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Análise dos Efeitos da Manobra de Recrutamento Alveolar na Oxigenação Sanguínea durante Procedimento Bariátrico*

Analysis of the Effects of the Alveolar Recruitment Maneuver on Blood Oxygenation during Bariatric Surgery

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RESUMO

Souza AP; Buschpigel M; Mathias LAST; Malheiros CA, Alves VLS — Análise dos Efeitos da Manobra de Recrutamento Alveolar na Oxigenação Sanguínea durante Procedimento Bariátrico.

JUSTIFICATIVAS E OBJETIVOS*: A manobra de recrutamento alveolar (MRA) é indicada no tratamento de atelectasias intraoperatórias. O objetivo do presente estudo foi comparar duas técnicas de MRA por meio da resposta da relação PaO_2/FiO_2 e da soma $[PaO_2+PaCO_2]$, em pacientes obesos grau III.*

MÉTODO*: Estudo prospectivo aberto em pacientes adultos, obesos grau III, submetidos a procedimento cirúrgico bariátrico em ventilação controlada a volume, pressão positiva no final da expiração (PEEP) de 5 cmH_2O e divididos em três grupos: G_{CONT}: PEEP de 5 cmH_2O; $G_{MRA10/15/20}$ após sutura da aponeurose: aumento progressivo da PEEP para 10,15 e 20 cmH_2O, pausa de 40 segundos e manutenção de cada valor da PEEP por 2 minutos; G_{MRA30}: após sutura da aponeurose: aumento súbito da PEEP para 30 cmH_2O, 40 segundos de pausa e manutenção da PEEP em 30 cmH_2O por dois minutos. Foram analisadas as variáveis frequência cardíaca, pressão arterial média, sistólica, diastólica, pressão média das vias aéreas (P_{MVA}) e de platô (P_{PLAT}), pressão arterial de oxigênio (PaO_2), pressão arterial de CO_2 ($PaCO_2$), relação PaO_2/FiO_2 (fração inspiratória de oxigênio) e soma $[PaO_2+PaCO_2]$.*

RESULTADOS*: As variáveis que apresentaram diferença estatística significativa entre os três grupos foram: P_{PLAT}, $P_{MVA,}$ PaO_2, relação PaO_2/FiO_2 e soma $[PaO_2+PaCO_2]$ ($p < 0,0001$). Na comparação dos grupos dois a dois, verificou-se diferença estatística significativa para as variáveis P_{PLAT} e P_{MVA}: G_{CONT} X $G_{MRA10/15/20}$ e G_{CONT} X G_{MRA30} e para as variáveis relação PaO_2/FiO_2 e soma $[PaO_2+PaCO_2]$: G_{CONT} X G_{MRA30}.*

CONCLUSÕES*: A técnica de MRA com aumento súbito da PEEP para 30 cm H_2O mostrou a melhor resposta da relação PaO_2/FiO_2.*

Unitermos: CIRURGIA, Bariátrica; COMPLICAÇÕES: atelectasia; VENTILAÇÃO: manobra de recrutamento alveolar, pressão positiva ao final da expiração

SUMMARY

Souza AP; Buschpigel M; Mathias LAST; Malheiros CA, Alves VLS – Analysis of the Effects of the Alveolar Recruitment Maneuver on Blood Oxygenation During Bariatric Surgery.

BACKGROUND AND METHDS: *Alveolar recruitment maneuver (ARM) is indicated in the treatment of intraoperative atelectasis. The objective of the present study was to compare two techniques of ARM using the response of the PaO_2/FiO_2 ratio and $[PaO_2 + PaCO_2]$ in patients with grade III obesity.*

METHODS: *This was an open prospective study with adult patients with grade III obesity who underwent bariatric surgery under volume-controlled mechanical ventilation with positive end-expiratory pressure (PEEP) of 5 cmH_2O, divided in three groups: G_{CONT}: PEEP of 5 cmH_2O; $G_{ARM10/15/20}$ after suture of the aponeurosis: progressive increase in PEEP to 10, 15, and 20 cmH_2O with a 40-second pause and maintaining each level of PEEP for 2 minutes; and G_{ARM30} after suture of the aponeurosis: sudden increase in PEEP to 30 cmH_2O with a 40-second pause and maintaining a PEEP of 30 for 2 minutes. Heart rate, mean arterial pressure, systolic and diastolic blood pressure, mean (P_{AW}) and plateau (P_{PLAT}) airways pressure, partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$), PaO_2/FiO_2 ratio (inspired fraction of oxygen), and $[PaO_2 + PaCO_2]$ were analyzed.*

