ORIGINAL ARTICLE

Effective Management of Neuromuscular Blockade in Obese Patients Undergoing Abdominal Surgery: A Comparative Study

Zhamilia Chyngyshova[1], Ernis Tilekov[2], Zhyldyzbek Raiymbekov[1], Zhyldyzgul Derkembaeva[1], Dinara Tyrdyshova[1], Daul Natharbekov[1], Krishna Chaitanya Meduri[3], Krishna Priya Kanteti[4]

[1]Department of Anesthesiology and Intensive Care of undergraduate and postgraduate studies, I.K. Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan, [2]Department of Hospital Surgery with the course of Operative Surgery named after academician M.M. Mamakeev, I.K. Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan, [3]Department of General Medicine, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India, [4]Department of General Medicine, Gandhi Medical College and Hospital, Secunderabad, Telangana, India

Abstract

Introduction: Overweight adults are 4 times more likely to experience these problems; therefore, restoring normal lung function requires the complete removal of any remaining neuromuscular blockade (NMB) and maintenance of muscle relaxation. This study aimed to identify an effective procedure for NMB in obese patients undergoing abdominal surgery. **Materials and Methods:** Our study included 34 participants ranging in age from 18 to 56 years, with a mean age of 36.8 ± 2.7 years. The study population comprised of 15 men (45%) and 19 women (55%). Participants were divided into two groups: The control group consisted of 21 individuals with a normal body mass index (BMI), whereas the experimental group consisted of 13 individuals with a BMI that varied between 30.1 and 40.0. **Results:** Patients in the control group, who responded to T2 and T3 stimulation in the in the four-stimulation mode, received sugammadex (2 mg/kg), totaling 205.90 ± 11.14 mg. The experimental group did not receive any medications to facilitate recovery from NMB. Patients in control group had a quicker recovery time for NMB, averaging 48.00 ± 12.82 minutes, compared to Group 2, which averaged 64.91 ± 4.68 min ($t = -4.636$; $P < 0.0001$). **Conclusions:** After surgery in obese individuals, it is essential to rapidly and absolute revival of NMB and perform neuromuscular monitoring to evaluate the efficacy of removing the muscle relaxant and ensuring that no residual NMB remains.

Key words: Body mass index, neuromuscular blockade, neuromuscular monitoring, obesity, sugammadex

INTRODUCTION

Obesity, as identified by the American Heart Association, is a widespread issue that has a considerable impact on a significant portion of the nation's population. In the United States, almost one-third of adults are classified as obese and 17% of children aged 2–19 years are affected. Approximately over 500 million obese individuals and 1.4 billion overweight individuals worldwide in 2010,[1] with no demographic, including age, gender, race, or smoking status, escaping this problem.[2] A body mass index (BMI) ≥30 kg/m^2 significantly increases the risk of mortality. Compared to those in the same age group who were not obese, the death rates for those with a BMI >40 kg/m^2 6-time increase in the 35–45 years age group and 12-time increase in the 25–30 years age group [Figure 1].

Collected data from several trials show the efficacy of surgical procedures in treating obesity and associated weight-related diseases.[3] Individuals with a high BMI frequently suffer from two chronic conditions: Non-alcoholic fatty liver disease and cardiovascular disease. Obesity can result

Address for correspondence:
Krishna Priya Kanteti, Gandhi Medical College and Hospital, Secunderabad, Telangana, India.
Phone: 09391660155.
E-mail: kpriya.kanteti@gmail.com

Received: 12-02-2024
Revised: 21-03-2024
Accepted: 29-03-2024

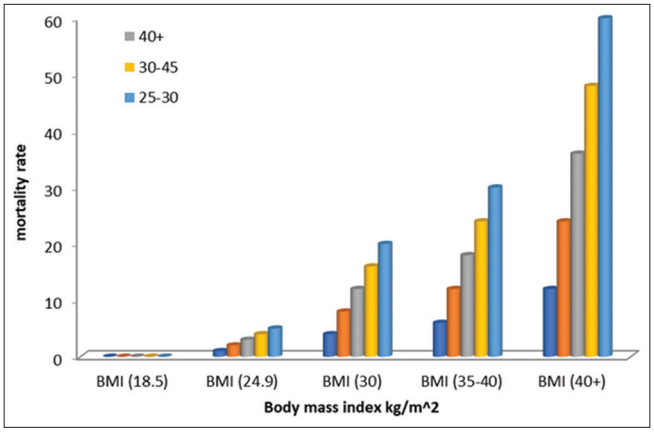

Figure 1: Incidence of relationship between death and BMI across various age groups

