

Fluid management in extensive liposuction

A retrospective review of 83 consecutive patients

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Abstract

Tumescent anesthesia makes it feasible to perform liposuction in an office setting. There are often patients who desire extensive liposuction on approximately 30% of total body surface area, which means the potential of fluid overload. In this study, the charts of 83 patients undergoing extensive liposuction were retrospectively reviewed. The intra-operative fluid ratio was 1.66 for the extensive liposuction. There were no episodes of pulmonary edema, congestive heart failure exacerbation, or other major complications. The average urine output in the operating room, the recovery room, and while on the floors was 1.35, 2.3, and 1.4 mL/kg/hour respectively. Intravenous (IV) fluid administration during operation was minimized to approximately 300 to 500 mL. The total volume of IV injection was also reduced to less than 1500 mL when the patient was in the recovery room and on the hospital floor. Our fluid management strategy in extensive liposuction reflects minimal risk of volume overload. Foley catheters are not applied and patients could resume oral intake in usual, so they can discharge after 6 hours of recovery room stay in our daily practice.

Abbreviations: ASA = American Society of Anesthesiologists, BMI = Body Mass Index, IV = intravenous, MEGX = monoethylglycinexyllidide.

Keywords: extensive liposuction, fluid overload, fluid resuscitation

1. Introduction

The volume of aspirate that can be removed safely by liposuction is limited by blood loss of 20% to 45% of aspirate associated with the dry technique.^[1] By contrast, the wet technique, which was introduced by Clayton and Hetter in the 1980s, decreased blood loss to 4% to 30% of aspirate.^[2] However, the need for autologous blood transfusions or the potential for hypovolemia is not eliminated. Aggressive fluid resuscitation regimens and preloading were commonly used for compensation during that period. In 1986, Fodor advocated the superwet technique (ratio of infiltrated-to-total aspirate=1:1) to further reduce the blood loss.^[1] Klein introduced the tumescent technique (ratio of infiltrate-to-total aspirate=2–3:1), which is performed totally under local anesthesia using minimal or no intravenous (IV) fluid replacement, and the estimated blood loss is approximately 1% of aspirate.^[3]

The development in liposuction technology has resulted in the gradual extension of body areas treated during 1 session to meet the demands of patients. In our practice, we usually perform extensive liposuction procedures on multiple targeted sites (approximately 30% of total body surface area) in 1 session.^[4] The potential of fluid overload in extensive liposuction is a serious concern because of the increase in aspirated volume and extended targeted areas. Fluid management is controversial and governed by various formulae that have been explored by many authors. The ratio of what goes into the patient and what comes out is important. This study was designed to analyze and evaluate resuscitation parameters in extensive liposuction patients. The conclusions were based on a review of intra-operative and post-operative clinical outcomes.

2. Materials and methods

A total of 83 patients who underwent extensive liposuction performed over a 19-month period from October of 2015 to May of 2017 were retrospectively reviewed. All patients were assessed and classified initially as either American Society of Anesthesiologists (ASA) physical status 1 or 2. Exclusion criteria were as follows: concurrent procedures; cardiopulmonary disease (ASA classes II and IV); significant hepatic and renal disease; significant arrhythmia; morbid obesity [Body Mass Index (BMI) >40 Kg/m² or BMI >35 Kg/m² in the presence of significant co-morbidities]. All patients were evaluated preoperatively and postoperatively by standardized medical photography and clinical examinations. The study was conducted after obtaining approval from the Second Affiliated Hospital of Soochow University and informed consent from the patients. All patients fasted over-night, and their data are presented in Table 1.

Targeted areas in the patients included the abdomen, waist, flanks, scapular roll, lower back, hips, anterior thigh, outer thigh, and inner thigh. The abdomen, waist, flanks, scapular roll, lower back, and hips are treated first, followed by the rest. Patients were marked preoperatively while standing (Fig. 1).

Editor: Perbinder Grewal.

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The authors report no conflicts of interest.

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Medicine (2018) 97:41(e12655)

Received: 19 October 2017 / Accepted: 12 September 2018

<http://dx.doi.org/10.1097/MD.0000000000012655>

Table 1**Patients' data [Means(SD)].**

Age, years	31 ± 9.1
Weight, Kg	59.1 ± 4.1
Height, meter	1.62 ± 0.05
BMI, Kg/m ²	22.6 ± 2.6

BMI = Body Mass Index; Kg = kilogram; SD = Standard Deviation.

