Effects of Abdominoplasty on Intra-Abdominal Pressure and Pulmonary Function

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Abstract

Background: Abdominal wall weakness is a consequence of rectus abdominis diastasis and flaccidity of the myofascial component. A degree of plicature of the rectus abdominis generates an increase of intra-abdominal pressure (IAP), which may result in an increase of intrathoracic pressure, thus affecting thoracic hemodynamics and leading to inadequate ventilation.

Objectives: To assess changes generated by plicature of the rectus abdominis on IAP and pulmonary function in patients undergoing abdominoplasty.

Methods: A total of 10 female patients with abdominal ptosis were included. Chronic smokers and patients with respiratory co-morbidities were excluded. The IAP was measured using a modified Kron's trans-bladder technique. Pulmonary function was assessed by pulmonary compliance (P-Comp) and was calculated with parameters provided by the mechanical ventilator. Both were calculated before and after plicature.

Results: The mean values for IAP before and after plicature were 6.6 and 9.3 mmHg respectively. Before plicature, the mean P-Comp value was 38.97 mL/cm of water, and after it was 36.54 mL/cm. Both differences were statistically significant.

Conclusions: Based on the results obtained, it is possible to conclude that plicature of the rectus abdominis generates significant physiological changes, such as an increase in IAP and a decrease of P-Comp, which do not have a clinically relevant impact on healthy individuals. Measuring IAP with the modified technique and the assessment of pulmonary function using P-Comp are both reliable and provide a more accurate correlation with such physiologic changes.

Level of Evidence: 3

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Due to the growth in rates of obesity and the overweight over recent years, the use of surgical procedures intended to decrease adipose tissue and improve body outlines have increased. Among such procedures are liposuction and abdominoplasty, ranking first and fourth place, respectively, of the most popular aesthetic surgical procedures performed in the United States in 2014.[1]

Obesity and multiparity result in the loss of abdominal wall resistance and consequent laxity. Such weakness is a consequence of rectus abdominis diastasis and flaccidity of the myofascial component. If abdominal ptosis is also present with the abovementioned, the procedure of choice is abdominoplasty.

Abdominoplasty includes two components: dermolipectomy and plicature of the musculoaponeurotic system. In general, morbidity and mortality of abdominoplasty is

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low (1%).[2,3] Historically, the reported risks of deep vein thrombosis (DVT) and pulmonary embolism (PE) have been 1.1% and 0.8%, respectively.[4] Recent studies show lower rates, with 0.04% for DVT and 0.02% for PE.[5] During this procedure, the degree of plicature of the rectus abdominis inevitably generates an increase of intra-abdominal pressure (IAP).

Intra-abdominal hypertension is defined as sustained or repeated pathological elevation of intra-abdominal pressure (IAP) of 12 mmHg or higher.[6] Intra-abdominal hypertension causes a decrease in venous return and venous stasis, and predisposes to DVT.[7-10] It may cause an increase in intrathoracic pressure and affect thoracic hemodynamics, resulting in inadequate ventilation with hypoxia and hypercarbia.[11]

The technique for IAP measurement was described by Kron et al[12] and modified by the International Conference of Experts on Intra-abdominal Hypertension and Abdominal Compartmental Syndrome in 2006.[6] There are no studies addressing IAP in abdominoplasty, with IAP measurement in this study following the current standards.

To assess pulmonary function, it is imperative to use a parameter that discriminates between changes in the restrictive and elastic work.

The aim of the present study is to evaluate the changes generated by plicature of the rectus abdominis on IAP and pulmonary function using the current measuring technique and adequate parameters on patients undergoing abdominoplasty.

METHODS

The present study is prospective. The sample size required to compare averages was calculated, with the group being its own control.[13] Inclusion criteria were the following: female gender; age older than 18 years; body mass index (BMI) ≤ 35 kg/m^2; non-smokers; absence of respiratory associated co-morbidities; and without a history of abdominoplasty. Ten patients who met the inclusion criteria were included. Patients were recruited and surgeries were performed between May and July 2013 at the Hospital Clínico Universidad de Chile by the same surgical team (N.P., C.S., F.P.), with prior authorization by the Scientific Ethics Committee of the same institution. All patients signed a written informed consent authorizing their inclusion in the study. All patients underwent routine preoperative assessment and examination.

A follow-up for postoperative complications was conducted during hospitalization and extended until 30 days after surgery (third postoperative visit).

