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USE OF LEAN BODY WEIGHT VERSUS BODY MASS INDEX FOR CALCULATION OF DOSE OF NON-DEPOLARISING MUSCLE RELAXANT FOR PATIENTS UNDERGOING SURGERIES: APP-BASED CALCULATION

DR RATHNA A
PROFESSOR, SAVEETHA MEDICAL COLLEGE, SIMATS, CHENNAI

DR NIVEDITA
POST GRADUATE, SAVEETHA MEDICAL COLLEGE, SIMATS, CHENNAI

Abstract

Background: Precise dosing of non-depolarizing muscle relaxants (NDMRs) is critical to achieve optimal neuromuscular blockade while minimizing risks of prolonged paralysis, residual curarization, and postoperative complications. Body Mass Index (BMI)-based dosing is widely used but does not distinguish between lean body weight (LBW) and fat mass, potentially leading to under- or overdosing, especially in obese or underweight patients. LBW, representing metabolically active tissue, may provide more accurate dosing metrics.

Aim: To compare LBW-based versus BMI-based dosing of NDMRs in surgical patients using an app-based calculation method.**M**

ethods: In this prospective randomized controlled trial, 60 ASA I–III patients aged 19–65 years undergoing elective surgery at Saveetha Medical College Hospital were randomized into two groups: Group A (LBW-based dosing) and Group B (BMI-based dosing). Dosing was calculated via a custom mobile app integrating patient anthropometry. Baseline demographics, ASA status, NDMR dose, and recovery parameters (train-of-four ratio, extubation readiness) were recorded. Statistical analyses were conducted using SPSS v26, with $p<0.05$ considered significant.

Results: Groups were comparable in age, sex, ASA status, and comorbidities. LBW-based dosing yielded significantly lower mean drug doses compared to BMI-based dosing ($p<0.05$), with reduced variability and favorable trends in recovery times. Extubation readiness was achieved earlier in the LBW group, though differences did not reach statistical significance.

Conclusion: LBW-based dosing of NDMRs via app-based calculation may improve dosing precision and perioperative safety compared to BMI-based methods. Integration of technology into anesthesia practice supports individualized dosing and potentially enhances postoperative recovery.

Keywords: Lean Body Weight, Body Mass Index, Non-Depolarizing Muscle Relaxants, Atracurium, Vecuronium, Anesthesia, Neuromuscular Blockade, App-Based Calculator, Dosing Accuracy, Perioperative Safety.

INTRODUCTION

Non-depolarizing muscle relaxants (NDMRs) are an integral component of modern anesthetic practice, facilitating endotracheal intubation, optimizing surgical exposure, and enabling controlled ventilation in both elective and critical care settings [1]. Agents such as atracurium, vecuronium, rocuronium, and cisatracurium achieve skeletal muscle

relaxation by competitively inhibiting acetylcholine at nicotinic receptors of the neuromuscular junction, thereby preventing depolarization and contraction [2].

While pharmacodynamic profiles differ between benzylisoquinolinium compounds (e.g., atracurium, cisatracurium) and aminosteroidal agents (e.g., vecuronium, rocuronium), both classes share a dose-dependent onset and duration of action influenced by patient physiology, drug metabolism, and dosing accuracy [3]. Atracurium, eliminated by Hofmann degradation and ester hydrolysis, is organ-independent in clearance, while vecuronium is primarily hepatically metabolized with biliary excretion [4,5]. These differences underscore the importance of individualized dosing, particularly in patients with hepatic or renal dysfunction.

Traditional NDMR dosing uses total body weight (TBW) or BMI. BMI, calculated as weight (kg) divided by height squared (m^2), provides a crude measure of body habitus but fails to distinguish between lean and fat mass [6]. In obese patients, TBW- or BMI-based dosing may lead to excessive drug administration, prolonging recovery and increasing complication risk [7]. Conversely, underweight patients may be at risk of underdosing. Lean body weight (LBW), representing metabolically active tissue including muscle, viscera, and organs responsible for drug distribution and clearance, may be a superior dosing metric [8].

Recent advances in mobile health technology permit rapid LBW calculation using validated formulas such as Janmahasatian's equation, incorporating sex, height, and weight [9]. App-based calculators can integrate LBW into drug dosing algorithms, reducing human error and enhancing dosing precision [10]. This study evaluates LBW- versus BMI-based dosing of atracurium and vecuronium in elective surgical patients using a custom app-based calculator, hypothesizing that LBW-based dosing would reduce dosing variability and improve recovery profiles.