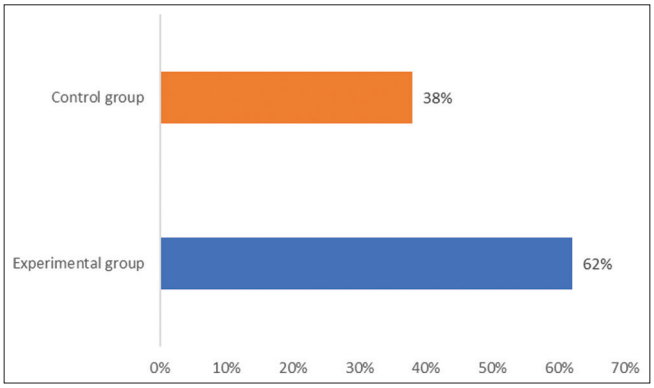

Figure 2: Distribution of obese patients into two distinct groups based on normal and elevated body mass index values

in various health conditions that can affect an quality of life of patients and increased medical care expenses. These conditions include diabetes, musculoskeletal issues, chronic renal disease, various types of cancer, mental health disorders, and varicosities, affecting 31–38% of obese individuals.[4,5] It is crucial to create a tailored plan for obese patients during the perioperative phase because to their increased vulnerability to problems compared to persons of normal weight.

Obese patients undergoing surgery require the effective removal of residual neuromuscular blockade (NMB) and the precise administration of muscle relaxation to guarantee the safety and efficacy of the surgical procedure.[6,7] The controlled administration of muscle relaxation is critical for safeguarding the lungs and preventing post-operative respiratory complications, as obese patients face a fourfold increased risk compared to individuals with normal body weights.[8]

Excess body weight can lead to a multitude of health issues, including metabolic syndrome, venous thrombosis, and obstructive sleep apnea. In addition, it can result in diaphragmatic hernias and respiratory failure. Furthermore, overweight individuals may experience an increase in stomach volume and a higher level of acidity in their digestive tract due to slow food passage.[9] This can also affect the ability of the heart to conduct electrical impulses, leading to irregular heartbeats and heightened blood flow. Two additional pulmonary function-related complications associated with obesity are hypoxemia and variations in lung capacity. In some cases, the body may react less intensely to carbon dioxide, which may affect breathing. This study aimed to assess a method for monitoring the neuromuscular system in obese individuals undergoing abdominal surgery.[10]

MATERIALS AND METHODS

Thirty-four patients were enrolled in this study in the Surgical Department of our hospital. The participants, aged between 18 and 56 years, underwent hernia surgery. The mean age was 37.0 years with a standard deviation of 3.0 years. This study included an equal number of male and female volunteers (15 men and 19 women). The participants were divided into two groups: the control group consisted of 21 individuals with a normal BMI, whereas the experimental group consisted of 13 individuals with a BMI that varied between 30.1 and 40.0 [Figure 2]. All patients received traditional anesthesia with muscle relaxants and objective perioperative monitoring.

Muscle relaxants, such as suxamethonium or rocuronium, may be administered along with fentanyl and propofol before surgery to expedite the process. The dosage of rocuronium used may be up to 1.2 mg/kg, and deep myoplegia may persist for up to an hour after administration. To maintain muscle relaxation, either bolus doses can be delivered fractionally or a constant maintenance dose can be injected. A bolus maintenance dose of antispastics and antispasmodics, with an mean duration of action of <25% of the intubating dose, is often used. The need for muscle relaxants may decrease by at least 20% when inhaled anesthetics are present, depending on the type of anesthetic used.

To assess neuromuscular function, the ulnar nerve was stimulated and muscle contraction controlling thumb movement in the hand was measured. The Train of Four (TOF) test involved delivering 4 electrical stimuli at a frequency of 2 hertz (Hz) rapidly, one after the other.

1. Electrocardiogram electrodes were placed directly above the projection of the ulnar nerve on the dry and fat-free distal portion of the forearm.
2. The sensor was positioned on the thumb pad, which was oriented such that the movement vector of the finger from the point to the brush was perpendicular to the area of the sensor.
3. The hand and the first five fingers were immobilized to prevent interference with the natural movement of the thumb.
4. After administering anesthesia, the monitor was activated and set to a current strength of 50 mA.
5. After calibration, a antispastic or antispasmodic was given, and TOF was recorded.

Anesthesia and muscle relaxation facilitate the installation of a monitor that enables examination of neuromuscular transmission. Statistical analysis was conducted using STATISTICA (V8.0; Statsoft, Tulsa, Oklahoma, USA), and the results are presented as *n* (%) and mean ± standard deviation. The parameters were compared using Student's *t*-test, and $P < 0.05$ was considered statistically significant. The study was approved by the Bioethics Committee of the National Surgical Center (Protocol No. 14, dated May 12, 2022), and the collected data were kept confidential.

