ORIGINAL ARTICLE

THE ROLE OF LASER AND ULTRASONIC DOPPLER FLOWMETRY IN THE CORRECTION OF COSMETIC DEFECTS OF THE ANTERIOR ABDOMINAL WALL AND PREVENTION OF COMPLICATIONS

DOI: 10.36740/WLek202107110

Orest V. Panchuk[1], Yaroslav M. Susak[1], Ievgen G. Donets[2], Pavlo I. Byck[1], Olena F. Panchuk[3], Ivan M. Leshchyshyn[1]
[1] BOGOMOLETS NATIONAL MEDICAL UNIVERSITY, KYIV, UKRAINE
[2] MEDICAL CENTER «LIKOMED», KYIV, UKRAINE
[3] STATERA CLINIC, KYIV, UKRAINE

ABSTRACT

The aim: Of work is to determine changes in blood flow in the vessels of the anterior abdominal wall that occur after plastic surgeries in order to improve the results of operations and to develop new methods for the prevention of complications.

Materials and methods: The study was conducted in 132 patients. Patients were divided into 2 groups: main group 64 and control group 68 patients. Main group has patients who underwent abdominoplasty in combination with liposuction; control group has patients who underwent abdominoplasty without liposuction. In both groups we make different simultaneous operations. Laser Doppler Flowmetry and Ultrasonic Doppler Flowmetry were performed to determine the blood flow indices in the flaps.

Results: Liposuction volumes averaged 3.57 ± 0.74 liters of lipoaspirate. In the main group there were totaly 4 complications, in the control group complications developed in 9 patients. Comparing daily indicators between the two groups, no statistically significant difference in the dynamics of MI changes was found during the entire study period ($p = 0.767$). Increase in caliber of vessels, on average, from 1.55 ± 0.8 mm in the preoperative period to 1.68 ± 0.75 mm on the 14th day of the postoperative period was statistically significant ($p < 0.05$).

Conclusions: The combination of abdominoplasty with liposuction and simultaneous operations does not lead to greater development of complications and allows to achieve good aesthetic results.

KEY WORDS: abdominoplasty, lipoabdominioplasty, laser Doppler flowmetry, ultrasound Doppler flowmetry

Wiad Lek. 2021;74(7):1605-1611

INTRODUCTION

Liposuction is the most common surgery in the world, according to the International Society of Aesthetic Plastic Surgery (ISAPS), it is second in number, inferior to augmentation mammoplasty (1677320 augmentation mammoplasty, 1573680 liposuction performed in 2017). According to ISAPS, 802234 abdominoplasty surgeries were performed in 2017 in the world [1].

The first recorded lipectomy was performed in the treatment of hernia. The term «abdominal lipectomy» was proposed in 1899 [1,2]. Since then, the technique has undergone a number of changes, which reduced trauma and mortality rates [3].

Important developments in the technique of abdominoplasty were introduced by Saldanha, who developed and described the technique of lipoabdominoplasty. He proposed to dissect the proximal flap superficially, to preserve the Scarpa fascia. According to the author, this preserves the network of lymphatic vessels of the anterior abdominal wall, which are located deeper than the Scarpa fascia in the hypogastric region [4,5].

Costa-Ferreira et al., published the results of a randomized clinical trial on the safety and efficacy of Scarpa fascia preservation. This study showed a 65% reduction in the amount of exudate that secreted by drainage and it could be removed 3 days earlier than in patients without preserving Scarpa fascia [5,6].

Swanson described the result of a high percentage of satisfied patients as a result of undergoing lipoabdominoplasty compared with classic abdominoplasty and isolated liposuction [7].

Lockwood described the main defective areas after abdominoplasty, including: "tense" zone in the central part of the abdomen, excess skin and laxity in the lateral and inguinal areas, suprapubic scar depression, proximal hair displacement, poor waist expressiveness, hypertrophic scarring [8].

