



# ФИЗИОЛОГИЯ. ЭКСПЕРИМЕНТАЛЬНАЯ ФИЗИОЛОГИЯ

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ORIGINAL RESEARCH

ОРИГИНАЛЬНОЕ ИССЛЕДОВАНИЕ

### Combination of neuromuscular block monitoring and hand grip strength assessment for patients undergoing emergency abdominal surgery

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**Abstract. Relevance.** The hand grip strength measurement together with neuromuscular block monitoring played an important role during surgery. They both helped in losing less time during surgery and also facilitate the task of the surgeon. The aim of this study was to reduce time on intubation, facilitate the task of the surgeon and to limit post-surgical pain. In rehabilitation, hand grip strength helps in determining further recuperation measures after a surgery. There are three fundamental principles for anesthesiologist to ensure that the patient after combined endotracheal anesthesia can be extubated, the first one is to ask the patient to move his head forward, the second one is to ask the patient whether the intubation tube is disturbing him in his mouth and the third most important one is to make the patient hold his wrist very firmly. **Materials and Methods.** Monitoring of muscle relaxant on induction, intra and post-surgery is carried out using a TOF Watch SX in coordination with handgrip strength measurement on 46 patients aged from 18 to 60 years of BMI of 18–30 kg/m<sup>2</sup> 15min before endotracheal intubation and 15min, 45min and 210min post extubation by using a dynamometer “MEGEON 34090” to help us understand whether after extubation muscle strength changes and to what extent. Also, pre-anesthesiology protocol, combined endotracheal protocol, Microsoft excel advanced, monitoring of hemodynamics, ECG, PEEP, PCO<sub>2</sub>, PO<sub>2</sub>, respiratory volume using Drager Fabius. **Results and Discussion.** The results showed that to reach deep muscle relaxation both atracurium benzilate (FKP Kursk Biofabric company, Kursk, Russia) at TOF 0 took  $258.5 \pm 83.5$  secs and Cisatracurium benzilate (ZAO Obninsk Chemical pharmaceutical company, Obninsk, Russia) at TOF0– $252.4 \pm 100.1$  secs in emergency patients and basically hand grip strength also was lesser as compared to planned cholecystectomy patients. **Conclusion.** Rehabilitation was necessary for patients undergoing massive abdominal

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emergency surgeries underlying the fact that on a pain scale 10/10 post surgery, further treatments should be implemented to reduce pain, reduce residual neuromuscular block and muscle weakness after extubation at TOF 90–95 %.

**Keywords:** hand grip strength, neuromuscular block, atracurium benzilate, cisatracurium benzilate, rehabilitation, emergency abdominal surgery

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**Author contributions.** Dhunputh N. — research concept, data collection; Dhunputh N. — Analysis of data obtained; Petrova M, Butrov A. — entry of the data obtained, Analysis of data obtained; Dhunputh N, Moroz V., Magomedov M — text writing. Each author contributed personally to the interpretation of the data and writing the manuscript. All authors read and approved the final manuscript.

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## Introduction

The A pilot study was carried out in the State Budgetary Healthcare Institution of the City of Moscow “City Clinical Hospital named after V.V. Vinogradov of the Moscow Healthcare Department”; (City Clinical Hospital No.64 of Moscow Department of Healthcare), Russia where 40 patients were assessed for their hand grip resistance 15minutes before surgery, 15, 45 and 210 minutes after extubation by using a dynamometer. Also, the level of muscle relaxation was being measured pre, intra and post operation using a TOF Watch Sx. The patients were divided into two groups Group I was patients undergoing laparoscopic cholecystectomy (control group) and Group II patients were emergency abdominal surgery patients notably: (ventral hernia resection, appendectomy, gastrectomy, ileostomy) considered as the investigation group. The TOF Watch

Sx stimulates the ulnar nerve to provide a twitch of the forefinger giving results such as TOF 0 meaning complete muscle relaxation, 25 % (deep muscle relaxation) stating that the effect of muscle relaxant is slowly fading, 75 % is average muscle relaxation and 90 %-100 % which is the time of recovery from neuromuscular block NMB. Many underlying factors affect hand grip and muscle strength notably: the BMI, the circumference of the waist size, the weight, the height, the skin rigidity, the sex, the age of the patient [1], the mental status underlying medical conditions such as diabetes, COPD, malnutrition, cancer survivors following chemotherapy after abdominal surgery [2–4]. The Megeon dynamometer is an easy and fast way and cost-effective to help understand muscle weakness after abdominal surgery and help to reassess the patient’s proper rehabilitation in PACU post anesthesiological care unit [5].

