Aesth Plast Surg
https://doi.org/10.1007/s00266-023-03633-3

Evaluation of Blood Loss in Third-Generation Internal Ultrasound-Assisted Liposuction

Hüseyin Kandulu[1]

Received: 19 June 2023 / Accepted: 20 August 2023

Abstract
Background In large-volume liposuction procedures, one of the most important limitations of total lipoaspirate volume is blood loss. In this study, we aimed to determine the amount of blood loss in individuals who underwent a third-generation internal ultrasound-assisted liposuction (UAL).
Methods Eleven female and eleven male participants with a mean age of 35.31 (range 20–47) were included in this prospective study. The third-generation internal UAL was performed on multiple anatomical regions using the VASER® Internal Ultrasound Device (Sound Surgical Technologies; Louisville, CO). The demographic characteristics of the participants, the amount of aspirate collected, and hemoglobin (Hgb) and hematocrit (Htc) values before and after the third-generation internal UAL were evaluated.
Results The mean third-generation internal UAL time was 74.81 ± 17.95 minutes, and the mean aspiration amount was 5,122.27 ± 1,597.43 ml. The aspirated amount was 6.64% ± 2.20 of body weight. The mean Hgb value was 13.87 ± 1.99 before the third-generation internal UAL and 11.26 ± 2.16 (g/dL) after the third-generation internal UAL ($z = 4.108$, $p < 0.001$). The mean reduction in Hgb levels with the third-generation internal UAL was 2.61 ± 1.73 and 0.53 ± 0.36 per liter of aspirate taken. The mean Htc value after the third-generation internal UAL was 33.91 ± 6.03 and was significantly lower than the mean Htc value before the third-generation internal UAL, 41.39 ± 5.13 ($z = -3.946$, $p < 0.001$). The mean reduction in Htc with the third-generation internal UAL was 7.48 ± 5.42, and the Htc value decreased by 1.50 ± 1.13 per liter of aspirate ingested. The amount of aspirated supernatant was responsible for 44.4% of the change in Hgb and 30.9% of the change in Htc after the third-generation internal UAL.
Conclusion Knowing the reduction rates in Hgb and Htc with the third-generation internal UAL is useful to plan the amount of aspirate to be taken, the amount of blood loss that may occur with the third-generation internal UAL, and the postoperative care of the patients.
Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Third-generation internal ultrasound-assisted liposuction · VASER® · Blood loss · Hemoglobin · Hematocrit

Introduction

Liposuction, one of the most commonly performed cosmetic surgeries, has gained popularity over the years and is now widely practiced [1–3]. According to the reports, it is the second most popular cosmetic surgery in the world. However, there are concerns and limitations regarding patient safety, particularly related to the amount of fat that can be removed through the procedure. The primary reason for these limitations is the potential for blood loss during liposuction [4, 5].

To mitigate or minimize blood loss during liposuction, several new techniques have been devised, and

✉ Hüseyin Kandulu
info@kandulu.com

[1] Huseyin Kandulu Clinic for Plastic Surgery, Terrace Fulya Teşvikiye Mah. Hakkı Yeten Cad.No.13 Center 1 Kat 11 D.59, Teşvikiye, Istanbul, Turkey

Published online: 27 September 2023

modifications have been made to existing methods. To achieve this objective, aspirating solutions containing various agents have been used to minimize trauma and bleeding. Additionally, tumescent liposuction has been employed by injecting a combination of Lactated Ringer's solution, diluted epinephrine, and lidocaine to minimize blood loss [6]. Ultrasound-assisted liposuction applications have been performed to help reduce blood loss and trauma in areas rich in fibrous tissue, alongside the other defined procedures including external ultrasound-assisted lipoplasty, power-assisted lipoplasty, laser-assisted lipoplasty, and vibrational amplification of sound energy at resonance (VASER®; Sound Surgical Technologies, LLC, Louisville, Col.)-assisted lipoplasty [7, 8]. VASER®-assisted lipoplasty is a third-generation internal ultrasound system that uses the minimal power required to specifically target and emulsify fat tissues.