Fat emulsification during liposuction, ultrasound or vibration energy facilitates aspiration, preserves vascularization and improves long-term aesthetic results. Combining this technique with abdominoplasty, you can achieve beautiful contours, emphasized by the refraction of surface

light and the formation of shadows, which is characteristic of athletic and natural abdomen [1,9].

Ultrasound and PAL (powered assisted liposaction) liposuction technologies help, during lipo-abdominoplasty, achieve the best liposuction result, emphasize contours and skin retraction [2,4,10].

The use of ultrasound and PAL liposuction enhances the viability of skin-fat flaps compared to classic liposuction [1]. However, some authors have indicated that ultrasound causes thermal damage to surrounding tissues and causes worse wound healing [11].

Volumetric liposuction (> 5000 cc) with resection of the flap causes blood loss, which leads to anemia in 18-20% of cases, which needs correction after surgery by haemotransfusion [5,12].

To reduce the risk of developing seroma, during the abdominoplasty, Baroudi and Ferreira described a technique for closing the free space under the flap, later Polock classified them as progressive tension sutures because, in addition, they also reduce the tension on the area of the suture on the skin leading to formation of a cosmetic scar [3,13].

The umbilical scar is the major stigma of lipoabdominoplasty. Its view change due to aging, pregnancy, development of hernias and hyperchromia [14]. Its external visible location is important in the aesthetics of the abdomen. The first description of umbilical reconstruction was reported in 1905; however, there were no descriptions until years 1960 [14,15]. The methods of umbilical plastic have been actively developed, and most of them use their own umbilical stem or change it location. Three main anatomical locations of umbilicus are described:

1. Located 60 percent down the line from the xiphoid process to the pubis [16].
2. At the point where the median line intersects with the line between the anterior superior processes of the iliac bones [14].
3. Fifteen centimeters up from the middle of the pubic bone [8,12].

THE AIM

The aim of work is to determine changes in blood flow in the vessels of the anterior abdominal wall that occur after plastic surgeries in order to improve the results of operations and to develop new methods for the prevention of complications.

MATERIALS AND METHODS

From the beginning of 2014 to the end of 2019, patients with anterior abdominal wall skin laxity were selected as candidates for lipoabdominoplasty. Patients were classified to type III-IV by Matarasso classification [11].

The risk of possible venous thromboembolism was assessed preoperatively using a Caprini score. For the prevention of venous thrombosis used: medium compression elastic stockings, low molecular weight heparin – enoxaparin (Klexan; Sanofi-Aventis, France), 0.5 mg/kg/day for 3 days in all patients 24 hours after surgery.

In the postoperative period, the examinations were performed by the surgeon using physical examination methods, taking pictures and surveys to determine satisfaction. The survey included the question: What is your overall satisfaction with the procedure on a scale of 1 to 4 and patients indicated the reason for their assessment.

SURGICAL TECHNIQUE

The procedure preferably consists of liposculpture followed by abdominoplasty and umbilicoplasty. Liposuction was the first stage. Infiltration was carried out with a solution of 1000 ml of 0.9% NaCl, 10 ml of 1% lidocaine and 1 ml of adrenaline 1:1000, calculating the volume ratio of infiltrate to aspirate 2:1 to 1.5:1. Fat aspiration was performed with 3 and 3.7 mm cannulas, following preoperative marking.

There is a low horizontal incision of the anterior abdominal wall. The proximal flap is dissected over the muscular fascia. As an additional stage, simultaneous surgical interventions were performed. Plication of diastasisof abdominal muscles was performed. The skin-fat flap is fixed to the muscular fascia using the midline progressive tension suture technique from the thoracic to the projection of the navel, below the navel, the fixation is performed by nodal sutures. Then the excess skin is removed and the wound closed.

PATIENTS

The study was conducted in 132 patients, women – 116 (87.9%), men – 16 (12.1%). The mean age of the patients was 43.2 ± 10.3 years. The patients were divided into 2 groups: the main group was 64 (48.5%) patients who underwent abdominoplasty in combination with liposuction; control group – 68 (51.5%) patients who underwent abdominoplasty without liposuction. In both groups additional simultaneous surgical interventions were performed Table I. All patients were obese I, II degree (mean BMI 32.8 ± 2.67 kg/m^2), the heaviest patient had a body weight of 117 kg with BMI – 35.32 kg/m^2.

