

Strategy to calculate magnesium sulfate dose in obese patients: A randomized blind trial

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Abstract

BACKGROUND

Magnesium sulfate has analgesic properties in the postoperative period. Among obese patients, there is a gap in the knowledge of its pharmacology related to the use of real, ideal, or corrected ideal body weight in calculating its dose. This trial compared postoperative analgesia using actual and corrected ideal body weight.

METHODS

Seventy-five obese patients scheduled to undergo laparoscopic cholecystectomy under general anesthesia were randomly assigned to three groups. Patients in the control group received no magnesium sulfate; patients in the other two groups received magnesium sulfate $40 \text{ mg}\cdot\text{kg}^{-1}$ of actual body weight or corrected ideal body weight. A ten nonobese patients group helped us as a model of the expected blood magnesium concentration after magnesium sulfate administration in general population.

RESULTS

Patients from the groups receiving magnesium sulfate showed significant reduction in morphine consumption ($p \leq 0.001$) and pain scores ($p = 0.006$) in the postoperative period compared to the control group. There was no significant difference in the consumption of morphine ($p = 0.323$) or pain scores ($p = 0.082$) between these groups. There was no difference in the total duration of neuromuscular block induced by cisatracurium among the three groups ($p = 0.181$) or in the blood magnesium concentrations throughout the study.

CONCLUSIONS

Magnesium sulfate decreased postoperative pain and morphine consumption without affecting cisatracurium recovery time in obese patients undergoing laparoscopic cholecystectomy. Analgesic profile was similar in groups receiving magnesium sulfate calculated through real or corrected ideal body weight.

TRIAL REGISTRATION

clinicaltrials.gov NCT04003688. (Date of registration: June 24, 2019)

Introduction

Magnesium sulfate (MS) has been used in various fields in medicine¹⁻⁸. It has shown many benefits, such as postoperative pain reduction and intra- and postoperative analgesic consumption reduction⁹⁻¹². It has been administered in bolus¹³⁻¹⁷ and associated with continuous infusion¹⁸.

Worldwide growth in obesity prevalence¹⁹ is associated with an increase in the frequency of obese patients in surgery rooms. This population has also taken the advantage of using MS in many situations²⁰. It is necessary to adjust the dosage of some drugs in obese populations due to pharmacokinetic changes caused by increased fat tissue²¹⁻²⁴. However, we found no studies analyzing the best way to calculate MS dose in obese patients, using actual, ideal, or corrected ideal body weight.

This trial tested the hypothesis that administering MS in obese patients calculating its dose using real body weight, compared to corrected ideal body weight, results in lower morphine consumption and postoperative pain scores.

We also investigated the level of interference of MS over cisatracurium action and blood magnesium concentration. The outcomes were onset and total duration of neuromuscular blockade²⁵ and blood magnesium concentrations over time.

Materials And Methods

This study was approved by the Institutional Review Board of the Universidade de Taubaté, SP, Brazil (IRB number 09006119.2.0000.5501) and written informed consent was obtained from all subjects participating in the trial. The trial was registered prior to patient enrollment at clinicaltrials.gov (NCT04003688, Principal investigator: Sebastião Ernesto da Silva Filho; Date of registration: June 24, 2019). This is a prospective, controlled trial, with random distribution covering the participants, medical staff, and evaluators, carried out at the hospital of the Sociedade de Beneficência Portuguesa de Santos, SP, with data collected from August 26, 2019, to November 12, 2020. This manuscript adheres to the applicable CONSORT guidelines.

Study Population

The inclusion criteria were patients aged 18 to 60 years, with American Society of Anesthesiologists physical status I or II and body mass index (BMI) $> 30 \text{ kg}\cdot\text{m}^{-2}$ and scheduled for video laparoscopic cholecystectomy. The exclusion criteria included history of allergy to any component of the study protocol, refusal to participate or sign the informed consent form, neuromuscular disorders, cardiac conduction block other than first-degree atrioventricular block, use of illicit drugs, psychiatric disorders that compromise the assessment of symptoms, use of calcium channel blockers, and renal failure.

