



The effect of tranexamic acid on blood loss in liposuction: a randomized controlled study

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Abstract

Background Liposuction is one of the most common procedures in the practice of plastic surgery. Since it evolved, continuous modifications have been to decrease blood loss so that patients are hemodynamically stable intra- and postoperatively. Tranexamic acid (TXA) has long been used for its antifibrinolytic properties that were beneficial in reducing blood loss, rate of transfusion, and hemoglobin drop in major trauma and surgeries. Its use in plastic surgery, however, is still limited. In this study, we aim to illustrate the effect of intravenous (IV) and local infiltration of TXA on blood loss in liposuction surgery.

Methods Between April 2019 and April 2021, 90 patients who requested liposuction for various body parts were randomly allocated into 3 equal groups: control group, IV TXA, and local infiltration of TXA. A sample was taken from infranatant and sent for hematocrit calculation. Volume of blood in lipoaspirate was then calculated. Patients were assessed for blood loss and postoperative bruising.

Results Volume of blood loss in lipoaspirate was considerably lower in the TXA groups, with 60% decrease in blood loss for the local TXA group in comparison with the control group. TXA has also been shown to markedly decrease bruising tendency in postoperative liposuction patients.

Conclusions TXA can be used to decrease blood loss in large-volume liposuction, modify the need for blood transfusion intra- and postoperative, and improve the results of liposuction procedure without the need for multiple sessions.

Level of evidence: Level II, Risk/Prognostic Study.

Keywords Liposculpture · Liposuction · Tranexamic acid · Antifibrinolytics · High-volume liposuction

Introduction

Liposuction is one of the most commonly performed aesthetic surgical procedures nowadays. Since its introduction in the 1980s, its popularity has been increasing significantly. However, concerns regarding patient safety have generated justifiable limits on the volume of fat that can be aspirated in one session. These limitations are influenced by the hemodynamic disturbance and blood loss that can occur during,

and shortly after the procedure. Although the Klein formula described in 1987, effectively decreased blood loss to around 1% of the lipoaspirate [1, 2], this may not be enough in cases of large-volume liposuction and recently mega-liposuction where some authors documented aspirating of 25 L per case [3, 4].

High-volume liposuction requires specific attention to blood loss, fluid imbalance, and restoration of normal circulation intra- and postoperative to avoid serious complications. Until today, the maximum permissible lipoaspirate volume is significantly controversial. Currently, there are minimal data to support a specific volume at which liposuction is considered risky. The current American Society of Plastic Surgeons guidelines defines 5000 ml of aspirate as large-volume liposuction that would likely foreshadow an increased risk for the procedure owing to fluid imbalance, blood loss, increased operative time, electrolyte imbalance, etc.... However, it was eventually concluded that “there is no scientific data available to support a specific maximum

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volume at which liposuction is no longer safe.” [5] Extra measures are needed to further reduce blood loss and hematoma formation.

TXA is an antifibrinolytic agent that works by competitive inhibition of the conversion of plasminogen to plasmin, thereby preventing the fibrin degradation. Recently, tranexamic acid (TXA) has been successfully used in various medical specialties, such as orthopedics, cardiothoracic surgery, and ObGyn to reduce blood loss and transfusion requirements. Some authors demonstrated decreased blood loss to the third. In plastic surgery, the surgical application of IV tranexamic acid for minimizing blood loss has undergone a revival, and its use has been popularized by many authors for reduction of intraoperative bleeding. This has proven particularly effective in certain fields like burns, craniomaxillofacial, and aesthetic procedures. Although its specific use in liposuction has been cited by some publications, its efficacy in reducing perioperative blood loss during liposuction has not yet been clearly proven [2, 6, 7]. Despite being an off-label use of the drug, research in this field has proven that there are no harmful side effects that can occur from this use within the safe dosage suggested in previous studies (10–30 mg/kg) [8, 9].

A recent study was carried on Egyptian females, where large-volume aspirate (more than 10 L) was performed. Reduction of hemoglobin level was 3–4 g/dl; however, it was concluded that bleeding following liposuction cannot be estimated accurately by blood analysis in the immediate postoperative period as third space loss cannot be estimated and drop of hemoglobin level is predicted to continue over the first week [10].

This is why in this study, we aimed at measuring the hematocrit levels in the infranatant rather than measuring the drop in patients’ Hb pre- and postoperative, to compare the safety and efficacy of different routes of administration of tranexamic acid on the blood loss in lipoaspirate. To our knowledge, this is the first randomized controlled study, with relatively large sample size to compare local and systematic administration of TXA to a control group, assessing its effect on blood loss as well as postoperative bruising.

Another objective of this study was to assess postoperative bruising in different patients’ groups. This was achieved using a bruising scale that was constructed using different shades of bruises from our patients. This visual scale helped minimize the subjectivity of results due to limiting personal opinion regarding variation in degree of bruise intensity.