Tissue tumescence was obtained in all patients by manual infiltration into subcutaneous tissue. Tumescent solutions consisted of lidocaine (800 mg), 125 mL 5% sodium bicarbonate, and 5 mg of epinephrine in 3 L of saline solution. Liposuction started 30 minutes after the termination of infiltration, and fat was aspirated using a standard technique. The solution was warmed to approximately 37°C to prevent hypothermia and pain. Incision sites were sutured instantly without drains after suction. Aspirates were collected and total volumes were measured.

All patients received monitored IV sedation during the infiltration of lidocaine solution. Sedation was maintained with continuous incremental dose of propofol (dose 1–2 mg/kg•h) and remifentanyl (dose 3–7 µg/kg•h). Noninvasive blood pressure, heart rate, electrocardiography, oxygen saturation, and temperature were monitored in the operating room, in the recovery room and on the floor. Foley catheters were used in the operating room and the recovery room.

Our modifications of fluid management in extensive liposuction patients were as follows:

- (1) the targeted areas were divided into 2 segments and treated in turn in 1 session, giving enough time to allow the large amount of tumescent solution to be absorbed.
- (2) preoperative fluid deficits should be minimal;
- (3) maintenance fluids (approximately 500 mL) should be administered throughout the operation, and additional intra-operative replacement fluids were eliminated;



Figure 1. Markings of target areas for liposuction (concentric circles) and surrounding transforming zones (straight lines).

Table 2
Operation times[Means(SD)].

	Infiltration Interval, min	Suction Interval, min
First segment	38.4 (7.5)	82.7 (9.8)
Second segment	26.9 (7.4)	84.2 (20.2)

min = minutes; SD = Standard Deviation.

- (4) maintenance fluids (approximately 250 mL crystalloid fluid with antibiotic) was prescribed postoperatively in the recovery room. All patients resumed oral intake after about 4 hours stay in the recovery room under monitored anesthesia care and then were transferred to the ward;
- (5) The patients had approximately 1250 mL of crystalloid fluid with antibiotic on the floor for 24 hours.

Hospital records were examined for the volume of fluid administered (subcutaneous and IV), total aspirate, urine output and vital signs. All data were extracted from the records of patients' basic information, anesthetic note, and nursing records. Data were recorded and assessed.

3. Results

The average time of the procedure was 221 ± 34 min (168–272 min), and the suction interval was generally longer than the infiltration interval (Table 2). The total volume of infusates and aspirates were 9521.3 ± 462 and 6975 ± 1207 mL, respectively. The ratio of total infiltrates-to-total aspirates is 1.66 ± 0.46. The total aspirated fat and fluids were 3800 ± 1005.7 and 3175 ± 526 mL, respectively (Fig. 2). The average IV fluid administered and average urine output in the operating room, recovery room, and on the floor are presented in Table 3, Figure 3 and Figure 4 respectively. The average urine output overtime curve is shown in

Table 3
Urine Output and Intravenous Fluid(ml/Kg/H).

Urine Output		
	OR	1.35 ± 0.66
	RR	2.3 ± 0.9
	Floor	1.4 ± 0.6
Intravenous Fluid		
	OR	2.2 ± 0.3
	RR	1 ± 0.1
	Floor	0.9 ± 0.1

Floor = On the Floor; OR = Operating Room; RR = Recovery Room.

Figure 5. All patients were observed for 24 hours after surgery. No significant variations in blood pressure or pulse rates or respiratory depression were observed in any patient. No patients require postoperative analgesia. No major complications such as death or pulmonary embolism or pulmonary edema or congestive heart failure occurred. Postoperative outcome was evaluated at the 3 month visits; no hematoma, or skin necrosis or under-correction, overcorrection, or irregular fat tissues with palpable irregularities were observed in the contoured area. 63 cases reported that their appearance after body contouring was “very good” (28) to “excellent” (35) and 20 cases responded that their contour was “good.” (Table 4)