Acute blood loss following liposuction, particularly after high-volume suction surgeries, is a significant complication. The objective of this study was to explore the impact of the third-generation internal UAL on hemoglobin (Hgb) and hematocrit (Htc) levels during the acute phase and to investigate whether changes in Hgb and Htc were linked to patient demographics and intraoperative characteristics.

Materials and Methods

Patients

This prospective study was conducted on a total of 22 patients who underwent a third-generation internal UAL procedure in the between July 2019–June 2022. Approval for the study was obtained from the local ethics committee. This study was conducted in accordance with the tenets of the Declaration of Helsinki, and written informed consent was obtained from all subjects. Patients with a BMI of 35 and above, history of bleeding disorders or under treatment with blood thinners, actively menstruating on the day or week of the procedure, a previous history of cancer, and/or previous liposuction surgery of any type were not included in the study.

Demographic data of all patients were recorded before and after the surgery. Hgb and Htc values were obtained from the whole blood count analyses of the patients which were conducted one day prior to the surgery and 1620 hours after the surgery. The reduction for both variables per aspirated liter were calculated and recorded.

The volume of tumescent solution injected and the total aspirated volume from each liposuction area were calculated dividing the total volume by the number of body parts that underwent liposuction.

Surgical Procedure

The third-generation internal UAL application was performed under general anesthesia. Initially, surgery was started following the infiltration of the tumescent solution composed of 1000 mL of lactated Ringer's solution including 1 mg adrenaline and 5 mL of 1% lidocaine was infiltrated in the areas of interest.

The solution content was prepared with 1 mg adrenaline and 10% anti-arrhythmic (Lidocaine Hydrochloride) into each 1000 mg Ringer's Lactate solution. No bleeding reducing agent (e.g., tranexamic acid) was applied. Then, the fat tissue was melted by working with the third-generation internal UAL at 100% C-mode to the point where there was no resistance under the skin (this corresponds to approximately 10 minutes of working time for each 1 liter of liquid given). Then, liposuction was applied by using 4.6 mm and 3.7 mm cannulas with 25 mmHg suction power in the required areas. All surgeries were performed by the same surgeon. Drains were used in patients who underwent operations on the abdomen and waist region. However, no drain was applied on those who underwent a procedure on the arm, leg, or back. Maintenance fluid therapy with a lowest amount of 2000 mL was initiated on patients and a follow-up in the hospital on the following day after the operation was performed.

Statistical Analysis

Statistical analysis was performed using SPSS v20 statistical software. A Shapiro–Wilk test was used to evaluate the suitability of the measured data for normal distribution. Mean and standard deviation values of continuous variables, n, and percentage values of categorical variables were determined. A Wilcoxon test was used to compare Hgb and Htc measurements before and after the third-generation internal UAL. A Partial correlation and a Spearman correlation were performed for the factors affecting the Hgb and Htc values before and after the third-generation internal UAL. For all statistics, a p value of less than 0.05 was determined to be significant.

Results

Demographic data of the participants are given in Table 1. Eleven of the participants included in the study were male and 11 were female; six of them were smokers. Three of the participants had allergies (cat, aspirin, and penicillin) and seven previously had a surgical operation. Liposuction was applied to 21 people from the abdomen, 20 people from the waist region, 15 people from the arm region, 10 people from the back region, and 8 people from the breast

Table 1 Demographic data of the patients.

	n (%)
Gender	11 (50%)
	11 (50%)
Cigarette	6 (27.3%)
	10 (45.5%)
Alcohol	14 (63.6%)
	1 (4.5%)
Substance use	14 (63.6%)
	1 (4.5%)
Allergy	3 (13.6%)
	11 (50%)
Previous surgery history	7 (31.8%)
	9 (40.9%)
Liposuction area	21 (95.5%)
	20 (90.9%)
	10 (45.5%)
	15 (68.2%)
	5 (22.7%)
	2 (9.1%)
	6 (27.3%)
	8 (36.4%)
	3 (13.6%)
	Mean ± S.D
BMI	26.72 ± 2.90
Age (year)	35.31 ± 7.53
VASER time (minutes)	74.81 ± 17.95
Aspirated volume (ml)	5122.27 ± 1597.43
Percentage of body weight aspirated	6.64 ± 2.20
The total volume of tumescent solution injected (ml)	7340.48 ± 2786
The volume of tumescent solution injected into each liposuction area (ml)	1008.85 ± 673.52
The total aspirated volume from each area (ml)	724.20 ± 554.14

side area. The mean age of the participants was 35.3 (range 2047), the mean third-generation internal UAL duration was 74.81 ± 17. minutes, the mean BMI was 26.72 ± 2.90, and the mean aspirate amount was 5122.27 ± 1597.43 ml. The percentage of aspirated body weight was 6.64 ± 2.20.

