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Ручной динамометр и клинические тесты для оценки восстановления нервно-мышечной проводимости при применении атракурия в сравнении с рокуронием у пациентов, перенесших лапароскопическую операцию

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РЕЗЮМЕ

Введение. Послеоперационная мышечная слабость не является чем-то необычным и может быть связана с послеоперационными осложнениями у пациентов после общей анестезии. Однако анестезиологи до сих пор редко используют мониторинг нервно-мышечной проводимости в клинической практике.

Цель. Оценить скорость нервно-мышечного восстановления после применения атракурия и рокурония и определить численное значение силы сжатия с использованием ручного динамометра, указывающее на безопасность перевода пациента из послеоперационной палаты.

Дизайн исследования. Проспективное, наблюдательное, клиническое сравнительное исследование.

Материалы и методы. Исследование одобрено местным комитетом по этике. 120 пациентов, направленных на лапароскопическую операцию, с физическим статусом I и II по шкале Американского общества анестезиологов (ASA) в возрасте от 20 до 49 лет были случайным образом разделены на две группы по 60 человек в каждой. Пациенты 1-й группы получали однократную дозу атракурия в размере 0,5 мг/кг идеальной массы тела, а пациенты 2-й группы получали однократную дозу рокурония в размере 0,6 мг/кг идеальной массы тела. Такие параметры, как модифицированная оценка по шкале Альдерете (MAS), сила пожатия руки и устойчивый подъем головы и ног в течение 5 секунд, сравнивались в обеих группах с 10-минутными интервалами.

Результаты. Послеоперационное восстановление нервно-мышечной проводимости (сила пожатия) в группе, получавшей атракурий, происходило быстрее, чем в группе, получавшей рокуроний (p = 0,042 через 20 мин и p = 0,00001 на 30-й, 40-й и 50-й мин после реверсии блока. Различие во времени получения модифицированного балла Альдерете (MAS) > 8 баллов было незначимым (p = 0,335). Положительный клинический тест на длительное поднятие головы был незначимым в течение большей части времени, за исключением 20-минутного периода, когда большинство пациентов в группе атракурия были способны удерживать голову в поднятом положении в течение 5 секунд (p = 0,021). В течение 10 и 20 мин большинство пациентов в группе, получавшей атракурий, могли удерживать ногу в поднятом состоянии в течение 5 секунд (p = 0,015 и p = 0,014 соответственно). Однако большинство пациентов в обеих группах могли поддерживать голову и ноги в приподнятом положении в течение 5 секунд на 30-й мин после реверсии блока.

Заключение. По сравнению с рокуронием, атракурий способствует более быстрому восстановлению мышц после однократного введения дозы для интубации трахеи во время короткой операции. Это было установлено с помощью электронного динамометра для измерения силы пожатия. Для безопасной выписки из послеоперационной палаты может потребоваться сила сжатия в 42% от исходного уровня. Оценка на кистевом динамометре выявила большее послеоперационное ослабление мышц, чем клиническая оценка.

Ключевые слова: атракурий, рокуроний, общая анестезия, ручной динамометр, сила хвата, восстановление мышц и клинический тест

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Hand dynamometer and clinical tests to evaluate the recovery of neuromuscular conductance in atracurium versus rocuronium in patients undergoing laparoscopic surgery

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ABSTRACT

Background. Postoperative muscle weakness is not unusual and may be related to postoperative complications in patients after general anesthesia. However, the clinical practice of neuromuscular conductance monitoring is uncommon among anesthesiologists.

The **objective** was to evaluate the rate of neuromuscular recovery after atracurium and rocuronium and to determine the numerical value of grip strength using a hand dynamometer, indicating the safety of transferring a patient from the postoperative ward.

Study design. A prospective, observational, clinical comparison study.

Materials and Methods. Upon proper authorization and approval from the local ethics committee, patients referred for laparoscopic surgery, 120 patients of the American Society of Anesthesiology (ASA) physical status I &II between ages 20–49 years were randomly assigned into 2 groups of 60 each. Group I received a single atracurium dose of 0.5mg/kg of ideal body weight and Group II patients received a single rocuronium dose of 0.6mg/kg of ideal body weight. Parameters such as modified Alderete score (MAS), grip strength, and sustained head and leg lift for five seconds were compared in both groups 50 minutes after giving the reversal agent at 10-minute intervals.