Laser Doppler Flowmetry (LDF) and Ultrasonic Doppler Flowmetry (UDF) were performed to determine the blood flow indices in the flaps.

UDF of the abdominal wall vessels was performed before surgery and on the 14th postoperative day. Arteries and muscule-skin perforators were detected and determined by their number and diameter, blood flow speed and location. The studies were performed on a Philips Ultrazound Affiniti 30 (Netherlands).

LDF of abdominal wall vessels was performed before surgery, immediately after surgery and up to 14 postoperative days. To register laser Doppler flowmetry Lakk-01 laser analyzer («Lasma», Russia) was used. The LDF-recorded signal was characterized by a microvascular blood flow in a tissue volume of about 2 mm^3 [7,20]. In this study,

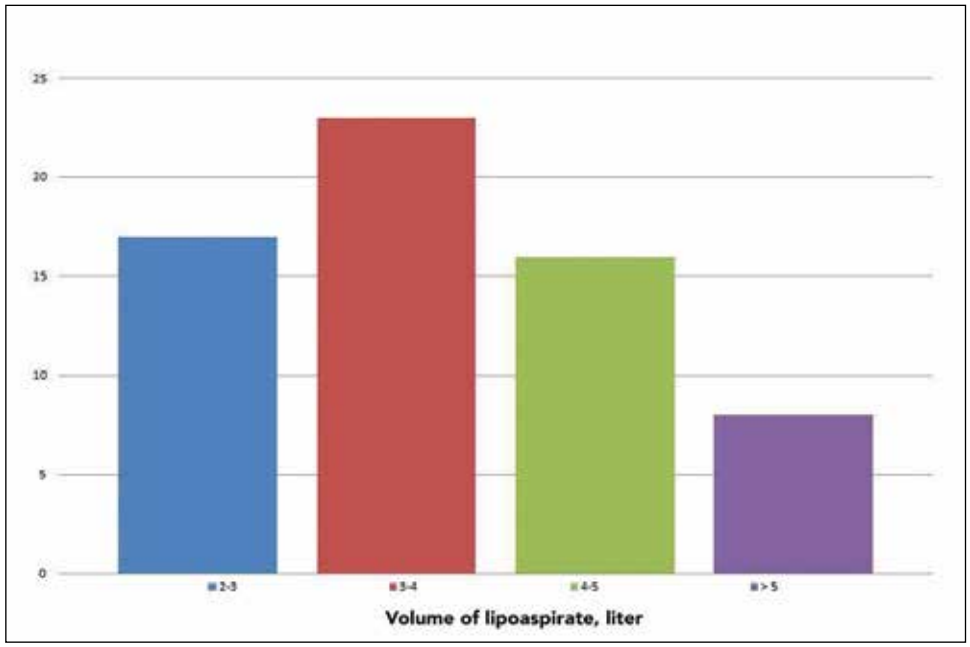

Fig. 1. Distribution of patients from the main group by volume of lipoaspirate

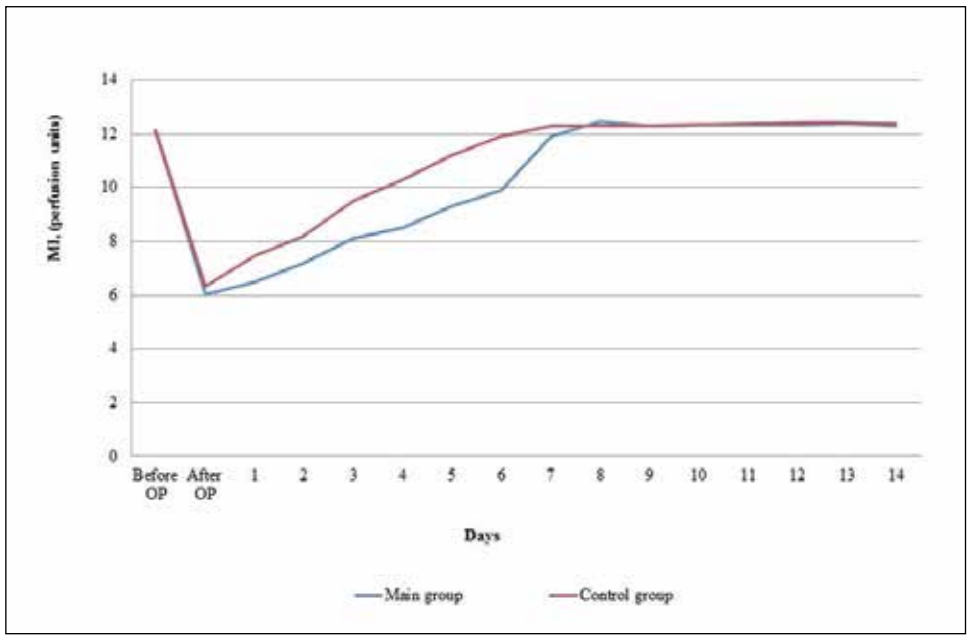

Fig. 2. Dynamics of PM changes in the main and control groups over a 14-day period

we analyzed the standard microcirculatory indexes: MI – microcirculation indicator, is the maximum value in the registration process; PK – blood flow reserve (%); σ – is the standard deviation of the amplitude of blood flow oscillations; Kv is the coefficient of variation corresponding to the ratio between the variability of perfusion (Flax) and the mean perfusion.

These methods are sensitive to the influence of external and internal factors, all examinations were carried out under the most standard conditions: temperature in the study room +20^{0}C, examination was carried out at 8:00 (except examination after the operation), in a supine position after 5-10 minutes rest, when the average rates of cardiac activity were at the level of: blood pressure – 125 ± 6,4 mmHg, pulse – 72 ± 3,1/min. The body temperature of the patients was at the level of 36.5 ± 0.2^{0}C [20].