4. Discussion

Extensive liposuction involves the creation of extensive subsurface trauma, comparable in many respects to the massive injury of an internal burn. Liposuction commences with cannula aspiration of several liters of fluid-engorged adipose tissue, during which small feeder vessels are inevitably torn. The fluid extravasation and stasis followed suction trauma lead to hypovolemic shock, but overhydration progressing to pulmonary edema is highly common. Although infiltrated liquid is

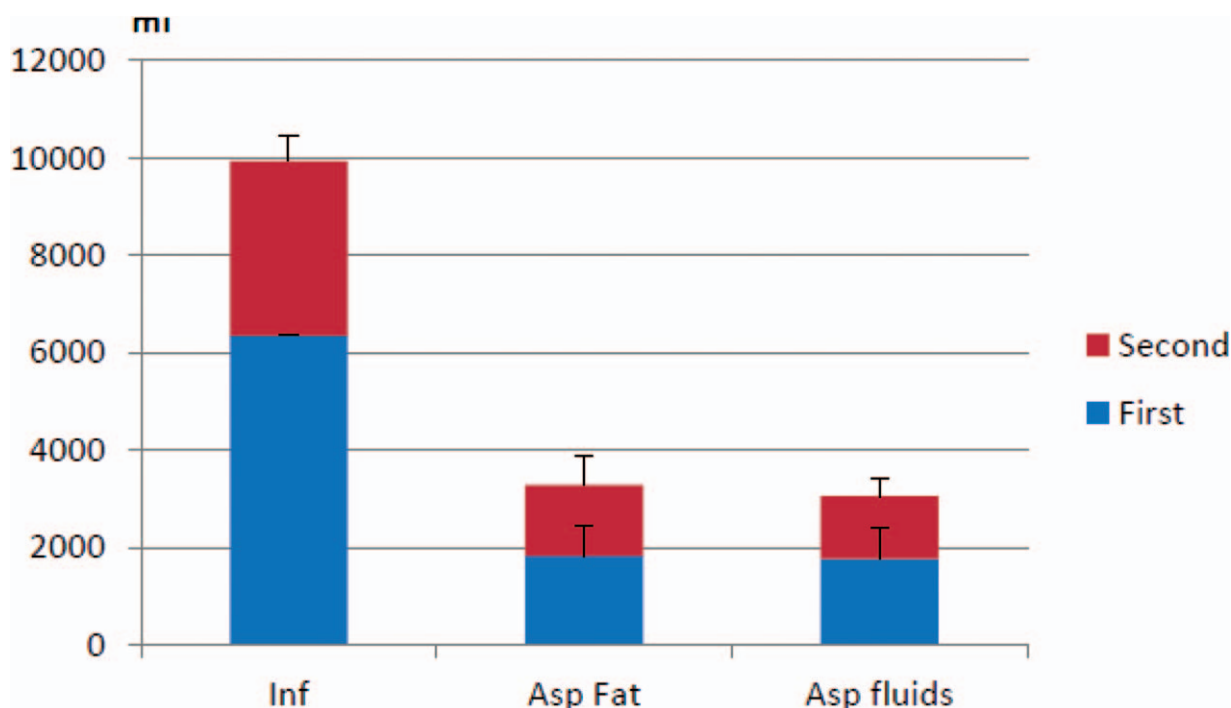


Figure 2. Infusates and Aspirates in 83 patients. (Asp Fat=aspirated fat; Asp Fluids=aspirated fluid; First=first segment; Inf=infusates; Second=second segment).

