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ORIGINAL ARTICLE BODY CONTOURING

Cell Salvage in Liposuction, a Safety Tool in a New Surgical Scenario

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Abstract

Background The improvement in liposuction and associated procedures seen in recent years has led to an increase in complications, particularly related to significant blood loss. This study aims to evaluate the intraoperative use of cell salvage to recover red blood cells from liposuction aspirate and reinfuse them into the patient.

Methods A prospective, randomized, blinded and controlled trial was conducted with 63 patients.

Results Postoperative hematocrit (HT) was significantly higher in the intervention group (34.8 ± 3.3) compared to the control group (31.1 ± 2.7, $p < 0.001$). Similarly, hemoglobin (Hb) levels were greater 24 hours after surgery (11.7 ± 1.1 vs 10.4 ± 0.8, $p < 0.001$). On average, 198.5 mL (198.50 ± 136.60) of red blood cells were recovered and reinfused.

Conclusion Patient blood management is a key strategy to enhance surgical outcomes globally. The use of cell salvage during liposuction helps preserve hemoglobin levels close to normal ranges and prevent acute anemia, contributing to faster and safer recovery. Cell salvage should be considered a standard tool and routinely used in extensive liposuction procedures.

Level of Evidence II 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.

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Keywords Liposuction · Patient blood management · Blood loss · Surgical blood loss · Postoperative complications

Introduction

Liposuction is currently the most commonly performed surgical procedure worldwide, with over 2.2 million operations reported in 2023—a 31,3% increase compared to 2019, particularly in the post pandemic context, data from ISAPS [1]. This surge not only reflects a rise in procedure volume but also in their complexity, often being combined with other interventions, which extends surgical time and increases the risk of complications [2, 3].

The technique presented by Illouz [4], in the early 1980s, has evolved significantly, incorporating advanced technologies such as power-assisted devices (PAL), laser-assisted fat harvesting (e.g., OneStep) and various skin-tightening tools (e.g., OneStep laser, Argoplasma, Renuvion, Bodytite). These advancements have enhanced precision and allowed for more refined body contouring.

Although complications rates vary between 0% and 10% [5], mortality is rare. Triana [6] reported a mortality rate of 0.01% across 26,259 cases over 25 years, while ISAPS cited a rate of 19.1 per 100,000 liposuctions [1].

With growing demand for advanced body sculpting techniques involving larger treatment areas and higher aspirated volumes [7], the risk of surgical trauma and associated blood loss has also increased, placing surgical safety at the forefront of discussion [8–11].

The primary concerns are related to direct blood loss (intraoperative) and indirect blood loss (third-space shift). Campos [12], in a prospective study of 30 post-liposuction

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patients, found an average drop in hemoglobin (Hb) of 3.01 g/dl, corresponding to 22.16% of the preoperative hematocrit, with 50% of patients experiencing symptoms like dizziness, dyspnea, tachycardia or orthostatic hypotension. Vendramin et al. [13] reported a 19,7% reduction in hemoglobin postoperatively in 16 patients. Abdelaal et al. [14] noted blood loss of as much as 100-200 mL per liter of liposuction aspirate.

Recognizing the critical role of blood conservation, the World Health Organization (WHO) advocates for Patient Blood Management (PBM) in the pre-, intra- and postoperative care as a core component for the surgery success [15]. Strategies such as controlled acute hemodilution (CAH) and self-hemotransfusion (SHT) work as savings measures, reserving a limited volume of the patient's own blood for replacement at the end of surgery. The tumescent technique, vibration-assisted devices such as Vaser/Safer and the use of antifibrinolytics (e.g., tranexamic acid) are some measures implemented seeking to reduce this blood loss [16–20]. However, little has been done to recover blood already lost.

This study investigates the use of a red blood cell (RBC) recovery system (AUTOLOG IQ-MEDTRONIC) in patients undergoing liposuction, an approach well established in other medical specialties such as thoracic and orthopedic surgery [21, 22], but underexplored in aesthetic plastic surgery. Our objective is to evaluate its safety and efficacy, proposing protocols for its implementation in patients undergoing plastic surgery.

Objectives

This study aims to evaluate the use of a red blood cell recovery system (AUTOLOG-MEDTRONIC) in patients undergoing liposuction, seeking a protocol for its use and evaluating the hematocrit (HT) and hemoglobin (Hb) of patients undergoing surgery in the preoperative period and at the time of discharge, as well as discussing its risks and benefits.

