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Effect of Rectus Plication during Abdominoplasty on the Mechanical Power and Airway Pressures: Comparison of Two Ventilatory Strategies

Sergio Soto-Hopkins[1*], Hector Milla[2], Israel Espino-Gaucin[2]

[1]Department of Anesthesiology, TJ Plast Advanced Center for Plastic Surgery, Tijuana, México
[2]Department of Plastic and Reconstructive Surgery, TJ Plast Advanced Center for Plastic Surgery, Tijuana, Mexico
Email:*sergio_sotohopkins@hotmail.com

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Abstract

Background: Abdominoplasty is a commonly requested procedure for aesthetic improvement of the affected soft tissue layers of skin, fat, and muscle through the slightest incision feasible. The degree of plicature generates an increase in intraabdominal pressure that causes an increase in intrathoracic pressure. Pressure, volume, flow, and respiratory rate are components of a unique physical variable, the mechanical power (MP), and is an integrated variable linked to most factors related to postoperative pulmonary complications. **Purpose:** To assess the effect of rectus plication (RP) during abdominoplasty on lung pressures and the contribution to increasing the MP. **Method:** A open-label study was conducted at TJ Plast Advanced Center for Plastic Surgery in Tijuana, México, from September 2021 to May 2022. The study included forty-six female patients subjected to abdominoplasty or liposuction with abdominoplasty. After the induction of general anesthesia and neuromuscular blockade, they were allocated into two groups: Group 1 pressure control ventilation-volume guaranteed (PCV-VG) and Group 2 volume control ventilation (VCV). Respiratory pressures and MP were assessed before and after RP. **Results:** During VCV, patients had a greater increase in peak pressure (PIP) ($P < 0.000$). Plateau pressure (P_{plat}) increased 1.78 ± 0.35 cmH_2O in group 2 after RP ($P = 0.001$). MP had a greater increase in group 2 after RP ($P < 0.01$). **Conclusion:** This prospective study showed that RP is related to an increase in PIP and P_{plat} and an increase in the MP better controlled with PCV-VG ventilation.

Keywords

Abdominoplasty, Mechanical Power (MP), Lung Pressures, General Anesthesia, Pressure Control Ventilation-Volume Guaranteed (PCV-VG), Volume Control

Ventilation (VCV)

1. Introduction

Abdominoplasty is a commonly requested procedure for aesthetic improvement of the affected soft tissue layers of skin, fat, and muscle through the slightest incision feasible. Full standard abdominoplasty with or without liposuction of the flap includes two components: dermo lipectomy and plicature of the rectus abdominis; during this procedure, the degree of plicature inevitably generates an increase in intraabdominal pressure that causes an increase in intrathoracic pressure resulting in inadequate ventilation [1] [2].

Studies suggest that respiratory decompensation can occur because muscle and fascial plication reduces the respiratory reserve by decreasing intraabdominal volume, thus diaphragmatic excursion. In a prospective study of healthy patients undergoing abdominoplasty surgery, Tercan M *et al.* reported a decrease in the mean forced vital capacity (FVC) corresponding to a restrictive respiratory dysfunction pattern [3].

Respiratory complications like bronchospasm, atelectasis, and pneumonia have been described in the postoperative period after abdominoplasty [4]. Mechanical ventilation (MV) is necessary for many surgical procedures to provide gas exchanges during general anesthesia (GA). The ventilator-induced lung injury (VILI) includes pressure, volume, flow, and respiratory rate. It results from the interaction between what the ventilator delivers to the lung parenchyma and how it accepts it. It is usually evaluated separately but the component of a unique physical variable, the mechanical power (MP) [5].

Studies reported that high levels of MP exceeding 12 J/min are associated with lung damage. However, clinical studies should be performed in healthy patients at lower MP before considering this parameter as a reference variable for intraoperative monitoring with other standard parameters [6].