Results. Postoperative muscle recovery (grip strength) was faster in the atracurium group than the rocuronium group, with a p-value of 0.042 at 20 minutes, and 0.0000 for 30, 40, and 50 minutes after giving the reversal agent. The time to obtain a modified Alderete score (MAS) > 8 scores was statistically insignificant with a p-value of 0.335. Positive clinical test for sustained head lift for 5 seconds was statistically insignificant within a majority of the time, except in the 20 minutes, most of the cases in the atracurium group were able to sustain head elevation for 5 seconds with a

p-value of 0.021. In the 10 &20 minutes, most cases in the atracurium group could sustain leg elevation for 5 seconds with a *p*-value of 0.015 and 0.014 respectively. However, most cases in both groups could sustain head and leg elevation for 5 seconds in the 30 minutes after giving a reversal agent.

Conclusion. Compared to rocuronium, atracurium has been associated with faster muscle recovery after a single tracheal intubation dose for a short surgery. This was determined by utilizing an electronic hand dynamometer to measure grip strength. 42% grip strength from baseline might be applicable for safe discharge from the recovery room. A hand dynamometer assessment revealed more post-operative muscle weakening than a clinical evaluation.

Keywords: atracurium, rocuronium, general anesthesia, hand dynamometer, grip strength, muscle recovery and clinical test

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Introduction

Historically, competitive neuromuscular block agents (CNMBAs) have been a regular element of general anesthesia (GA). These intermediate muscle relaxants are correlated with a variety of side effects, which can be outlined as early after injection that might be less noticeable as compared with delayed adverse effects, such as post-anesthesia residual paralysis (PARP), which is closely listed with long-acting muscle relaxants around 36–42% as well as noted with intermediate-acting neuromuscular blockers approximately 5%–10%. However, the overall (PARP) is 57% in patients shifted to the recovery room (RR) [8, 13]. Additionally, the periods of action and residual paralysis in atracurium versus rocuronium are various, attributed to the patient's characteristics and anesthesia techniques [15, 35], and the chance of prolonged paralysis rises with a wide duration of action [26].

Current intermediate neuromuscular block agents that are utilized can have lethal adverse effects post-general anesthesia, including pulmonary issues due to muscle fatigue, breathlessness, upper airway blockage, and mild to exceeding hypoxemia that might need re-intubation or even ICU admission [1, 11]. This might be due to post-anesthesia residual paralysis (PARP), which seems to have the ability to raise post-operative mortality and morbidity [5].

Visual qualitative assessment of muscular recovery in the recovery room is common and effortless, such as a permanent head lift and leg lift for 5 seconds. While it remains not the optimum and blinding method for many expert anesthesiologist providers to be considered for monitoring of the muscle recovery in the RR because it provides insufficient sensitivity, as with the train of four (TOF) subjective, despite its widely used as a monitoring tool for those patients who received (CNMBAs), it seems to be less used recently due to machine limitations that can't recognize the different levels of residual paralysis and associated with pain in awake patients which is not permitted by ethical committee [27, 29, 32, 36]. Hand dynamometer (HD) monitoring provides an easy technique to assess muscle recovery following general anesthesia, lessens discomfort, and may be additionally utilized in the recovery room to monitor postoperative muscle recovery [31]. Our aim of the study is to compare Atracurium and Rocuronium concerning recovery from muscle recovery, we also tried to find the numerical value for grip strength which is needed for safe discharge from the recovery room using a hand dynamometer.

Materials and Methods

Patients and measurement. Basically, as a requirement of the Al Najaf health director, Al Sader Teaching Hospital, and Al Najaf Teaching Hospital, the study was approved and accepted by an ethical committee with the code number (62124) in October 2022. The research was further authorized by the University of Sousse, Faculty of Medicine Ibn Al Jazzar, and the trial was listed at Clinical Trials.gov (NCT05657756). The research was also advisable by experienced specialist anesthesiologists and neurophysiologists, gathering cases taken from two center studies; Al Sader Medical City and Al Najaf Teaching Hospital between 2nd October 2022 to 2nd April 2024. Patients in all groups are given oral consent to enroll in this study. 120 patients aged between 20–49 years, with body mass index 18–30 Kg/m^2, of both sexes with American Society of Anesthesia physical status either ASA I or ASA II participated in scheduled laparoscopic surgery within one or less hour.