Patients and methods

A randomized controlled study was conducted on candidates presenting for liposuction of various parts of the body through the time period between April 2019 and April 2021,

after being approved by our Institutional Review board. By reviewing similar articles, we found that Consancao et al. used a sample of 20 patients and Klein et al. used a sample of 45 patients. By combining their data and using a sample size calculator, 90 patients were included in our study. The candidates were divided into three equal groups of 30 patients each. Group “A” included candidates receiving local tranexamic acid (TXA) in addition to the regular Klein’s formula, group “B” included those receiving intravenous (IV) TXA, and the last was a control group “C,” with added normal saline equal to the amount of TXA that would have been used in the other groups.

– Inclusion criteria:

- Patients between 16 and 50 years old
- Patients with BMI < 35
- Both males and females were included

– Exclusion criteria:

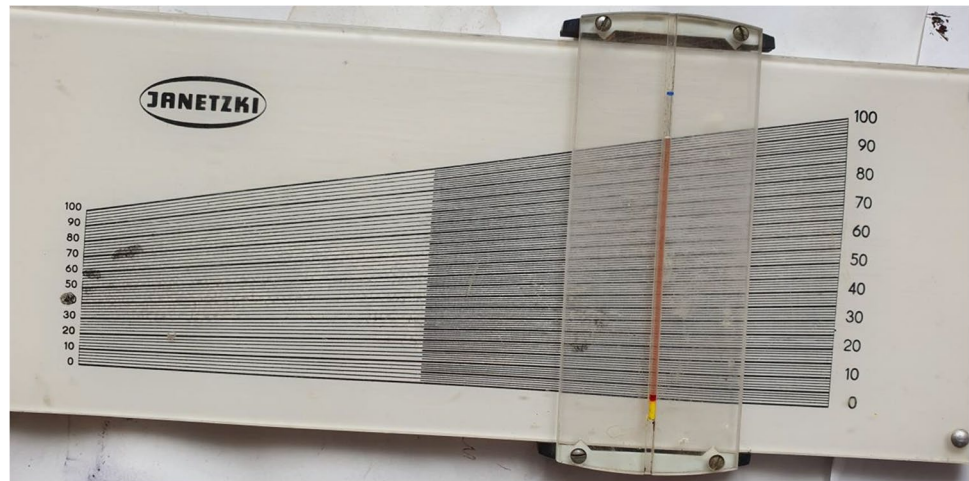
- Patients with known allergy to tranexamic acid
- Patients with abnormal coagulation profile (according to American Society of Anesthesiologists (ASA) guidelines for preoperative preparation of surgical patients)
- Patients who are receiving treatment for known hyper-coagulable state.
- Patients with history of cardiac disease or thromboembolic events.

Patients consenting for the study were assigned to one of three groups by computer generated randomization system using “research randomizer” [11] from the website www.randomizer.org. The program randomly allocated 30 unique patient numbers to each of the three sets so that the first set for example will include patients number 1, 5, 7, 8, 6, 22, 45,....etc., and based on this arrangement, patients were assigned to the study group according to their order of attendance in the clinic. This was done by the anesthesiologist, who was not part of this study. This is to ensure blinding of the surgeon and all participants in this study starting with patient selection and till the end of follow-up for this study.

After that, patients were admitted to the hospital on the day of the procedure. Routine preoperative blood work was done including full blood count and coagulation profile (prothrombin time (PT), prothrombin concentration (PC), and international normalized ratio (INR), according to the ASA guidelines and results were recorded.

The procedure was performed using general, regional, or local anesthesia with sedation in selected cases. Superwet technique [12] was the standard tumescence used for

Fig. 1 Micro hematocrite tube after centrifugation showing a hematocrite reading of “2”



infiltration; the solution was prepared using the usual Klein's formula (25 ml lidocaine 2%, 1 ml 1:1000 epinephrine, 12.5 ml 8.4% sodium bicarbonate added to 1000 cc normal saline). In the local TXA group, 1 cc (100 mg) of tranexamic acid was added to each 500 cc of the tumescence solution to be injected while, in the IV TXA group, the drug was added in the same ratio to the IV fluid administered by the anesthesiologist half an hour before liposuction starts and during the procedure, provided the maximum dose of 15 mg/kg was not exceeded in either group. In all groups, we waited for 30 min after infiltration before starting aspiration. By having the anesthesiologist add the drug to the tumescence or to the IV fluids, the operating surgeon was kept completely blinded and was not able to predict to which group the patient belongs during surgery and thereafter. In this study, and in trials to unify dose in the tumescence formula as well as the IV infiltration, it was decided that 1 cc of TXA would be added to each 500 cc normal saline, which means that 100 mg TXA was added to each 500 cc of the tumescence formula would be used in all cases. With this formula, the average dose of TXA was found to be 8.1 mg/kg for the local TXA group and 7.8 mg/kg for the IV group.