The sample size calculated via the ANOVA effect for 95% confidence level and 80% statistical power resulted in 14 individuals for each of the three groups. We increased it to 25 participants per group to compensate for losses, with a total of 75 participants. Individuals from the population of interest were invited to participate voluntarily, and after signing the informed consent, the 75 selected individuals were divided electronically, using the resource of the website www.random.org, into three groups. In the control group (CG), 25 patients received only general anesthesia. In the real body weight group (RWG), patients received general anesthesia and MS at a dose of $40 \text{ mg}\cdot\text{kg}^{-1}$ of real weight. In the corrected ideal body weight group (CWG), patients received general anesthesia and MS at a dose of $40 \text{ mg}\cdot\text{kg}^{-1}$ of corrected ideal body weight, calculated using the Broca²⁶ index: male = $\text{height} - 100 + \{0.4 \times [\text{actual} - (\text{height} - 100)]\}$ and female = $\text{height} - 105 + \{0.4 \times [\text{actual} - (\text{height} - 105)]\}$.

The electronic drawing allowed 75 envelopes with information about the related groups and procedures that were performed by a professional blinded to the study protocol. Another team member prepared concealed solutions.

The study also included a group of 10 patients with BMI $20\text{--}30 \text{ kg}\cdot\text{m}^2$ to receive magnesium sulfate $40 \text{ mg}\cdot\text{kg}^{-1}$ and undergo the same protocol as the participants of the real body weight group. They helped us to create a

model or base of the expected blood magnesium concentration after magnesium sulfate administration in general population to be compared to obese patients.

Anesthetic Technique

Participants were monitored with continuous electrocardiography, pulse oximetry, noninvasive blood pressure on a multiparameter monitor (Mindray, model IPM-9800, China), and hypnosis level (patient state index, SedLine® Sedation Monitor, USA), before receiving any medication. Patients were also attached to a neuromuscular function monitor (TOF-Watch SX, Ireland). Immediately after venipuncture, we collected the first blood sample (2 mL) to measure the blood magnesium concentration. Next, the infusion of the concealed solution was performed and completed in 10 min. The concealed solution, depending on the group, comprised of a 100 mL saline solution or saline solution with MS for a total of 100 mL.

Patients were also administered dipyrone 15 mg·kg⁻¹, clonidine 2 µg·kg⁻¹, cefazolin 2 g, dexamethasone 4 mg, ketoprofen 100 mg, and lidocaine 1.5 mg·kg⁻¹, following the institutional protocol to prevent infection, and reduce pain, nausea, and vomiting presentation. At the end of the concealed solution, they received pre-oxygenation/denitrogenating with fraction of inspired oxygen = 1 for 3 min and propofol in target-controlled infusion to reach a concentration of 4 µg·mL⁻¹ guided by a hypnosis monitor. After appropriate hypnosis (Patient State Index [PSI] < 50), calibration of the neuromuscular function monitor was performed using train of four (TOF) monitoring, followed by 0.15 mg·kg⁻¹ cisatracurium intravenously and remifentanil infusion through target-controlled infusion until 5 ng·mL⁻¹ effect target concentration was reached. The anesthesia was maintained with propofol in target-controlled infusion to maintain PSI of 25 to 50, remifentanil in target-controlled infusion (target concentration of 3 a 5 ng·mL⁻¹), and cisatracurium 0.03 mg·kg⁻¹ if TOF > 2. The administration of cisatracurium was avoided in the last 20 min of surgery. At the end of surgery, patients with TOF > 2 were administered 20 µg·kg⁻¹ atropine and 40 µg·kg⁻¹ neostigmine. Blood samples were collected to measure the magnesium blood concentration in the arm contralateral to the arm receiving the medication, through another venous catheter put in place after anesthetic induction and kept in place throughout surgery. The collection times were as follows: venipuncture (before any medication) and at 15, 30, 60, 120, and 240 min.

Before extubation, all patients were administered morphine 0.05 mg·kg⁻¹ and dipyrone 15 mg·kg⁻¹ intravenously. Five minutes after anesthetic recovery and at every 30 min, patients received another morphine dose if the pain score was higher than 3 on the verbal numeric scale (VNS: 0 [no pain] to 10 [the highest possible pain]). In the ward, they received dipyrone 1 g intravenously (every 6 h), nalbuphine hydrochloride 10 mg every 8 h, and morphine 0.05 mg·kg⁻¹ if the pain score was higher than 3 in the VNS. All patients were discharged from the hospital on the first morning after surgery.