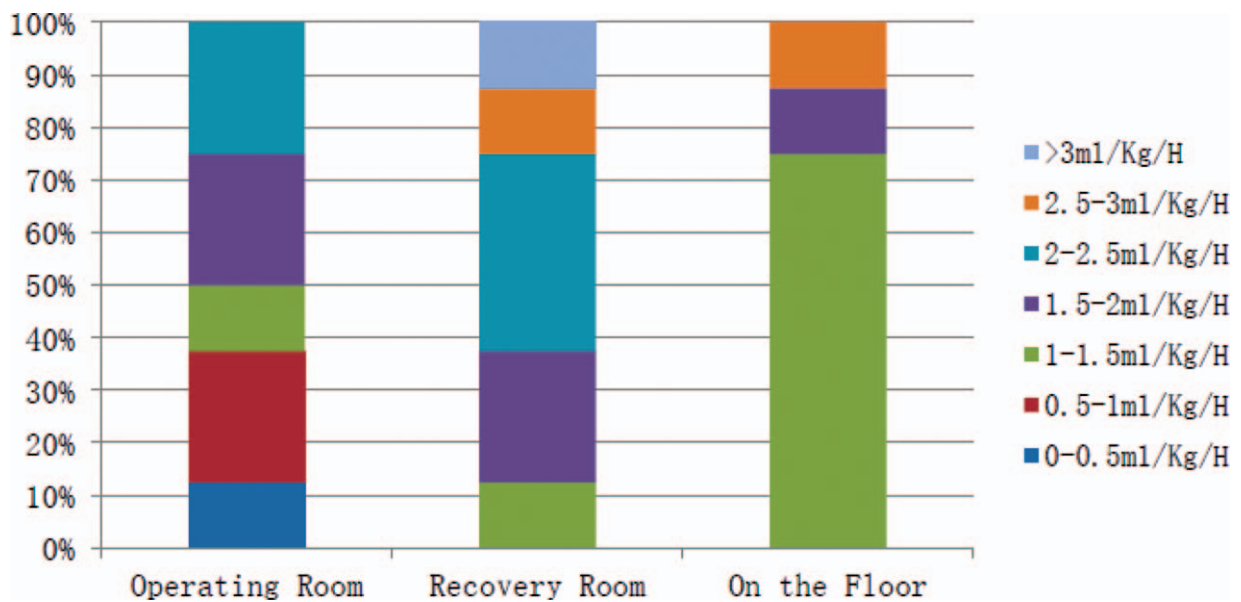


Figure 3. Urine Output in 83 patients.

apparently suctioned out again, 60% to 70% of the solution is actually retained for absorption and contribution to plasma volume.^[5] Blood loss using the superwet or tumescent technique is negligible and replacement is not required, whereas high-volume (more than 4–5L) liposuction demands supplemental fluids. Trott et al showed that additional IV fluid replacement is delivered at a ratio of 1 cubic centimeter for each cc aspirated only after removal of more than 4L of fluid. They suggested that the intraoperative fluid volume ratio is 1.4 for large-volume liposuction (>4L). Intraoperative fluid ratio is the sum of the superwet infiltration volume plus the intraoperative IV fluid volume divided by the volume of aspiration.^[6] However, the patients appeared to be slightly overhydrated under this fluid management strategy. This formula was revised and Rohrich delivered replacement fluid at 0.25 cc crystalloid for each 1 cc

over 5000 cc of aspirates.^[7] The ratio was decreased to 1.2 which implied less subcutaneous infiltration. The revised fluid management strategy still reflected a mild degree of over-resuscitation with potential risk of volume overload. The superwet technique with total infiltrate-to-total aspirate ratio of 0.95:1 was applied in the studies of Trott and Rohrich. The intraoperative fluid ratio was 1.66, which indicated that much larger volume of fluids would be infiltrated in our series if the same volume of aspirates was suctioned. Higher amount of infiltrated tumescent solution ensured sufficient anesthetic effects of local anesthesia in combination with sedation, compared with relatively lower requests of effective pain relief caused by the use of general anesthesia or epidural anesthesia with sedation.^[8,9] Fluid overload may exist with relatively large volumes of infused tumescent fluids, so fluid replacement was abandoned in our