The procedure was performed using suction-assisted liposuction as a standard technique in all patients. No laser, ultrasound, radiofrequency, or any other assisting technology was applied in the trial to unify the harvest process. Surgeries were mostly done in university

hospital but some of the cases were performed in some private centers due to governmental restrictions at times of COVID 19 pandemic. The procedure was performed mainly by 3 different surgeons; this was one of the study limitations that will be referred to later in the discussion section. After finishing the procedure, the lipoaspirate was left to settle for at least 30 min before collection of the samples. Due to difference in duration of each procedure, the timing between TXA administration and sample collection was not standardized. However, we were able to standardize the timing between finishing the procedure and collection of the measurements and sample to give the aspirate time to settle and the infranatant to sediment. Total volume of lipoaspirate, supranatant, and infranatant were recorded by the surgeon before a sample was taken from the infranatant fluid using a Nelton tube and syringe. Samples were then transferred to the laboratory the day after, making sure it was stored in temperature of 4 °C for being processed. For the calculation of hematocrit, samples were centrifuged and then a manual hematocrit measurement ruler (Fig. 1) was used to calculate the hematocrit value. Three readings were obtained for each sample by the laboratory technician and an average of the results was obtained in order to minimize human errors. This manual method was used due to the technical difficulty of automated sample processing because of the high risk of damaging the machines by the suspended fat particles, even if the sample was filtered. Volume of blood loss was calculated using the Klein's Eq. (2).

$$\text{Volume of blood loss in lipoaspirate} = \frac{\text{infranatant volume} + (0.16 \times \text{supranatant volume})}{\text{patients hematocrit}} \times \text{hematocrit of lipoaspirate} \quad (1)$$

Fig. 2 Bruising scale

Upon discharge, patients were advised to maintain a compression garment for 4–6 weeks and follow-up with the treating physician starting 2 days postoperative. On the first follow-up visit, patients were assessed for any postoperative complication, including hematoma, seroma, or skin complications. Patients were also assessed for degree of bruising.

The bruising scale was developed using standardized pictures from multiple patients after their permission. The treating physician, patient, and a third party were asked to record the degree of bruising subjectively for each patient at the 2nd postoperative day. The scale ranges from 0 to 5 where grade 0 indicates no bruises at all, while grade 5 was the most severe bruises encountered in the study (Fig. 2). The surgeon, patient, and the third party were not informed whether the patient received TXA in any form except after recording their opinion regarding the bruising scale, to make sure that the blinding process initiated with patient selection is completed till the end of the study. Follow-up of the patients' local and general condition was continued for 4–6 weeks, depending on the procedure performed. Postoperative blood work was requested 10 days postoperative, unless a patient manifested any sign

of anemia or other morbidity calling for earlier investigations. However, some of candidates did not consent repeating the blood work for research purposes at 10 days postoperatively. In addition, as aforementioned, third space loss continues for 2–3 weeks postoperative, which makes hemoglobin or hematocrit measurement immediately postoperative of very questionable value.

Data was sent for statistical analysis using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Comparisons between quantitative variables were done using Kruskal–Wallis and Mann–Whitney tests [13]. For comparing categorical data, the chi-square (χ^2) test was performed. *p*-values less than 0.05 were considered as statistically significant [14].

Results

In the interval between November 2019 and May 2021, 90 patients, 72 females, and 18 males with different kinds of lipodystrophy underwent liposuction in different centers in Egypt. The mean age for patients in this study was 35 years

(± 8). Patients' mean BMI was 29 kg/m² (± 3). Candidates were categorized into 4 groups according to area of liposuction performed, gynecomastia group (6 patients), abdomen and back (25 patients), abdomen and flanks (39 patients), and other areas, for example, arms, thighs, ... etc. (20 patient). The mean tumescence volume was 4.7 l (± 3.2) for the control group, 3.5 l (± 2.3) for the local TXA infiltration, and 3.3 l (± 1.9) for the IV TXA group. Average TXA dose used was 683.3 mg, 8.1 (± 5.2) mg/kg for the local TXA group and 653.3 mg, 7.8 (± 4.2) mg/kg for the IV group. Average volume of lipoaspirate was 5.1 l (± 3.5), 3.8 l (± 3.1), and 3.3 l (± 2.1) for the control, local TXA, and IV TXA respectively. Average supranatant volume was 3.6 l (± 2.5), 2.9 l (± 2.4), and 2.5 l (± 1.7), and average infranatant volume was 1.4 l (± 1.4), 0.9 l (± 0.9), and 0.8 l (± 0.5) for the same groups, while the average percentage of body weight aspirated was 6.1% (± 4), 4.5% (± 3.4), and 3.9% (± 2.3) (Table 1).