We conducted this open-label study to assess the effect of rectus plication (RP) during abdominoplasty on lung pressures and the contribution to increased MP.

2. Materials and Methods

2.1. Cases Data

The study included forty-six female patients subjected to abdominoplasty or liposuction with abdominoplasty from September 2021 to May 2022 performed in TJ Plast Advanced Center for Plastic Surgery in Tijuana, Mexico. The ethics committee and the institutional review board approved the study. Informed consent was obtained according to regulations. The same surgical team performed all surgeries.

Inclusion criteria: 1) Age ≥ 18 years old; 2) Undergoing abdominoplasty or liposuction with abdominoplasty; 3) BMI < 30 kg/cm^2; 4) General anesthesia; 5)

ASA 1-2.

Exclusion criteria: 1) Age < 18 years old; 2) ASA ≥ 3; 3) Patients with respiratory comorbidities; 4) Tobacco users.

2.2. Design

All patients were allocated non-randomly in two groups after the induction of general anesthesia and neuromuscular blockade, with twenty-three patients in each group. Group 1 with pressure control ventilation-volume guaranteed (PCV-VG) and Group 2 with volume control ventilation (VCV). Patients were assigned to receive a tidal volume (V_T) of 6 ml/kg of predicted body weight.

Respiratory pressures were assessed before and after RP by pulmonary compliance (P-Comp), peak pressure (PIP), plateau pressure (P_{Plat}), mean airway pressure (P_{aw}), driving pressure (DP), and airway resistance (Raw) were measured with flow sensors that are differential pressure sensors that measure inspiratory pressures and both inspiratory and expiratory volumes and localized near the advanced breathing system with 2.7 L circuit vent volume designed of the Aisys CS^2 General Electric anesthesia machine. We calculated the energy delivered per breath to the lungs with the algebraic method using the comprehensive formula (1) for VCV ventilation and surrogate formula (2) for PCV-VG ventilation [7].

$$\mathrm{MP} = 0.098 \cdot \mathrm{RR} \cdot \mathrm{V_T} \cdot \left[\mathrm{PIP} - 1/2\left(\mathrm{P_{plat}} - \mathrm{PEEP}\right)\right] \tag{1}$$

$$\mathrm{MP} = 0.098 \cdot \mathrm{RR} \cdot \mathrm{V_T} \cdot \left(\mathrm{PEEP} + \Delta \mathrm{P_{insp}}\right) \tag{2}$$

Factor 0.098 is a conversion from cmH_2O l min in J/min, RR the respiratory rate, V_T the tidal volume in liters, and ΔP_{insp} the pressure (cmH_2O) above PEEP during PCV-VG.

Surgical Technique

Abdominoplasty was performed using the classic pattern of resectioning excess tissue in the hypogastric region through a transverse incision 6 cm from the pubis with lateral extension to the iliac spines. Subsequently, a central tunnel is created towards the xiphoid process to perform complete exposure of the rectus abdominis diastasis. The abdominal plication was performed in all cases in the direction of the linea alba from the xiphoid process to the superior border of the pubis, and 1 cm lateral to the medial border of the rectus abdominis muscle, with #1 Quill® bidirectional barbed suture in 3 planes, and reinforcement with separate single stitches of #1 polypropylene [8] [9].

2.3. Statistical Analysis

The data were consistent with the normal distribution and the homogeneity of variance. Continuous variables were expressed as means with standard deviation and percentages for categorical variables. Data were statistically tested with Student's t-test or Chi-square test when appropriate. *P*-values < 0.05 were considered statistically significant. Analyses and calculations were conducted using SPSS Statistics 21.0 (IBM, NY, USA).