The change in blood values following the third-generation internal UAL is given in Table 2. The mean value of Hgb before the third-generation internal UAL was 13.87 ± 1.99 (g/dL), and it was significantly higher than the mean Hgb value of 11.26 ± 2.16 (g/dL) after the third-generation internal UAL ($z = 4.108$, $p < 0.001$). The mean reduction in Hgb with the third-generation internal UAL was 2.61 ± 1.73 and decreased 0.53 ± 0.36 for each liter of aspirate taken. The mean Htc value before the third-generation internal UAL was 41.39 ± 5.13, and it was significantly higher than the mean Htc value after the third-generation internal UAL, 33.91 ± 6.03 ($z = 3.946$, $p < 0.001$). The mean reduction in Htc with the third-generation internal UAL was 7.48 ± 5.42, and the value of Htc decreased by 1.50 ± 1.13 for each liter of aspirate taken.

The amount of aspirated supernatant was strongly correlated with the change in Hgb and Htc values following the third-generation internal UAL (Table 3).

The relationship between the change in Hgb and Htc after the third-generation internal UAL and demographic data is shown in Table 4. There was a strong positive correlation between the reduction in both Hgb and Htc and female gender after the third-generation internal UAL. There was a strong positive correlation between the reduction in Hgb and smoking after the third-generation internal UAL.

Discussion

Especially in large-volume liposuction procedures, one of the most important limitations of total lipoaspirate volume is blood loss [9, 10]. The most important determinants of blood loss are aspiration volume, operation time, and patient weight [11]. Approximately 2045% of the lipoaspirates collected during dry liposuction are blood. With the wet technique, the blood loss rate was reduced from 10% to 30% of the aspirate. With the use of epinephrine, the loss rate was reduced to 15% of the aspirate [12]. With the super wet technique, blood loss was reduced to approximately 2% of the aspirated volume [13, 14].

In this study, the effect of the third-generation internal UAL application on Hgb and Htc values of patients was evaluated. After the third-generation internal UAL application, a significant decrease was determined in both Hgb and Htc values. A decrease in Hgb value of 0.53 ± 0.36 g/dL and Htc value of 1.50 ± 1.13 g/dL were determined for each liter of aspirate taken with the third-generation internal UAL. There was a strong positive correlation between the reduction in Hgb after the third-generation internal UAL and female gender and smoking. We suggest that the relatively lower blood loss in males might be due to their higher fibrous content, and a gender-related conclusion from our findings needs to be supported by further research.

In their study, Cansancao et al. [4] reported that blood loss in the group treated with tranexamic acid decreased significantly compared to those who did not receive the agent (37.7 ml vs. 59.9 ml). They determined that blood loss per liter of supernatant was 8.8 ml in the group treated with tranexamic acid versus 20.1 ml in the non-treated group. There was 56.2 percent less blood loss per liter of

Table 2 Changes in hemoglobin and hematocrit after the third-generation internal UAL.

		z, *p*
pre-op hemoglobin (g/dl)	13.87 ± 1.99	$Z = -4.108$, $p < 0.001$
post-op hemoglobin (g/dl)	11.26 ± 2.16	
pre-op hematocrit (g/dl)	41.39 ± 5.13	$Z = -3.946$, $p < 0.001$
post-op hematocrit	33.91 ± 6.03	
Hematocrit reduction	7.48 ± 5.42	
Hematocrit reduction per aspirated liter, g/dl/liter	1.50 ± 1.13	
Hemoglobin reduction (g/dL)	2.61 ± 1.73	
Hemoglobin reduction per aspirated liter, g/dl/liter	0.53 ± 0.36	

Wilcoxon test

Table 3 The relationship between amount of liposuction and preoperative and postoperative hemoglobin and hematocrit changes.