The average hematocrit of lipoaspirate was 5.5 g/dl (± 3.5) for the control group, 3.2 g/dl (± 2) for the local TXA group, and 4.1 g/dl (± 2) for the IV TXA group. This difference was found to be statistically significant with *p* value 0.015 (Table 2, Fig. 3). Further analysis demonstrated it was the local TXA demonstrated the most significant infranatant

hematocrit reduction with a *p*-value of 0.011. In addition, the average volume of blood loss in lipoaspirate per milliliter was found to be 339.5 ml (± 384), 130.8 ml (± 179), and 132.8 ml (± 142.6), and the average volume of blood loss per liter lipoaspirate was found to be 65 ml (± 58), 33.3 ml (± 24.7), and 42 ml (± 27.2) for the control, local TXA, and IV TXA groups respectively (*p* value 0.008). Further analysis demonstrated that it was local TXA that showed the most significant reduction in blood loss (*p* value 0.009) (Table 3, Fig. 4).

It was found that despite the IV TXA group showed decreased volume of blood loss, however, the difference was not statistically significant for hematocrit of lipoaspirate blood loss per milliliter (Fig. 5) or blood loss/liter aspirate (*p* value 0.451, 0.097, and 0.238 respectively) (Fig. 6). On the other hand, the local TXA infiltration vs control group yielded highly statistically significant results in all the previously mentioned calculations with *p* value 0.011, 0.009, and 0.006 respectively.

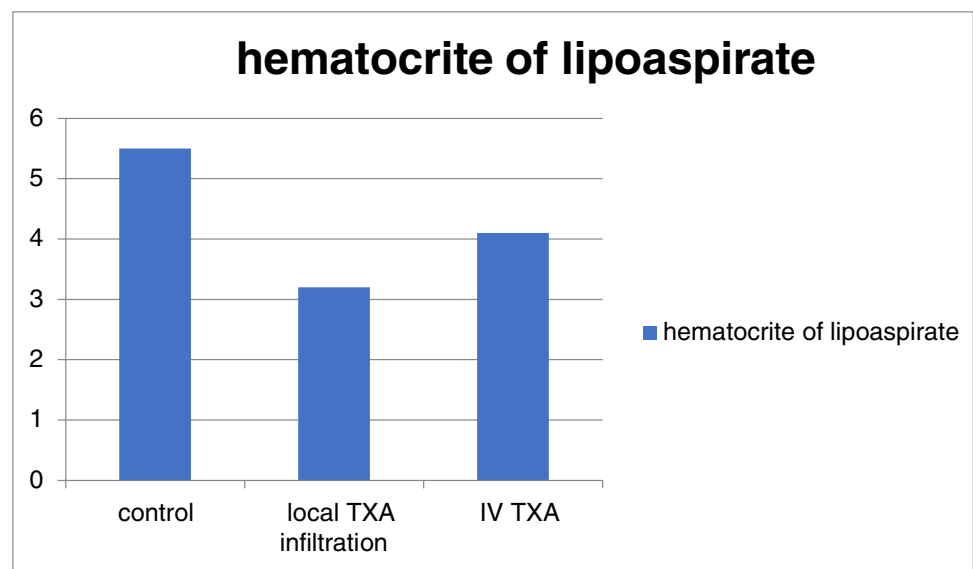
As for the bruising scale, we found that both local and IV TXA had a highly significant role in reducing postoperative bruising with a *p* value of < 0.001, with a mean patient bruising scale of 3.7 (± 1.2), 1.6 (± 1.2), and 2 (± 1.4) for the control, local TXA, and IV TXA groups

Table 1 Patients' data

		Control	Local TXA	IV TXA	<i>p</i> value
Age	Mean	33.23	35.73	36.97	0.181
	Standard deviation	8.74	8.36	9.18	
	Median	33.00	36.00	37.00	
	Minimum	21.00	23.00	23.00	
	Maximum	61.00	51.00	53.00	
Weight	Mean	84.20	83.66	85.40	0.854
	Standard deviation	9.03	12.28	18.88	
	Median	84.00	83.00	86.00	
	Minimum	62.00	58.00	52.00	
	Maximum	102.00	109.00	118.00	
Height	Mean	166.23	170.70	167.77	0.056
	Standard deviation	6.17	7.63	9.18	
	Median	165.50	169.50	167.50	
	Minimum	155.00	151.00	153.00	
	Maximum	181.00	186.00	187.00	
BMI	Mean	30.46	28.52	30.20	0.111
	Standard deviation	2.86	3.43	4.69	
	Median	30.20	29.10	31.10	
	Minimum	24.50	21.00	21.60	
	Maximum	36.10	35.70	36.80	
Vol. of lipoaspirate/liters	Mean	5.11	3.82	3.34	0.137
	Standard deviation	3.51	3.18	2.17	
	Median	4.20	2.35	3.00	
	Minimum	0.70	0.70	0.50	
	Maximum	13.70	15.00	10.00	