3. Results

3.1. Analysis of Patients' Baseline Data

Forty-six patients met inclusion criteria and were enrolled. The baseline data are shown in Table 1. The mean ventilation parameters were V_T 360 ± 23 mL, RR 14.15 ± 0.9, PIP 14.85 ± 1.6 cmH_2O, P_{plat} 13.78 ± 1.76 cmH_2O (VCV group), P_{aw} 9.35 ± 1.8 cmH_2O, DP 7.78 ± 1.7 cmH_2O, P-Comp 47 ± 11.6 cmH_2O and Raw 10 ± 2.2 cmH_2O.

During VCV patients had a greater increase in PIP 17.22 ± 1.53 cmH_2O vs 15.3 ± 1.57 cmH_2O in PCV-VG (P = 0.000) with a difference pre and post RP of 2 ± 0.36 cmH_2O and 0.7 ± 0.30 cmH_2O (P = 0.001) respectively. P_{plat} was 15.22 ± 1.47 cmH_2O in group 2, with a post RP increase of 1.78 ± 0.35 cmH_2O (P = 0.001). There was no significant difference between the study groups in Raw, DP, Paw, and P-Comp.

3.2. Mechanical Power

As presented in Figure 1. The MP pre plicature was similar in both groups

Table 1. Baseline data: Comparision between PCV-VG and VCV.

Demographic Characteristics	PCV-VG (n = 23)	VCV (n = 23)	P-Value
Age, yrs	39.6 ± 7.6	40 ± 7.8	0.85
Body Mass Index, kg/m^2	27.1 ± 2.9	26.8 ± 2.8	0.80
Preoperative risk scores			
POSPOM	0.049 %± 0.02%	0.05% ± 0.03%	0.90
ARISCAT	1.59% ± 0.02%	1.60% ± 0.01%	0.32
ASA (I/II)	14/9 (61/39%)	15/8 (65/35%)	0.76
Types of surgery			
Abdominoplasty	6 (26.1%)	16 (69.6%)	0.74
Liposuction + Abdominoplasty	17 (73.9%)	7 (30.4%)	0.73
Laboratory variables			
Hb (mg/dl)	13.26 ± 0.92	13.32 ± 0.88	0.82
Hct (%)	39.87 ± 2.62	40 ± 2.50	0.77
Glucose (mg/dl)	88.77 ± 6.50	88.90 ± 6.45	0.94
Cr (mg/dl)	0.63 ± 0.11	0.66 ± 0.19	0.91
BUN (mg/dl)	12.54 ± 3.0	12.48 ± 2.89	0.91
Platelets (10^9/L)	197.9 ± 13.8	196.6 ± 13.7	0.97

POSPOM: Preoperative score to predict postoperative mortality; ARISCAT: Assess respiratory risk in surgical patients for postoperative pulmonary complications; ASA: American Society of Anesthesiology physical status classification system.

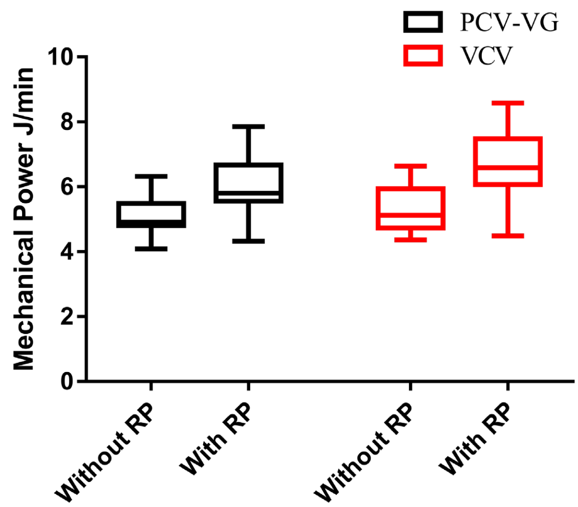

Figure 1. Mechanical Power pre and post-rectus plication in both groups.

5.15 ± 0.59 J/min in group 1 and 5.32 ± 0.66 J/min in group 2 (P = 0.34). MP increases with RP at 6.06 ± 0.83 J/min and 6.74 ± 0.99 J/min (P = 0.016), with higher energy delivered per breath post-RP in group 2 at 1.41 ± 0.66 J/min and 0.90 ± 0.12 J/min group 1 (P = 0.01).