RESULTS: *The following parameters showed statistically significant differences among the study groups: P_{PLAT}, P_{AW}, PaO_2, PaO_2/FiO_2 ratio, and $[PaO_2 + PaCO_2]$ ($p < 0.0001$). Comparing the groups two by two, the following parameters showed statistically significant differences: for P_{PLAT} and P_{AW}: G_{CONT} x $G_{2ARM10/15/20}$ and G_{CONT} x G_{ARM30}; and for PaO_2/FiO_2 ratio and $[PaO_2 + PaCO_2]$: G_{CONT} x G_{ARM30}.*

CONCLUSIONS: *Alveolar recruitment maneuver with sudden increase of PEEP to 30 cmH_2O showed a better response of the PaO_2/FiO_2 ratio.*

Key Words: COMPLICATIONS: atelectasis; SURGERY, Bariatric; VENTILATION: alveolar recruitment maneuver, positive end-expiratory pressure.

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constatação foi possível, mesmo quando obesos foram ventilados com parâmetros menores de VC (entre 10 e 11 $mL.kg^{-1}$) e FiO_2 reduzida (0,4) [7].

A manutenção do volume corrente também é passível de discussão na literatura, sendo relacionada quando acima de 12 $mL.kg^{-1}$ à hiperinsuflação alveolar, compressão de capilar pulmonar adjacente e inadequada troca gasosa. Hedenstierna [13] chama a atenção como principais causas de colapso alveolar a perda do tônus muscular e o uso de altas frações inspiradas de oxigênio (FiO_2). No presente estudo, a manutenção de VC constante de 10 $mL.kg^{-1}$ e FiO_2 de 0,5, seguiu a orientação do consenso de ventilação mecânica brasileiro com resultado semelhante ao de Coussa e col. [2] e Pelosi e col. [14], em que pacientes obesos ventilados com VC de 10 $mL.kg^{-1}$ demonstram melhora significativa da PaO_2, pois o IMC está relacionado à diminuição da CRF.

O emprego da PEEP é tipicamente associado ao aumento da P_{MVA} que nos três grupos pesquisados mostrou-se constante desde o início da intervenção cirúrgica, havendo o aumento proporcional ao emprego de maiores níveis de PEEP [32].

A P_{MVA} elevada sugere maior vulnerabilidade da mecânica pulmonar, porque o incremento nos níveis de PEEP aumentava a P_{PLAT} significativamente. A resistência sofrida pelo tecido adiposo na região torácica dos pacientes analisados pode também ter contribuído para alteração significativa da P_{MVA} em todas as fases de alteração da PEEP [1,7,15].

A relação entre o IMC e a CRF foi relatada por vários autores que estudaram as alterações nas trocas gasosas em obesos [7,15-19]. A diminuição da CRF é também característica comum ao período após a instalação da ventilação mecânica, com o relato de Pelosi e col. [9] propondo a relação entre a redução da oxigenação e do volume pulmonar de forma inversa ao IMC.

Tendo isso em vista, a manobra de recrutamento alveolar (MRA) é uma técnica que, utilizando o aumento sustentado de pressão na via aérea, proporciona a abertura de unidades alveolares colapsadas, aumentando a área pulmonar disponível para a troca gasosa e, consequentemente, a oxigenação arterial [20].

As respostas à MRA para lesão pulmonar aguda (LPA) e síndrome do desconforto respiratório agudo (SARA) com pressões de 45 cmH_2O em pacientes não obesos podem apresentar diferentes perfis pulmonares classificados como: pouco recrutáveis, razoavelmente recrutáveis ou potencialmente recrutáveis [18]. Obesos também podem ser assim classificados, pelo IMC elevado, comprometimento da caixa torácica, aumento da resistência e diminuição da complacência. Isso pode dificultar a comparação dos resultados obtidos para o recrutamento alveolar como já relatado em diversos estudos [8,9,15].