Patients were omitted, if their ages were < 20 or > 49 years, surgery other than laparoscopic; body mass index > 30 Kg/m^2; emergency surgery; pregnancy; patients who received medications that potentiated or increased resistance to neuromuscular block agents (NMBAs); all patients who suspected to have factors that increase the difficulty of NMB reversal; neuromuscular disorder; electrolyte disturbance; patient with severe hepatic or renal disease; the endocrine disease that effects metabolic rate and any known of allergic reaction to the anesthetic agents that utilized in the study. We also dropped the cases who received the second or multiple doses of neuromuscular block agent; Observer's Assessment of Alertness/Sedation Scale OAA/SS < 5 at recovery room; surgery extended to more than 1 hour; all patients who felt pain in their surgical site during maximum grip strength in the postoperative

period; and patients who were unable to complete the postoperative grip test.

Pre-operative evaluation. All patients were evaluated one day before surgery and fasting for eight hours on the day of surgery. An initial test of grip strength was applied after grip size adjustment for each patient until the second joint of the index finger was 90° of the handles, the patients were sitting on the operating table, feet flat on the floor back supported, the elbow placed on the individual sides at 90° angle [12]. Grip strength settings such as age, weight, and gender were set individually. Then we instructed the patients to squeeze an electronic hand dynamometer as hard as they could for 2 to 3 seconds without holding their breath and then release, we repeated test three times at the one-minute interval, and we chose only the maximum reading of grip strength and recorded it as initial reading. We also informed all the participants to repeat the test of handling the hand dynamometer device with maximal grip strength as much as they could on the transport trolley in the supine position with 45° head elevation postoperative in the recovery room.

Anesthesia techniques and equipment. The operation theater temperature was 20 to 25 C°, the patient was supine in position, standard monitoring according to the ASA standardization such as pulse-oximeter; electrocardiography (ECG), temperature prop; non-invasive blood pressure monitoring, capnometer, and peripheral nerve stimulator were attached to all participants, peripheral intravenous cannula gauge 20 was inserted on the opposite side of the dominant hand away from neuromuscular monitoring. A co-loading crystalloid fluid of 10 ml/kg at the first hour of surgery was given at the time of the anesthetic induction performed.

Pre-oxygenation started with 100% oxygen at regular breath within 3 minutes; patients were divided into two groups: atracurium group and rocuronium group. An induction agent was performed using intravenous midazolam (5mg), ketamine (0.5 mg/kg), propofol (2 mg/kg), atracurium (0.5 mg/kg) in the atracurium group, and rocuronium (0.6 vmg/kg) in rocuronium group, the selected one of the two neuromuscular blockers based on the anesthesiologist's preference.

The contraction of the adductor policies muscle was measured for monitoring neuro-muscular activity utilizing an acceleromyograph, two electrodes were placed over the ulnar nerve at the wrist after cleaning it with alcohol and letting it dry, and an acceleration transducer cable was attached to the thumb and fixed by tape, the hand was supported to prevent movement. Following the induction of anesthesia and loss of consciousness and completely paralyzed muscle (no response to train of four (TOF) stimulation), intubation was performed using direct laryngoscopy, endotracheal was inflated and fixed and anesthesia was maintained using 1.2–1.5% isoflurane, intraoperative adjuvant drugs were given in both groups such as acetaminophen (1 g/8 hs), nefopam hydrochloride (20 mg/6 hs, and antiemetic agents such as ondansetron (4 mg) or dexamethasone (4 mg) were used to avoid postoperative nausea and vomiting (PONV). Volume control ventilation was used to augment ventilation during the apneic period, at the end of the surgery, the isoflurane vaporizer was switched off, the lever was converted to bag mode, and the patient spontaneously breath with a tidal volume ⩾ 5 ml/kg, reversal agent was mixed of (0.04 mg/kg neostigmine with 0.02mg/kg atropine and diluted with 10 ml normal saline and given when a train of four ratios (TOFR) reaches between ⩾ 0.7 or ⩽ 0.9, and extubation was done immediately.

Postoperative evaluation and measurement. Patients were transferred to the recovery room, classic monitoring was attached and, oxygen was administered using a simple face mask; otherwise, most of our patients were on room air.