RESULTS

All patients underwent surgery under general anesthesia. The average duration of surgery was 174.2 ± 21.2 minutes in the control group, 255.3 ± 23.5 minutes in the main group, which was caused by the additional stage of liposuction. Liposuction volumes averaged 3.57 ± 0.74 liters of lipoaspirate and ranged from 2200 to 5300 ml (Fig. 1). The average percentage of lipoaspirate from the total body weight was 3.92%, and maximum we aspirated 6.39%. The highest mass of the removed skin-fat flap was 5100 g, the patient from control group.

In the main group complications developed in 4 patients (6.3%): seroma 1 (1.6%); umbilicus ischemia occurred in 2 (3.1%) patients who had umbilical hernias and used mesh grafts; marginal necrosis of the central part of the proximal flap in 1 (1.6%) case. There were two needs

Table I. Distribution of patients by simultaneous pathology

Nosology	Number of patients, n	%
Hernias	89	67.4
Diastasis of the rectus abdominis	98	74.2
Chronic calculous cholecystitis	32	24.2
Uterine leiomyoma	17	12.9
Ovarian cysts	15	11.4

Table II. Distribution of complications in the main group and the comparison group

Complication	Main group		Control group		p
	n	%	n	%	
Seroma	1	1,6	3	4.4	
Hematoma	0	0	2	2.9	
Flap necrosis	1	1,6	2	2.9	
Umbilicus ischemia	2	3,1	2	2.9	
Total number	4	6,3	9	13.3	0,287

Table III. Distribution of LDF indicators for treatment in the main and control group

Indicators	Main group, n=64	Control group, n=68
MI, (perfusion units)	12,1 ± 1,49	12,14 ± 1,42
PK, (%)	579,7 ± 47,6	571,7 ± 46,9
σ, (perfusion units)	1,2 ± 0,49	1,1 ± 0,45
Kv, (%)	61,31± 3,8	61,8± 3,4
P = 0,83		