MATERIALS AND METHODS

A Prospective randomized controlled trial was conducted in the department of Anesthesiology, belonging to Saveetha Medical College and Hospital situated in Chennai, South India. The approval from institutional ethics committee was obtained after a proper reviewing of the study protocol . This study was registered in clinical trial registry of India (CTRI registration number CTRI/2024/07/089495) Written informed consent obtained from all participants.

The study was conducted among adult participants who fulfilled specific eligibility criteria. Individuals aged between 19 and 65 years with an American Society of Anesthesiologists (ASA) physical status classification of I to III were included. All patients were scheduled to undergo elective surgery under general anesthesia where the use of non-depolarizing muscle relaxants (NDMRs) was deemed necessary. By defining this population, the study ensured the inclusion of patients who were relatively stable and representative of the surgical population where neuromuscular blocking agents are routinely administered.

Certain exclusion criteria were applied to maintain the safety of the participants and the validity of the study outcomes. Patients with known neuromuscular disorders were excluded, as such conditions could independently alter the pharmacodynamics and pharmacokinetics of NDMRs, thereby confounding the study results. Likewise, individuals with significant hepatic or renal impairment were not enrolled, since these organ systems play crucial roles in drug metabolism and elimination, which could unpredictably affect neuromuscular blockade. Patients with documented hypersensitivity to the study drugs were also excluded to avoid adverse reactions. Additionally, emergency surgeries were omitted from the study design, as the urgency of such situations precludes the controlled administration and monitoring necessary for research standardization.

Eligible participants were randomized into two groups to ensure comparability and minimize selection bias. In Group A, drug dosing was calculated based on lean body weight (LBW), which was derived using the Janmahasatian formula integrated into a dedicated mobile application. In Group B, the dosing strategy was based on body mass index (BMI) categories according to the World Health Organization (WHO) classification. The mobile application was specifically designed to accept key patient characteristics, including sex, height, and weight, and subsequently compute both LBW and BMI. Using this data, the application provided a recommended dose of the chosen NDMR for administration. This digital approach not only standardized dose calculations but also minimized manual errors.

For both groups, either atracurium or vecuronium was administered according to the institutional anesthetic protocol, with the calculated dose adjusted based on the assigned dosing strategy. Standard ASA monitoring was applied throughout the perioperative period. This included continuous electrocardiography, non-invasive blood pressure monitoring, pulse oximetry, and end-tidal carbon dioxide measurements, thereby ensuring comprehensive surveillance of the patients' hemodynamic and respiratory status. In addition, neuromuscular monitoring was conducted using train-of-four (TOF) stimulation applied at the adductor pollicis muscle, which allowed for precise assessment of the degree of neuromuscular blockade and recovery.

The study identified both primary and secondary outcome measures. The primary endpoint was the dose of NDMR administered, expressed in milligrams per kilogram of body weight, reflecting the efficacy of the two different dosing strategies. Secondary endpoints included the time taken to achieve a TOF ratio of 0.9, which indicated satisfactory neuromuscular recovery, and the time to readiness for tracheal extubation. Intraoperative hemodynamic stability was also assessed as part of the secondary outcomes, ensuring that the dosing strategies did not compromise patient safety. Together, these parameters provided a comprehensive evaluation of the clinical impact of LBW-based dosing compared to BMI-based dosing for neuromuscular blocking agents.

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) software, version 26. Continuous variables were summarized and presented as mean values with standard deviations, providing an overview of central tendency and variability within the study groups. Categorical variables, on the other hand, were expressed as frequencies and percentages to highlight distribution patterns among participants. For comparisons between the two groups, independent t-tests were applied to continuous variables, while the chi-square test was used for categorical data. A p-value of less than 0.05 was considered statistically significant, thereby establishing the threshold for rejecting the null hypothesis and confirming the presence of meaningful differences between the groups.

RESULTS

A total of sixty patients completed the study, with thirty participants in each group. The baseline demographic and clinical characteristics of the study population are presented in **Table 1**. The mean age of patients in the LBW group was 42.1 ± 11.3 years, compared with 44.5 ± 10.8 years in the BMI group, and the difference was not statistically significant (p=0.34). The sex distribution was well balanced, with 53% males and 47% females in the LBW group compared to 50% males and 50% females in the BMI group (p=0.79). Similarly, the distribution of ASA physical status was comparable across the two groups, with ASA I/II/III proportions being 40/47/13 in the LBW group and 43/43/14 in the BMI group (p=0.88). These results confirm that the groups were homogenous at baseline, allowing meaningful comparisons of dosing and recovery parameters.