Table 2 Postoperative data

		control	local TXA	IV TXA	<i>p</i> value
Vol. of blood in lipoaspirate/ml	Mean	339.51	130.77	132.84	0.009
	Standard Deviation	384.04	178.95	142.60	
	Median	198.80	63.70	103.66	
	Minimum	0.00	0.00	0.00	
	Maximum	1585.70	938.40	790.40	
Vol. of blood/liter lipoaspirate	Mean	65.03	33.28	41.95	0.008
	Standard Deviation	57.97	24.65	27.24	
	Median	47.03	24.30	30.65	
	Minimum	0.00	0.00	0.00	
	Maximum	310.10	115.60	100.00	
Hematocrite preop	Mean	37.99	37.38	40.21	0.228
	Standard Deviation	4.91	4.52	6.71	
	Median	38.00	36.00	38.70	
	Minimum	30.80	28.00	29.60	
	Maximum	48.40	48.20	56.30	
Hematocrit of lipoaspirate	Mean	5.53	3.22	4.07	0.015
	Standard Deviation	3.51	2.00	2.04	
	Median	5.00	3.00	4.00	
	Minimum	0.00	0.00	0.00	
	Maximum	14.00	9.00	8.00	
Hematocrite postop	Mean	30.90	30.87		1
	Standard Deviation	3.39	6.26		
	Median	30.90	33.10		
	Minimum	28.50	23.80		
	Maximum	33.30	35.70		

Fig. 3 Bar chart showing hematocrit in lipoaspirate in 3 different groups

respectively. Mean treating physician bruising scale for the same groups was 3.6 (\pm 1.1), 1.6 (\pm 1.1), and 2 (\pm 1.3) and mean third party scale was 3.6 (\pm 1.2), 1.7 (\pm 1), and 2 (\pm 1.5). All three bruising scales showed almost similar results, regarding the three groups of patients (Fig. 7).

Complications occurred in less than 10% of the patients in the form of hematoma or seroma that ranged between mild and moderate and were managed conservatively. No correlation was established between the use of TXA and incidence of complications. No complications regarding

Table 3 Independent samples of Kruskal–Wallis test

Hematocrit in lipoaspirate	<i>p</i> -value
Local TXA-IV TXA	0.426
Local TXA-control	0.011
IV TXA-control	0.451
Blood loss in lipoaspirate	<i>p</i> -value
Local TXA-IV TXA	1.000
Local TXA-control	0.009
IV TXA-control	0.097

the use of tranexamic acid as seizures, hypersensitivity to the drug, or thromboembolic events were recorded throughout the whole study.

Discussion

In the recent years, several authors advocated the use of tranexamic acid in plastic surgery aiming at reducing blood loss, hematoma formation, and bruising. Concerns about safety and efficacy were raised though. This study was conducted to investigate the efficacy and safety of tranexamic acid administration through different routes to answer these concerns. It is not only those studies about TXA use in liposuction are sparse, additionally, but the sample sizes in such studies were also mostly small. Only 2 studies regarding TXA use in liposuction are available up till now. First is the study by Cansancao et al., where the IV route was chosen to estimate its effect on blood loss in 20 liposuction patients [2], while the other one by Fayman et al. used local TXA infiltration to study its effect on bruising tendency in one flank compared to the other that was used as control in 33 patients [15], compared to

Fig. 4 Bar chart showing volume of blood in lipoaspirate

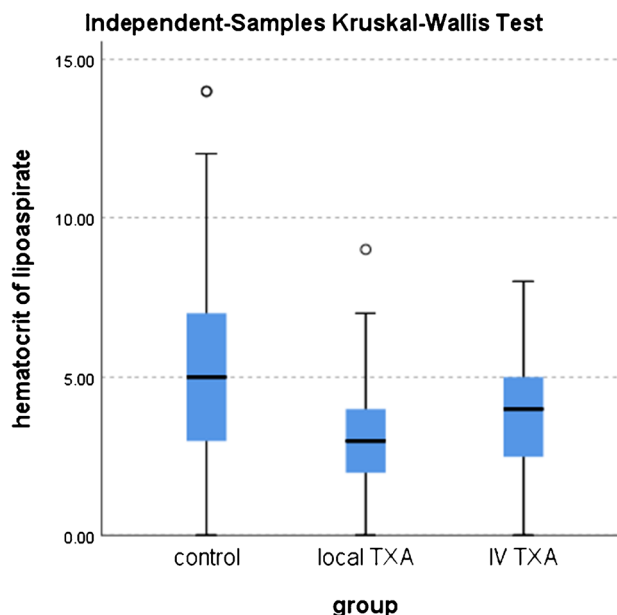
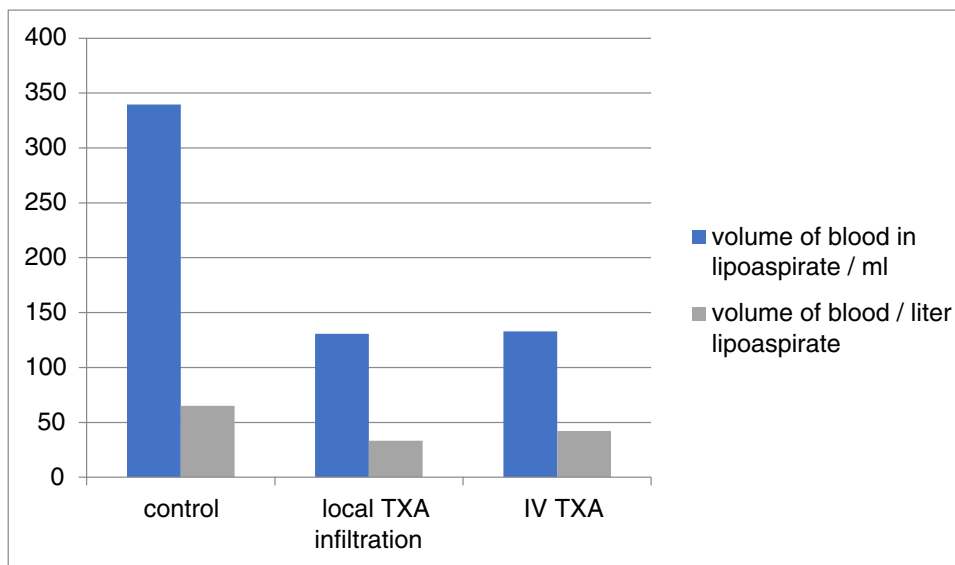