## Materials and methods

The study was conducted on 46 patients both male and female with body mass index  $18 < \text{BMI} < 30 \text{ kg/m}^2$  aged from eighteen to sixty years old who verbally gave their consent and

signed an approval protocol for TOF watch Sx Organon (Dublin Ireland Serial no.14-2007058) and handgrip measurements using a MEGEON 34090 dynamometer made in China (Fig. 1).



**Fig. 1.** Megeon 34090 wrist Dynamometer measuring the hand grip strength of an 18-year-old female patient 30 minutes after laparoscopic appendectomy

Monitoring of other parameters blood pressure, pulse, body temperature and ( $\text{MAK} \geq 1,0$ ) inhalational anesthetics using Drager Fabius. While using the dynamometer to test for muscle weakness, the patients should be fully conscious before administering 30 mkg/ml phentanyl, 150mg propofol and muscle relaxant whether 0.4mg/kg atracurium benzilate (FKP Kursk Biofabric company, Kursk, Russia) or 0.15 mg/kg cisatracurium benzilate (ZAO Obninsk Chemical pharmaceutical company, Obninsk, Russia) depending on the choice of the anesthesiologist for

laparoscopic cholecystectomy and emergency abdominal surgery patients.

*Inclusion Criteria:* age limit from 18 to 60 years old adult male or female, the severity of the condition – ASA classification (American Society of Anesthesiologists) ASA Class I–IV, patients with body mass index  $18 < \text{BMI} < 30 \text{ kg/m}^2$ , patients who have agreed to participate in the study, have read the patient information sheet and signed the informed consent of the patient and are willing to cooperate in the course of the study, patients who are scheduled to undergo surgery using

total intravenous anesthesia or combined endotracheal anesthesia (propofol, fentanyl, midazolam, etc.) with an estimated duration of surgery 30–120minutes.

### Exclusion criteria

Any patients with rheumatoid arthritis, open wounds of the hand, upper limb surgery, patients who have contraindications to the use of the TOF Watch device (including Pacemaker, etc.), patients who are allergic to any one of the two muscle relaxants used.

### Statistical analysis

Data that was normally distributed were represented as mean  $\pm$  SD. Student t-test was used to determine the level of statistical significance. Differences were considered statistically significant when  $p < 0.05$ .

## Results and discussion

The combination of the TOF watch sx and handgrip is an asset to evaluate the pre and post physiological status of the patient and implement further rehabilitation measures for the quick recovery of the patients after surgery. The aging process is natural but we can practice some daily handgrip exercises to avoid it. Further research proved that hand grip strength benefits cognitive health, physical health and overall holistic health. Healthy hands and maintaining good hand grip strength Hand grip strength is related to the

improvement of life, to increased longevity, to greater independence and to lower one's blood pressure. There is a high association between robust grip strength and healthy hands, which are two important biological components that influence aging. This is also true for increased muscle mass and bone mass. To put it another way, older persons with better grips are more likely to have larger muscles and stronger bones which promote greater mobility. Additionally, there are fewer bone fractures, falls and bone diseases because of this.

Furthermore, induced paralysis by neuromuscular blocking medications ensures ideal airway management circumstances and enhances surgical filed quality. Deep neuromuscular blockade had also been shown to lessen post operative pain in several surgical scenarios. International standards now strongly advise against general anaesthesia without neuromuscular block monitoring. To prevent postoperative residual curare, maintain ideal surgical circumstances and reduce postoperative morbidity and length of stay, these factors must be taken into consideration.

Hand grip strength is slowly at 25 % restored within 15min after extubation for both abdominal surgeries using the muscle relaxants (whether atracurium and cisatracurium benzilate) then gradually at 70 % after 45 min and at 90 % 210 min respectively for mainly patients who underwent planned laparoscopic cholecystectomy (Table 1).

Table 1

The dynamometer results before intubation and after extubation for planned and emergency abdominal surgeries (kg)

Dynamometer	15 min before intubation	15 min after extubation	45 min after extubation	210 min after extubation
Atracurium Benzilate Planned Cholecystectomy	36.3 $\pm$ 14.6	17.1 $\pm$ 8.2	22.6 $\pm$ 8.5	31.5 $\pm$ 10.9
Atracurium Benzilate Emergency Abdominal Surgery	33.4 $\pm$ 11.5	16.8 $\pm$ 6.6	20.2 $\pm$ 7.6	23.5 $\pm$ 7.2
Cisatracurium Benzilate Planned Cholecystectomy	27.8 $\pm$ 9.8	15.9 $\pm$ 11.5	17.7 $\pm$ 11.6	21.4 $\pm$ 11.1
Cisatracurium Benzilate Emergency Abdominal Surgery	32.5 $\pm$ 10.4	23.6 $\pm$ 8.2	27.2 $\pm$ 9	29.8 $\pm$ 8

**Note:** For emergency abdominal surgery with both atracurium benzilate and cisatracurium benzilate it takes a longer period for hand grip strength to be restored as 15min before intubation and hand grip strength for planned cholecystectomy is mostly rapidly restored ANOVA (average, standard deviation).