The dosing patterns of the two groups are summarized in **Table 2**. For patients who received atracurium, the mean dose in the LBW group was 0.45 ± 0.05 mg/kg, which was significantly lower than the mean dose of 0.51 ± 0.07 mg/kg in the BMI group (p=0.01). A similar trend was observed with vecuronium, where the LBW group required a mean dose of 0.085 ± 0.009 mg/kg compared with 0.095 ± 0.011 mg/kg in the BMI group (p=0.02). These findings demonstrate that LBW-based dosing resulted in consistently lower drug requirements compared with BMI-based dosing, with the added advantage of reduced variability in dose calculations, suggesting greater precision in determining neuromuscular blocker requirements.

Recovery characteristics of the two groups are presented in **Table 3**. The mean time to achieve a train-of-four (TOF) ratio of ≥0.9 was 9.4 ± 1.5 minutes in the LBW group and 10.7 ± 2.1 minutes in the BMI group. Although the LBW group exhibited a faster recovery profile, the difference did not reach statistical significance (p=0.06). Similarly, the mean time to readiness for extubation was shorter in the LBW group at 11.2 ± 1.8 minutes compared to 12.4 ± 2.0 minutes in the BMI group, again showing a favorable trend but without statistical significance (p=0.07). These observations suggest that while LBW-based dosing reduced drug administration, it did not adversely affect recovery, and may even facilitate earlier reversal and extubation, albeit not at a statistically significant level.

Overall, the results highlight that lean body weight–based dosing significantly reduces neuromuscular blocker consumption without compromising recovery characteristics. The trends observed in recovery times further suggest

that LBW dosing may provide a more consistent and efficient strategy for individualized dosing in patients undergoing general anesthesia.

Table 1. Baseline Demographics of the study subjects :

Variable	LBW Group (n=30)	BMI Group (n=30)	p-value
Age (years, mean ± SD)	42.1 ± 11.3	44.5 ± 10.8	0.34
Male/Female (%)	53 / 47	50 / 50	0.79
ASA I / II / III (%)	40 / 47 / 13	43 / 43 / 14	0.88

Table 2. Dosing Comparison between two groups of study subjects :

Drug	LBW Dose (mg/kg, mean±SD)	BMI Dose (mg/kg, mean±SD)	p-value
Atracurium	0.45±0.05	0.51±0.07	0.01*
Vecuronium	0.085±0.009	0.095±0.011	0.02*

Table 3. Recovery Parameters of the two groups of study subjects:

Parameter	LBW group	BMI group	p-value
Time to TOF ≥0.9 (min)	9.4±1.5	10.7±2.1	0.06
Time to extubation readiness (min)	11.2±1.8	12.4±2.0	0.07

DISCUSSION

This randomized controlled trial compared lean body weight (LBW)-based dosing with body mass index (BMI)-based dosing of non-depolarizing muscle relaxants (NDMRs) in patients undergoing elective surgery, using a mobile application to facilitate real-time dosing calculations. The findings demonstrated that LBW-based dosing yielded significantly lower mean drug doses with reduced variability compared to BMI-based dosing. Moreover, recovery parameters, including time to train-of-four (TOF) ratio ≥0.9 and time to extubation readiness, showed favorable trends in the LBW group, although these differences did not reach statistical significance. Taken together, the results suggest that LBW-based dosing may offer a clinically relevant advantage by optimizing drug administration without compromising recovery.

The comparison of LBW versus BMI in drug dosing is particularly relevant in anesthesia practice. BMI has been widely used as a proxy for body size, yet it does not differentiate between adipose and lean tissue compartments \[6]. This distinction is crucial for hydrophilic drugs such as atracurium and vecuronium, which distribute predominantly within lean tissues \[8,13]. Lean body weight more closely reflects physiologic determinants of drug distribution, including cardiac output, blood volume, and organ size \[9,15]. As a result, it correlates better with drug clearance and pharmacologic behavior. Previous recommendations by Erstad et al. \[11] emphasize the use of LBW or adjusted body weight for neuromuscular blockers in obese patients to minimize overdosing. The present study reinforces this recommendation, as LBW-based dosing resulted in lower drug requirements while maintaining comparable efficacy.

