ **Correspondence:** Ceyhan Oflezer, MD
Department of Anesthesiology, University of Health Sciences, Bakirkoy Training and Research Hospital for Psychiatry, Neurology and Neurosurgery, Zuhuratbaba, Doktor Tevfik Sağlam Cd. 25/2, Istanbul 34147, Turkey
Tel: +90-5322668484, **Fax:** +90-212-4091590, **E-mail:** zlmgrbz@yahoo.com

lism by plasma pseudocholinesterase; severe prolongation of the neuromuscular blockade can occur in patients with pseudocholinesterase deficiency or genetic abnormality.[6] Moreover, succinylcholine has many side effects, such as myalgia, an increase in plasma potassium, and an increase in intragastric and intraocular pressures.[7,8] When succinylcholine is contraindicated, a nondepolarizing neuromuscular blocking agent has to be used. Rocuronium, which is increasingly used in ECT as an alternative to succinylcholine, is a neuromuscular blocking agent with a steroidal structure, with an effect of moderate duration, and is characterized by nondepolarizing properties.[9] Unlike succinylcholine, rocuronium does not lead to serious side effects, such as myalgia, headache, intragastric pressure, increased intraocular pressure, risk of malignant hyperthermia, or hyperkalemia.[9] Sugammadex is a selective relaxant binding agent indicated for the reversal of moderate to deep neuromuscular block with a high affinity for rocuronium.[10]

Today, the combination of rocuronium and sugammadex may be an alternative to succinylcholine since several reports demonstrated that sugammadex produced a complete and rapid reversal of induced neuromuscular blockage without other safety concerns.[11,12] The body of evidence was heterogeneous with regards to the patient population and the doses of rocuronium-sugammadex and succinylcholine, and the outcomes that were reported.[10] Literature indicates that there was also limited information on the combined use of rocuronium-sugammadex and propofol versus succinylcholine and propofol combination on seizure variables, recovery, and adverse effects in ECT applications.[11-16] The evidence was obtained from the studies conducted in adult patients undergoing ECT using different dose combinations of rocuronium, sugammadex, and succinylcholine.[11-16]

Saricicek et al.[13] compared 0.3 mg kg^{-1} rocuronium and 4 mg kg^{-1} sugammadex combination with 1 mg kg^{-1} succinylcholine for ECT anesthesia and reported reduced myalgia and headache after ECT, faster recovery, and comparable motor seizure duration in rocuronium group. Kadoi et al.[14] reversed the deep neuromuscular blockade in patients who were treated with 0.6 mg kg^{-1} of rocuronium using various doses of sugammadex (4, 8, and 16 mg kg^{-1}, respectively) and compared with succinylcholine and showed no significant difference in seizure duration between the groups. Comparing the combination of 0.6 mg kg^{-1} rocuronium and 4 mg kg^{-1} sugammadex or 1 mg kg^{-1} succinylcholine in ECT anesthesia, Koksal et al.[15] found prolonged seizure duration, sufficient muscle relaxation, and early recovery during ECT in the rocuronium group. Hoshi et al.[16] showed that the patients who were given 0.6 mg kg^{-1} rocuronium and antagonized with 16 mg kg^{-1} sugammadex for ECT anesthesia, recovered from the muscle relaxation faster than did the patients who were given 1 mg kg^{-1} succinylcholine and reported a longer seizure duration with rocuronium compared with succinylcholine. In a case report, Postaci et al.[11] reported no agitation during neuromuscular recovery in a patient switched to a combination of 0.4 mg kg^{-1} rocuronium and 2 mg kg^{-1} sugammadex instead of 0.5 mg kg^{-1} succinylcholine after severe agitations during the recovery period of all his five consecutive ECT sessions. In a patient with pseudocholinesterase deficiency and treated with low dose succinylcholine (0.24±0.23 mg kg^{-1}) for the first seven ECT sessions, and with rocuronium (0.52±0.02 mg kg^{-1}) and 200–400 mg sugammadex for other eight sessions, Takazawa et al.[17] reported that the recovery time from muscle relaxation after succinylcholine administration was remarkably longer than that after rocuronium-sugammadex administration.