Fig. 5 Value of hematocrite of lipoaspirate in each group

90 patients in this study. While the previously mentioned studies compared control group to either IV or local TXA administration, comparing IV as well as local infiltration to a control group has never been done before in previous plastic surgery studies, making this the first study, to our knowledge, to discuss this matter.

One challenging aspect of this study design was the dose of TXA used. Trials have been ongoing to establish a dose high enough to fulfill the desired effect yet avoid the unfavorable side effects of the drug manifested as hypercoagulability states or seizures. Since it is suggested that TXA concentrations between 10 and 15 mg/l provide near maximal inhibition of fibrinolysis, a recent systematic review of

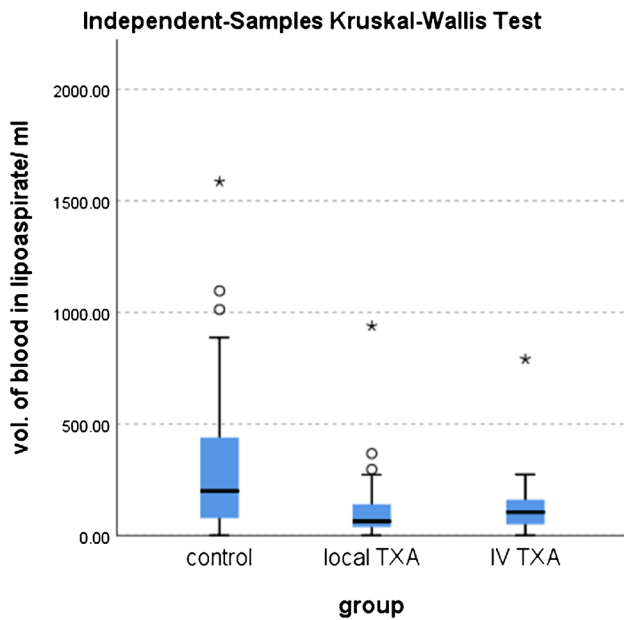


Fig. 6 Volume of blood loss in lipoaspirate in 3 groups

pharmacodynamics of TXA published by Picetti and coworkers revealed that concentrations between 5 and 10 mg/l can also provide significant inhibition [16].

The dose of IV TXA used was 7.8 mg/kg compared to 10 mg/kg used by Cansanco and 1000 mg used by Cohen et al. both of whom investigated the effect of the same route on rate of blood loss and hematoma formation respectively. Both authors also used an additional dose of postoperative TXA in addition to the one given preoperative [2, 17].

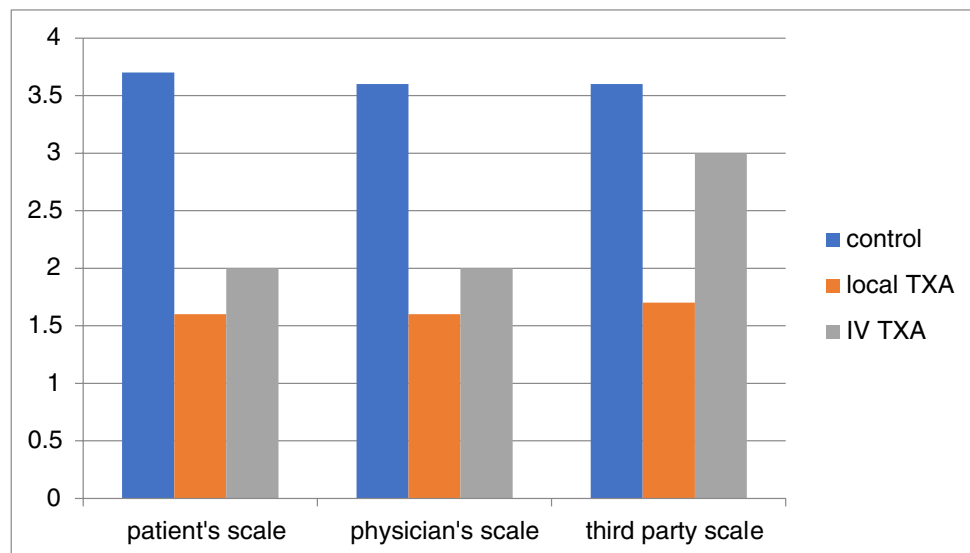
The local TXA dose however was 8.1 mg/kg, compared to 1 mg/ml diluted in 2% local anesthesia infiltration used