For patients who underwent emergency abdominal surgery not only there was a delay in TOF to reach zero but also in the duration after intubation with both atracurium benzilate and cisatracurium benzilate (Table 2). Also, there is a difference for P-value of 0.0286 between planned laparoscopic cholecystectomy

and emergency abdominal surgery using atracurium benzilate and P-value of  $-0.09187$  using cisatracurium benzilate which denoted that a brief period of recovery more than 24 hours is needed for the emergency patients to regain their original hand grip strength as initially before surgery.

**Table 2**

**TOF results for planned (control group I) and emergency (group II) surgeries (kg)**

Types of surgeries	Group I		Group II	
	Atracurium Benzilate 0.4mg/kg N=10	Cisatracurium Benzilate 0.15mg/kg N=11	Atracurium Benzilate 0.4mg/kg N=12	Cisatracurium Benzilate 0.15mg/kg N=13
TOF 0	158.6 ± 43.9	179.4 ± 38	258.5 ± 83.5	252.4 ± 100.1
TOF 25%	46.7 ± 7	62.6 ± 12	48.3 ± 10.6	55.1 ± 15.1
TOF 75%	63 ± 10.7	72.2 ± 10.5	67.1 ± 16.5	74.3 ± 14.8
TOF 90%	75 ± 8.6	86.4 ± 14.4	78.5 ± 17.1	89.3 ± 15.4

**Note:** For Group II at TOF 0 and 75% for the atracurium benzilate and cisatracurium benzilate is higher as compared to group I. Also, an additional minimal dose of 0.1–0.2mg/kg of atracurium should be given to reach complete muscle relaxation at 90seconds – TOF0 and same applied for cisatracurium benzilate. TOF – train-of-four.

4 patients were excluded for handgrip measurement (Table 1) for atracurium benzilate and 3 patients under cisatracurium benzilate in emergency surgery because they were transported under mechanical ventilation from surgical department to intensive care unit. It was discovered that planned laparoscopic surgery patients recovered within 24–36 hours and their hand grip strength came back to normal as before surgery and they could be easily discharged from hospital as compared to the patients undergoing emergency abdominal surgery whereby it took more than 36 hours for their hand grip strength to be restored. Relatively, it was sought that on a pain scale the emergency surgery patients were mostly after operation in a very painful state remarkably on an eight-to-ten-unit scale and their recovery period also was within five days to a week time. Thus, their rehabilitation period and their period of stay in hospital was longer as compared to planned laparoscopic cholecystectomy (control group) patients. Controversially, though the TOF Watch Sx was showing complete recovery from muscle relaxant at a ratio of 0.9 after extubation, muscle weakness was still present because the dynamometer was displaying a smaller value at 25% even though the patients were

able to lift their head forward as a principle of recovery from muscle relaxant and anaesthetics denoting the fact that further care should be provided in PACU (post anaesthesiological care unit) to the patients. Proper nutrition, rehabilitation and antipain treatment at some point should be provided to the patients so that they reach their original hand grip strength and in this way muscle weakness will be eliminated. A further dose of 0.1–0.2 mg/kg of atracurium benzilate instead of 0.4 mg/kg is estimated to be the optimal dose to reach complete muscle relaxation at TOF 0 would be better considered to facilitate intubation. A further investigation should be carried out using a dynamometer to determine the appropriate values together with the circadian time to understand how they vary before and after abdominal surgery.

With an incidence of 10–40%, residual neuromuscular block is still a serious postoperative consequence. To restore airway protection, a train-of-four (TOF) ratio recovery of greater than 0.9 is advised. Even after a sufficient recovery of the TOF ratio, post-operative respiratory dysfunction is still a possibility. Some researchers have found that partial neuromuscular inhibition can result in partial



inspiratory airway collapse, even to a degree that does not produce stridor or oxygen desaturation. The recovery of motor function following surgery should therefore be objectively assessed [6].