We present here a retrospective study covering the time interval when rocuronium was used as a suitable alternative muscle relaxant for ECT when succinylcholine was not available in Turkey. The manufacturer shortage of succinylcholine, the standard neuromuscular blocking agent for ECT in Turkey, has occurred for the past year. In its absence, practitioners have been forced to use alternative agents, such as rocuronium-sugammadex. Although limited, the small quantity of heterogenous evidence suggests that the clinical effectiveness of rocuronium with sugammadex in patients requiring rapid sequence induction was not different or better compared with succinylcholine.[10] However, the potential benefits associated with sugammadex may not be sufficient to offset its high cost, which may limit its widespread use.[18] It is obvious that seizure duration is an important parameter in the selection of different muscle relaxants and anesthetic drugs in ECT.[19-21] Hence, we aimed to compare seizure variables in patients who underwent ECT after administration of either rocuronium-sugammadex or succinylcholine as a muscle relaxant with propofol anesthesia.

METHODS

Patients

This is a retrospective, single-center study conducted at Bakirkoy Training and Research Hospital for Psychiatry, Neurology and Neurosurgery, Istanbul, a tertiary University Hospital.[21] It is the largest regional mental hospital in Turkey. The Bakirkoy ECT Center functions every workday and patients are referred from the psychiatric units of the hospital for ECT. The staff includes a psychiatrist (coordinator), 1 anesthesiologist, 2 anesthesiology technicians, a supervising nurse, and 3 nurses. One psychiatrist and one psychiatry resident from each unit attend the ECT sessions of their patients every session. The data was collected from the ECT center and patients' medical records.

We evaluated 134 patients who received ECT from July 2020 to February 2021, of either sex, aged 18 or over with American Society of Anaesthesiologists physical status I to III. The medical records of the patients who were treated with ECT during the succinylcholine shortage (November 2020 and February 2021) were included. Patients under 18 years old; patients who received an ECT cure in the last six months or undergoing maintenance ECT and those who had insufficient data were excluded. Sixty-six patients treated with rocuronium-sugammadex comprised Group R were compared with 68 consecutive ECT patients treated with succinylcholine (Group S) matched for age, sex, and body mass index (BMI), treated just before the shortage period. None of the patients had a history of cardiovascular, hepatic, renal, or neuromuscular disease or an unstable medical condition. The decisions on diagnosis and ECT indications were given by the patients' attending psychiatrists. The patients were informed about ECT and written informed consent was obtained from either patient and/or their relatives/representatives. In cases of emergency, ECT was administered with 2 psychiatrists' written approval. The seizure variables of the first ECT session were used for the evaluation. Overall adverse effects were recorded. In addition, clinical response to treatment was evaluated with Clinical Global Impression-Improvement (CGI-I) scale.

The approval from the institutional ethics committee (Clinical Research Ethics Committee of University of Health Sciences, Bakirkoy Dr. Sadi Konuk Training and Research Hospital: 2021-08-34 code and 19-04-2021 date with 2021/253 protocol number) was obtained.

The general electroconvulsive therapy procedure

ECT application in the institution[22] complies with the criteria of the American Psychiatric Association[23] and the Royal College of Psychiatrists.[24] The pre-ECT evaluation included a physical examination by an internist and an anesthesiologist and pre-operative laboratory workup with hemogram, biochemistry, and hormone tests. Patients were fasted for 8 hours for solid foods and 4 hours for clear liquids before ECT sessions. An ECT administration form and observation form were filled, and the patient was scheduled for the intervention and transferred to the ECT center. Bitemporofrontal ECT was administered with a brief-pulse square-wave ECT device Thymatron IV (Thymatron system IV device; Somatics, Inc., Lake Bluff, IL, USA) at the ECT center. In the preparation room, variables such as the patient's weight, height, heart rate (HR) systolic blood pressure (SBP) and diastolic blood pressure (DBP), and body temperature were recorded before ECT; the intravenous line was checked, and electrodes for recording (electroencephalogram, electrocardiogram, and electromyogram) were placed. Cardiovascular effects were assessed through monitoring with a noninvasive digital monitor (Braun BP, 4000; Braun, Lausanne, Switzerland). Ventilation was maintained with a mask. A pulse oximeter (Nonin 2500A, pulse oximeter; Nonin, Plymouth, MN, USA) was placed on the index fingers of the patients, and oxygen saturation and pulse were monitored. ECT electrodes were placed in the bilateral frontotemporal manner, as this approach has been demonstrated to possess greater clinical efficacy. Stimulus dosage was adjusted by the "half-age method." The half-age method was used in determining the initial intensity of stimulus because this approach was considered more convenient for setting and starting the first bilateral ECT treatment in an institution administering a great number of treatments per day. The patients were restimulated at a higher intensity when seizure duration was less than 25 seconds (s), by our institution's dosing protocol.