by Couto and colleagues [18] and 500 mg for each 500 cc of tumescence injected per flank used by Fayman regardless the weight of the patient [15]. It is worth mentioning that both studies by Sagiv et al. and Zilinsky et al., examining subcutaneous injections, employed a TXA concentration of 50 mg/mL diluted in 1% lidocaine [19, 20]. However, since our study employs the concentration in gram per kilogram, all studies with local infiltration with ought tumescent solution are considered partially irrelevant concerning the TXA concentration.

Other studies evaluated the rate of blood loss using more subjective methods like measure of bloodstain size to surgical wound size ratio in the study by Zilinski et al. [19], while in the study by Sagiv et al. the surgeon was asked to rank the efficacy of hemostasis as excellent “1,” good “2,” moderate “3,” or poor “4” [20]. However, they used the weight of blood in surgical pads to objectify the results of the study. Whereas in the study by Couto et al., subjective “dramatic” decrease in bleeding was compared to their previous facelift patients, as described by the author. The field of the operation was surprisingly dry and the time taken for hemostasis was decreased by almost half the usual (12.5 instead of 20–30 min) [18].

One very tricky measure in studies about TXA is the evaluation of bruising level. Most studies rely on the surgeons or patient’s opinion regarding bruising severity. In the study by Sagiv et al., location as well as degree of ecchymosis were both graded on a scale from 0 to 4, giving 1 point for each of the following parameters: ecchymosis in one half of the upper eyelid, more than one half of the upper eyelid, lower eyelid ecchymosis, or ecchymosis outside the eyelid area [20]. Similarly, Cohen et al. also asked the patients subjectively to rate their lower facial/neck bruising and swelling

Fig. 7 Bar chart showing average results of bruising scale



on a scale of 1 (mild), 2 (moderate), or 3 (severe) on days 1, 6, and 9 postoperative [17].

This was the case in this study as well, but in a trial to unify the bruising scores and decrease the objectivity, the bruising scale was constructed. This way, the intensity of the bruise was not left up to the imagination of the patient or surgeon but rather compared to a specific color scale. Fayman, on the other hand, constructed a special software program by which the surface area of the bruise could be exactly measured, which eliminated the human factor in assessment of the bruise color [15].

Results of our study showed that the effect of IV TXA on blood loss, despite being evident, yet it was insignificant, unlike those of the local TXA infiltration group which were found statistically significant. The average value of hematocrit level in lipoaspirate in the IV TXA group was found to be 2.04 g/dl, compared to 2 g/dl for the local TXA group and 3.51 g/dl for the control group. The average volume of blood in lipoaspirate was found to be 339.5 ml for the control group and 132.8 ml for the IV group, representing 60.9% decrease in the total volume of blood in lipoaspirate (p value 0.097), compared to 59.9 ml in the control group and 37.7 ml in the IV group, representing 37% decrease in the study by Cansanco et al. Despite the fact that the percentage decrease in blood loss in their study was found to be obviously lower than that of this study, Cansanco's results were found to be statistically significant most probably owing to the larger sample size [2]. It is however, of importance to notice that values of the IV group were too close to statistical significance given the p value mentioned above. As for the results of the tumescent TXA group, volume of blood loss in lipoaspirate was found to be 130.8 ml, with percent reduction of 61%, that turned to be highly statistically significant. These results however cannot be compared to any of the other studies since none of those who used local TXA had numerical calculated value for blood loss. There were, however, other measures for estimation of efficacy of TXA in reducing blood loss, some subjective, and others more objective as shown below. In the study by Sagiv et al., for example, there was no significant difference in the total time taken by hemostasis during surgery, total time of surgery, or weight of net blood loss in surgical pads [20]. At the end of surgery, the surgeon's assessment for average hemostasis (on a scale of 1–4 as mentioned before) was similar in both groups. The surgeon's assessment of whether the local anesthetic contained TXA, based upon bleeding events and use of hemostasis was, however, accurate in 16 patients out of 34 [20].