Table IV. Results of the LDF study immediately after surgery and at 14 days

Indicators	After surgery		14 days	
	Main group, n=64	Control group, n=68	Main group, n=64	Control group n=68
MI, (perfusion units)	6,02 ± 1,02	6,35 ± 1,2	12,3 ± 1,35	12,38 ± 1,47
PK, (%)	351,4 ± 27,1	362,2 ± 25,2	569,5 ± 45,4	573,5 ± 44,5
σ, (perfusion units)	0,77 ± 0,21	0,81 ± 0,18	1,18 ± 0,41	1,12 ± 0,38
Kv, (%)	38,1± 3,1	36,3± 2,8	63,12± 3,22	62,3± 3,1
P	0,79		0,72	

Table V. Average blood flow speed in perforator vessels before and after surgery

Average blood flow speed					
Before surgery, ml/min		2 days after surgery, ml/min		14 days after surgery, ml/min	
Main group	Control group	Main group	Control group	Main group	Control group
21,1±0,85	22,5±0,92	28,8±0,98	29,1±1,01	23,1±0,91	23,4±0,9

for additional liposuction to improve the contour of the anterior abdominal wall, this procedure was performed under local anesthesia, and does not apply to postoperative complications.

In the control group, complications developed in 9 patients (13.3%). Among them: seroma – 3 (4.4%), ischemia of the umbilicus 2 (5.9%), hematoma requiring aspiration – 2 (4.4%) marginal necrosis of the central part of the proximal flap developed in 2 (5.9 %) cases (Table II).

LASER DOPPLER FLOWMETRY

In the study of LDF in the control and main groups before treatment, no statistically significant difference between the parameters was found (P = 0.83), groups of patients were comparable in the preoperative period (Table III).

The results of the measurements in the postoperative period are presented in Table IV and in the Fig. 2.

At patients after operation the relation between low-frequency rhythms (LF) characterizing the active mechanism

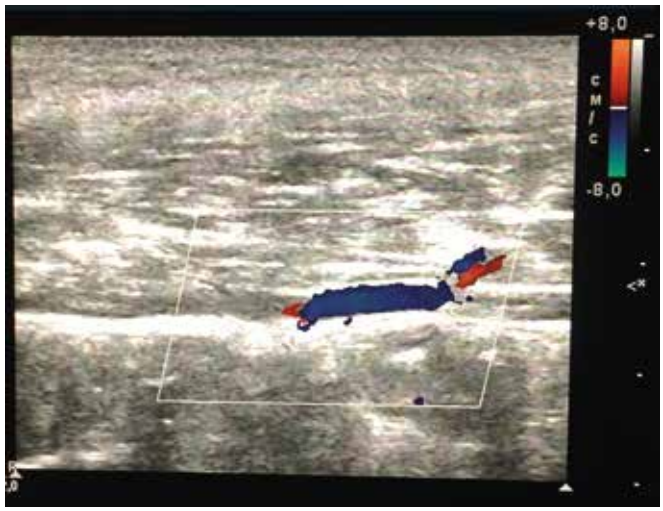

Fig. 3. Perforator vassel from a. Epigastrica inferior, study performed before surgery

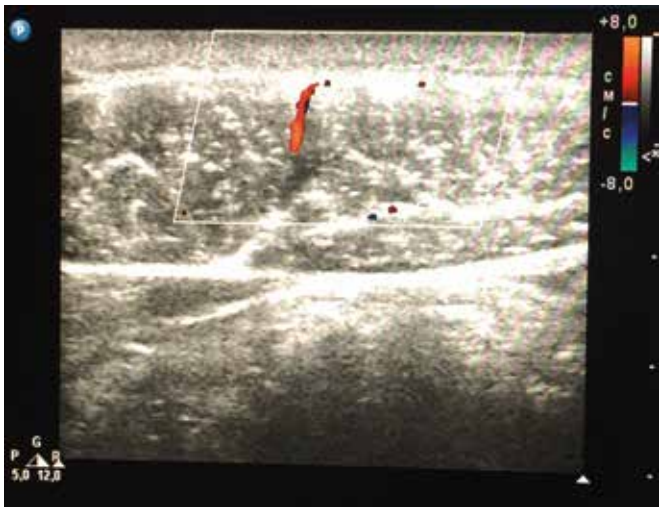

Fig. 4. Perforator vassel exit from the muscle, examination at 14 days after surgery