Anesthesia management for electroconvulsive therapy

All sessions were conducted under general anesthesia, with propofol as the first-line agent, similar to many other countries. In this group of patients, anesthesia was induced using propofol 1.0 mg kg^{-1} intravenously (IV) over 5 s, followed by either succinylcholine 0.5 mg kg^{-1} IV or rocuronium 0.3 mg kg^{-1} IV over 5 s, followed by a 10-mL saline bolus. In Group S, at the end of the fasciculation and 90 s after a succinylcholine dose (0.5 mg kg^{-1}), an electrical stimulus was delivered via bifrontotemporal electrodes with a Thymatron IV device. In Group R, rocuronium 0.3 mg kg^{-1} IV was administered after 60 s propofol administration, and a supra-threshold electrical stimulus was administered 120 s after a rocuronium dose. For patients who were given rocuronium, 1.5 mg kg^{-1} IV sugammadex[25,26] was infused with a 10-mL saline bolus immediately after the cessation of the seizure. Electroencephalographic (EEG) seizure duration was recorded by a two-channel EEG after the electrical stimulus. Motor seizure activity was observed and measured with a chronometer. Subsequently, all the patients were ventilated with a face mask with 100% oxygen until the beginning of spontaneous respiration. All the patients were monitored for changes in HR, mean arterial pressure, SpO_2, ECG changes, and respiratory rate before induction of anesthesia, after the administration of the study drug, after giving muscle relaxants, after applying ECT, then every 5 minutes throughout the procedure till the transfer of the patient to the post-anesthesia care unit. Cardiovascular effects were assessed through monitoring the SBP and DBP levels, as well as HR with a noninvasive digital monitor, and measurements were recorded at 2-time points: preparation, and postictal 15th minute. The patient with adequate spontaneous breathing was followed up with a finger probe. Shortly there-

after, the patient could breathe adequately and opened their eyes in response to verbal instructions and responded adequately to verbal commands. In a normal course, after 10 minutes of preparation and 10 minutes of practice, 20 minutes of awakening and recovery, and 20 minutes of final recovery, patients can return to the clinic with the service team.

The CGI-I scale was performed within a week after the last ECT session. This scale ranges from 1 to 7 (very much improved, much improved, minimally improved, not improved, minimally worse, much worse, and very much worse). A CGI-I score of 1 and 2 was considered improved, a CGI-I score of 3 was considered partly improved and a CGI-I score of 4 or greater was considered not improved.[27]

Statistical analysis

Data were analyzed using SPSS for Windows (version 20.0; IBM Co., Armonk, NY, USA). The Shapiro–Wilk test was applied to test if the data were normally distributed. A comparison of continuous variables between the study groups was done using an independent t-test for parametric distribution and the Mann–Whitney Utest for nonparametric distribution. For comparing categorical data, a chi-square test was performed, and the exact test was used when the expected frequency was <5. The level of statistical significance was set at $p<0.05$.

RESULTS

A total of 134 patients were evaluated (73 males and 61 females). The sample's mean age was 33.65±10.48 years (mean±standard deviation [SD]; range, 18–63 yr), and the BMI was 26.66±6.15 kg/m^2 (mean±SD). The demographic and clinical characteristics of the patients are summarized in Table 1, with no significant difference between the groups ($p>0.05$) except for smoking status ($p=0.02$).

All of the variables for the first ECT session are presented in Table 2. The groups showed no significant differences either in values of HR, SBP, DBP, and SpO_2 at 15 minutes following the ECT procedure. The EEG seizure duration was comparable in the rocuronium group (55.09±36.11 s) and the succinylcholine group (47.00±26.33 s), and there was no statistically significant difference between the two groups ($p=0.432$). Duration of motor seizure activity after succinylcholine and rocuronium amounted to 33.15±17.35 s and 36.61±19.46 s, respectively, with no statistically significant difference ($p=0.329$). In addition to the abovementioned values, no significant difference was detected in values for seizure energy between the two groups ($p=0.330$) (Table 2). The adverse effects are also presented in Table 2. There were no major complications or death during or after ECT. There were no differences between the two groups of muscle relaxants in terms of overall adverse effects ($p=0.376$).

