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ARTIGO ORIGINAL

Impact of two methods of pulmonary re-expansion in patients undergoing bariatric surgery by videolaparoscopy

Impacto de dois métodos de reexpansão pulmonar em pacientes submetidos a cirurgia bariátrica por videolaparoscopia

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Abstract

Evaluating the impact of lung re-expansion methods on the postoperative pulmonary function and respiratory complications such as atelectasis, pneumonia and hypoxemia in videolaparoscopy-based bariatric surgery. Prospective clinical study conducted with 105 patients randomly divided into three groups: control (conventional postoperative physical therapy), recruitment (intraoperative alveolar recruitment) and decompression (postoperative chest compression and decompression maneuver). Spirometry, respiratory and hemodynamic variables were analyzed. All groups have presented worsened values in spirometry measurements within the postoperative period ($p < 0.00$) and there was significant decrease in respiratory rates in comparison to the immediate preoperative period (p = 0,01). Mean end-expiratory carbon dioxide pressure in the recruitment group was higher than in the control in all assessed time intervals (p = 0.03). Chest compression and decompression maneuver and alveolar recruitment were beneficial to pulmonary function recovery. There were no differences in postoperative pulmonary complications and function in the three assessed groups, except for significant decrease in respiratory rates and in the end-expiratory carbon dioxide pressure level in the recruitment group.

Keywords: bariatric surgery, pulmonary atelectasis, Physical Therapy.

Resumo

Avaliar o impacto de métodos de re-expansão pulmonar na função pulmonar e incidência de complicações respiratórias como as atelectasias, pneumonias e hipoxemia no pós-operatório de cirurgia bariátrica por videolaparoscopia. Estudo clínico, prospectivo realizado com 105 pacientes, randomizado em três grupos: grupo controle (fisioterapia convencional no pós-operatório), grupo recrutamento (recrutamento alveolar no intraoperatório) e grupo descompressão (manobra de compressão e descompressão torácica no pós-operatório). Foram analisadas variáveis espirométricas, respiratórias e hemodinâmicas. No pós-operatório todos os grupos apresentaram piora nas medidas espirométricas (p < 0,00) e redução significativa da frequência respiratória quando comparado o período pré e pós-operatório imediato em todos os grupos (p = 0,01). As médias de pressão expiratória final de gás carbônico no grupo recrutamento foram maiores que no grupo controle em todos os intervalos de tempos avaliados (p = 0,03). A manobra de compressão e descompressão torácica e o recrutamento alveolar foram benéficos para a recuperação da função pulmonar. Nos três grupos avaliados não houve diferença nas complicações e função pulmonar no pós-operatório, exceto redução significativa da frequência respiratória e da pressão expiratória final de dióxido de carbono no grupo recrutamento alveolar.

Palavras-chave: cirurgia bariátrica; atelectasia pulmonar; Fisioterapia.

Introduction

Bariatric surgery is an effective method adopted to treat obese patients [1], but patients face the risk of developing postoperative pulmonary complications such as bronchospasm, respiratory failure, pneumonia, atelectasis and hypoxemia [2,3], that mostly derive from the association between patients' obesity and intraoperative factors such as the use of anesthetics, neuromuscular blockers and analgesics, prolonged surgical time, inadequate mechanical ventilation, age, and postoperative pain [4,5].

According to Pazzianotto-Forti *et al.* [6], preoperative and postoperative respiratory physical therapy is beneficial and essential to help morbid obesity patients maintaining their pulmonary function and to prevent pulmonary complications. Manual chest compression and decompression maneuver (CCDM) is a physical therapy technique adopted to help opening collapsed alveoli by both increasing the transpulmonary pressure gradient and guiding air flow and volume to the airways to increase oxygenation [7].

Some ventilatory strategies, such as alveolar recruitment maneuver (ARM) and protective intraoperative ventilation with lower tidal volume and higher positive end-expiratory pressure (PEEP) level [8,9] are used to improve pulmonary gas exchange during, and after, anesthesia in patients subjected to bariatric surgery [10-13].

Based on the hypothesis of respiratory physical therapy improves the pulmonary function and respiratory mechanics, the aim of the study was to evaluate the effects of ARM, as well as of CCDM on pulmonary function recovery and on the incidence of postoperative pulmonary complications in patients subjected to bariatric surgery by video laparoscopy.