When the participants arrived at the recovery room (10 minutes after giving reversal agent), OAA/SS was assessed, the grip strength with the same dominant hand was reassessed, MAS, as well as clinical evaluation such as sustaining head and leg, lifting for 5 seconds at the following interval times 10 (arrival), 20, 30, 40 and 50 minutes after giving a reversal.

The time interval between initiating anesthesia and tracheal extubation is known as the duration of anesthesia, while the time frame from the induction of anesthesia until the skin's closing was considered the duration of the surgery.

Statistical methods. An Excel document was created once all the data was obtained, to determine whether or not there were differences between the research variables, independent t-test analysis was used to compare the two variables of the study, and the analyses run with the Statistical Package of Social Sciences (SPSS) Version 27 software program (SPSS Inc., Chicago, Illinois, United States). The percentage of the grip strength recovery at different times of giving reversal was calculated for each patient as:

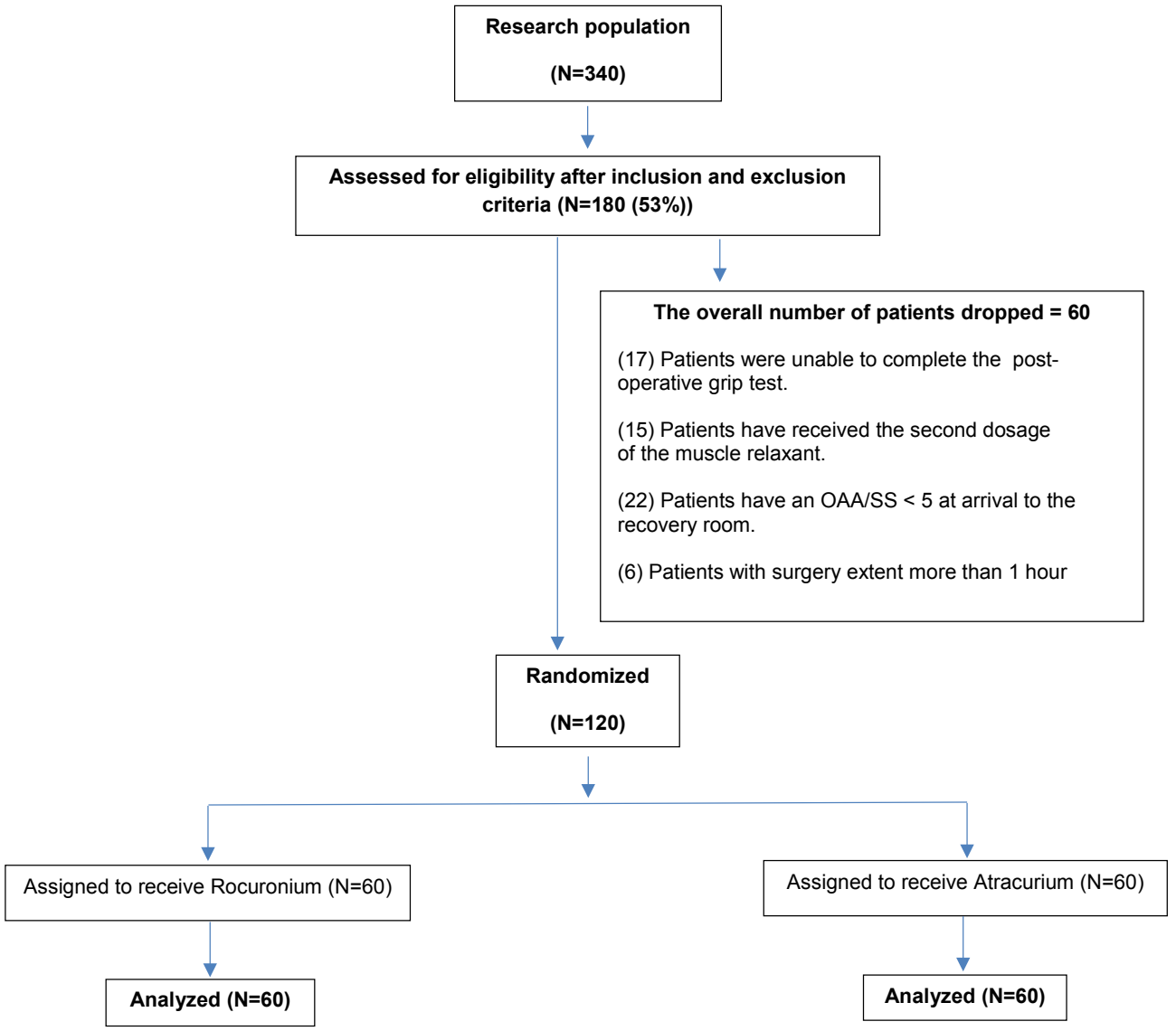
$$\% = \frac{\text{Grip strength at different times of giving reversal}}{\text{Grip strength before starting anesthesia}} \cdot 100.$$