The clinical response to treatment was evaluated with the CGI-I scale between the two groups. Clinical response to

Table 1. Comparison of demographic and clinical variables between Group R and Group S

	Group R (N=66)	Group S (N=68)	p-value
Age (yr)	33.62±10.75	33.68±10.30	0.975†
Sex			
Male	36 (54.5)	37 (54.4)	0.988‡
Female	30 (45.5)	31 (45.6)	
Education (yr)	8.91±3.72	7.96±4.13	0.164†
Weight (kg)	75.39±20.42	75.57±16.61	0.957†
Length (cm)	169.27±9.32	167.16±8.90	0.182†
BMI (kg/m^2)	28.16±6.02	25.15±6.28	0.354†
Smoking	31 (47.0)	45 (66.2)	0.020*‡
Alcohol	17 (25.8)	12 (17.6)	0.254‡
Substance	16 (24.2)	12 (17.6)	0.348‡
ASA			0.376‡
I	29 (43.9)	22 (32.4)	
II	35 (53.0)	44 (64.7)	
III	2 (3.0)	2 (2.9)	
Systemic disease			0.401
None	58 (87.9)	60 (88.2)	
Hypertension	3 (4.5)	1 (1.5)	
Diabetes mellitus	2 (3.0)	0	
Diabetes mellitus+ obesity	1 (1.5)	1 (1.5)	
Hypothyroid	2 (3.0)	3 (4.4)	
Asthma	0	3 (4.4)	
Diagnosis			0.402‡
Unipolar depression	9 (13.6)	8 (11.8)	
Bipolar depression	1 (1.5)	1 (1.5)	
Schizophrenia	23 (34.8)	24 (35.3)	
Bipolar mania	9 (13.6)	10 (14.7)	
Atypical psychosis	22 (33.3)	19 (27.9)	
Schizoaffective depression	0	1 (1.5)	
Schizoaffective mania	0	5 (7.4)	
Catatonia	1 (1.5)	0	
Substance-induced bipolar disorder	1 (1.5)	0	
Pseudocholinesterase (U/L)	7.77±1.08	7.90±1.90	0.636†

Values are presented as mean±standard deviation or number (%). *p<0.05; †independent t test; ‡Pearson chi-square test. BMI, body mass index; ASA, American Society of Anesthesiologists; S, succinylcholine; R, rocuronium-sugammadex

Table 2. Comparison of electroconvulsive therapy variables between Group R and Group S

	Group R (N=66)	Group S (N=68)	p-value
EEG seizure duration (s)	55.09±36.11	47.00±26.33	0.432‡
Motor seizure duration (s)	36.61±19.46	33.15±17.35	0.329‡
Seizure energy (mC)	22.88±8.50	24.34±8.50	0.330‡
HR (beats per min^{-1})			
Pre-ECT	94.02±17.58	85.76±16.42	0.006**†
Post-ECT	92.06±19.65	89.37±15.62	0.381†
SBP (mm Hg)			
Pre-ECT	123.47±14.02	121.26±15.46	0.389†
Post-ECT	123.35±14.28	126.53±16.89	0.242†
DBP (mm Hg)			
Pre-ECT	80.62±11.23	79.00±9.74	0.373†
Post-ECT	77.95±11.75	80.18±12.04	0.282†
SpO_2 (%)			
Pre-ECT	97.79±1.22	97.22±0.82	0.002**
Post-ECT	97.94±1.68	97.85±1.35	0.743†
Adverse effect			0.376§
No complication	50 (75.8)	56 (82.4)	
No seizure	2 (3.0)	4 (5.9)	
Short seizure	7 (10.6)	5 (7.4)	
Prolonged seizure	6 (9.1)	2 (2.9)	
Prolonged recovery	1 (1.5)	0	
Hypersalivation+ prolonged seizure	0	1 (1.5)	
CGI-I score			0.075§
Improved	28 (42.4)	36 (52.9)	
Partly improved	38 (57.6)	29 (42.6)	
Not-improved	0	3 (4.4)	

Values are presented as mean±standard deviation or number (%). **p<0.01; †independent t test; ‡Mann–Whitney U test; §Pearson chi-square test. EEG, electroencephalographic; mC, milicoulomb; HR, heart rate; ECT, electroconvulsive therapy; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO_2, peripheral oxygen saturation; CGI-I, Clinical Global Impression-Improvement (improved, 1–2; partly improved, 3; not improved, 4 or greater); S, succinylcholine; R, rocuronium-sugammadex

treatment evaluated with the CGI-I scale is shown in Table 2. Rocuronium-sugammadex was comparable to succinylcholine in terms of clinical efficacy (p=0.075). At the end of the acute treatment stage, 28 patients (42.4%) improved and 38 patients (57.6%) partly improved in the rocuronium-sugammadex group, while 36 patients (52.9%) improved, 29 patients (42.6%) partly improved, and 3 patients (4.4%) did not improve in the succinylcholine group based on CGI-I scores.