Methods

A prospective, randomized, blinded, controlled trial was conducted to assess the feasibility and effectiveness of intraoperative cell salvage using an autologous blood recovery system (AUTOLOG IQ, Medtronic, USA) in liposuction procedures (Fig. 1). The study was carried out between March 2024 and January 2025.

The sample size was estimated based on preliminary data [23] indicating an average difference of 1.3 g/dL in postoperative hemoglobin levels between the groups, with

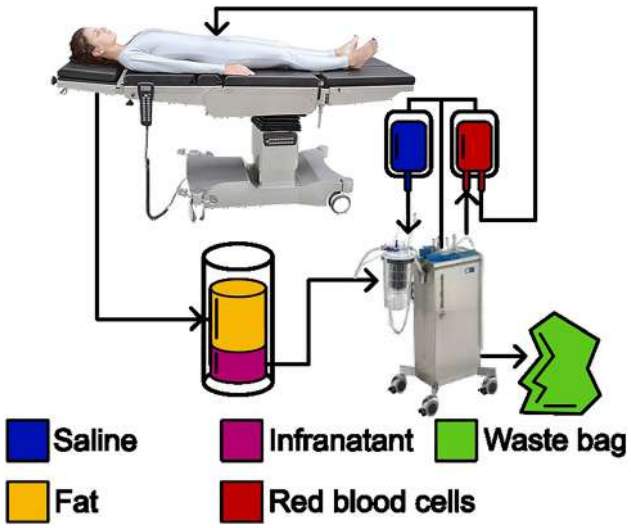

Fig. 1 Liposuction cell salvage diagram

an estimated standard deviation of 1.0 g/dL. Assuming a statistical power of 80% and a significance level of 5% ($\alpha = 0.05$), a minimum of 29 patients per group was required. To account for potential dropouts, the total sample size was increased to 63 participants and they were randomly assigned in a 1:1 ratio to either the intraoperative cell salvage group (ICS) or the control group.

Upon obtaining informed consent, each patient received a unique Patient Identification Number (PID) for tracking throughout the study process. Randomization was performed using a computer-generated sequence via *random.org*. This clinical trial was approved by the Ethics Committee of Hospital Agamenon Magalhaes (77318823.2.0000.5197) and registered with the Brazilian Registry of Clinical Trials (ReBEC) RBR-9tr6hb4 on March 6th, 2024.

Data were collected using spreadsheets and analyzed using SPSS version 29.0 (Statistical Package for the Social Sciences) software for Windows and Excel 365. Statistical significance was set at p-value ≤ 0.05. Categorical data are presented as absolute and relative frequencies, and numerical variables are expressed using measures of central tendency and dispersion.

The Shapiro–Wilk Normality test was used to assess the normality for quantitative variables. For comparisons between independent groups, the Student's t-test was applied for normally distributed variables and Mann–Whitney U test for non-normal distributions. For paired data, the paired Student's t test (normal distribution) or the Wilcoxon test (non-normal) was used.

Inclusion and Exclusion Criteria

Eligible participants were men and women with lipodystrophy, cleared for liposuction by the hospital's medical board with ASA I and with baseline hemoglobin >12 g/dl. Exclusion criteria were patients with diabetes mellitus; cardiovascular diseases, prolonged preoperative prothrombin time (PT) and activated partial thromboplastin time (aPTT) (>1.2x normal values), previous surgery in the same anatomical area; use of anticoagulants; blood transfusion within the past 90 days prior to the liposuction and surgical complications requiring reoperation (e.g., hematoma).

Interventions

All participants were assessed preoperatively for demographics (sex, age, weight, height, body mass index) and laboratory values (complete blood count including hemoglobin (Hb), hematocrit (HT), prothrombin time (PT) and activated partial thromboplastin time (aPTT). All patients provided written informed consent.

Surgeries were performed under general or epidural anesthesia combined with sedation. The type, dose and management of anesthetics were determined by the attending anesthesiologist. Intravenous fluids (Saline 0,9% and Ringer's lactate) were administered to maintain a urine output of 0,5–1,0 ml/kg/hour. No plasmatic expansion solutions were used (e.g., Voluven, Hisocel).

The surgical technique involved tumescent liposuction with prior infiltration of saline 0,9% containing adrenaline 1:500.000UI in a 1:1 ratio of volume to the aspirated volume. Cannulas measuring 3.5 mm, 4.0 mm and 4.5 mm were used with a vacuum pressure of − 60 mm Hg and a flow rate of 120 L/min.