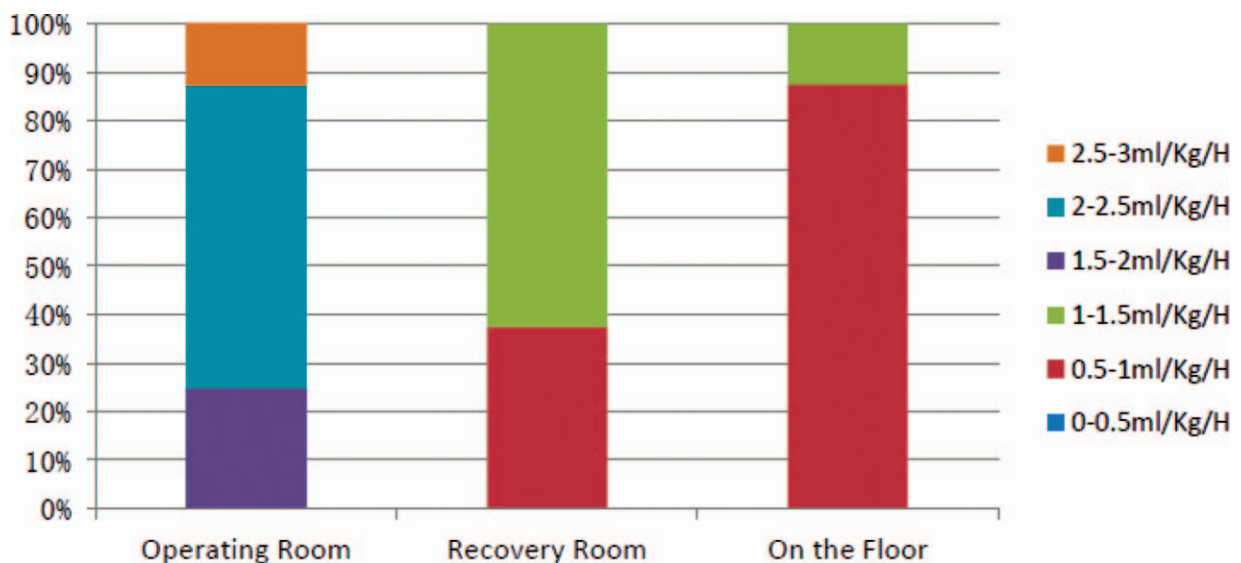


Figure 4. Intravenous fluid rate in 83 patients.

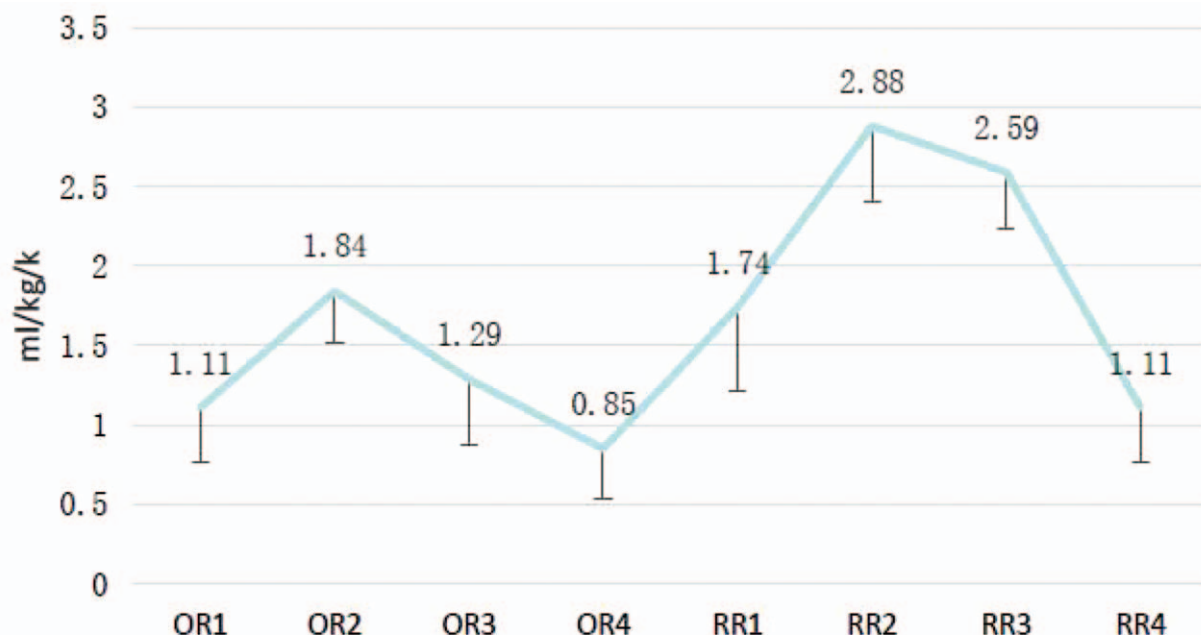


Figure 5. Average urine output overtime curve. (OR=operating room; RR=recovery room).

practice. Additionally, the average total aspirated volume (6,975 mL) was higher than those in the studies of Trott and Rohrich. Approximately 38% of the patients have aspirated volume of more than 7000ml compared with 17% and 7% in Trott’s and Rohrich’s studies, respectively. Such a high volume could reduce the risk of fluid overload. Finally, IV fluid administration was reduced, and the average IV fluid rate was lower than those reported in previous studies. These could contribute to the low risk of fluid overload and possible pulmonary edema.