Methods

Prospective, randomized, and quantitative research carried out at Galileo Hospital. The research was approved by the Research Ethics Committee of Medical Sciences School/UNICAMP-N. 392672. All participants have signed the Free Informed Consent Form.

The study included patients in the age group 18 to 59 years subjected to Roux-en-Y gastric bypass surgery. Patients who required laparotomy intervention were excluded from the study.

All pulmonary function tests were following guidelines set by the American Thoracic Society [12]. Spirometric measurements were performed in Contec™ Med SP10® Digital Spirometer calibrated for each patient. The measurements were taken in the preoperative period, right after the surgery, in the first and second postoperative days. The measured parameters included forced expiratory volume in one second (FEV1), forced vital capacity (FVC), maximal voluntary ventilation (VVM) and forced expiratory flow at 25-75% of pulmonary volume (FEF25-75 %).

Randomization was carried out after patients underwent a pre-operative evaluation. The patients were randomly divided into three intervention groups by a draw using sealed envelopes: control (CG) - patients subjected to conventional physical therapy (CP); recruitment group (RG) - patients subjected to intraoperative ARM; and decompression group (DG) - patients subjected CCDM in the postoperative period.

All surgeries were performed by the same professionals. The same anesthesia and protective mechanical ventilation recommended in the Brazilian Guidelines for Mechanical Ventilation [13] were applied to all groups. The volume-controlled mode was applied to ventilation patients during anesthesia carried out with anesthetic machine (Takaoka®).

Patients from the all intervention groups were removed from bed and taken to armchair six hours after surgery, and after 1 hour they were taken for a walk. Subsequently, they were subjected to CP session, which consisted of 40 repetitions in load-free incentive spirometer and 20 repetitions of breathing exercises.

Patients belonging to the recruitment group (RG) were subjected to intraoperative ARM after pneumoperitoneum deflation based on the protocol recommended by the institution, as well as to CP. The volume-controlled mode was initially adjusted to pressure-controlled ventilation. The initial control pressure was set at 20 cmH_2O, respiratory rate was adjusted to 10 cycles per minute, PEEP was set at 5 cmH_2O and the inspired oxygen fraction was adjusted to 50%. This technique consisted of increasing PEEP and control pressure to 20 and 40 cmH_2O respectively, at most by the addition of 5 cmH_2O every 2 minutes.

Besides undergoing CP, patients in the decompression group (DG) were subjected to CCDM, six hours after surgery. They were placed in dorsal decubitus and anatomical position with their heads elevated at 30° to enable 10 repetitions of CCDM in each hemithorax within 10 consecutive breaths - this technique consists of compressing patients' chest at the final expiratory phase. Chest compression was kept until the initial third of the inspiratory phase, when it was abruptly released.

Statistical analysis

Sample size was calculated based on a pilot study conducted with ten patients. ANOVA was applied to repeated measurements to compare variables and time-periods between groups at type I error equal to 5% (significance level) and type II error equal to 20% (test power equal to 80%). At least 30 patients were gathered per group during the trial.

Kruskal-Wallis test was used to compare age, body mass index and surgery duration between groups. Repeated measures ANOVA was applied to compare hemodynamics and spirometry parameters and surgery duration between groups. Significance level was set at 5%. The Statistical Analysis System (SAS) software for Windows, version 9.3, was used to calculate the sample and in the statistical analyses.

Results

Two out of 107 patients were excluded from the research in the intraoperative period. One of them had severe bronchospasm after anesthetic induction and the other one needed surgery conversion into laparotomy due to technical difficulties. Thus, only 105 patients composed the cohort.

Based on the comparison between groups, patients were homogeneous in factors age, sex, body mass index (BMI) and comorbidity incidence. The most common comorbidities were arterial hypertension 43.80%, metabolic syndrome 36.19% and diabetes mellitus 14.28% (Table I).