Outcomes Measured

The analgesic effectiveness of different doses of MS was assessed through the following outcomes: VNS at 5, 15, 30, 60, 120 and 240 minutes after awakening, and after that at 1 hour interval if the participant was awake, until the next morning, when they were all discharged. It was also recorded the highest pain score in the perioperative period during hospital stay (VNS), and morphine consumption during hospital stay.

The effects of MS on cisatracurium pharmacology were evaluated by means of onset time (time from cisatracurium administration to TOF = 0) and total duration time (time from cisatracurium administration to TOF reaching T4/T1 = 0.9). The differences in blood magnesium concentrations between the groups were compared by the concentrations verified at the collection times defined in the study protocol. The 10-patient group (BMI 20 to 30 kg.m²), called here non-obese group, was used as a reference to show how close or far the average magnesium concentration in obese patients receiving different doses of MS was from the average concentration in non-obese patients at those times.

Statistical Analysis

The hypotheses of interest were tested using a parametric test ANOVA or repeated measures ANOVA when the observations were taken over time. Samples without normal distribution were compared using the Kruskal–Wallis test. All results with a descriptive level of less than 5% ($p < 0.05$) were considered significant.

Results

CG, control group; RWG, real weight group; CWG, corrected ideal weight group.

One patient was excluded from the study (CONSORT flowchart, Fig. 1). Table 1 shows similar ASA physical status, duration of anesthesia, weight, height, and BMI.

Table 1
Demographic data, duration of anesthesia and ASA I and II distribution.

		ASA		Duration (min)	Age (years)	Weight (kg)	Height (m)	BMI (kg.m ⁻²)
		I	II					
CG (n = 25)	N	13 (52.0%)	12 (48.0%)	25	25	25	25	25
	Mean	**	**	55.960	43.720	95.160	1.648	34.969
	CI 95%*	**	**	53.353	39.523	90.589	1.615	33.985
		**	**	58.567	47.917	99.731	1.681	35.952
CWG (n = 24)	N	10 (41.7%)	14 (58.3%)	24	24	24	24	24
	Mean	**	**	58.125	42.125	92.542	1.642	34.285
	CI 95%*	**	**	54.671	37.773	87.906	1.610	32.964
		**	**	61.579	46.477	97.177	1.674	35.606
RWG (n = 25)	N	17 (68.0%)	8 (32.0%)	25	25	25	25	25
	Mean	**	**	57.000	41.760	94.320	1.644	34.801
	CI 95%*	**	**	53.861	37.630	88.167	1.616	33.124
		**	**	60.139	45.890	100.473	1.672	36.478
<i>p</i> value				0.594	0.770	0.757	0.960	0.749
ASA: American Society of Anesthesiologists physical status score; CG: control group; CWG: corrected ideal body weight group; RWG: real body weight group; CI 95%*: Confidence interval for mean; **: not applicable; <i>p</i> value of means.								

The pain scores at awakening were similar between all participants. Of note, the real and the corrected ideal body weight groups had one patient referring pain score 3, and four patients in control group referred pain level 2. Regarding the highest postoperative pain scores during their hospital stay, the real body weight group and the corrected ideal body weight group did not differ from each other, and both had lower pain scores than the control group. Pain scores and morphine consumption did not show a normal distribution. Comparison among groups showed a difference ($p = 0.006$, Kruskal–Wallis test).

The *post hoc* test for multiple comparisons revealed a statistically significant lower pain score between the real body weight group and the control group ($p = 0.005$, Bonferroni) and between the corrected ideal body weight group and the control group ($p = 0.016$, Bonferroni), but there was no statistical difference between the real weight group and the corrected ideal body weight group ($p = 0.082$, Bonferroni) (Table 2).

Table 2

Mean and CI 95% of opioid doses and highest postoperative pain scores of patients before hospital discharge

	Morphine doses (mg.kg ⁻¹)			Higher pain in hospital				
	Mean	CI 95% for mean		Median [#]	Mean	CI 95% for mean		Median [#]
CG	0.046	0.028	0.064	0.050	4.480	3.511	5.449	5.000
CWG	0.013	0.003	0.022	0.000*	2.792	2.133	3.450	2.500*
RWG	0.006	0.003	0.015	0.000**	2.400	1.705	3.095	2.000**
CWG, corrected ideal body weight group; RWG, real body weight group; CG, control group; CI, Confidence interval. Statistical significance in text.								
#Kruskal-Wallis test								
* p-value < 0.05 (Bonferroni correction) – CWG < CG								
**p-value < 0.05 (Bonferroni correction) – RWG < CG								

The real body weight group and the corrected ideal body weight group showed no significant difference in postoperative morphine consumption, and both groups showed less morphine consumption than the control group.