The findings are consistent with earlier investigations. Lee et al. \[10] demonstrated that LBW-based dosing of rocuronium, when facilitated by a mobile application, improved alignment between dose and clinical effect and reduced dosing errors in obese individuals. Similarly, Lemmens \[12] underscored the value of LBW-based dosing in avoiding unnecessary drug exposure and preventing prolonged neuromuscular blockade. A systematic review by Ingrande and Lemmens \[16] concluded that LBW is the most appropriate metric for most intravenous anesthetics and neuromuscular blockers, particularly in obese patients. Conversely, some studies have suggested that BMI-adjusted dosing may serve as a pragmatic alternative when LBW calculation tools are not readily accessible \[17]. However, the availability of mobile technology now enables rapid LBW calculation in clinical settings, reducing the reliance on

BMI approximations. Our findings, therefore, challenge the continued use of BMI-based dosing in resource-equipped environments.

Pharmacologic considerations also support LBW-based dosing. Atracurium and vecuronium have distinct elimination pathways: atracurium undergoes Hofmann degradation and ester hydrolysis, making it less dependent on hepatic or renal clearance, whereas vecuronium is metabolized hepatically with biliary excretion \[4,5]. Despite these differences, both agents demonstrate dose-dependent durations of action that can be prolonged when excessive doses are administered. This risk is particularly relevant in obese patients, where TBW- or BMI-based dosing may overestimate requirements. Overdosing not only delays recovery but also increases the risk of residual curarization, a complication strongly linked to postoperative respiratory compromise \[18,19]. In this study, earlier recovery of TOF ratio in the LBW group, although not statistically significant, suggests a potential benefit in airway safety and post-anesthesia care efficiency.

Another key aspect of this trial is the role of mobile applications in guiding anesthetic dosing. App-based tools represent a practical extension of precision medicine into perioperative care. By integrating the Janmahasatian formula, the application used in this study provided individualized dosing recommendations within seconds, eliminating manual calculation errors and promoting standardization. Yamakage et al. \[20] similarly reported that app-based anesthetic calculators improve accuracy and reduce human error. Beyond dosing, mobile tools can incorporate safety alerts, dose range checks, and pharmacokinetic modeling, further enhancing their clinical utility \[14,20]. The present findings support the incorporation of such digital platforms into routine anesthetic practice, especially in environments where workload and time pressures make manual calculations prone to error.

The clinical implications of adopting LBW-based, app-facilitated dosing extend beyond dose precision. First, reduced total drug use translates into potential cost savings without sacrificing efficacy. Second, trends toward faster neuromuscular recovery may shorten post-anesthesia care unit (PACU) stays and reduce monitoring requirements. Third, by lowering the risk of residual blockade, LBW-based dosing enhances patient safety, potentially reducing postoperative pulmonary complications. Together, these benefits align with modern goals of enhanced recovery protocols and value-based perioperative care.

Nonetheless, the study has limitations. Being a single-center trial with a relatively modest sample size, its generalizability is limited. The exclusion of patients with extreme obesity (BMI >40 kg/m²) means that the applicability of findings to morbidly obese populations remains uncertain. Furthermore, the study included only ASA I–III patients undergoing elective surgery, which excludes higher-risk populations where the benefits of LBW-based dosing might be even more pronounced. Another limitation is that the study focused on intraoperative and immediate recovery endpoints without evaluating long-term outcomes such as residual neuromuscular blockade incidence, postoperative pulmonary complications, or cost-effectiveness of app integration. Future multicenter studies with larger and more diverse cohorts are required to address these gaps.

CONCLUSION

In summary, this randomized controlled trial demonstrates that LBW-based dosing of atracurium and vecuronium, when calculated through a mobile application, significantly reduces drug requirements and narrows dosing variability compared to BMI-based dosing. Although recovery outcomes showed favorable trends with LBW, the differences were not statistically significant, likely due to the modest sample size. These findings highlight LBW-based dosing as a physiologically rational and clinically advantageous strategy for NDMR administration. The use of mobile applications further enhances precision and feasibility, supporting their integration into routine anesthesia practice. Future research should evaluate the broader clinical and economic impact of app-based LBW dosing across larger and more diverse surgical populations.

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