of microcirculation and high-frequency (HF) and cardiac (CF) rhythms is disturbed, there is a so-called «spectral narrowing» of LDF-grams. If the normal vasomotor amplitude (ALF) is 20 – 25% of the level of LDF signal, then immediately after the operation ALF decreases to 46 – 55% at a frequency of fluctuations of 6 – 8 per minute. However, the most significant changes are observed in the field of HF- and CF-oscillations, the contribution of HF-oscillations in the total spectrum of oscillations increases to 35%, whereas in the norm it is about 5-10%, in the field of cardiorhythm it increases to 6 – 7% (in the rate of 1.1 – 1.3%).

Fig. 2 shows the dynamics of MI changes in the main and control groups over a 14-day period. Based on the LDF data, we can conclude that the «ischemic crisis» in the flaps after surgery is on the first 2 days of the postoperative period. Further progressive recovery of microcirculation was noted.

Comparing the dynamics of MI in the study groups, a decrease in the level of microcirculation was found immediately after surgery in the group where liposuction was performed on 5.2% more than in the control group. Comparing daily indicators between the two groups, no find statistically significant difference in the MI changes during the study period (P = 0.767).

ULTRASONIC DOPPLER FLOWMETRY

Most perforators are located at an average distance of 5.2 ± 0.42 cm from the medial edge of the rectus abdominis along the upper and lower epigastric arteries. In the preoperative period, 8,33±2,11 perforators was found in main group and 8,35±2,09 in control group, the maximum number of perforants detected in one patient on the anterior abdominal wall was 13, the minimum number was 5. The average vessel diameter was 1.55 ± 0,8 mm. On day 14 after surgery, on 12,8% more perforated vessels were detected in the main group, which was explained by the smaller area of flap dissection due to it's greater mobility after liposuction, although there were no significant difference between results in both groups (P = 0,205).

On the 14th day after operation, an average diameter of perforated vessels in main group was 1,67±0,9, in control group 1,69±0,6, but there were no significant difference between results (P = 0,845).

The Doppler effect helps determine the speed and direction of blood flow in the blood vessels. After determining this indicator in patients, the data presented in Table V was obtained.

On Fig. 3 and Fig. 4 present the perforator vessels of the anterior abdominal wall that were detected during the ultrasound examination.

Increase caliber of vessels, on average, from 1.55 ± 0.8 mm in the preoperative period to 1.68 ± 0.75 mm on the 14th day of the postoperative period is statistically significant (P < 0.05). The average blood flow in the vessels increased by a maximum of 56% from 21.8 ml/min before surgery to 29.0 ± 0.9 ml/min after surgery (P > 0.05), which is not statistically significant and has a compensatory character. Obtained vasodilation changes are explained by a decrease in blood supply to the tissues caused by surgical trauma, a decrease in the total number of perforants and an overload of residual vessels.

DETERMINING THE LEVEL OF SATISFACTION

Aesthetic results were evaluated on a 4-point scale, based on: were serious complications requiring further surgery to save the patient's life (bad); minor interventions in the early postoperative period to correct (satisfactory); only aesthetic, requires later intervention, such as liposuction or correction of «dog's ears» (good); no intervention required, the result is completely satisfactory to the patient (excellent). The evaluation was performed on 1 and 12 months after surgery. In the main group of 64 patients after 1 month, the result was: excellent in 52 cases (81.3%), good in 10 (15.6%) and satisfactory in 2 (3.1%) cases, there was no bad result. In the control group among 68 patients, the excellent result was in 39 cases (57.4%), good

in 21 (30.9%) and satisfactory in 8 (11.7%) cases, there was no bad result.