Urine output, a well-accepted noninvasive parameter for monitoring renal blood flow and cardiac output in a patient with normal renal function, is considered adequate when it exceeds 0.5 to 1 mL/Kg/H.^[10] The average urine output in the operating room, recovery room and on the floor in our study was similar to those in Trott’s and Rohrich’s studies, which implied that the absence of replacement fluid did not increase the risk of underhydration. Additionally, all patients had urine outputs greater than 1 mL/kg•h in the recovery room and on the floor in our study, whereas the percentages in Trott’s and Rohrich’s study were about 80% and 81%, respectively. The urine output in the operating room peaked after 2 hours and then gradually declined (Fig. 5). It approached the maximum

value after 2 hours in the recovery room and then gradually declined again. This trend represented the principle of hypodermodysis, in which subcutaneously injected fluid enters the intravascular space. Subcutaneous infiltration is assumed to result in the first peak in urine output in the operating room. A previous study reported that the average absorption time of 1 L of isotonic fluid in the medial thigh of 33 patients was 167 minutes.^[11] Fluid extravasations and stasis followed by suction trauma reduces urine output. Compressive garments during postoperative recovery room further aided in promoting the shift of subcutaneous fluid into the intravascular space and led to the second peak in urine output, which was also observed in previous studies.^[1,6]

In addition to the intraoperative fluid ratio, residual volume theory provides a guideline for a desirable final fluid volume balance left in the patient at the end of the procedure to avoid overhydration or underhydration.^[8] To calculate the final residual fluid volume for any patient, all intakes and outputs should be meticulously measured as follows: residual fluid volume=(total fluid volume in) – (total volume out); total fluid volume in=(total fluid volume of wetting solution used) +(total volume of IV fluid used)+(volume of bupivacaine/steroid solution); and total volume out=[total volume of aspirated wetting solution (which is approximately 30% of the total aspirated volume in most cases)]+urine output. The volume of actual fat aspirated was not considered in the calculations, because it results in minimal physiological effect when compressive garments are used to aid in hemostasis and eliminate dead space. The residual volume represents fluid available for autoresuscitation by hypodermoclysis.^[12] Thus, the fluid in the subcutaneous space acts as a slowly absorbing hydrating system during the early phase of recovery after surgery. The average residual volume of 110mL/kg (range, 75–141mL/kg) in our series was highly similar to 120mL/kg (range, 90–140mL/kg) in the report of Commons et al^[8] The success of the theory depends on limiting the overall amount of IV hydration intraoperatively to less than 1L because IV fluid has a more immediate physiological

Table 4
Results in body contouring.

	Before liposuction (cm)	After liposuction (cm)
Average of minimum waist circumference	81.63±6.48	73.85±2.69
Average of abdominal circumference	95.73±5.66	89.28±3.14
Average of hip circumference	99.59±6.05	97.03±5.62

Minimum waist circumference is the smallest horizontal lumbar girth between the costal arch and iliac crest

Abdominal circumference is the horizontal abdominal girth at the level of iliac crest

Hip circumference is the horizontal hip girth at the level of groin level

effect than slow absorption of fluid in the subcutaneous space, thereby promoting hypervolemia.

The potential for fluid overload in large-volume liposuction is a serious concern. Patients are usually monitored using noninvasive hemodynamic monitoring, including a blood pressure cuff, pulse oximeter, and cardiac monitor. Jain, A.K., et al used stroke volume variation as a guide for intraoperative fluid administration in 15 patients subjected to large-volume liposuction.^[13] The average BMI was 31, and the intraoperative fluid ratio was 0.93 ± 0.084 , which implied that much more infiltration solution would be acquired if the patients were treated in our practice. The average urine output was 1.12 to 1.27 mL/kg-h, which was neither underhydration nor overhydration. Our IV infiltration solution could be further reduced if application of the stroke volume variation in fluid management during the recovery room stay and on the floor is validated. Stroke volume and pulse pressure variation, as dynamic parameters, could result in an appropriate amount of IV fluid use in patients undergoing extensive liposuction.