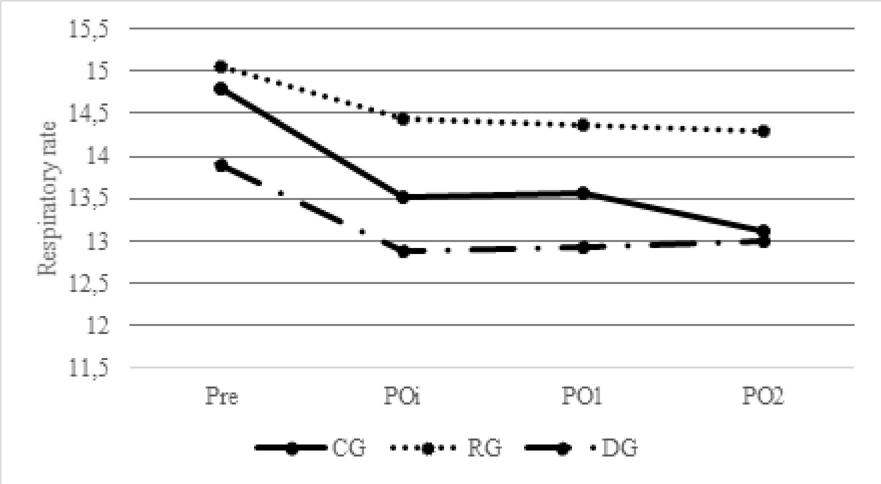
Table I - *Demographic profile of the overall population in the study*

Variable	CG (n = 34)	RG (n = 36)	DG (n = 35)	p-value
Age (years)	33.7 ± 8.9	37.1 ± 9.6	35.8 ± 10.6	0.30
BMI (kg/m²)	39.4 ± 2.9	39.2 ± 3.1	40.1 ± 3.6	0.57
Sex (F) %	76.4	80.5	77.1	
Comorbidities %	79.4	80.5	91.3	

F = female; BMI = Body Mass Index. Values were expressed as mean ± SD and percentage

Based on the analysis applied to the Torrington-Henderson scale criteria, all patients presented minimal risk of developing respiratory complications. The adopted protocols did not cause significant changes in patients' peripheral oxygen saturation, heart rate and mean arterial pressure.

Respiratory rate analysis performed right after the surgery showed significantly lower values than the ones observed in the preoperative period in all groups and evidenced statistically significant difference between RG and DG; this variable presented higher values in RG than in DG at all periods ($p = 0.0152$), as shown in graphic 1.



Pre = preoperative; Poi = immediate postoperative period; PO1 = first postoperative day; PO_2 = second postoperative day

Graphic 1 - *Respiratory rate*

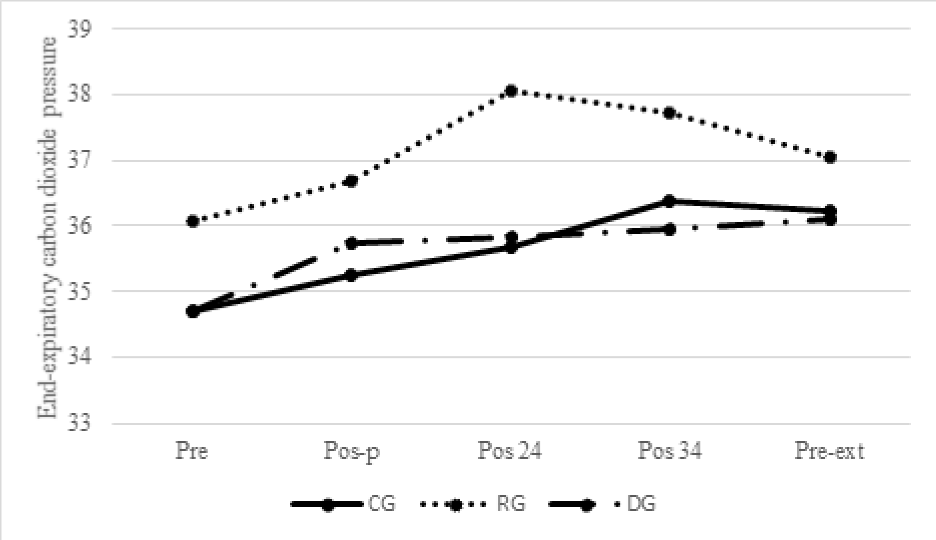
Spirometry variable comparisons in the postoperative period did not show statistically significant differences between groups; however, all groups presented improved values for all variables recorded between moments right after the surgery and the second postoperative day ($p < 0.0001$), as shown in Table II.