Malnutrition is widely known to cause changes in muscle shape. After two weeks of hunger, muscle biopsy samples from morbidly obese patients, children with malnutrition 38, untreated anorexics and 37, and untreated anorexics and all exhibit myopathic alterations with selective type II fiber (anaerobic, glycolytic, fast twitch) atrophy. Malnutrition is another factor that causes Z band degeneration. Higher BMI, a clinical indicator of central obesity is linked to larger overall body mass and stronger grip strength, but higher waist circumference, which is a clinical indicator of peripheral obesity and is linked to weaker grip strength. The most metabolically active adipose tissue is abdominal fat which sheds light on probable mechanisms driving the interactions between fat and skeletal muscle. Additionally, it was supported that waist circumference measurements should be taken in clinical settings, particularly when BMI was below obese categories [7]. Even when TOF has returned to unity and even when there were no clinical symptoms of muscular weakness, a considerable loss in postoperative muscle strength can be identified using an objective forced dynamometer to test hand grip strength. A new metric for tracking post-operative muscle weakness may be the objective measurement of grip strength using a forced dynamometer. The postoperative PEFR is significantly impacted by the persistent muscle weakness supported by the authors Krishna Prasad et al. These findings indicate that female patients are more likely than male patients to still have paralysis after using muscle relaxants in our institution's standard clinical practice [8]. Muscle atrophy and weakening are linked to critical illness that results in mechanical ventilation and a lengthy stay in the intensive care unit; it is known that this weakness affects proximal limb muscles in addition to respiratory muscles [9]. The presence of sepsis, the development of multiple organ failure, hyperglycemia, the severity of the illness, aging, and prolonged immobilization are only a few of the

factors that contribute to muscular weakness in the intensive care unit [10].

Hand grip strength, a straightforward, noninvasive test that can be evaluated quickly and is highly connected with the Medical Research Council (MRC) scale score, the gold standard test for determining peripheral muscle weakness in ICU patients, represents muscular weakness [11–12]. Strong inverse relationship between hand grip strength and the length of mechanical ventilation was found, with hand grip strength significantly increasing from day 1 to day 5 of mechanical breathing. Cottreau et al. observed that hand grip strength strongly linked with extended weaning but did not correlate with extubation failure [13]. Hand grip strength has been reported to be influenced by a number of variables, including psychological state, physical activity, sickness severity, inflammation, and comorbidities, medicines, and anthropometric measurements. Using hand grip strength as a reliable indicator of weaning success is a straightforward test [14–15]. Numerous studies have shown that measuring the strength of the peripheral muscles in the hands coincides with the activity of the entire muscle group, including the diaphragm in patients under mechanical ventilation. Following mechanical respiration, Levine et al. discovered the diaphragm atrophy and becomes inactive within hours to days as a result of increased proteolysis, making weaning challenging [16–17]. People who passed away had lower hand grip values on day of mechanical ventilation than people who survived. This finding was corroborated by Ali et al. who noted a higher mortality risk in patients who developed ICU paralysis as measured by MRC and hand grip strength, as well as a significant relationship between hand grip strength and ICU stay duration [18]. They contend that hand grip strength is a reliable indicator of ICU mortality and a bad prognosis, and that it can be used to screen for and detect acquired ICU paralysis. This result differs from that reported by Cottreau et al., who reported that hand grip strength did not predict extubation failure and explained this by the existence of multiple factors involved in extubation failure, but on the other hand suggested that this point needs to be further investigated in a larger population

group [19]. Additionally, given that the majority of our patients had COPD, this may be attributable to the study groups. Acute respiratory failure, shock, coma, and drunkenness were among the groups that Cottreau et al. included. The ability of hand grip strength to predict both short- and long-term mortality and morbidity has been demonstrated in numerous clinical and epidemiological investigations. Impaired grip strength in patients is a sign of increased surgical problems, longer hospital stays, a higher rehospitalization rate, and a decline in physical condition. Loss of grip power means loss of independence, especially in older people. Further-more, epidemiological research has shown that in healthy adults, a weak grip increases the chance of functional limitations and disability as people age, as well as all-cause death [20]. Hand grip strength has also developed into a common indicator of nutritional status and is increasingly being used as an outcome variable in nutritional intervention studies because muscle function responds early to dietary deficiency according to Kristina Norman and colleagues.