The total aspirated volume was decanted for 15 minutes in a specific canister (2800 ml FAGA) when the infranatant phase (containing the blood elements) was drained (Fig. 2) and processed using the AUTOLOG IQ (Medtronic) system, which performs triple filtration, selective centrifugation and a saline wash of the recovered RBC (Videos 1 and 2). The processed red blood cells were reinfused into the patient intraoperatively using standard transfusion technique.

Hemoglobin and hematocrit levels were measured immediately after the procedure and again 24 hours postoperatively. Hematimetry measurements were performed using YUMIZEN H1500 equipment (Horiba Labs)

Clinical symptoms such as dizziness, nausea and vomiting were monitored, and a visual grade scale was used to assess patients' well-being status on the first day after surgery.

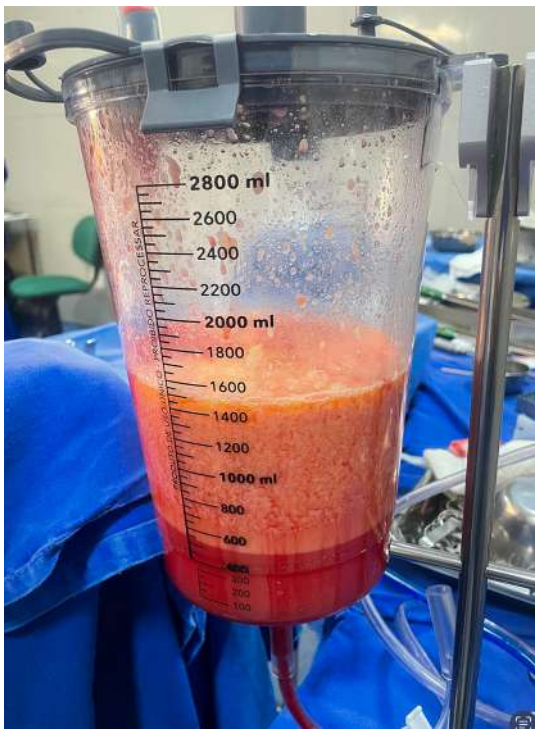

Fig. 2 Canister after 15 minutes of decantation showing the infranatant phase containing the blood elements

Results

Descriptive analysis of the data is presented in Table 1 detailing demographic and laboratory characteristics of the study population. The mean age was 43.9 ± 8.2 years, with a median of 45.0 (39.0; 48.0) and a range between 21.0 and 62.0 years. The average height was 1.60 ± 0.1 meters, and the mean weight recorded was 70.1 ± 11.1 kg, with a median of 69.0 (62.0; 76.0) kg. Body mass index (BMI) had an average of 26.4 ± 2.7, ranging between 19.9 and 32.3.

The mean liposuction volume across the entire sample was 1824.8 ± 472.5 mL, with a median of 1700.0 mL and a range between 1100.0 and 3700.0 mL. In the intervention group, the average infranatant volume collected was 460.0 ± 169.1 mL, and the mean reinfused volume was 157.3 ± 82.6 mL, with individuals' values ranging from 105.0 and 560.0 mL.

Data analysis (Table 2) showed no statistically significant differences between the intervention and control groups regarding age (p= 0.881) and height (p = 0.118), confirming group homogeneity. However, the intervention group had a significantly higher average weight (73.7 ± 11.7 kg) compared to the control group (66.9 ± 9.6 kg, p = 0.014), as was the body mass index (BMI), which also presented higher values in the intervention group (27.2 ± 2.7 vs 25.7 ± 2.5, p = 0.030).

Table 1 Demographic and laboratorial data from the sample

Variables	Average ± SD	Median (P_{25}; P_{75})	Min–Max
Age	43.9 ± 8.2	45.0 (39.0; 48.0)	21.0–62.0
Height	1.6 ± 0.1	1.6 (1.6; 1.7)	1.5–1.8
Weight	70.1 ± 11.1	69.0 (62.0; 76.0)	51.0–99.0
BMI	26.4 ± 2.7	26.5 (24.5; 28.3)	19.9–32.3
Volume			
Liposuction	1824.8 ± 472.5	1700.0 (1550.0; 1900.0)	1100.0–3700.0
Infranatant*	460.0 ± 169.1	449.5 (346.5; 533.5)	170.0–996.0
Reinfused*	157.3 ± 82.6	133.0 (129.0; 143.0)	105.0–560.0