A relação PaO_2/FiO_2 e índice da soma $[PaO_2 + PaCO_2]$ nos três grupos estudados mostraram aumento progressivo, porém sem haver alterações entre os grupos e a soma representada pela $[PaO_2 + PaCO_2]$, revelando ausência de lesão pulmonar (valor normal: ≥ 400 mmHg com $FiO_2 = 1$). Entretanto, pacientes do G_{MRA30} tiveram melhor resposta da relação PaO_2/FiO_2 e da soma $[PaO_2 + PaCO_2]$, com este último índice ainda sendo pouco utilizado durante a pesquisa da resposta à MRA em pacientes com LPA e SARA.

Borges e col. [24], analisando pacientes com lesão pulmonar aguda associada à hipoxemia precoce, mostraram que a LPA pode ser revertida quando se utilizam elevados índices de pressão na via aérea (acima de 60 cmH_2O). Entretanto, os efeitos deletérios (barotraumas, hiperinsuflações, diminuição do índice cardíaco e hemodinâmica prejudicada) são mais comumente vistos quando estes mesmos valores de pressão inspiratória são utilizados por tempo prolongado [25].

O procedimento da MRA com PEEP com 30 cmH_2O utilizado no G_{MRA30} foi idealizado conforme proposta do Consenso Americano-Europeu, mostrando melhor resposta na relação PaO_2/FiO_2, PaO_2 e da soma $[PaO_2+PaCO_2]$ [26].

De acordo com a literatura, o método mais utilizado entre os autores para o uso de pressão sustentada na via aérea é realizado pela modalidade ventilatória em CPAP (pressão positiva contínua nas vias aéreas), com níveis de pressão que variam de 30 a 40 cmH_2O durante 30 a 90 segundos em pacientes com SARA [20,27,28].

Em outros estudos [6,29], este valor de pressão foi mantido por 15 segundos com a área do recrutamento sendo acompanhada por tomografia computadorizada enquanto a MRA era realizada. Dessa forma os autores perceberam que, após sete segundos de recrutamento, houve melhora significativa da PaO_2 e diminuição efetiva das áreas com atelectasias.

A vantagem da menor duração da MRA é a menor incidência da diminuição do débito cardíaco e da pressão arterial [9], porém o estudo possui amostra pequena, sendo classificado como recomendação nível D de evidência científica. No presente estudo o tempo de manutenção dos altos níveis de PEEP foi de dois minutos e não alterou a hemodinâmica dos pacientes.

Nas condições do estudo realizado a melhor resposta da relação PaO_2/FiO_2 foi encontrada com PEEP de 30 cmH_2O com tempo de dois minutos de manobra de recrutamento alveolar.

Analysis of the Effects of the Alveolar Recruitment Maneuver on Blood Oxygenation during Bariatric Surgery

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INTRODUCTION

The development of atelectasis is common during general anesthesia due to the reduction in residual functional capacity (RFC) [1,2]. This situation tends to be worse in patients with

grade III obesity since their RFC is already reduced during spontaneous breathing [3].

Alveolar recruitment maneuver (ARM) consists of sustained insufflations, mainly with the use of positive end-expiratory pressure (PEEP). The use of ARM is indicated in the presence of atelectasis or alveolar hypoventilation, in the initial stages of pulmonary lesion and acute respiratory distress syndrome, and in patients with alveolar instability [4-6]. In open bariatric surgery, the use of PEEP to prevent the development of areas of atelectasis has been suggested, although the levels have not been established, which motivated this study.

The objective of the present study was to compare two techniques of ARM using the response of the ratio between the partial pressure of oxygen and the inspired fraction of oxygen (PaO_2/FiO_2) and the sum of the partial pressure of oxygen with the partial pressure of carbon dioxide [$PaO_2 + PaCO_2$] in patients with grade III obesity undergoing open bariatric surgery.

METHODS

After approval by the Ethics Committee of the Irmandade da Santa Casa de Misericórdia de São Paulo, patients from the Department of Surgery of the Stomach, Duodenum and Obesity Division with the diagnosis of grade III obesity undergoing sylastic ring gastric bypass with Y-en-Roux anastomosis, from March 2004 to June 2005, were enrolled in this open, prospective study.

Patients underwent preoperative evaluation by a multidisciplinary team, all necessary explanations were given, and an informed consent was signed.