DISCUSSION

In this retrospective study, which included the time interval in which rocuronium was used as an alternative muscle relaxant suitable for ECT due to manufacturer shortage of succinylcholine, we found that the use of rocuronium-sugammadex as a neuromuscular blocker instead of succinylcholine during ECT with propofol anesthesia produces similar results in terms of seizure variables at the first session and overall adverse effects. The clinical efficacy of ECT measured by CGI-I in both groups was comparable. Therefore, the combination of rocuronium-sugammadex may be an alternative to succinylcholine for ECT. However, the required dose of sugammadex in this clinical situation is not well established, rocuronium-sugammadex is much more expensive than succinylcholine therefore the cost of sugammadex continuous to be an important factor that limits its use.[10,18] Even at low doses, the combination of rocuronium-sugammadex seems to be an ideal alternative in ECT anesthesia when seizure duration, the incidence of side effects, and hemodynamic parameters are taken into account, especially in cases where succinylcholine is contraindicated.[17]

Hemodynamic parameters were similar in both groups. The postoperative period was generally uneventful in both groups, and the patients were discharged from the post-anesthesia care unit approximately 60 minutes later. There were no major complications or death during or after ECT. No adverse effects, such as nausea, vomiting, myalgia, or headache occurred with either muscle relaxants. We routinely use succinylcholine with propofol anesthesia in our ECT clinics, the data is clearly in favor of use of rocuronium-sugammadex, especially when succinylcholine is not available.

Rocuronium (0.6−1.2 mg kg^{-1}) typically produces a complete neuromuscular block within 2 minutes, as compared with an average of 1 minute with 1 mg kg^{-1} succinylcholine.[16,28] However, at this dose, rocuronium has a longer duration of action, making it inappropriate for use in ECT where rapid recovery of neuromuscular function is required.[16] Rocuronium 0.3 mg kg^{-1} IV dose is half of the recommended intubating dose for rocuronium.[29,30] A previous report by Turkkal et al.[31] using subjective tools to assess the recovery from neuromuscular blockade, showed that 0.3 mg kg^{-1} rocuronium was suitable for ECT in a crossover study in which they compared 13 patients given 0.3 mg kg^{-1} rocuronium or 1 mg kg^{-1} succinylcholine for ECT. Saricicek et al.[13] compared 0.3 mg kg^{-1} rocuronium and 4 mg kg^{-1} sugammadex combination with 1 mg kg^{-1} succinylcholine for ECT anesthesia and found that the recovery from neuromuscular blockade was faster in the rocuronium-sugammadex group compared to succinylcholine. In a case study, Postaci et al.[11] used 0.4 mg kg^{-1} ro-

curonium, and 2 mg kg^{-1} sugammadex and reported that the ECT seizure parameters of the patient were more effective and recovery times shorter than in sessions in which succinylcholine was applied. Another study[32] showed that neuromuscular recovery time was significantly longer in patients treated with low-dose rocuronium 0.25 mg kg^{-1} and low-dose sugammadex 0.5 mg kg^{-1} compared to patients treated with low-dose succinylcholine 0.5 mg kg^{-1} for bronchoscopy. We use routinely 0.5 mg kg^{-1} IV succinylcholine with 1 mg kg^{-1} IV propofol for induction anesthesia in the ECT unit.[33] Based on the fact that only partial paralysis is required for ECT, we used a rocuronium dose of 0.3 mg kg^{-1} and a sugammadex dose of 1.5 mg kg^{-1} [25,26] in this study. However, it should not be forgotten that despite all its superior properties, the expensiveness of sugammadex in today's conditions still means a very high cost for ECT when repetitive applications are taken into account, and this is an important factor limiting the use of sugammadex as a routine reversal agent.[10,18] We suggest that use of low-dose sugammadex in this clinical situation to reverse 0.3 mg kg^{-1} rocuronium block may reduce cost.