Surgical Technique

A triple lumen Foley catheter French #16 (Well Lead Medical, Guangzhou, China) was placed prior to surgery for IAP measurement.

Classic abdominoplasty was performed under general anesthesia and neuromuscular blockade (TOF ≤ 0.3), with plicature of the rectus abdominis muscles through continuous suture with #1 polypropylene, either at supra and infra-umbilical levels (from xiphoid to pubis in all cases). A necessary extent of plication was applied to bring together the medial edges of the rectus muscles. IAP was measured in accordance with the technique described by Kron et al[12] modified according to the current recommendations.[6] The drainage channel of the Foley catheter was connected to the collection bag. A three-way stopcock was added on to the irrigation channel, to which a pressure transducer (DTX Plus Single transducer set; Argon Medical Devices, Plano TX) and a syringe were connected. The syringe was used for instillation of 25 mL of saline solution each time a measurement was required.

Mechanical ventilation of the patient during surgery was performed (Indura Lifecare Integra 102, Santiago, Chile). Various parameters were measured with the ventilator, such as: programmed tidal volume (PTV); measured tidal volume (MTV); maximum inspiratory pressure (MIP); inspiratory pause pressure (IPP); positive end-expiratory pressure (PEEP); and capnography. Pulmonary compliance (P-Comp) was calculated with the following formula:[14]

$$\text{P-Comp (mL/cm of water)} : \frac{\text{MTV(mL)}}{\text{IPP} - \text{PEEP(cm of water)}}$$

IAP and ventilatory variables were measured on four occasions during surgery: (1) before initiating surgery; (2) before plicature; (3) after plicature; and (4) before cutaneous closure. The IAP was not measured after skin closure, because it should be performed with the patient in a semi-seated position, while the measurement technique requires the patient in a fully supine position (0°) at the end of expiration.

Additionally, the perimeter of the abdominal circumference (AC) at the level of the umbilicus was documented before and after surgery.

Statistical Analysis

The primary variables analyzed were IAP and P-Comp; their correlation with secondary variables (age, weight, height, BMI, and AC) were also analyzed. A *t* test for paired samples, a Pearson correlation coefficient, and multiple linear regressions were used for data analysis using the Stata 10.2 program (StataCorp, College Station). A *P*-value of $\leq .05$ was considered statistically significant.

RESULTS

Ten female patients in total were included in the study. Their mean age was 43.5 ± 8.4 years (range, 34-60 years) and their BMI was 27.16 kg/m^2 ± 3.4 (range: 23.23-33.32 kg/m^2). A follow-up for postoperative complications was conducted during hospitalization and extended until 30 days after

Table 1. Prospective Series with Age (years), BMI (kg/m^2), IAP (mmHg), and P-Comp (mL/cm of water) Before and After Plicature, Prior to Cutaneous Closure

Patient	Age	BMI	Preoperative IAP	Postoperative IAP	Preoperative P-Comp	Postoperative P-Comp
1	47	33.32	9	12	27.85	28.46
2	60	30.83	6	8	45.55	36.36
3	34	27.04	6	8	50	42.22
4	39	23.37	4	6	41.11	37.77
5	45	26.48	5	8	36	34
6	45	31.22	11	14	29.33	31.53
7	39	25.70	4	8	48.88	41
8	37	25.15	6	11	43	41
9	35	23.23	8	9	57.14	48.75
10	54	25.28	7	9	46.67	45.56

BMI, body mass index; IAP, intra-abdominal pressure; P-Comp, pulmonary compliance.

surgery (postoperative days 7, 14, and 30; mean total follow-up, 30 days).

Both IAP and P-Comp measurements before plicature (pre-plicature) and before cutaneous closure (post-plicature) were used, since there were no variations when comparing them with measurements before initiating surgery and after plicature. Table 1 shows the results obtained for each patient.

Effect of the Rectus Abdominis Plicature on IAP

The average pre-plicature and post-plicature IAP values were 6.6 mmHg and 9.3 mmHg, respectively. Figure 1 depicts the impact of plicature on IAP. The difference in IAP between both periods of surgery was statistically significant ($P \leq .05$).

Effect of the Rectus Abdominis Plicature on P-Comp

The average pre-plicature and post-plicature P-Comp values were 38.97 mL/cm of water and 36.54 mL/cm of water, respectively. Figure 2 depicts the impact of plicature on P-Comp. The difference in P-Comp between both surgical stages was statistically significant ($P = .0076$).