Patients were randomly divided in three groups:

- Control group (G_{CONT}): ventilation with PEEP of 5 cmH_2O;
- ARM 10/15/20 group ($G_{ARM10/15/20}$): progressive ARM with PEEP of 10, 15, and 20 cmH_2O;
- ARM 30 group (G_{ARM30}): conventional ARM, according to the American-European Consensus, using PEEP of 30 cmH_2O and plateau pressure (P_{PLAT}) of 35 cmH_2O [5,6].

Inclusion criteria were as follows: BMI > 40 $kg.m^{-2}$; and normal pulmonary function tests or with mild abnormalities. Patients with history of spontaneous pneumothorax and laparoscopic gastroplasty were excluded.

The sequence of care of patients in all three groups was identical. In the operating room, a peripheral vein was cannulated with an 18G catheter and hydration with Ringer's lactate was initiated.

Patients were placed in dorsal decubitus with discrete head-up tilt. The following parameters were monitored: heart rate (HR); electrocardiogram (ECG); non-invasive systolic (SBP) and diastolic (DBP) blood pressure; and peripheral hemoglobin saturation (SpO_2).

Ventilation was initiated with 100% O_2 with a face mask, followed by anesthetic induction with the sequential administration of intravenous midazolam (5 to 10 mg), alfentanil (300 µg), propofol (2 to 3 $mg.kg^{-1}$), and atracurium (50 mg). Anesthesia was maintained with propofol, 0.075 to 0.1 $mg.kg^{-1}.min^{-1}$, and alfentanil, 0.75 to 1.0 $\mu g.kg^{-1}.min^{-1}$.

After tracheal intubation, patients were maintained with volume-controlled mechanical ventilation using the anesthesia equipment in a semi-closed circular system (model LINEA A Intermed® Brazil), with tidal volume (VT) of 8 to 10 $mL.kg^{-1}$ of ideal weight, limiting pressure to 45 cmH_2O, inspired fraction of O_2 (FiO_2) of 0.5, respiratory rate of 12 to 14, and PEEP of 5 cmH_2O.

Study groups:

- G_{CONT}: ventilation with PEEP of 5 cmH_2O until the end of the surgery (Figure 1).

In the other two groups, ARM was done after suture of the aponeurosis as follows (Figure 1):

- $G_{ARM10/15/20}$:
  - progressive increase of PEEP to 10 cmH_2O; 40-second pause; PEEP of 10 cmH_2O maintained for 120 seconds;
  - progressive increase of PEEP to 15 cmH_2O; 40-second pause; PEEP of 15 cmH_2O maintained for 120 seconds;
  - progressive increase of PEEP to 20 cmH_2O; 40-second pause; PEEP of 20 cmH_2O maintained for 120 seconds; and
  - gradual reduction in PEEP to the initial level of 5 cmH_2O every 5 ipm.
- G_{ARM30}:
  - sudden increase of PEEP from 5 to 30 cmH_2O; 40-second pause; PEEP of 30 cmH_2O maintained for 120 seconds;
  - gradual reduction in PEEP to the initial level by 5 cmH_2O every 5 ipm.

Parameters analyzed included: age, gender, weight, height, and BMI; length of surgery; HR, SBP, and DBP; SpO_2, PaO_2, $PaCO_2$, PaO_2/FiO_2 ratio, [$PaO_2 + PaCO_2$], plateau pressure (P_{PLAT}), and mean airways pressure (P_{MAV}); and intraoperative complications.

Heart rate, SBP, DBP, and SpO_2 were analyzed before induction and every 5 minutes until the end of the procedure. Partial pressure of oxygen, $PaCO_2$, $PaO_2/PaCO_2$ ratio, [$PaO_2 + PaCO_2$], plateau pressure (P_{PALT}), and mean airways pressure (P_{AW}) were analyzed immediately after suture of the aponeurosis (before ARM) and at the end of ARM.

ANOVA was used to compare quantitative parameters in relation to the three groups, and the Kruskal-Wallis test and the Tukey method were used for multiple comparisons. The chi-square test was used to compare qualitative parameters. The level of significance adopted was 5%.

The software SPSS (Statistical Package for the Social Sciences) for Windows 10.01 and the Epi Info version 3.2.2 were used for the statistical analysis.