The quality and duration of the induced seizure by ECT have been associated with the efficacy of the procedure.[34] Duration of seizure is a parameter that is measured during the ECT session and is thought to be an indicator of quality. There are several reports evaluating the effects of rocuronium versus succinylcholine on seizure variables of ECT.[11,13-17,31] In their cross-over study, Turkkal et al.[31] reported that motor seizure duration was greater after 0.3 mg kg^{-1} rocuronium compared with 1 mg kg^{-1} succinylcholine (33 and 24 s, respectively) and suitable for ECT. They stated that this difference may be due to the electrical stimulation given after the cessation of fasciculations in the succinylcholine group, and the electrical stimulation 90 s after the muscle relaxant administration in the rocuronium group. The authors interpreted that this situation may have caused higher serum levels of propofol in the succinylcholine group, and as a result, the patients in the succinylcholine group were still under the influence of the central nervous system depressant effect, while the patients in the rocuronium group might have been freed from the depressant effect of propofol, resulting in longer motor seizures. Koksal et al.[15] interpreted that this prolongation in seizure duration in the rocuronium group might be related to the decreased effectiveness of propofol since ECT was applied later in rocuronium-administered patients. Similarly, Hoshi et al.[16] reported a longer seizure duration with rocuronium compared with coadministration of succinylcholine. The authors suggested that a possible explanation might be minor differences in the state of hyperventilation before electrical stimulation. In addition, they stated that it may be possible that the number of ECT sessions affected the seizure duration due to the improvement in the depressive state caused by ECT.[35] On the other hand, Kadoi et al.[14] compared rocuronium with 0.6 mg kg^{-1} and different doses of sugammadex and 1 mg kg^{-1} of succinylcholine in propofol anesthesia and found no significant difference in seizure duration among all groups. Takazawa et al.[17] reported succinylcholine below the normal application dose (0.24±0.23 mg kg^{-1}) in the first seven ECT sessions in a schizophrenic patient with pseudocholinesterase deficiency, rocuronium (0.52±0.02 mg kg^{-1}) in the next six ECT sessions, and to reverse the block, 200−400 mg sugammadex was used and they reported that seizure duration was not different between succinylcholine and rocuronium-sugammadex. They interpreted that improvement in a depressive state with ECT may affect seizure duration, therefore, the use of rocuronium after succinylcholine may mask ECT seizure duration, which is likely to be longer with rocuronium administration. Saricicek et al.[13] compared 1 mg kg^{-1} propofol anesthesia together with 0.3 mg kg^{-1} rocuronium-1.5 mg kg^{-1} sugammadex combination and 1 mg kg^{-1} succinylcholine for ECT anesthesia and reported that the patients in the two groups did not show a significant difference in terms of motor seizure duration. We compared retrospectively the seizure variables of the first session in patients who underwent ECT after administration of rocuronium-sugammadex or succinylcholine as a muscle relaxant with propofol anesthesia. Consistent with several previous studies,[13-15,17] there were no significant differences in seizure variables between the rocuronium group and the succinylcholine group and the duration of EEG seizures in both groups was also in clinically effective ranges.

The limitation of this study was its retrospective nature and, therefore, all of the variables affecting seizure duration could not be taken into account such as concomitant medications affecting the seizure duration. Moreover, we did not present the recovery times from muscle relaxation between succinylcholine and rocuronium-sugammadex, because neuromuscular monitoring during treatments was assessed but not recorded for all sessions. Adequate recovery of postoperative neuromuscular function cannot be guaranteed without objective neuromuscular monitoring.

In conclusıon, the main finding of the current study is the potential of rocuronium-sugammadex as an alternative to succinylcholine with comparable seizure during for ECT. However, further randomized and controlled studies are needed to compare these two muscle relaxants in terms of all factors affecting the success of ECT. A well-conducted economic evaluation of sugammadex would help reduce the uncertainty about the cost-effectiveness of sugammadex in the context.[10]

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: all authors. Data curation: Ceyhan Oflezer. Formal analysis: Ceyhan Oflezer. Investigation: Ceyhan Oflezer, Özge Atay, Zümrüt Ela Kaşdoğan. Methodology: all authors. Project administration: Ceyhan Oflezer. Supervision: Özge Atay. Validation: Ceyhan Oflezer. Visualization: Ceyhan Oflezer. Writing—original draft: Ceyhan Oflezer, Hakan Bahadır. Writing—review & editing: all authors.

ORCID iDs

Ceyhan Oflezer	https://orcid.org/0000-0001-5396-5939
Özge Atay	https://orcid.org/0000-0001-7681-2329
Zümrüt Ela Kaşdoğan	https://orcid.org/0000-0001-6808-5715
Gülay Özakay	https://orcid.org/0000-0002-3188-115X
Derya İpekçioğlu	https://orcid.org/0000-0001-6143-5671
Hakan Bahadır	https://orcid.org/0000-0002-2822-5741

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None

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