When performing the Pearson test, there was no correlation between the change in IAP and the change in AC or in P-Comp.

Using a multiple linear regression model, the relationship of dependency between the magnitude of IAP and P-Comp changes and secondary variables (age, weight, height, BMI, AC) were analyzed. Both primary variables were independent from themselves and from secondary variables.

In addition, there were no complications during the early postoperative period, or within the 30 days after surgery.

DISCUSSION

In the present prospective study, IAP and pulmonary compliance were measured in patients undergoing abdominoplasty with plicature of the rectus abdominis muscles. Plicature was observed to cause an increase in IAP and a decrease in P-Comp, with both changes being statistically significant.

Indirect measurement of IAP through intra-bladder pressure is widely validated in the trauma literature and there is current consensus on its utility.[6] Its application in this type of study represents a good indication, provided it is performed in accordance with the established guidelines. These guidelines are the following[6]: (1) IAP must be expressed in mmHg and be measured at the end of expiration in a fully supine position (0°), after ensuring the absence of abdominal contractions and zeroing the transducer at the level of the middle axillary line; and (2) for intermittent measurement of IAP, 25 mL of saline solution must be instilled on each occasion.[6]

As reported by Al-Basti et al,[15] our results demonstrate that plicature of the rectus abdominis muscles generates an elevation of the IAP, which although statistically significant, did not have a relevant clinical impact on this patient group without associated co-morbidities.

Other attempts to investigate IAP in patients undergoing abdominoplasty, with a degree of flexed position in bed or the use of a binder,[16] have been undertaken. However, we believe that for this type of investigation, intra-bladder measurement of IAP is not the appropriate method since

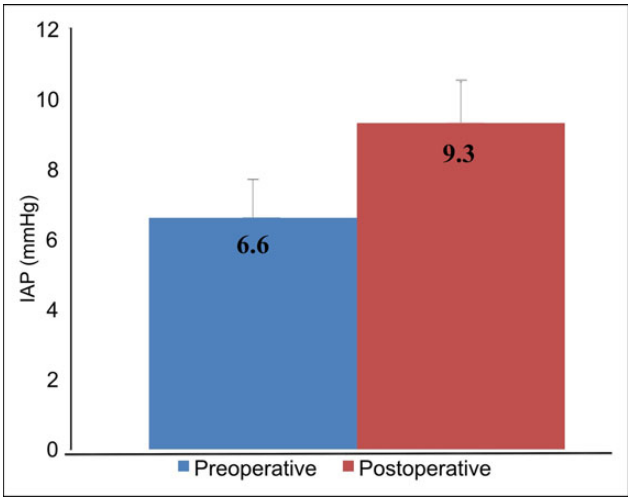

Figure 1. Effect of the rectus abdominis plicature on intra-abdominal pressure (IAP); before plicature (preoperative) and after plicature, prior to cutaneous closure (postoperative).

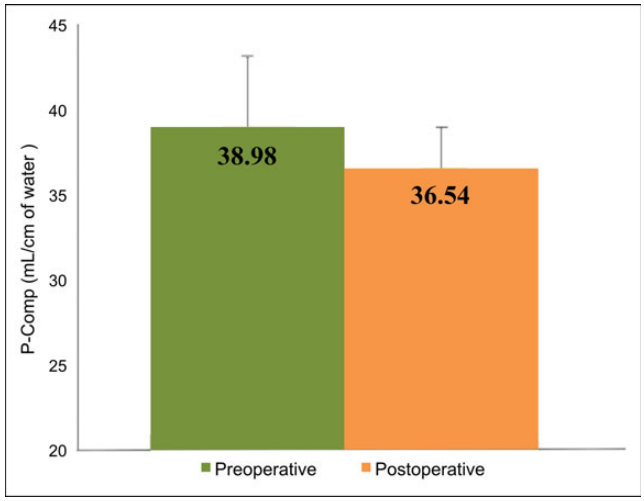

Figure 2. Effect of the rectus abdominis plicature on pulmonary compliance (P-Comp); before plicature (preoperative) and after plicature, prior to cutaneous closure (postoperative).

such a parameter is overrated when introducing other variables that can affect it, such as the absence of decubitus in 0°, or of neuromuscular blockade.