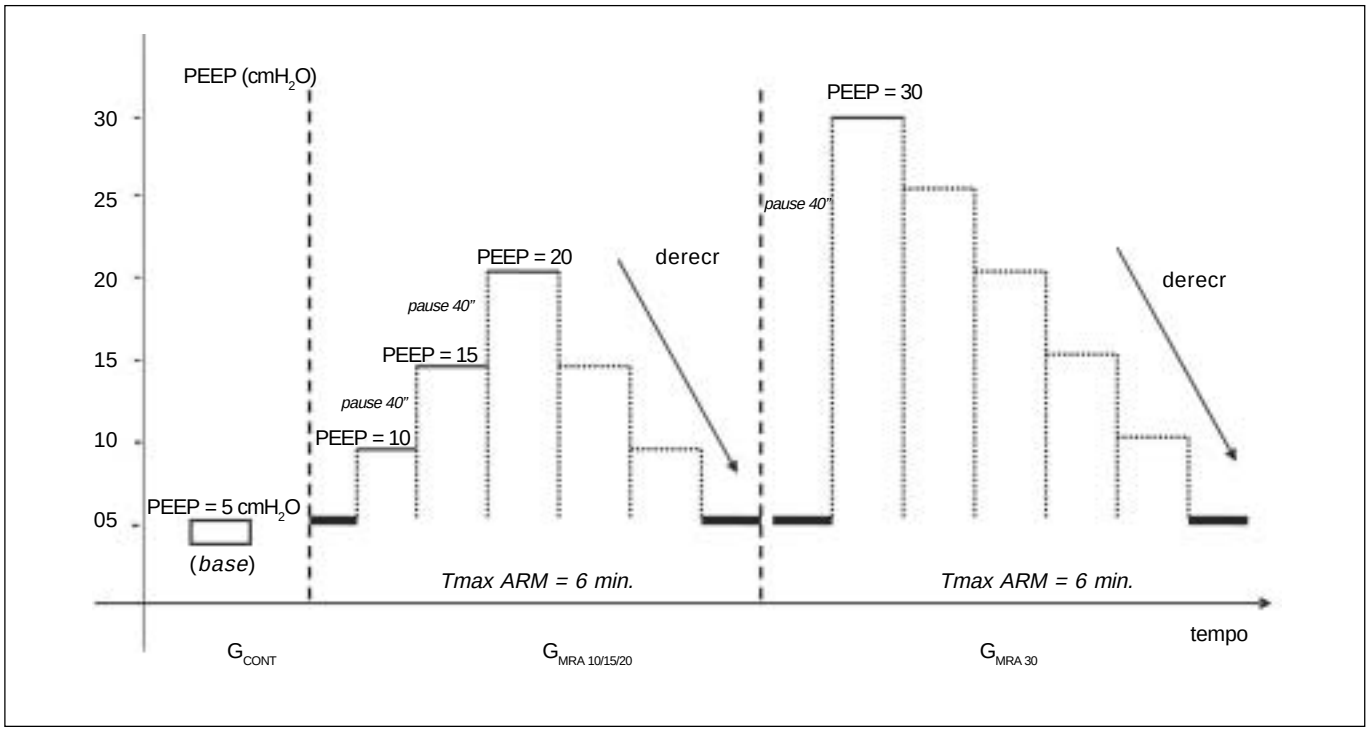

Figure 1 – Representation of Alveolar Recruitment Maneuvers Procedures in the Three Study Groups (G_{CONT}, $G_{ARM10/15/20}$ e $G_{ARM\ 30}$). G_{CONT}: ventilation with PEEP=5 cmH_2O until the end of surgery; $G_{ARM10/15/20}$: progressive ARM with PEEP of 10, 15 e 20 cmH_2O; G_{ARM30}: ARM with sudden increase of PEEP from 5 to30 cmH_2O; *Tmax*: mean time of recruitment; Derecr = derecruitment.

RESULTS

The final sample was composed of 47 patients, 14 in G_{CONT}, 17 in $G_{ARM10/15/20}$, and 16 in G_{ARM30}. Demographic data, length of surgery, and initial hemodynamic parameters and SpO_2 did not show statistically significant differences (Table I).

Hemodynamic parameters and SpO_2 did not show statistically significant differences throughout the study.

Immediately before ARM, PaO_2, $PaCO_2$, PaO_2/FiO_2 ratio, [PaO_2 + $PaCO_2$], P_{PLAT}, and P_{AW} did not show statistically significant differences among the three groups (Table III).