In the study by Zilinski et al., patients in the TXA group had significantly lower bloodstain size to surgical wound size ratio than those in the placebo group, this applied to both subgroups, those who are on anticoagulant therapy, and those who are not. The hemostasis assessment performed

by the surgeon using the 4-point scale was significantly better in the TXA group compared with the placebo group. Furthermore, in the anticoagulant subgroup, the hemostasis evaluation was significantly better, with larger number of excellent and good assessments for the TXA group (92.8%) compared with the placebo group (57.2%). However, no significant differences were observed for the anticoagulant-free subgroup [19].

Cuoto reported subjective dramatic reduction in bleeding compared to their previous experience with patients who did not receive TXA. Instead of rebound bleeding, the field was surprisingly dry, and the average time spent achieving hemostasis on the right, left, and the 2 sides of the face combined was 6.5 min, 6.3, and 12.9 min respectively. Previously, the author would spend 20–30 min gaining hemostasis on each side. Therefore, the total surgical time saved was approximately 25 to 60 min. Although the dose of TXA used by the authors of the aforementioned study is lower than what is described in literature (1 mg/ml), dramatic reduction in intraoperative bleeding was consistently observed [18].

We believe that the discrepancies of outcome of blood loss in the IV group among this study and those in literature might be explained by the different number of candidates enrolled in each study, variable dosage of TXA solutions used, and different techniques employed to calculate blood loss. However, it is worth noticing that even with the very high dose used in the study by Cohen et al., results were still statistically insignificant [17].

In contrast to the results obtained in this study with TXA local infiltration where despite using an average of only 8.1 mg/kg, significant reduction in blood loss was achieved. Regarding the effect of TXA on bruises intensity, it appears that both IV and local infiltration of TXA have a dramatic effect on bruising in liposuction patients. Although the bruising scale used in this study is considered a subjective method for measurement, it was, however, obvious that TXA significantly decreased bruising tendencies post liposuction. The average score of patients', physician's, and third-party scale was almost the same giving 3.7 for the control group, 1.6 for the local, and 2 for the IV TXA groups which was shown to be highly statistically significant with p value < 0.01.

In the study by Fayman et al., they reported that none of the participants showed increased bruising on the active side on either assessment day, unlike the control side where more extensive bruising was observed a day as well as a week after the procedure. Furthermore, the use of TXA consistently resulted in a smaller bruise area on days one and seven after liposuction. Results were statistically significant and TXA was found to markedly reduce bruises in the infiltrated side [15].

Cohen et al. reported statistically significant reduction only in surgeon bruising scores, while Sagiv et al. reported

no statistical significance regarding postoperative ecchymosis on days 1 and 7 in patients undergoing blepharoplasty with local TXA when compared to the placebo group [17, 20]. Neither our study nor any other one from those mentioned above encountered any side effects that could be related to the use of TXA like seizures or thromboembolic disease, even with the significantly high dose used by Cohen et al., which further ensures the safety of TXA use within the recommended dose [2, 6, 7, 15, 17–20].

This study, despite our effort to try and standardize most variables, however, still have some limitations, most important of which was the inability to unify the surgeon performing the procedure. This might cause difference in the technique of liposuction which might cause some bias in our results. Another limitation was the area of liposuction, where it would be probably better to perform the study for one unified area in all patients rather than comparing blood loss in different areas. However, there is no evidence in literature to suggest that blood loss is different for liposuction of different areas in the body.

Moreover, we would recommend that preoperative and postoperative labs specifically hemoglobin and hematocrit would be measured, preferably on days 0, 7, 14, and 21 and compared to assess whether blood loss in lipoaspirate is directly related to hemoglobin reduction or not. This, however, can be performed in an extended study later.

Conclusions

Even though both IV and local TXA showed reduction in volume of blood lost in lipoaspirate, local TXA infiltration was, however, found to be superior to that of the IV TXA group, with significant decrease in blood loss. Given these results, we recommend that further research regarding the use of local TXA should be carried on larger cohort, perhaps with a more unified study sample in terms of areas to be aspirated, as well as single surgeon operating. This can further support the observation made in this study. Although IV administration of the drug did not result in any complications, we still believe more surgeons would rather adopt the tumescent route for being safer. We also advocate adding 1 cc (100 mg) of TXA, a concentration that has been discussed before in the discussion section, as an integral constituent of the routinely used Klein's tumescent formula, so that it becomes as follows.

*1gm Lidocaine 1% + 1 mg epinephrine in 100 ml
+ 2 ml tranexamic acid added to 1000 ml of 0.9% saline solution*

Formula 1 Minawi's formula (A modification of Klein's formula)

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Declarations

Conflict of Interest The authors have no conflicting interests to declare that are relevant to this article.

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Cairo University approved this study (MD-229–2019).

Informed consent Informed consent was obtained from all patients enrolled in the. Separate written consent was obtained from the patients whose photos were used in this research.

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