The threshold for statistical significance was established at a P-value less than 0.05, indicating that differences with a probability of less than 5% were deemed statistically significant.

Results

Concerning inclusion, and exclusion criteria, 180 (53%) patients from the 340 patients in the research population comprise the entire sample. However, 120 patients were involved after 60 patients were dropped. Sixty Patients in each group of the atracurium and rocuronium were finished performing the necessary testing and analyzed (Figure).

Table 1 illustrates the distribution of patients based on their demographics and surgery parameters. Sixty patients were given atracurium and sixty had received rocuronium. The patients' ages ranged from 20 to 49 years and their body mass index ranged 18–30 kg/m^2. Both groups' sex, age, and BMI distributions were comparable. However, ASA, time to MAS > 8 after reversal



Research flowchart

Table 1. **Patient characteristics**

Variables	Atracurium group	Rocuronium group	P-value
Sample size	60	60	–
Age, yr	34.73 ± 8.72	34.57 ± 8.85	0.917 ns
BMI, kg/m2	25.60 ± 4.03	25.49 ± 2.73	0.855 ns
The sex ratio of male/ female	32/28	36/24	0.461
Duration of surgery (min)	29.43 ± 10.91	30.40 ± 11.00	0.630 ns
Duration of anesthesia (min)	37.78 ± 12.45	41.10 ± 12.43	0.147 ns
ASA (I/II)	37/23	41/19	0.686
Time to MAS > 8 after reversal agent (min)	17 (10–30)	18.33 (10–30)	0.335

N o t e. Data are expressed as mean ± standard deviation (SD) or number (N). No significant differences (ns). BMI – Body mass index, ASA – American Society of Anesthesia, MAS – modified Alderete score.

agent, the duration of surgery, and anesthesia were similarly comparable across the two groups, p-value > 0.05.

Participants could follow instructions when they arrived at the recovery room, Observer's Assessment of Alertness/Sedation Scale OAA/SS = 5. Table 2 demonstrated the comparison of grip strength at baseline and 50 minutes after giving the reversal agent with 10-minute intervals in both atracurium and rocuronium groups. The baseline and the first ten minutes after giving reversal showed no significant differences between groups, p-value > 0.05. Whereas for the remaining 40 minutes, there were substantial differences in the group that received atracurium as compared with the group that received rocuronium, with p-value > 0.05, the atracurium group showed a rapidly rising percentage of grip strength compared with rocuronium.

Table 2. **Comparison between grip strength Kg (%) at baseline, arrival, and 10-minute intervals in the recovery room in the atracurium and rocuronium groups**

Time (min)	Atracurium Group	Percentage of baseline	Rocuronium group	Percentage of baseline	P-value
Baseline	32.62 ± 10.42	100	29.58 ± 6.94	100	0.062ns
10 (arrival)	4.8 ± 0.88	14.7	3.77 ± 0.66	12.7	0.236ns
20	8.75 ± 0.99	26.8	6.75 ± 0.80	22.8	0.042*
30	13.6 ± 1.43	41.7	9.61 ± 0.83	32.5	0.0001**
40	17.76 ± 1.83	54.4	12.61 ± 0.95	42.6	0.0001**
50	21.45 ± 1.83	65.7	16.08 ± 1.11	54.3	0.0001**

N o t e: Data are expressed as mean ± standard deviation, ns = non-significant, * = significant at $p \leq 0.05$, ** = significant at $p \leq 0.01$, independent t-test.