At the time of ARM (Table III), a statistically significant difference was observed among the three groups for: PaO_2, PaO_2/FiO_2 ratio, [PaO_2 + $PaCO_2$], P_{PLAT}, and P_{AW}. Subsequently, the Tukey test was used to analyze those parameters, which showed statistically significant differences between G_{CONT} and G_{ARM30} ($p < 0.05$) for PaO_2, PaO_2/FiO_2 ratio, and [PaO_2 + $PaCO_2$]. For P_{PLAT} and P_{AW}, Tukey test showed statistically significant differences in all groups when compared two by two (G_{CONT} x $G_{ARM10/15/20}$, $p < 0.001$; G_{CONT} x G_{ARM30}, $p < 0.001$; $G_{ARM10/15/20}$ x G_{ARM30}, $p < 0.01$), except when G_{PLAT} was compared with $G_{ARM10/15/20}$ and G_{ARM30} ($p > 0.05$).

Intraoperative complications were not observed.

Table I – Demographic Data and Descriptive Level of the Statistical Tests

Parameters	G_{CONT}	$G_{ARM10/15/20}$	G_{ARM30}	p
Age (years)	46.5 ± 9.7	38.8 ± 13.0	40.6 ± 1.2	0.189 *
Gender (M/F)	3/11	6/11	4/12	0.124 ‡
Height (m)	1.62 ± 0.07	1.64 ± 0.08	1.63 ± 0.09	0.053 *
Weight (kg)	129.9 ± 22.4	136.4 ± 26.6	123.7 ± 20.6	0.305 *
BMI ($kg.m^{-2}$)	49.2 ± 6.3	50.5 ± 7.2	46.3 ± 5.0	0.161*

* Descriptive level of the ANOVA; ‡ Descriptive level of the Chi-square test;
G_{CONT}: PEEP = 5 cmH_2O; $G_{ARM10/15/20}$: ARM with PEEP of 10, 15, and 20 cmH_2O; G_{ARM30}: ARM with PEEP=30 cmH_2O; BMI: body mass index.

Table II – Pre-ARM Respiratory and Ventilatory Parameters

Parameters	G_{CONT}	$G_{ARM10/15/20}$	G_{ARM30}	p
PaO_2 (mmHg)	113.1 ± 41.0	137.0 ± 41.5	134.8 ± 40.5	0.193
$PaCO_2$ (mmHg)	43.4 ± 12.8	43.8 ± 7.9	41.7 ± 6.9	0.799
PaO_2/FiO_2 ratio	226 ± 82.1	285.7 ± 99.9	269.2 ± 80.5	0.175
$[PaO_2+PaCO_2]$	156.4 ± 36.4	181.1 ± 42.6	176.5 ± 37.3	0.208
P_{PLAT} (cmH_2O)	25.9 ± 4.9	25.0 ± 3.3	23.2 ± 4.6	0.214
P_{AW} (cmH_2O)	25.6 ± 5.5	21.8 ± 4.2	22.6 ± 5.6	0.104

Results expressed as Mean ± SD.
G_{CONT}: PEEP = 5 cmH_2O; $G_{ARM10/15/20}$: ARM with PEEP of 10, 15, and 20 cmH_2O; G_{ARM30}: MRA with PEEP=30 cmH_2O; P_{PLAT}: plateau pressure; P_{AW}: mean airways pressure.

Table III – Respiratory and Ventilatory Parameters at the Time of the Alveolar Recruitment Maneuver

Parameters	G_{CONT}	$G_{ARM10/15/20}$	G_{ARM30}	p
PaO_2(mmHg)	113.06 ± 41.04	145.94 ± 48.53	158.31 ± 41.45	0.034
$PaCO_2$ (mmHg)	43.36 ± 12.81	47.08 ± 6.52	43.04 ± 7.34	0.375
PaO_2/FiO_2	266.11 ± 82.07	291.88 ± 97.07	323.4 ± 91.3	0.018
$[PaO_2+PaCO_2]$	156.41 ± 37.75	193.02 ± 47.93	201.36 ± 39.22	0.017
P_{PLAT} (cmH_2O)	25.9 ± 4.9	33.2 ± 2.5	33.7 ± 2.4	< 0.0001
P_{AW} (cmH_2O)	25.5 ± 5.5	35.2 ± 5.4	42.6 ± 6.4	<0.0001

Results expressed as Mean ± SD.
G_{CONT}: PEEP = 5 cmH_2O; $G_{ARM10/15/20}$: ARM with PEEP of 10, 15 and 20 cmH_2O; G_{ARM30}: ARM with PEEP of 30 cmH_2O; P_{PLAT}: plateau pressure; P_{AW}: mean airways pressure.