The multiple *post hoc* comparisons adjusted by the Bonferroni correction showed similarity in the consumption of morphine in the real body weight group and the corrected ideal body weight group ($p = 0.108$; corrected $p = 0.323$). The real body weight group ($p \leq 0.001$; corrected $p \leq 0.001$) and the corrected ideal body weight group ($p = 0.013$; corrected $p = 0.040$) had significantly lower morphine consumption than the control group (Table 2).

The real body weight group and the corrected ideal body weight group showed higher pain scores when compared to control group 30 minutes after awakening, but they were similar to each other (Table 3 – One-way ANOVA). At 60 minutes after awakening the corrected ideal body weight group was similar to control and real body weight group, but the real body weight group showed lower pain scores, when compared to control group (Table 3). Pain scores were similar between groups 120 and 240 minutes after awakening.

Table 3

Mean percentiles to pain scores (0 - no pain to 10 - the highest possible pain) taken after surgery in four moments (in minutes)

Group	30 [#]			60 [#]			120 [#]			240 [#]		
	Mean	25th	75th	Mean	25th	75th	Mean	25th	75th	Mean	25th	75th
CG	3.09	1.00	6.00	2.48	1.00	4.00	2.25	1.5	2.00	1.79	1.00	2.00
CWG	1.05*	1.00	1.00	1.67	1.00	2.00	1.79	2.00	2.00	1.96	1.50	2.00
RWG	1.00**	0.00	1.00	1.25**	1.00	1.00	1.6	1.00	2.00	1.88	2.00	2.00

CWG, corrected ideal body weight group; RWG, real body weight group; CG, control group

#One-way ANOVA

* p-value < 0.05 (Bonferroni correction) - CWG < CG

**p-value < 0.05 (Bonferroni correction) – RWG < CG

The latency and total duration of action of cisatracurium were analyzed independently using the one-way ANOVA test, with no statistical differences among the groups in any of the two variables studied (Table 4).

Table 4

Medians (minimum – maximum) and *p* value for comparison of latency and total duration of neuromuscular blockade between groups

	Latency	Total duration
CWG (n = 24)	194,5 (148–276)	4262 (3405–5112)
RWG (n = 25)	196 (156–287)	4056 (2411–5530)
CG (n = 25)	204 (171–279)	3862 (3038–5005)
<i>p</i> value	0,651	0,181

CWG, corrected ideal body weight group; RWG, real body weight group; CG, control group.

One-way ANOVA (Welch correction)

Blood magnesium concentrations in the perioperative period were tested using a two-way ANOVA test for repeated measurements. The control group had a similar blood concentration of magnesium throughout the study. A violation of the sphericity was demonstrated in the Mauchly's test. To correct this bias, the Greenhouse–Geisser method was used. The analysis showed similar blood concentrations of magnesium in all measurements performed in the control group, as expected. The real body weight group and the corrected ideal body weight group showed similar baseline blood magnesium concentrations to the control group, but an

increase at 15 min, with a progressive decay in the subsequent moments. There was no significant difference in blood magnesium concentrations between the real body weight group and corrected ideal body weight group at times of collection times provided by the study protocol (Fig. 2 and Table 5).

CG, control group; CWG, ideal corrected body weight group; NOG, non-obese group; RWG, real body weight group. *P*-value according to the times: T0: 0.753, T15: 0.162, T30: 0.108, T60: 0.136, T120: 0.445, T240: 0.341. Two-way repeated measures ANOVA test.