Table 3. **Clinical symptoms of muscle recovery in the recovery room in both atracurium and rocuronium groups**

Sustaining head lift for 5 seconds	Atracurium group	Rocuronium group	P-value
10 min (arrival)	15 (25)	14 (23.3)	0.831
20 min	50 (83.3)	39 (65)	0.021
30 min	59 (98.3)	57 (95)	0.327
40 min	60 (100)	60 (100)	–
50 min	60 (100)	60 (100)	–
Sustaining leg lift for 5 seconds	–	–	
10 min (arrival)	46 (76.7)	25 (41.7)	0.015
20 min	55 (91.7)	45 (75)	0.014
30 min	58 (96.7)	53 (88.3)	0.083
40 min	60 (100)	59 (98.3)	0.315
50 min	60 (100)	60 (100)	–

N o t e: Data are expressed as *n* (%) patients have positive clinical tests. ns = non-significant, * = significant at $p \leq 0.05$, Chi-squared test.

Table 4. **Grip strength (%) at different times after injection of atracurium or rocuronium and reversal agent**

Time after giving reversal (min)	Atracurium grip strength (%)	Time after the Atracurium injection (min)	Rocuronium grip strength (%)	Time after the Rocuronium injection (min)
Baseline	100	–	100	–
10 (arrival)	14.7	47	12.7	51
20	26.8	57	22.8	61
30	41.7	67	32.5	71
40	54.4	77	42.6	81
50	65.7	87	54.3	91

N o t e: Data are expressed as % of grip strength and time in minutes.

The parameters of the clinical test were monitored in the atracurium and rocuronium groups during the recovery room stay are listed in Table 3. Repeated evaluation of the clinical test showed that five-second head lifts against gravity in the atracurium group were comparable as compared with rocuronium in 10 (arrival), 30, 40, and 50 minutes after giving reversal with insignificant differences between them, *p*-values more than 0.05 except 20 minutes, 50 cases in the atracurium group were able to sustain head lift for 5 seconds while only 39 in the rocuronium group, *p*-value less than 0.05.

There were significant differences regarding sustained leg lift for 5 seconds upon arrival to the recovery room (10 minutes after giving reversal), and 20 minutes later between atracurium and rocuronium groups with p-value < 0.05. Otherwise, the remaining 30 minutes in the recovery room showed no significant differences between both groups with p-value > 0.05.

Table 3, shows the grip strength percentage through 50 minutes after giving the reversal agent, simultaneously we recorded the time interval from the injection of either atracurium or rocuronium until the last 10 minutes of our recording data in the recovery room.

Discussion

The current study was conducted in the context of daily routine practice, which investigated the use of the hand dynamometer device to evaluate the return of muscle power in the recovery room after administrating a single intubation dose of atracurium or rocuronium in patients under laparoscopic surgery at two-center study in the city of Najaf- Iraq.

In the present research, an objective forced hand dynamometer was used, which was described previously as potentially a novel marker for assessing post-operative muscle recovery [18], also had a strong correlation with TOF monitoring [31], while using a train of four monitoring might be associated with machine limitations, which reported the incidence of mild to severe

pain at the post-anesthesia care unit [19, 30] alongside, M. Grayling and B. P. Sweeney (2007) reported that 62% of anesthesiologists never use the neuromuscular monitor for the estimated level of block [9].

Generally, with no comparable previous research found, our results confirmed neuromuscular recovery was faster in the atracurium group than the rocuronium group after administering a neuromuscular antagonist (neostigmine) using grip strength measurement. In the past numerous results [2, 7, 16, 37] supported our finding concerning the uses of neuromuscular monitoring (TOF monitoring), reporting that rocuronium was associated with post-residual paralysis (less TOF ratio) than atracurium over time in the recovery room, this might be as a result of two neuromuscular block agents metabolize through essentially different pathway [17, 38].

The three main criteria for discharging a patient from the recovery room are the modified Alderete score (MAS) ⩾ 8, TOF ⩾ 0.9, and a positive clinical test [28, 33]. In the current study, in the last 30 minutes of our time recording, the MAS was between 8-10 scores. No previous studies have reported the time needed to obtain the TOF ratio ⩾ 0.9 after a single intubation dose of atracurium and rocuronium. In Table 3, we determined the time from the start of injection of atracurium or rocuronium until the last 10 minutes of reporting data in the recovery room including 50 minutes' grip strength recording after giving reversal. In the paper of Murphy, S. Glenn et al. found that the time to obtain TOF ⩾ 0.9 in young adult patients who received rocuronium is 62.5 minutes [25], M. E. Sfeir said that the total recovery time TOF ⩾ 0.9 was 63 range from (51.1 to 74.5) in patients receiving rocuronium and total intravenous anesthesia, A. Milan concluded that the total recovery time TOF ⩾ 0.9 in both genders was 71 range from (51–91) minutes in patients received rocuronium with total intravenous anesthesia [22]. Both, N. Baykara et al. (2010) and F. N. C. Santos et al. (2017), studies found that the recovery time (TOF = 0.9–1.0) was about 90 minutes with either volatile agent or total intravenous anesthesia [4, 34].