DISCUSSION

Perioperative pulmonary complications represent a significant cause of morbidity and mortality [8], and atelectasis affect almost 90% of the patients undergoing general anesthesia, with a positive correlation with the perioperative values of pulmonary shunts [1,8-12]; this explains why the moment of the surgery and respiratory monitoring were chosen to evaluate the ventilation/perfusion imbalance.

Immediately after general anesthesia, atelectasis, which are responsible for the perioperative changes in oxygenation, develop in dependent areas of the pulmonary parenchyma; PEEP, maintained at 5 cmH_2O throughout the surgery, led to the opening and maintenance of alveolar permeability [10], which was confirmed by the analysis of the levels of hyperoxia demonstrated by SpO_2 and PaO_2 in all three groups before and after alveolar recruitment maneuver (ARM), in which PaO_2 was elevated in every phase. It was possible to demonstrate it even when obese patients were ventilated with lower levels of VT (between 10 and 11 $mL.kg^{-1}$) and FiO_2 (0.4) [7].

Maintenance of the tidal volume is also debated in the literature and, when above 12 $mL.kg^{-1}$ it is associated with alveolar hyperinflation, compression of the adjacent pulmonary capillary, and inadequate gas exchange. Hedenstierna [13] stated that the main causes of alveolar collapse include the loss of muscular tone and high inspired fractions of oxygen (FiO_2). In the present study, the orientation of the Brazilian consensus on mechanical ventilation, maintaining constant VT at 10 $mL.kg^{-1}$ and FiO_2 of 0.5, was followed, leading to results similar to those of Coussa et al. [2] and Pelosi et al. [14], in which obese patients ventilated with a VT of 10 $mL.kg^{-1}$ showed a significant improvement in PaO_2, since the BMI is related with the reduction of RFC.

The use of PEEP is typically associated with an increase of P_{AW}, which was constant in all three groups from the beginning of the surgery on, with a proportional increase with increasing levels of PEEP [32].

The elevated P_{AW} suggests greater mechanical pulmonary vulnerability, because the increase in PEEP increased P_{PLAT} significantly. The resistance exerted by the adipose tissue in the thoracic region of the patients in this study could also have contributed to the significant change in P_{AW} in all phases of changes in PEEP [1,7,15].

The relationship between BMI and FRC has been reported by several authors who study the changes in gas exchange in obese individuals [7,15-19]. The reduction in FRC is also com-

mon after the institution of mechanical ventilation, as reported by Pelosi et al. [9], who proposed the inverse relationship between the reduction in oxygenation and pulmonary volume and the BMI.

In view of what was explained above, the alveolar recruitment maneuver (ARM) is a technique that leads to the opening of collapsed alveolar units through the sustained increase in airways pressure, increasing the pulmonary area available for gas exchange and, consequently, arterial oxygenation [20].

The response of acute pulmonary lesion (APL) and acute respiratory distress syndrome (ARDS) to ARM with pressures of 45 cmH_2O in non-obese patients can present different pulmonary profiles, which are classified as: difficult to recruit, reasonably recruitable, or potentially recruitable [18]. Obese patients can also be classified, in a similar fashion, by the elevated BMI as compromised thoracic cage, increased resistance, and decreased complacence. This can hinder comparison of the results obtained for alveolar recruitment, as reported by several studies [8,9,15].

The PaO_2/FiO_2 ratio and $[PaO_2 + PaCO_2]$ in the three study groups increased progressively, but without changes among the groups and $[PaO_2 + PCO_2]$, demonstrating the absence of pulmonary lesion (normal level: e 400 mmHg with FiO_2 = 1.0). However, patients in G_{ARM30} showed better response of the PaO_2/FiO_2 ratio and $[PaO_2 + PaCO_2]$, but this last index is not commonly used during studies on the response to ARM in patients with APL and ARDS.