After 1 year the result was re-evaluated. In the main group in 2 patients with excellent result, the postoperative scar was slightly extended to a width of 7 and 8 mm in the central part, which caused dissatisfaction in the patient, and they were transferred to the group with a good result. In other patients, the result remained stable. In the control group, in 5 patients with excellent results the proximal skin flap due to ptosis formed a fold over the horizontal scar, which produced a cosmetically unacceptable result, in 4 patients the horizontal scar extended to > 1 cm wide, which in 3 patients caused dissatisfaction, and they were transferred to a group with good results.

DISCUSSION

The current tendency to combine abdominoplasty and liposuction is aimed at improving results and obtaining better aesthetic results [20]; studies have been conducted to demonstrate the safety of combining these operations [4].

The correlation was not found between the type of surgery and the level of complication, and in the main group the risk of developing complications same that in the control group (P = 0,287). This indicates the safety of combining these techniques with other simultaneous operations in abdominal cavity.

In patients who underwent surgery, there was a significant decrease in microcirculation rates immediately after surgery and a gradually increase to baseline. The average period of complete restoration of microcirculation indicators to baseline was noted within 7 days, the maximum period was 9 days observed in smokers with type II diabetes.

When comparing changes in the control and the main group, we notice a sharp decrease in the average MI immediately after surgery in the flaps. There was no statistically significant difference between the control and the main groups throughout the 14-day registration period.

This study proves the safety of performing simultaneous operations in combination with lipoabdominoplasty. One-time liposuction with abdominoplasty does not lead to a critical decrease in the level of microcirculation in the flaps.

A study of flap microcirculation demonstrates the safety of single-stage abdominoplasty with liposuction, which does not require additional anesthesia for the patient in the case of sequential surgery, and reduces the associated risks. Liposuction results is a better mobilization and reduces the necessary flap dissection, preserves perforators.

Preoperative determination of perforated vessels helps to plan in detail the possibilities of flap resection, the area of possible dissection, and the volume of the entire operation in the preoperative examination.

Despite all the complications that was mention in this article, abdominoplasty and lipoabdominoplasty are reproducible and very comforting operations for patients and surgeons. This is due to the long process of research by various authors who shared their experiences, including not only successful cases, but also the most complex complications, which allows to develop more modern techniques and reduce the risk of complications.

CONCLUSIONS

Lipoabdominoplasty is a safe and helps to achieve good aesthetic results and athletic body contours. The risk of major complications after abdominoplasty can be reduced by using the described technique of surgery. This study shows that during lipoabdominoplasty, there is no critical reduction of microcirculation in flaps compared to classic abdominoplasty. The average period of complete restoration of microcirculation indicators to baseline was noted within 7 days, the maximum period was 9 days. The so-called «ischemic crisis» in the flap after lipoabdominoplasty falls on the first 2 days of the postoperative period. Further progressive restoration of microcirculation in flaps was noted.

Comparing daily indicators between the two groups, no statistically significant difference in the dynamics of MI changes was found during the entire study period (P = 0.767). A study of flap microcirculation demonstrates the safety of single-stage abdominoplasty with liposuction, which does not require additional anesthesia for the patient and reduces the associated risks.

The risk of major complications after abdominoplasty can be reduced with the help of the described technique of operation, which includes limited flap dissection and preservation of perforated vessels in the flap. In the main group the risk of developing complications was such as in the control group (P = 0,287). This indicates the safety of combining these techniques with other simultaneous operations in abdominal cavity.