Table II - *Values recorded for spirometry variables in the preoperative period (pre), after the surgery (POi), first (PO1) and second (PO_2) postoperative days*

Group	Variable	Pre	POi*	PO1*	PO2*	p - value
	FVC (L)	3.8±0.8	1.8±0.7	2.1±0.7	2.7±0.8	* p < .0001
	FEV_1 (L)	3.2±0.7	1.5±0.6	1.7±0.6	2.3±0.6	* p < .0001
CG	25-75% (L/s)	3.7±1.1	1.9±1.2	2.3±1.1	2.9±1.3	* p < .0001
	VVM (L/min)	138.9±25.7	73.7±25.4	83.0±24.5	102.8±23.8	* p < .0001
	FVC	3.3±0.6	1.6±0.4	2.0±0.3	2.6±0.7	** p = 0,35
	FEV_1	2.9±0.5	1.4±0.3	1.8±0.3	2.3±0.5	** p = 0,83
RG	25-75%	3.5±1.1	2.0±0.8	2.4±0.7	3.1±0.8	** p = 0,62
	VVM	125.2±20.0	70.6±13.9	85.0±11.8	103.4±19.0	** p = 0,89
	FVC	3.5±0.7	1.8±0.5	2.1±0.4	2.5±0.5	
	FEV_1	3.0±0.5	1.5±0.4	1.86±0.3	2.3±0.4	
DG	25-75%	3.6±0.7	1.8±0.7	2.4±0.7	3.2±0.8	
	VVM	129.1±21.7	74.1±15.5	84,7±14,2	102.6±16.6	

L = liters; L/s = liters per second; L/min = liters per minute; % = percentage; values were expressed as mean ± standard deviation. p = value compared with times (preoperative period (pre), after the surgery (POi), first (PO1) and second (PO_2) postoperative days), **p = value compared with the groups (control group (CG); recruitment group (RG) and decompression group (DG))

There were significant changes in end-expiratory carbon dioxide pressure ($PETCO_2$) between time intervals ($p = 0.00$) and between groups ($p = 0.03$). RG recorded higher $PETCO_2$ means than CG in all tested time-intervals, as shown in graphic 2.



Pre = before pneumoperitoneum; Pos-p = after pneumoperitoneum; Pos 24 = 24 minutes after pneumoperitoneum; Pos 34 = 34 minutes after pneumoperitoneum; Pre-ext = before extubation

Graphic 2 - *End-expiratory carbon dioxide pressure at pre and postoperative alveolar recruitment*

Mean hospitalization time was 4.58 days. All patients were subjected to one-month follow-up in the postoperative period. None of the groups presented postoperative pulmonary complications such as atelectasis, pneumonia and hypoxemia.

Discussion

There were no significant differences in FVC, FEV1, FEF 25%-75% and MVV values in the preoperative period between groups. This outcome can be explained by the prevalence of patients with obesity grade II in the sample, unlike the sample assessed by Paisani *et al.* [14], whose patients presented mean BMI 50.4 kg/m^2 and were categorized as super obese. However, values recorded for spirometry variables have decreased in the three postoperative periods. This result is like outcomes in the studies by Paisani *et al.* [14] and Remístico *et al.* [15].

According to Pouwels *et al.* [16] and Alsumali *et al.* [17], patients have recorded significantly worsened values for spirometry variables due to the adopted surgical procedure, although it was performed by videolaparoscopy, as well as to the administered anesthetics. Consequently, this technique seems to lead to deleterious effects on patients' pulmonary function, besides increasing their likelihood to develop respiratory complications such as atelectasis, pneumonia, and hypoxia [3].

Almarakbi *et al*. [18] observed that the best oxygenation results were recorded right after ARM application and the maintenance of ARM effects depends on maneuver repetition. Almarakbi *et al.* [18] also investigated the effect of ARM repetition on patients' oxygenation and atelectasis reduction. Their studies have evidenced that ARM repetition increased lung compliance and PaO_2, as well as reduced $PaCO_2$, improved gas exchange efficiency and respiratory mechanics, and maintained its beneficial effects at the postoperative period.

ARM was applied only once during the procedure and there were no differences in spirometry variables and postoperative pulmonary complications in comparison to the conventional or decompression groups. On the other hand, like results in the present study, Defresne *et al.* [19] did not find any additional benefit from alveolar recruitment application in association with protective ventilation to FVC, FEV1; or any oxygenation changes in the postoperative period.