In the study of W. T. Nell et al. (2004) manifested that the time to obtain TOF ratio = 0.9 was almost 60 minutes in patients under atracurium anesthesia [28], F. S. Xue et al. (1999) informed that the total duration of atracurium extends to 75.8 minutes [39], C. McCaul. et al. (2002) demonstrate that the atracurium action duration to obtain TOF equal to 0.9 prolong to 77 minutes [21], C. Motamed et al. (2005) provided that the time need to acquire TOF ratio 90% with atracurium and isoflurane anesthesia might be extended to 57 minutes [23]. All these previous studies in both atracurium and rocuronium describe the exact time from the last dose (not a single intubation dose) until full recovery TOF ratio ⩾ 0.9.

Regarding the previous studies, we found that the mean time to obtain the TOF ratio ⩾ 0.9 was 71.6 minutes in the rocuronium agent, and 67.4 minutes in the atracurium agent. In our study, in the atracurium group, 30 minutes after giving reversal (67 minutes after injection of atracurium), the grip strength was about 41.7%, while in the rocuronium group, 30 minutes after giving reversal (71 minutes after injection of rocuronium), the grip strength was about 32.6%. To follow a more conservative approach, we believe in taking the highest value as a cutoff point ≈ 42% of grip strength from baseline in both groups.

T. Fuchs-Buder et al. (2010) said that after administering 10 to 30 mcg/kg of neostigmine, none of the patients experienced a drop in their TOF ratio. In our study, we administered 40mcg/kg neostigmine [14].

However, even when the TOF ratio exceeds 0.9, clinical examinations such as tongue depressor or head lift tests must be carried out [10]. Fortunately, in the current study, we provided a clinical test of sustained head and leg lift for 5 seconds, which both have a specificity of 0.88 and 0.84 respectively, with week sensitivity of 0.19 and 0.25 [6].

The incidence rate and severity of symptoms of muscle weakness were increased in the recovery room in patients with TOF ratio of less than 0.9 [24]. In the presented research, 30 minutes after giving reversal, most cases could sustain head and leg lifts for 5 seconds in both study groups.

The inadequacy of handgrip strength after tracheal extubation has been recognized as an indicator of functional impairment [3], 50 minutes after giving reversal, the grip strength in our study was 65.7% from baseline in the atracurium group, which is similar to a study reported by P. Ch. Rama Krishna et al. (2022) [18]. However, the grip strength in the rocuronium group was 54.3% from baseline, which is lower than the grip strength reported by the study of D.-Q. P. et al. (2019) [31], the reason might be explained by the use of total intravenous anesthesia rather than inhalational anesthesia.

The hand dynamometer grip strength test has many limitations. Firstly, it cannot be used on pediatric patients. Secondly, patients undergoing surgical procedures may experience difficulties with the test. Lastly, patient cooperation is required.

Conclusion

With a single intubation dose for a short surgical procedure, atracurium is associated with rapid muscle recovery when compared with rocuronium by measuring grip strength using an electronic hand dynamometer.

Approximately 42% of grip strength will return from baseline by holding the patients for 20 minutes in the recovery room (30 minutes after giving reversal) in the atracurium group, and 30 minutes (40 minutes) in the rocuronium group.

A clinical test was less effective in measuring post-operative muscular weakening than grip strength test using hand dynamometer

Recommendations.

1. Further studies are needed with a large sample size to avoid the weakness of our study

2. Hand dynamometer monitoring device can be used as an additional tool for safe discharge from the post-anesthesia care unit.

3. Combinations of both objective hand dynamometer and clinical test for assessed postoperative neuromuscular recovery are also suggested.

4. Moreover, studies are needed to prolong the follow-up time with reported complication rates at different grip strength values.

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Conflict of Interests. The authors state that they have no conflict of interests.

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