Table 5

Mean and standard deviation of blood magnesium concentration in the groups overtime (mg.dL⁻¹)

Time	Group	N	Mean	Standard deviation	<i>p</i> -value
T0	NOG	10	1.94	0.39	0.753
	CWG	24	2.01	0.30	
	RWG	25	2.03	0.32	
T15	NOG	10	3.49	0.92	0.162
	CWG	24	3.32	0.45	
	RWG	25	3.64	0.49	
T30	NOG	10	3.22	0.65	0.108
	CWG	24	3.08	0.40	
	RWG	25	3.36	0.40	
T60	NOG	10	2.92	0.50	0.136
	CWG	24	2.88	0.34	
	RWG	25	3.09	0.34	
T120	NOG	10	2.73	0.33	0.445
	CWG	24	2.71	0.33	
	RWG	25	2.82	0.33	
T240	NOG	10	2.40	0.29	0.341
	CWG	24	2.47	0.29	
	RWG	25	2.56	0.32	

NOG: nonobese group, CWG: corrected ideal body weight group, RWG: real body weight group, T0, T15, T30, T60, T120 and T240: baseline, and 15, 30, 60, 120, and 240 minutes after magnesium sulfate administration. Two-way repeated measures ANOVA test.

We compared the mean blood concentrations of magnesium in the obese groups with the mean concentrations generated in the nonobese group and the mean blood concentrations of magnesium evolved with values similar in all groups that received MS (Fig. 2 and Table 5).

In the corrected ideal body weight group, we compared the participants' average real body weight (92.54 kg) and the average corrected ideal body weight (73.54 kg). There was an average difference of 18.72 kg. Thus, these participants received a dose of MS 21.6% lower than the one they would have received if we had calculated this dose based on their actual weight.

Discussion

The effect of MS dose calculated using the actual body weight was similar to that calculated using the corrected ideal body weight in obese patients in terms of the blood concentration of magnesium, postoperative analgesia and recovery of neuromuscular block.

The increase in adipose tissue and muscle mass results in changes in the pharmacokinetics of many medications²¹⁻²⁴. Moreover, diseases associated with obesity reduce the physiological reserves of this population²⁷.

Despite the benefits of MS in various areas of medicine¹⁻⁸ it has side effects^{11,27,28}, such as delayed recovery of neuromuscular function and orotracheal extubation²⁹.

The low-level pain at awakening has bias related to multimodal analgesic strategy used.

In this trial, patients in groups receiving MS showed lower mean postoperative pain scores and morphine consumption. This result, already reported in other studies⁹⁻¹², is attributed to the action of magnesium in the calcium channels and N-methyl-D-aspartate (NMDA) receptors^{4,5}.

There was a difference of 21.6% between the actual body weight and the corrected ideal body weight in the corrected ideal body weight group participants in the present study. Although receiving proportionally less MS these participants showed similar analgesic outcomes, compared to the real body weight group. That lower dose might have decreased the risk of adverse effects.

The onset of the cisatracurium effect in this trial was not altered by MS. Germano et al.³⁰ did not find difference in latency of rocuronium $0.6 \text{ mg}\cdot\text{kg}^{-1}$ after MS. Czarnetzki et al.¹⁵ found a significant reduction in the latency (average of 77 versus 120 s) rocuronium $0.6 \text{ mg}\cdot\text{kg}^{-1}$ after MS at higher doses than in Germano's and in the present study ($60 \text{ mg}\cdot\text{kg}^{-1}$). The difference in the time gap between the administration of MS and the administration of rocuronium might have interfered in the results. In the aforementioned studies rocuronium was the neuromuscular blocker agent, whereas cisatracurium was the neuromuscular blocker agent in our study. Thus, the absolute times in this study cannot be compared to those found by them.

In the current study, the groups showed no differences in the total duration of the neuromuscular block. This result is different from that reported by Czarnetzki¹⁶, who found that the average total recovery time was 73.2 min (SD = 22 min) with previous administration of MS 57.8 min (SD = 14.2 min) in the control group. However, a MS dose of $60 \text{ mg}\cdot\text{kg}^{-1}$ was used before administration of rocuronium $0.6 \text{ mg}\cdot\text{kg}^{-1}$. The absolute times in this study could not be compared to those found in ours.

The 21.6% difference in the MS dose administered in the groups did not result significant difference in the resulting magnesium blood concentrations. These concentrations were always within the safe values for patients in the study³¹.

This study included a nonobese group of 10 patients, who received MS at a dose of $40 \text{ mg}\cdot\text{kg}^{-1}$, as a reference for the average magnesium concentration in the non-obese population. The comparison between the magnesium concentrations in obese patients and the nonobese group did not show any significant difference. The concentrations were also similar to those reported by Taheri et al.¹⁷.