	Post-op hemoglobin	Post-op hematocrit	R^2
Pre-op hemoglobin	$r = 0.667$, $p < 0.001$		0.444
Pre-op hematocrit		$r = 0.556$, $p < 0.001$	0.309

Partial correlation coefficient.

Table 4 The relationship between gender and smoking and preoperative and postoperative hemoglobin and hematocrit changes.

		Hemoglobin	Hematocrit
Gender smoking	Male	$r = -0.072$, $p = 0.834$	$r = -0.388$, $p = 0.238$
	Female	$r = 0.693$, $p = 0.018$	$r = 0.636$, $p = 0.035$
	No	$r = 0.749$, $p = 0.086$	$r = 0.522$, $p = 0.288$
	Yes	$r = 0.666$, $p = 0.036$	$r = 0.431$, $p = 0.213$

[r] Pearson correlation coefficient

supernatant in the group treated with tranexamic acid. They observed a 1.3 percent decrease in hematocrit per liter of supernatant in the tranexamic acid-treated group and a 2.7 percent decrease in the non-tranexamic acid-treated group. The patients receiving tranexamic acid had a 48 percent less reduction in Htc. Massoud et al. [15] reported that external blood loss was reduced by approximately 27% in their pilot study involving 14 women who had laser lipolysis. Abdelaal and Aboelatta [11] found an overall 54% reduction in blood loss with laser-assisted liposuction. They reported that reductions in blood loss were most common in cases of gynecomastia (58%), back (57%), limbs (53%), and abdomen (51%). Despite the evidence that suggest tranexamic acid as a potential protective agent against blood loss, we refrained from utilizing this agent for our group of patients. This decision was influenced by the scarcity of available reports on the subject and the fact that studies regarding the use of tranexamic acid have only been recently published and require more comprehensive supporting evidence.

There are not many studies evaluating blood loss in the third-generation internal UAL cases. In a study comparing suction-assisted lipoplasty (SAL) and the third-generation internal UAL, the Htc value in the third-generation internal UAL aspirate was reported to be lower than the Htc value in the SAL aspirate (0.61% vs 3.98%). It was also observed that the Hbg value in the third-generation internal UAL aspirate was less than the Hbg value in the SAL aspirate (0.3 g/dl vs. 2.23 g/dl). The mean Hgb content in the SAL aspirate was documented to be 7.5 times higher than that of the third-generation internal UAL aspirate. Additionally, the mean Htc value in the SAL aspirate was 6.5 times higher than that in the aspirate from the third-generation internal UAL group [16]. In another study, which collected similar proportions of aspirate (671 cc vs. 781 cc) with SAL and the third-generation internal UAL, blood loss with the third-generation internal UAL was found to be 26% less than with SAL (11.2 versus 14.0 cc blood per 100 cc) [7]. In both studies mentioned, blood loss was obtained from the subjective evaluation of the blood in the aspirate.

In our study, we investigated the effect of the third-generation internal UAL applied in 22 patients on blood loss. The mean reduction in Hgb after the third-generation internal UAL was 2.61 ± 1.73 (mg/dL), and there was a

0.53 ± 0.36 reduction in Hgb for each liter of aspirate ingested. The mean reduction in Htc after the third-generation internal UAL was 7.48 ± 5.42, and a reduction in Htc of 1.50 ± 1.13 was observed for each liter of aspirate taken. The mean amount of aspirate taken with the third-generation internal UAL was 5.12 ± 1.59 ml and constituted 6.64 ± 2.20 percent of body weight. In our cases, a high-volume liposuction is typically performed, as evidenced by the amount of aspirate collected, resulting in a corresponding increase in blood loss as the volume of aspirate collected increases. However, the fact that the change in Hgb and Htc is less than in previous studies shows that the third-generation internal UAL is an effective method in preventing and/or reducing blood loss.