### Conclusion

The dynamometer MEGEON 34090 was a low-cost instrument, non-invasive, simple and fast way to test for hand grip strength before and after abdominal surgery. By principle in the anesthesiological department to grab tightly the hand of the anesthetist, to bend the head forward or to validate that the intubation tube is disturbing the patient on operation table are verification standards to ensure that the patient recovered from inhalational anesthetics and that there was no residual muscle relaxant in their body. Muscle weakness is still present at TOF 0.9 even after extubation proving that further care should be provided to the patients transferred to PACU. A strict monitoring of handgrip strength was required in this case with digital sensors was mostly plausible to determine the accuracy of the hand grip strength. Hand strength proved to be very minimal in intensive care unit on critically ill patients with sepsis, peritonitis, diabetes type 1, massive blood loss after surgery and hemorrhagic shock since there is a correlation between neuromuscular agents







modestly potentiating in critically ill neuromuscular dysfunction. The MEGEON dynamometer also helped in understanding the risks and complications related to undernourished or malnourished patients after surgery which is due to diminished muscle protein synthesis and in the same context a newly designed schema of nutritive feeding to critically ill patients should be implemented following their hourly or daily nutritional requirements. For instance, the inclusion of more protein, healthy carbohydrates, vitamin, fibers and minerals in their diet if they are deficient of one of these nutritional values could be helpful to boost their immunity after surgery. Rehabilitation is necessary for patients undergoing massive abdominal emergency surgeries underlying the fact that on a pain scale of 10/10 post surgery, further treatments should be implemented to reduce pain (e.g. non-invasive physio-therapy, heat therapy improved circulation and blood flow to a particular area hence increasing the temperature of the afflicted area even lightly could soothe discomfort and increase muscle flexibility), reduce residual neuromuscular block (e.g. the use of proserine to reverse atracurium and cisatracurium benzilate). Also, muscle weakness after extubation at TOF 90–95 % could be remedied by assessing the altered levels of electrolytes such as calcium, potassium, sodium and magnesium and compensating their lack in the patient's body.

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## Комбинация мониторинга нервно-мышечного блока и оценки силы захвата рук у пациентов, перенесших экстренную абдоминальную операцию

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**Аннотация.** *Актуальность.* Измерение силы захвата руки вместе с мониторингом нервно-мышечного блока сыграли важную роль во время операции. Они оба помогли сократить время, потраченное на операцию, а также облегчили задачу хирурга. *Целью* этого исследования было сократить время интубации, облегчить задачу хирурга и ограничить



послеоперационную боль. В реабилитации сила захвата руки помогает определить дальнейшие меры восстановления после операции. Есть три основополагающих принципа для анестезиолога обеспечивающих возможность экстубации пациента после комбинированной эндотрахеальной анестезии: первый — попросить пациента подвинуть голову вперед, второй — спросить пациента, не беспокоит ли его интубационная трубка во рту, и третий по важности шаг — заставить пациента очень крепко держать запястье. *Материалы и методы.* Мониторинг миорелаксанта при индукции, во время и после операции проводился с помощью TOF Watch SX в сочетании с измерением силы захвата у 46 пациентов в возрасте от 18 до 60 лет с ИМТ 18–30 кг/м<sup>2</sup> за 15 минут до эндотрахеальной интубации и через 15, 45 и 210 минут после экстубации с использованием динамометра «МЕГЕОН 34090», чтобы помочь нам понять, меняется ли после экстубации мышечная сила и в какой степени. Также, преданестезиологический протокол, комбинированный эндотрахеальный протокол, мониторинг гемодинамики, ЭКГ, ПДКВ, PCO<sub>2</sub>, PO<sub>2</sub>, дыхательного объема с помощью Drager Fabius. *Результаты и обсуждение.* Результаты показали, что для достижения глубокой мышечной релаксации как атракурию (ФКП «Курская Биофабрика», Курск, Россия) при TOF 0 требовалось 258,5 ± 83,5 с, так и цисатракурию (ЗАО «Обнинская химико-фармацевтическая компания», Обнинск, Россия) при TOF0–252,4 ± 100,1 с у экстренных пациентов, а в основном сила захвата рук также была меньше по сравнению с пациентами с плановой холецистэктомией. *Выводы.* Реабилитация была необходима пациентам, перенесшим обширные экстренные операции на брюшной полости, поскольку при шкале боли 10/10 после операции необходимо проводить дальнейшее лечение для уменьшения боли, уменьшения остаточного нервно-мышечного блока и мышечной слабости после экстубации при TOF 90–95 %.

**Ключевые слова:** сила хвата руки, нервно-мышечный блок, атракурия бензилат, цисатракурия бензилат, реабилитация, экстренная абдоминальная хирургия

**Информация о финансировании.** Исследование выполнено при поддержке Программы стратегического академического лидерства РУДН.

**Вклад авторов.** Данпут Н. — концепция исследования, сбор данных; Петрова М, Данпут Н. — Анализ полученных данных; Данпут Н., Мороз В., Магомедов М. — ввод полученных данных, анализ полученных данных; Данпут Н., Бутров А. — написание текста. Каждый автор внес личный вклад в интерпретацию данных и написание рукописи. Все авторы прочитали и одобрили окончательный вариант рукописи. Информация о конфликте интересов.

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