*Intervention group

Table 2 Comparison between intervention and control groups

Variables	Group		*p*-value
	Intervention Average ± SD	Control Average ± SD	
Age	44.1 ± 7.7	43.8 ± 8.7	0,881*
Height	1.6 ± 0.1	1.6 ± 0.1	0,118*
Weight	73.7 ± 11.7	66.9 ± 9.6	0,014*
BMI	27.2 ± 2.7	25.7 ± 2.5	0,030*
Preoperative: HT	40.3 ± 2.6	39.9 ± 2.7	0,584*
Postoperative: HT	34.8 ± 3.3	31.1 ± 2.7	< 0,001*
Postoperative: Hb	11.7 ± 1.1	10.4 ± 0.8	< 0,001*
	Median (P_{25}; P_{75})	Median (P_{25}; P_{75})	
Liposuction volume	1725.0 (1547.5; 1960.0)	1700.0 (1555.0; 1800.0)	0,513**
Preoperative : Hb	13.2 (12.7; 14.0)	13.2 (12.7; 13.9)	0,847**

* t student, ** Mann-Whitney

Postoperative hematological parameters showed statistically significant differences between the groups. Hematocrit (HT) was significantly higher in the intervention group (34.8 ± 3.3) compared to the control group (31.1 ± 2.7, $p < 0.001$), as was hemoglobin (Hb) 24 hours after the surgery (11.7 ± 1.1 vs 10.4 ± 0.8, $p < 0.001$). These results suggest a positive impact of the intervention in preserving hematological levels due to the process and reinfusion of an average of 198.5 ml (198.50 ± 136.60) of recovered red blood cells.

There were no significant differences in the volume of liposuction between groups ($p = 0.513$), indicating that this variable did not influence the outcomes. Preoperative hemoglobin levels were also comparable between groups ($p = 0.847$).

The data presented in Table 3 reveals statistically significant differences in hematocrit (HT) and hemoglobin (Hb) levels between the pre and postoperative moments, both in the intervention group and in the control group. In the intervention group, a significant reduction in mean HT values was observed, going from 40.3 ± 2.6 preoperatively to 34.8 ± 3.3 postoperatively ($p < 0.001$). Similarly, Hb levels decreased from 13.4 ± 0.9 to 11.7 ± 1.1 ($p < 0.001$), demonstrating an impact of the intervention on hematological parameters throughout the surgical procedure. In the control group, the analysis of the median values also demonstrated a significant decline in HT levels, reducing from 39.5 (38.2; 41.3) preoperatively to 31.2 (29.8; 32. 6)

Table 3 Comparative hematimetry between intervention and control groups

Variables	Moments		*p*-value
	Preoperative average ± SD	Postoperative average ± SD	
Intervention group			
HT	40.3 ± 2.6	34.8 ± 3.3	< 0,001*
Hb	13.4 ± 0.9	11.7 ± 1.1	< 0,001*
Control group	Median (P_{25}; P_{75})	Median (P_{25}; P_{75})	
HT	39.5 (38.2; 41.3)	31.2 (29.8; 32.6)	< 0,001**
Hb	13.2 (12.7; 13.9)	10.2 (10.1; 10.8)	< 0,001**

* Paired t student, ** Wilcoxon Test

postoperatively ($p < 0.001$). Hb followed the same trend, with preoperative values of 13.2 (12.7; 13.9) and postoperative values of 10.2 (10.1; 10.8), with a statistically significant difference ($p < 0.001$).

Discussion

As early as 1874, Highmore attempted—albeit unsuccessfully—to reinfuse blood lost during obstetric procedures. Following World War II, the emergence of blood banks diminished interest in autologous blood recovery. However, with the rise of transmission–transmissible diseases in the 1990s, interest was reignited, leading to the development of strategies to use patient's own blood through self-hemotransfusion (SHT) and acute controlled hemodilution (CAH) or the recovery of intraoperative red blood cells (Cell Salvage) that would otherwise be discarded.

The modern cell salvage technique, introduced in the late 1990s, combines multi-stage filtration, selective centrifugation and saline washing of red blood cells. This method effectively separates erythrocytes from contaminants, including leukocytes, heparin, fat and surgical debris, and has become standard practice in procedures involving major blood loss (>500 mL), particularly in cardiac, orthopedic and neurosurgical procedures. More recently, its application has expanded into obstetrics and general surgeries [22, 24]. Despite the high blood loss associated with liposuction, the use of this technique in plastic surgery remains uncommon, almost embryonic. The formal contraindications for red blood cell recovery are the presence of infection or oncologic disease, which are already exclusionary when preparing aesthetic plastic surgery patients. The cell salvage process is automatic, without interrupting the surgical flow, without requiring time or competing with the surgeon's attention and has an estimated cost per surgery of USD 500,00, similar to the transfusion of one unit of allogeneic red blood cell concentrate by blood banks.