Borges et al. [24], analyzing patients with acute pulmonary lesion associated with early hypoxemia, demonstrated that APL can be reverted when elevated pressures are used in the airways (above 60 cmH_2O). However, the harmful effects (barotrauma, hyperinsufflation, decreased cardiac index, and disrupted hemodynamics) are more commonly seen when the same levels of inspiratory pressure are used for prolonged times [25].

The alveolar recruitment maneuver with PEEP of 30 cmH_2O used in G_{ARM30} was idealized according to the American-European Consensus, and showed better response of the PaO_2/FiO_2 ratio and $[PaO_2 + PaCO_2]$ [26].

According to the literature, CPAP (continuous positive airways pressure), with pressure levels ranging from 30 to 40 cmH_2O for 30 to 90 seconds in patients with ARDS, is the method used more often by authors to sustain airways pressure [20,27,28].

In other studies [6,29], this level of pressure was maintained for 15 seconds and the area of recruitment was followed-up by CT scan during ARM. The authors noticed that, after seven seconds of recruitment, PaO_2 improved significantly and the areas of atelectasis reduced. The lower incidence of reduced cardiac output and blood pressure is the main advantage of the shorter ARM [9]; however, the study population is small, being classified as a level D scientific evidence recommendation. In the present study, increased PEEP levels were maintained for two minutes, which did not change the hemodynamic parameters of the patients.

Under the conditions of the present study, the best response of the PaO_2/FiO_2 ratio was seen with the alveolar recruitment maneuver with PEEP of 30 cmH_2O for two minutes.

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RESUMEN

Souza AP; Buschpigel M; Mathias LAST; Malheiros CA, Alves VLS — Análisis de los Efectos de la Maniobra de Reclutamiento Alveolar en la Oxigenación Sanguínea durante el Procedimiento Bariátrico.

JUSTIFICATIVAS Y OBJETIVOS*: La maniobra de reclutamiento alveolar (MRA) se indica en el tratamiento de atelectasias intraoperatorias. El objetivo del presente estudio fue comparar dos técnicas de MRA por medio de la respuesta de la relación PaO_2/FiO_2 y de la suma $[PaO_2+PaCO_2]$, en pacientes obesos con grado III.*

MÉTODO*: Estudio prospectivo abierto en pacientes adultos, obesos grado III, sometidos a procedimiento quirúrgico bariátrico en ventilación controlada a volumen, presión positiva al final de la expiración (PEEP) de 5 cmH_2O y divididos en tres grupos: $G_{CONTROL}$: PEEP de 5 cmH_2O; $G_{MRA10/15/20}$ después de la sutura de la aponeurosis: aumento progresivo de la PEEP para 10,15 y 20 cmH_2O, pausa de 40 segundos y mantenimiento de cada valor de la PEEP por 2 minutos; G_{MRA30}: después de la sutura de la aponeurosis: aumento súbito de la PEEP para 30 cmH_2O, 40 segundos de pausa y mantenimiento de la PEEP en 30 cmH_2O por dos minutos. Se analizaron las variables frecuencia cardíaca, presión arterial promedio, sistólica, diastólica, presión promedio de las vías aéreas (P_{MVA}) y de meseta (P_{PLAT}), presión arterial de oxígeno ($PaO_{2)}$, presión arterial de CO_2 ($PaCO_2$), relación PaO_2/FiO_2 (fracción inspiratoria de oxígeno) y suma $[PaO_2+PaCO_2]$.*

RESULTADOS*: Las variables que presentaron una diferencia estadística significativa entre los tres grupos fueron: P_{PLAT}, $P_{MVA,}$ $PaO_{2,}$ relación PaO_2/FiO_2 y suma $[PaO_2+PaCO_2]$ ($p < 0,0001$). En la comparación de los grupos dos a dos, se verificó una diferencia estadística significativa para las variables P_{PLAT} y P_{MVA}: $G_{CONTROL}$ X $G_{MRA10/15/20}$ y $G_{CONTROL}$ X G_{MRA30} y para las variables relación PaO_2/FiO_2 y suma $[PaO_2+PaCO_2]$: $G_{CONTROL}$ X G_{MRA30}.*

CONCLUSIONES*: La técnica de MRA con aumento súbito de la PEEP para 30 cm H_2O mostró la mejor respuesta de la relación PaO_2/FiO_2.*