Each gram of MS contains 98.6 mg of magnesium (Fresenius Kabi Canada, Toronto ON). In the current study, the real body weight group participants had an average actual body weight of 94.32 kg, while corrected ideal body weight group participants, had an average corrected ideal body weight of 73.54 kg. Therefore, average total doses of 3,772.8 mg and 2,941.6 mg were administered to the real body weight group and the corrected ideal body weight group participants, respectively. Based on the calculated total blood volume of $70 \text{ mL}\cdot\text{kg}^{-1}$ of ideal body weight^{22,24,32-34} we estimated an average plasma volume of 2700 mL in both groups. Based on the information above, we calculated that the corrected ideal body weight group and the real body weight group participants received 290 mg and 372 mg of magnesium, respectively. Accordingly, and ignoring the tissue distribution volume, it is expected an increase in magnesium concentration of $1.07 \text{ mg}\cdot\text{mL}^{-1}$ and $1.38 \text{ mg}\cdot\text{mL}^{-1}$, respectively. It is similar to concentrations reached after 30 min of administration, after the highest peak in the first 15 min.

The average body content of magnesium is 24 g in an individual weighing 70 kg^{35,36}. Only about 0.3% of this content is distributed in the plasma^{35,36}. This is a possible cause for the rapid balance in the concentration and similar analgesia between the groups that received MS. The patients had an average increase in body magnesium of 1.2% in the corrected ideal body weight group and 1.55% in the real body weight group. Pascoal et al.³⁷ compared two groups of 31 patients undergoing treatment with MS to prevent pre-eclampsia. After an initial dose of 6 g of MS patients received a continuous infusion of $1 \text{ g}\cdot\text{h}^{-1}$ or $2 \text{ g}\cdot\text{h}^{-1}$. The initial concentration was statistically equal between the groups ($3.7 \text{ mEq}\cdot\text{L}^{-1}$; $p = 0.96$). Thereafter, concentrations increased in the group that received an infusion of $2 \text{ g}\cdot\text{h}^{-1}$ and decreased in the group that received $1 \text{ g}\cdot\text{h}^{-1}$. The authors concluded that infusion of $1 \text{ g}\cdot\text{h}^{-1}$ can be as effective as infusion of $2 \text{ g}\cdot\text{h}^{-1}$, with a small reduction in side effects. This knowledge may be transferred to the use of MS for analgesic purposes.

Finally, there is a huge variety of volume of distribution among patients as shown in the literature. This fact might have been an important bias affecting every outcome assessed in this study⁸. But, because of the safety concerns, the present study included relatively low BMI range of the participants. Studies with participants with a higher BMI range are needed to assess behavior with even more different doses between groups.

Sugimoto et al.³⁸ recorded a reduction in the production of inflammatory cytokines (tumor necrosis factor and interleukin 6) in pregnant women submitted to MS, a mechanism that needs to be investigated in the context of the use of the substance for analgesic purposes.

Future research may clarify advantages and disadvantages of MS infusion association, the main mechanism of magnesium elimination, the role of reduction of inflammatory cytokines induced by MS in analgesia and the

therapeutic window of this medication.

In conclusion, MS decreased postoperative pain and morphine consumption without affecting the recovery time of cisatracurium in obese patients undergoing laparoscopic cholecystectomy. Compared to dose based on actual weight in obese patient, the dose of MS based on corrected ideal weight induces similar analgesia. On the other hand, the resultant magnesium blood concentration is not different with both strategies.

Abbreviations

ANOVA: analysis of variance

ASA: American Society of Anesthesiologists

BMI: body mass index

CG: control group

CI: confidence interval

CONSORT: Consolidated Standards of Reporting Trials

CWG: corrected ideal body weight group

IRB: Institutional Review Board

MS: magnesium sulfate

NCT: The National Clinical Trial

NMDA: N-methyl-D-aspartate

PSI: patient state index

RWG: real body weight group

TOF: train of four

VNS: verbal numeric scale

Declarations

Ethics and Consent to participate

The study has been approved by the Institutional Review Board of the Universidade de Taubaté, SP, Brazil (IRB number 09006119.2.0000.5501) and written informed consent was obtained from all subjects participating in the trial before the data collection. The trial was registered prior to patient enrollment at clinicaltrials.gov (NCT04003688, Principal investigator: Sebastião Ernesto da Silva Filho; Date of registration: June 24, 2019).