We did not find any correlation between the decrease of AC and the increase in IAP. Similar results were reported by Rodrigues et al,[17] who found that the width of diastasis did not influence the variation in IAP. The few studies addressing IAP measurement in the context of abdominoplasty that are available[15,16,18-20] were conducted prior to the establishment of recommendations made by the International Conference of Experts on Intra-abdominal Hypertension and Abdominal Compartmental Syndrome in 2006, where the technique was standardized.[6] In other studies[17,21] conducted after 2006, IAP was measured in this same setting. However, such studies used the technique described by Kron et al in 1984,[12] without applying the changes recommended by the International Conference.[6] This is why, to date, the effects of plicature of the rectus abdominis on IAP were only partially known, and prior studies lose their validity in terms of the clinical applicability of their results.

From the standpoint of respiratory physiology, it is important to determine whether the resulting increase in airway pressure after rectus plication corresponds to an increase either in resistive work or in elastic work. To this end, a maneuver is made on the mechanical ventilator that consists of a sustained pause at the end of inspiration. During such a pause, there is no airflow; therefore, the airway pressure drops, due to a lack of airway resistance.[22] In the absence of airflow, the only resistance that has to be overcome by the mechanical ventilator is elastic recoil of the lung (elastic work), expressed by the IPP. Thus, measurement of IPP enables qualitative discrimination between P-Comp or airway resistance disorders (alterations in resistive work). An increase in airway resistance will result in an increase of MIP with no variations in IPP. On the other hand, a decrease in thoraco-pulmonary compliance, such as after diastasis plicature (and therefore, an increased elastic recoil of the lung), will manifest as an increase in MIP and IPP. In the absence of airway resistance alteration, the difference between MIP and IPP should remain unchanged.[23]

Tercan et al[24] measured the changes in respiratory function before and after abdominoplasty with spirometry on 14 patients, and concluded that such a surgical procedure would improve forced vital capacity. Rodrigues et al[21] measured the ventilatory function with spirometry on 18 patients, concluding that volumes and capacities decreased on the second and seventh postoperative days and tended to normalize on the fifteenth day. In a similar attempt, Al-Basti et al[15] tried to correlate the impact of abdominoplasty on intraoperative MIP and lung function before and 2 months after surgery in 43 patients. However, there were no significant changes in this aspect. All these attempts to assess changes in lung function after plication of the rectus abdominis are inaccurate, as they are unable to differentiate whether alterations correspond to a change either in the resistive or the elastic work (P-Comp).

We correlated, in real time, the increase in IAP with the decrease in P-Comp. This happens either because of an increase in the IPP, or because of a decrease of the MTV, clinically represented by a greater difficulty in inhalation. Similar results published by Jansen et al in 1999[25] indicated that this decrease in pulmonary compliance after the abdominoplasty is related to an increase in the incidence of respiratory morbidity during the postoperative period. Similarly, as there was no correlation between the diastasis

width and IAP variation,[17] we failed to find a correlation between IAP increase and P-Comp decrease.

Our study has some limitations, one of them being the small number of patients studied. However, the number is adequate to obtain statistically significant results. While it might be interesting to know the postoperative BMI in the follow-up, BMI was not evaluated because it was not part of the study objectives and we considered it to have no influence on our current results.

It would be useful to know the behavior of IAP and P-Comp after skin closure, but due to our surgical technique the patient is left in a semi-seated position, a condition that impedes the proper measurement of these parameters.

The assessment of P-Comp seems to be a much more adequate parameter to estimate the impact of plicature of the rectus abdominis on respiratory mechanics. This is because P-Comp expresses more accurately the effect of the increase in IAP on thoraco-pulmonary mechanics, discriminating between changes in either restrictive or elastic work.

CONCLUSIONS

Plicature of the rectus abdominis during abdominoplasty results in a statistically significant increase of IAP and a statistically significant decrease of P-Comp. Such changes do not generate a clinically relevant impact on healthy individuals.

The present study represents the only research that has been conducted to investigate the effect of plicature of the rectus abdominis muscles on IAP, according to the current standards and guidelines. Moreover, it shows how pulmonary compliance is affected by real-time IAP changes.

For future research regarding the topic of the present article, as well as its application to other challenges that create tension on the abdominal wall (ie, closure of abdominal wall defects through separation of the components), we recommend the use of the intra-bladder technique to measure IAP, as suggested by the consensus. We also recommend estimating pulmonary compliance if it is necessary to measure the effect on ventilatory mechanics, since it is a more accurate parameter reflecting the impact on the thoraco-pulmonary system.

IAP measured with the modified technique and assessment of pulmonary function using P-Comp are reliable and provide more accurate correlation with such physiologic changes than other described techniques.

Disclosures

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