4. Discussion

Abdominoplasty is a commonly requested and efficient procedure Nevertheless, it can affect ventilatory function, especially related to the degree of plicature [10] [11]. The central findings of our study are that RP contributes to increasing intraabdominal and respiratory pressures associated with an increase in the MP.

After RP, we observed a predominantly increased PIP in the VCV group: 17.22 ± 1.53 cmH_2O vs. 15.3 ± 1.57 cmH_2O in PCV-VG (P = 0.000). This is explained because PCV-VG is a mode of ventilation utilizing a decelerating flow and constant pressure and is adjusted automatically for each breath to assure the target VT without increasing airway pressure [12].

Al-Basti *et al.* published a study that demonstrated an increase in PIP from 13.46 ± 3.13 to 14.24 ± 3.3 cmH_2O (P = 0.005) after RP in patients undergoing abdominoplasty [13].

We bear out that the correction of the rectus diastasis has an essential effect on pulmonary pressures during MV and may depend on the size of the plication: Park JM *et al.* reported changes in intraoperative Paw of 20 healthy patients. The mean Paw increased by 6.6 cmH_2O associated with muscle and fascial plication [14].

Furthermore, MP in both groups increased after RP, even being healthy, non-smokers and young patients with better control with PCV-VG. This occurred because MP was calculated according to the mathematical equation that includes PIP and $P_{plat.}$ These two factors increased with RP, but the difference and essential characteristic of MP is that it combines three critical components: 1) Respiratory system elastance ($VT/\Delta P_{insp}$); 2) airway resistance that is related to gas movement and the third component, the energy needed to overcome tension in the fibers due to PEEP [15].

Karalapillai D *et al.* in a recent study, showed that an increase in MP during non-cardiac surgery was independently associated with an increased risk of PPC_S [odds ratio (OR 1.34, 95% CI, 1.17 to 1.52); $P < 0.001$) and acute respiratory failure (OR 1.40, 95% CI, 1.21 to 1.61; $P < 0.001$). The mean MP was 8 (6.4 - 10.6) J/min [16].

In multiple studies, MP is independently associated with hospital mortality. Tonna JE. found that MP has different strengths of association with mortality that can be modified by RR and PEEP, highlighting that below a RR of 26 or above a PEEP of 10, MP has a stronger relationship with mortality [17]. MP is a latent and integrated variable linked to most of the factors related to VILI. Due to the kind of variables used in the calculation, there are different ways of reducing this force: controlling or reducing DP and RR [18].

The repair of rectus diastasis depends on the protrusion of the abdominal wall and the repositioning of the rectus abdominis muscles. It causes an increase in intraabdominal pressure (IAP) aggrandized by the aponeurotic plication and causes an increase in the IAP due to compression. The increase in IAP may cause a decrease in respiratory compliance and a reduction in thoracic compliance, increasing the inspiratory pressure [19].

Strengths and Limitations

This is one of the first studies focused on measuring MP in the operating room. The results demonstrate that even though our team uses conservative plication of the rectus abdominis, looking for a secure and reproducible technique and considering that the sample of our patients was healthy, non-obese and non-smokers, it can be seen that there are changes in MP directly related to IAP.

The study has limitations. This is a non-randomized study. In consequence, cause and effect relationship cannot be established. We don't evaluate the impact of MP on the risk of PPC_S nor if these changes are maintained in the long term. A randomized clinical trial is needed to assess the cause-effect relationship of these variables.

5. Conclusion

This prospective study of healthy female adult patients undergoing abdominoplasty with rectus abdominis diastasis correction receiving MV showed that RP is related to an increase in PIP and P_{plat} and an increment in the MP that was better controlled with PCV-VG ventilation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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