REFERENCES

1. Abramson D.L. Ultrasound-assisted abdominoplasty: Combining modalities in a safe and effective technique. Plast Reconstr Surg. 2003;112:898–902.
2. Avelar J.M. Abdominoplasty: A new technique without undermining and fat layer removal. Arq Catarinense Med. 2000:29:147149.
3. Baroudi R., Ferreira C.A. Seroma: how to avoid it and how to treat it. Aesthet Surg J. 1998;18(6):439-41.
4. Chow I., Hanwright P.J., Gutowski K.A. et al. Is there a limit? A risk assessment model of liposuction volume on complications in lipoabdominoplasty. Plast Reconstr Surg. 2015;136:92–93.
5. Costa-Ferreira A., Rebelo M., Silva A. et al. Scarpa fascia preservation during abdominoplasty: randomized clinical study of efficacy and safety. Plast Reconstr Surg. 2013;131(3):644-51.
6. Costa-Ferreira A., Rebelo M., Vasconez L.O. et al. Scarpa fascia preservation during abdominoplasty: a prospective study. Plast Reconstr Surg. 2010;125:1232-9.
7. Fisher M., Bark A., Loureiro A.et al. Doppler flowmetry in the flap of abdominoplasty. Arq Catarinense Med. 32:173178, 2003.
8. Hoyos A.E., Millard J.A. VASER-assisted high-definition liposculpture. Aesthet Surg J. 2007;27:594–604.
9. International Society of Aesthetic Plastic Surgery. The International Survey on Aesthetic Procedures Performed in 2017. http://www.isaps.org/news/isaps-global-statistics.
10. Lockwood T.E. Maximizing aesthetics in lateral-tension abdominoplasty and body lifts. Clin Plast Surg. 2004;31:523–537.
11. Matarasso A. Liposuction as an adjunct to full abdominoplasty revisited. Plast Reconstr Surg. 2000;106:11971206.

12. Pitanguy I. Abdominal lipectomy: An approach to it through an analysis of 300 consecutive cases. Plast Reconstr Surg.1967;40:384–391.
13. Pollock T., Pollock H. Progressive tension sutures in abdominoplasty. Clin Plast Surg. 2004;31(4):583-9.
14. Regnault P. The history of abdominal dermolipectomy. Aesthetic Plast Surg. 1978;2:113–123.
15. Saldanha O.R., Federico R., Daher P.F. et al. Lipoabdominoplasty. Plast Reconstr Surg. 2009;124(3):934-42.
16. Saldanha O.R., Pinto E.B.S., Matos Jr. W.N. et al. Lipoabdominoplastia – Técnica Saldanha. Rev Bras Cir Plást. 2003;18(1):37-46.18
17. Shestak K.C., Walgenbach K.J., Azari K. Marriage: Abdominoplasty and short scar technique. Aesth Surg J. 2002;22:294301
18. Swanson E. Prospective outcome study of 360 patients treated with liposuction, lipoabdominoplasty, and abdominoplasty. Plast Reconstr Surg. 2012;129(4):965-78.
19. Wall S.H. Jr., Lee M.R. Separation, aspiration, and fat equalization: SAFE liposuction concepts for comprehensive body contouring. Plast Reconstr Surg. 2016;138:1192–1201.
20. Panchuk O.V., Mishalov V.H., Leshchyshyn I.M. et al. Lipoabdominoplastyka v korektsii defektiv cherevnoi stinky [Lipoabdominoplasty – complex method of correction of the anterior abdominal wall defects].Khirurhiia Ukrainy. 2018; 4: 13-17. (In Ukrainian).

ORCID and contributionship:
Orest V. Panchuk: 0000-0001-6962-6851 [A,B,D,E,F]
Yaroslav M. Susak: 0000-0002-5102-485X [A,E,F]
Ievgen G. Donets: 0000-0001-6440-1442 [D]
Pavlo l. Byck: 0000-0002-2215-3978 [C]
Olena F. Panchuk: 0000-0001-8805-1280 [A,E]
Ivan M. Leshchyshyn: [C,F]

Conflict of interest:
The Authors declare no conflict of interest.

CORRESPONDING AUTHOR
Orest V. Panchuk
Bogomolets National Medical University
13 T. Shevchenko blvd., 01601 Kyiv, Ukraine
tel: +380967766953
E-mail: orestpv@gmail.com

Received: 2020-05-05
Accepted: 2021-06-01

A – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article