In comparison to non-obese individuals, morbid obesity and pneumoperitoneum compromise patients' respiratory mechanics and lead to carbon dioxide retention [20]. Systemic carbon dioxide resorption during videolaparoscopy surgeries can have deleterious effects on lung function, as well as increase ventilatory load due to increased transperitoneal pressure; thus, it is in opposition to diaphragmatic contraction.

The collected data have shown increased $PETCO_2$ right after alveolar recruitment due to decreased tidal and minute volumes during alveolar recruitment, whose values significantly dropped until pre-extubation. Similar findings were recorded by Remíticos *et al.* [15], who observed increased $PETCO_2$ right after ARM application with PEEP at 30 cmH_2O and inspiratory pressure at 45 cmH_2O - $PETCO_2$ values dropped minutes after ARM application. According to the literature [21,22], reduced $PETCO_2$ indicates improved alveolar ventilation due to higher alveoli recruitment and lower collapsed alveoli rates. Literature still lacks studies focused on investigating the immediate effect of CCDM in comparison to ARM during the postoperative period of patients subjected to bariatric surgery. Therefore, the present study included a group of patients who were subjected to CCDM right after surgery to test the hypothesis that lungs subjected to this maneuver can present lower atelectasis incidence without patients' subjection to ARM.

The use of CCDM right after surgery has reduced atelectasis incidence and improved patients' lung function. This outcome was like the ones recorded when ARM and conventional physical therapy were adopted in the intraoperative period. The positive response of obese patients to CCDM use in the postoperative period (six hours after surgery) likely derived from hypoventilation correction. According to Via *et al.* [7], CCDM reduced the incidence of pulmonary complications such as hypoventilation and atelectasis, as well as the development of acute hypoxemia after surgery due to pulmonary ventilation restoration, which improved oxygenation and decreased CO_2 levels. Unoki *et al.* [23] applied CCDM to 31 mechanically ventilated patients and found that this maneuver enabled bronchial hygiene by increasing expiratory time and peak expiratory flow. However, the maneuver did not contribute to pulmonary re-expansion because it required the application of high inspiratory pressure.

Lack of pulmonary expansion after CCDM application in the study conducted by Unoki *et al.* [23] was explained by differences in protocols adopted in other studies. Patients assessed in the current study did not present changes in bronchial hygiene needs. Via *et al.* [7] performed bronchial hygiene before CCDM application in all patients; however, Unoki *et al.* [23] performed CCDM without previous bronchial hygiene, which may have reinforced its effects on bronchial hygiene, but not on pulmonary expansion.

According to Paisani *et al.* [13], obese patients presented shallower breathing in the postoperative period, as well as increased respiratory rate due to the need of maintaining the minute volume. This finding was not observed in the present study. In compliance with Tomich *et al.* [24], exercises performed through slow and deep inspirations contributed to uniform inhaled-gas distribution in pulmonary parenchyma, increased the transpulmonary pressure, improved tidal volume and, consequently, reduced respiratory rates.

Lack of gasometry, ventilometry, manovacuometry and the impossibility of performing patient follow-up after hospital discharge can be considered limitation factors in the current study. Based on these mechanisms, other important ventilation variables could be explored during the respiratory follow-up of morbid obesity patients.

The assessed parameters should be investigated in future clinical trials focused on clarifying the best follow-up protocol to be applied to bariatric surgery patients during the postoperative period.

Conclusion

Conventional physical therapy, manual chest compression and decompression maneuver, and alveolar recruitment were beneficial to pulmonary function recovery. There were no differences in postoperative pulmonary complications and pulmonary function of patients in the three experimental groups, except for significant decrease in respiratory rate and end-expiratory carbon dioxide pressure level in the ARM group.

Authors' contribution

Conception and design of the study, acquisition of data, analysis and interpretation of data, manuscript writing: Fabiana Della Via and Desanka Dragosavac; *Technical* *procedures, final approval*: Admar Concon Filho; Preparation and critical revision: Carolina Kosour; *Alveolar recruitment and critical review*: Carlos Eduardo Ferraresi Andrade and Emanuel Guedes

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