Over the past five years, plastic surgery has seen a rapid evolution in both technology and technique. Advanced liposuction modalities, fat grafting and the integration of skin-tightening technologies have significantly expanded the scope and complexity of these procedures, increasing the potential for excessive blood loss. In this context, the use of cell salvage offers a novel solution, with a cost comparable to that of allogeneic transfusion, while improving intraoperative safety and broadening the candidate pool-including post-bariatric patients, individuals with chronic anemia and those with religious objections to blood products (e.g., Jehovah's Witnesses) previously deprived of surgical indication.

Our findings demonstrate that patients in the intervention group experienced a smaller reduction in hematocrit (13.64%) compared to the control group (22.05%). The latter being consistent with values reported by Campos [12] (22.16%) and Vendramin [13] (19.7%). Furthermore, the reinfused volume represented 9.82% of the total aspirated volume, aligning favorably with Abdelaal's [14] estimate of 100–200 mL blood loss per liter of liposuction aspirate representing a substantial replacement of the blood that is lost in liposuction.

No adverse events or transfusion reactions were observed during reinfusion, which was conducted intraoperatively under anesthetist supervision. Clinically, patients in the intervention group did not report symptoms such as dizziness and/or fatigue. In contrast, six patients (18.2%) in the control group reported such symptoms, substantially lower than the 50% of complaints reported by Campos [12], yet still notable. Additionally, many patients in the intervention group subjectively reported improved postoperative well-being and earlier return to their normal activities, although this was not formally quantified in this study.

It is important to highlight that although all patients had normal baseline preoperative hemoglobin levels (13.4 ± 0.9), even though it was not the main focus of this study, we found 4 patients with mean corpuscular hemoglobin (MCH) below normal (<23.8 pg), suggesting subclinical iron deficiency. This highlights the importance of preoperative optimization and iron supplementation protocols, even in non-anemic patients, as part of a comprehensive patient blood management (PBM) strategy.

This study presents promising findings on the intraoperative use of cell salvage during large-volume liposuction; however, some limitations must be acknowledged. Despite being designed as a randomized controlled trial, the relatively small sample size of 63 patients limits the statistical power to generalize findings to broader populations due to statistical limitations dealing with small groups. Further multicenter studies with larger cohorts are needed to validate these results and ensure external validity. Long-term safety and efficacy, including potential delayed complications such as infection, fat embolism or immune response to reinfused blood, warrant further investigation. While hematological parameters were objectively measured, the study did not quantify patient-centered outcomes such as postoperative fatigue, return to activity or overall well-being through validated tools, which limits the clinical interpretation of the results.

This study presents promising findings regarding the intraoperative use of cell salvage in large-volume liposuction; however, several limitations must be acknowledged. Despite being designed as a randomized controlled trial, the relatively small sample size of 63 patients limits

the statistical power and generalizability of the results. Larger, multicenter studies are necessary to validate these findings and strengthen their external validity.

The financial implications of implementing cell salvage technology in routine aesthetic practice were not explored. Although the cost of the procedure is comparable to allogeneic transfusion, a formal cost-benefit analysis would strengthen the argument for broader clinical adoption. The reproducibility of the technique may vary due to differences in surgeon experience, liposuction devices and patient anatomy. Standardized protocols are essential to minimize variation in outcomes and ensure consistent safety and efficacy.

The study did not assess the synergistic or additive effects of combining cell salvage with other perioperative blood management techniques, such as tranexamic acid or iron supplementation. Future studies should explore integrated strategies for comprehensive blood conservation.

Conclusion

Cell salvage represents a valuable addition to the surgical armamentarium in modern liposuction. By allowing the intraoperative recovery and reinfusion of autologous red blood cells, this technique contributes to the preservation of hematological stability, reduces the risk of acute postoperative anemia and enhances patient recovery. Given its safety, efficacy and compatibility with the aesthetic surgical context, should be considered a standard adjunct in large-volume liposuction procedures, aligned with global trends in patient blood management and expanding surgical options for previously restricted patient populations.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00266-025-05283-z.

Declarations

Conflict of interests The authors declare that they have no conflicts of interest to disclose.

Ethical Approval This clinical trial was approved by the Hospital Agamenon Magalhaes Ethical Committee (77318823.2.0000.5197) and was registered on Brazilian Registry of Clinical Trials (ReBEC) RBR-9tr6hb4 on March 6th, 2024.

Informed Consent All patients signed an informed consent regarding all the risks and benefits of this study.

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