RESULTS

Patients in the control group, who responded to T2 and T3 stimulation in the TOF method, received sugammadex (2 mg/kg), totaling 205.90 ± 11.14 mg. Sugammadex caused full reversion of NMB (TOF index ≥90%), with an average of 62.91 ± 13.35 s. The experimental group experienced spontaneous recovery from NMB. Individuals with a TOF index >90% fully recovered muscular function following extubation, demonstrating an evident cough reflex, capacity to swallow, strong spontaneous breathing, head stability for >5 s, and clear speech articulation. In the control group, the period from the final rocuronium dosage to the removal of the respiratory tube was 48.00 ± 12.82 min, whereas in the experimental group it was 64.91 ± 4.68 min. Individuals in the control group were cured from NMB substantially faster than those in the other groups ($t = -4.636$; $P < 0.0001$). There were no indications of NMB recurrence. No excess threshold of 1.2 mg/kg of optimal body mass was found when comparing the actual dosages computed based on the ideal weight of these individuals. Sugammadex did not cause any significant adverse effects. Within the control group, the time required for recovery phases following the deep block level (T0-T2) to extubation of the trachea (TOF 90%) was 25 ± 15 min in 99% of patients, and no instances of NMB were reported.

Laparotomy is a surgical procedure that is widely performed and requires access to the abdominal organs. To carry out this procedure successfully, the anesthesiologist must administer deep blocking while the surgeon must achieve optimal muscle relaxation. During procedures involving the upper abdominal cavity, manipulation of muscle arrays in difficult-to-reach areas is necessary to ensure proper relaxation. The duration of the procedure from laparotomy to aponeurosis suturing requires sufficient muscle relaxation, and it is recommended to focus on TOF T0-T1 indicators to maintain it. In the event of diaphragmatic contraction, the block should be strengthened. A study found that events such as diaphragmatic contractions, intestinal loops bursting into the surgical site, and the limbs and head movements occurred in 11–20% of patients at different stages of the operation.

In 22% of the patients, there was an rise in alveolar pressure, and in 26% of the cases, an overdose of a muscle relaxant was required. 38% of surgeons think that a patient's failure to muscle relaxation throughout surgery is directly related to the onset of difficulties; however, anesthesiologists usually do not acknowledge this connection. Surgeons (72%) and anesthesiologists (83%) agreed that insufficient NMB led to lengthier procedures. Since maintaining profound muscular relaxation naturally postpones the removal of endotracheal tube when muscle relaxants are provided during the final phase of treatment, many anesthesiologists decline to do so. Laparotomy sutures and wounds are worsened by subsequent surgical rejection of deep-induced myoplegia, which does not improve patient safety.

DISCUSSION

It is essential to closely monitor TOF T0-T1 signals during procedures involving the abdominal organs to achieve and maintain optimal muscle relaxation. This is particularly important because of the deep location of the structures involved and the need to prevent damage to surgical instruments. When performing surgeries on organs located in the upper part of the abdominal cavity, it is especially crucial to keep the muscles relaxed. Even if a patient does not breathe at the end of anesthesia, complete restoration of neuromuscular transmission is necessary. The use of nondepolarizing muscle relaxants in cases of subclinical NMB can result in lasting curarization, which may cause breathing difficulties in the early post-operative period. It can be challenging to diagnose, particularly in high-risk patients. Obesity is associated with hypoxemia, changes in the lung volume, and poor respiratory test results. In some cases, reduced ventilation responsiveness to carbon dioxide can affect up to 5–10% of individuals.[10]

The extensive use of contemporary muscle relaxants with superior pharmacokinetic features has facilitated enhanced patient safety and optimized anesthetic procedures.[11] Despite these advancements, existing muscle relaxants do not ensure complete control over NMB. When treating obese individuals, the depth of NMB may be quickly and precisely adjusted, leading to a significant degree of relaxation.[12,13] Compared to individuals with normal body weight, obese patients have a fourfold increased risk of postoperative pulmonary complications.[14,15] These complications are primarily caused by pneumothorax, desaturation, aspiration, bronchospasm, and laryngospasm.[16] In addition, tracheal intubation and respiratory issues are more common in obese individuals, necessitating additional precautions and preparation.[17]

CONCLUSIONS

Effective restoration of NMB in obese patients after surgery is of utmost importance, and the use of neuromuscular monitoring for evaluating the success of decurarization and no residual NMB is recommended. However, the clinical

indications for NMB recovery may not always be reliable, necessitating the use of other methods to evaluate NMB conditions objectively. Monitoring the response to TOF stimulation is the best approach for determining whether to extubate, and a minimum safety requirement of 0.9 (90%) must be met. Anesthesiologists should be able to assess the impact of muscle relaxant-induced alterations in NMB regulation through the extensive adoption of quantitative neuromuscular monitoring of NMB.

ACKNOWLEDGMENT

None.

AUTHOR CONTRIBUTIONS

Clinical management: ZC, ET, ZR, and ZD; Performed work: ZD, DT, and DN; Designed and generated idea: ZR, AD, KM, and KK; Prepared manuscript: DT, DN, KM, and KK.

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Source of Support: Nil. **Conflicts of Interest:** None declared.