There are several limitations to our study that should be considered. Firstly, we did not compare our results with those obtained from other liposuction techniques. Furthermore, the study would benefit from the employment of a tranexamic acid arm. We did not perform measures of the lipoaspirate Hb and Htc, owing to the analytical concerns from the laboratory we consulted, since the lipoaspirate is a heterogenous and challenging solution for processing in the automated analyzers for differential measurement of blood components. Additionally, the small sample size and the fact that the study was conducted at a single center are also important limitations to acknowledge. However, our study included patients of both genders and provides information on the initial hematological findings after the third-generation internal UAL procedure.

In conclusion, it was determined that there was a 0.53 ± 0.36 g/dL decrease in Hgb and a 1.50 ± 1.13 g/dL decrease in Htc for each liter of aspirate taken with the third-generation internal UAL in our study. The amount of aspirated supernatant was responsible for 44.4% of the change in Hgb and 30.9% of the change in Htc following the third-generation internal UAL. Having knowledge of these values can aid in determining the appropriate amount of aspirate to be extracted during the third-generation internal UAL procedure and predicting potential blood loss, as well as guiding the postoperative care of patients.

Declarations

Conflict of interest The author declares that he has no conflict of interest to disclose.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent Informed consent was obtained from the study participants.

References

1. Cosmetic Surgery National Data Bank (2012) statistics. Aesthet Surg J 33:1S-21S
2. Beidas OE, Gusenoff JA (2021) Update on liposuction: what all plastic surgeons should know. Plast Reconstr Surg 147:658e–668e
3. Kandulu H (2023) The short-term effect of vaser assisted liposuction on lipid profile. Aesthetic Plast Surg 47:685–689
4. Cansancao AL, Conde-Green A, David JA, Cansancao B, Vidigal RA (2018) Use of tranexamic acid to reduce blood loss in liposuction. Plast Reconstr Surg 141:1132–1135
5. Cao H, Liu H (2022) Current status and prospects of clinical application of liposuction. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 36:127–132
6. Pitman GH, Aker JS, Tripp ZD (1996) Tumescent liposuction a surgeon's perspective. Clin Plast Surg 23:633–641
7. Nagy MW, Vanek PF Jr (2012) A multicenter, prospective, randomized, single-blind, controlled clinical trial comparing VASER-assisted Lipoplasty and suction-assisted Lipoplasty. Plast Reconstr Surg 129:681e–689e
8. Duscher D, Atashroo D, Maan ZN, Luan A, Brett EA, Barrera J, Khong SM, Zielins ER, Whittam AJ, Hu MS, Walmsley GG, Pollhammer MS, Schmidt M, Schilling AF, Machens HG, Huemer GM, Wan DC, Longaker MT, Gurtner GC (2016) Ultrasound-assisted liposuction does not compromise the regenerative potential of adipose-derived stem cells. Stem Cells Transl Med 5:248–257
9. Chen L, Chang K, Chen Y, Xu Z, Shen W (2022) Does autologous transfusion decrease allogeneic transfusion in liposuction surgery of lymphedema patients? Front Med (Lausanne) 9:778230
10. El Minawi HM, Kadry HM, El-Essawy NM, El Saadany ZA, Nouh OM (2023) The effect of tranexamic acid on blood loss in liposuction: a randomized controlled study. Eur J Plast Surg 46:227–237
11. Abdelaal MM, Aboelatta YA (2014) Comparison of blood loss in laser lipolysis vs traditional liposuction. Aesthet Surg J 34:907–912
12. Illouz YG (1983) Body contouring by lipolysis: a 5-year experience with over 3000 cases. Plast Reconstr Surg 72:591–597
13. Fodor PB, Watson JP (1999) Wetting solutions in ultrasound-assisted lipoplasty. Clin Plast Surg 26(289–93):ix
14. Rohrich RJ, Beran SJ, Fodor PB (1997) The role of subcutaneous infiltration in suction-assisted lipoplasty: a review. Plast Reconstr Surg 99:514–519
15. Massoud K, Hussein H, Aboulfotouh S, El Sherbiny K (2008) Evaluation of blood-loss in laser-assisted liposuction. Egy J Plast Recons Surg. 32:237–241
16. Garcia O Jr, Nathan N (2008) Comparative analysis of blood loss in suction-assisted lipoplasty and third-generation internal ultrasound-assisted lipoplasty. Aesthet Surg J 28:430–435