Consent for Publication

Not applicable.

Availability of data and material

All the data used and analyzed are available from corresponding authors upon the reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author's contributions

Sebastião Ernesto da Silva Filho helped in the project creation, data analysis and drafting the manuscript. Omar S. Klinsky contributed to project creation, data collection and conduction of anesthesia. Joaquim Edson Vieira helped in the project creation, in randomization, allocation and in building the manuscript.

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Implication statement

This manuscript adheres to the CONSORT guidelines.

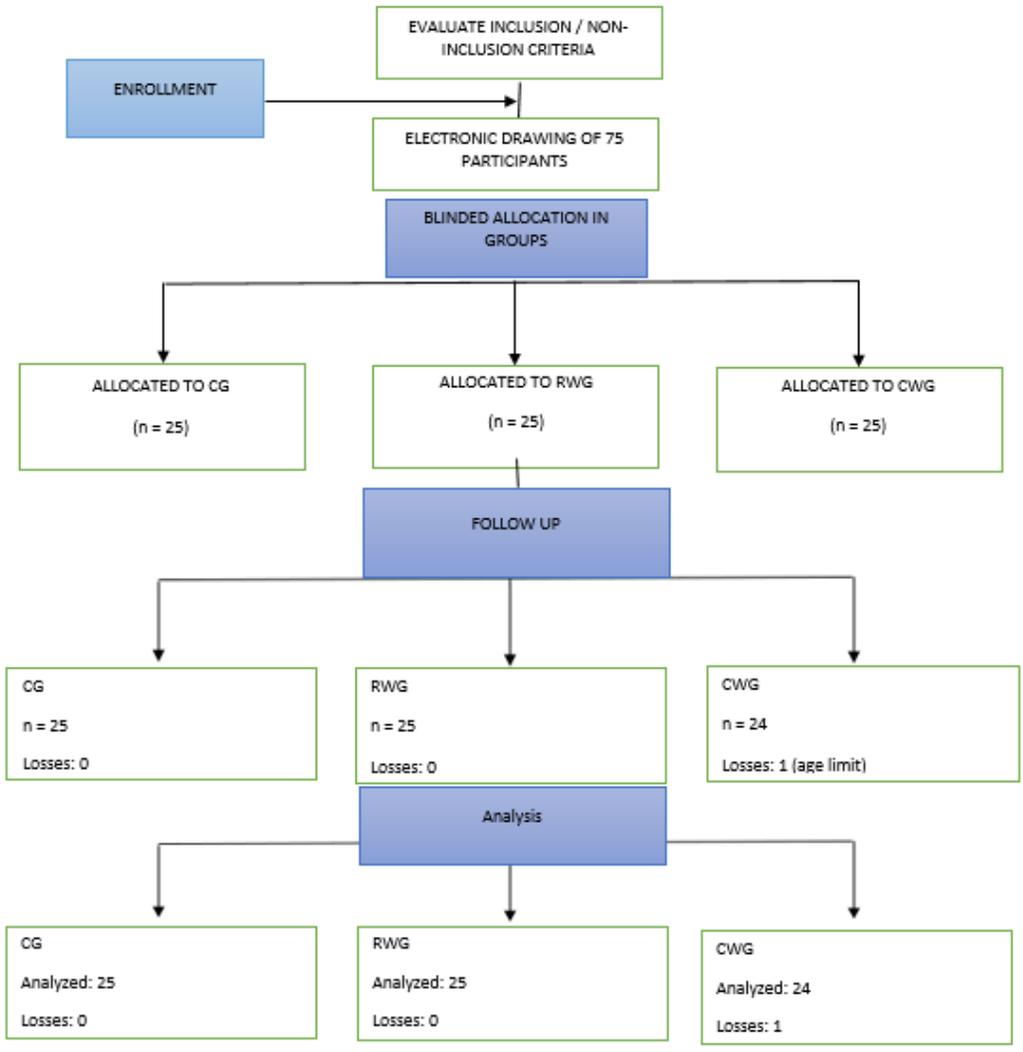
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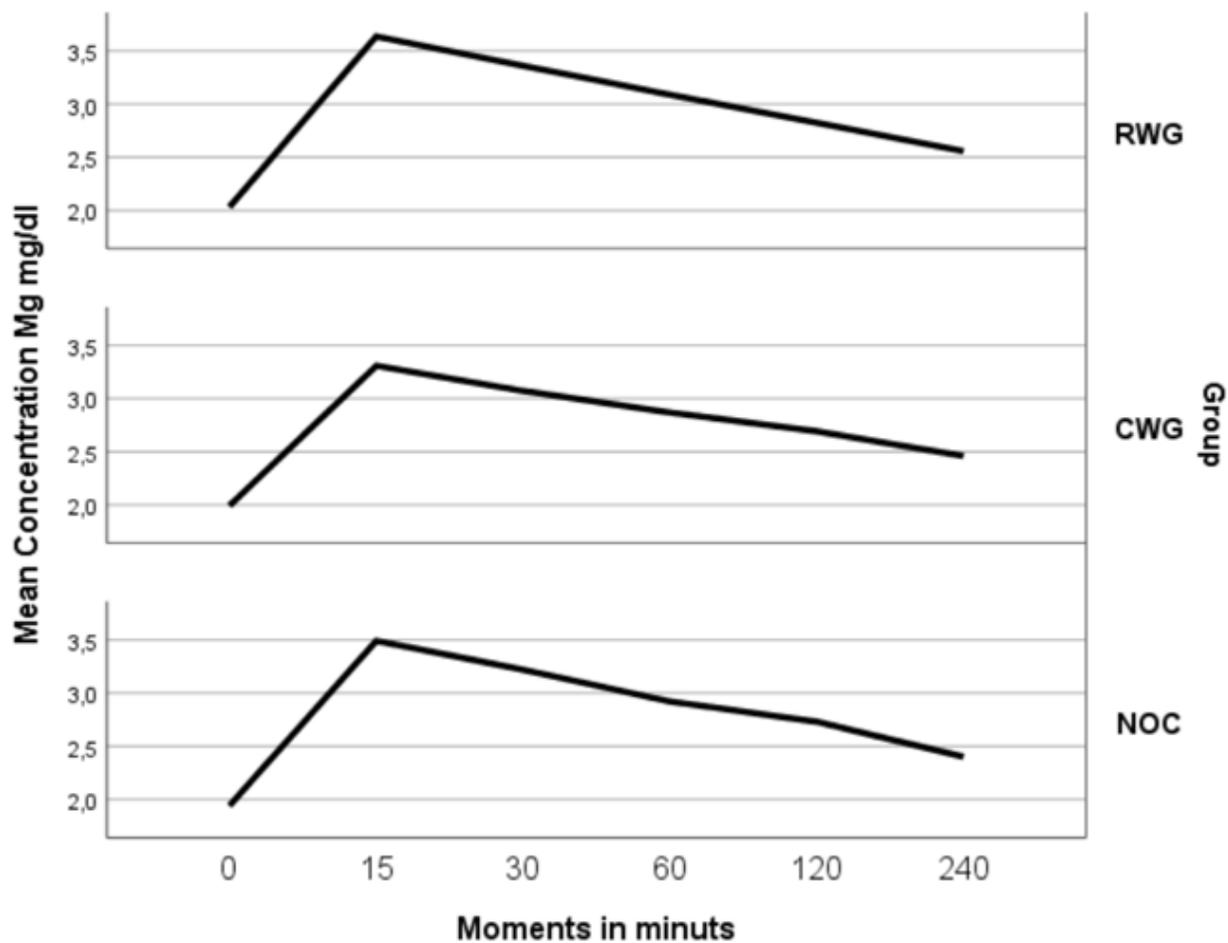
Figures



CG, control group; RWG, real weight group; CWG, corrected ideal weight group.

Figure 1

CONSORT Flowchart



CG, control group; CWG, ideal corrected body weight group; NOG, non-obese group; RWG, real body weigh group. *P*-value according to the times: T0: 0.753, T15: 0.162, T30: 0.108, T60: 0.136, T120: 0.445, T240: 0.341. Two-way repeated measures ANOVA test.

Figure 2

Blood magnesium concentration throughout the study