In extensive liposuction cases, the superwet or tumescent technique is often accompanied by sedation, general anesthesia, or epidural anesthesia to ensure adequate patient comfort. General anesthesia is safe and effective in accredited office-based surgery facilities, particularly suitable for complex or long operations.^[14,15] Epidural anesthesia associated with sedation is applied. Lumbar and thoracic levels are obtained depending on

the areas to be aspirated.^[16,17] Light sedation can be performed for large-volume liposuction, implying short recovery time, earlier discharge, and low cost to the patient.^[18,19] However, if infiltration is not uniform, some areas will lack analgesia, thereby requiring more sedation. Light sedation was applied in our practice, and variations in blood pressure and heart rates were not significant pre-operatively and intra-operatively.

Medical history should be obtained to rule out cardiovascular, renal, pulmonary, and hepatic diseases in extensive liposuction. While most patients can tolerate a significant intraoperative fluid challenge when cardiac, pulmonary, hepatic, and renal status is normal, unrecognized systemic disease can significantly reduce this margin of safety. Traditional fluid replacement policy corrects the pre-existing deficits, provides maintenance fluid, and replaces additional surgical losses. Preoperative volume deficits in healthy liposuction patients may not be sufficient to warrant replacement. IV fluid administration during operation was minimized to approximately 300 to 500 mL. The total volume of IV injection was also reduced to less than 1500 mL when the patient was in the recovery room and on the hospital floor. These values might be further reduced with the new monitoring method.

The extensive liposuction also means the lidocaine total dose might be over the dosing recommendation. Additionally, monoethylglycinexylidide (MEGX) is 80% to 90% as potent as an antiarrhythmic drug as lidocaine, and its relative toxicity is



Figure 6. Preoperative view of 22-year-old woman who received extensive liposuction on her legs and bottom and postoperative view (1 month).



Figure 7. Preoperative view of 20-year-old woman who received extensive liposuction on her legs and bottom and postoperative view (2 month).

approximately equal to lidocaine. In our practice the segmental infiltration is applied and the concentration of lidocaine in tumescent fluid is gradually reduced to 0.0252%.^[20] Our previous study demonstrated that the risk of toxicity is low because the peak lidocaine level is below the toxic threshold ($3 \mu\text{g/mL}$).^[4] Our another previous study demonstrated that the risk of MEGX toxicity was as low as that of lidocaine toxicity in extensive liposuction operations.^[21]

The development in liposuction technology has resulted in the gradual extension of body areas treated during 1 session to meet the demands of patients. The majority of Chinese ladies whose BMI are $< 25 \text{ Kg/m}^2$ prefer much thinner body figure which could make them tall visually. For example, the patient whose BMI is

18.1 Kg/m^2 complains of the adipose tissue accumulation in her legs which makes her legs short and thick visually. In our practice, we performed extensive liposuction procedures on her legs and bottom in 1 session to make her legs thin and straight visually (Fig. 6, Fig. 7, Fig. 8). BMI is not the only indicator for extensive liposuction to Chinese ladies. Additionally, all patients are assessed and classified initially as either ASA physical status 1 or 2 preoperatively. The malnutrition or morbid obesity is excluded for the sake of safety.

No invasive hemodynamic monitoring were performed in previous studies by Trott and Rohrich or our present study. This provides the reader with less assurance regarding the conclusions, but few volunteers would accept invasive hemodynamic



Figure 8. Preoperative view of 26-year-old woman who received extensive liposuction on her legs and bottom and postoperative view (3 month).

monitoring in extensive liposuction. Additionally, no appropriate controls or multi-centers design was adopted and no records of oral intake in the recovery room and on the floor were saved. The electrolyte balance was taken seriously in perioperative period, but was not recorded. With the same ethnic group and targeted areas and surgeon and anesthesiologist, our conclusions which

were drawn on the observational study of extensive liposuction with segmental infiltration could not be taken as guidelines. Few data exist to support definitive guidelines, and the technique is highly surgeon-dependent. Meticulous calculations of intakes and outputs during and after the procedures can aid in fluid management decisions. Good communication between the

surgeon and anesthesiologist is critical for optimal care and safety. As few paper about the fluid management in extensive liposuction among oriental patients are published, our observational study on fluid resuscitation in liposuction among oriental patients provides new information which would be helpful to future study.

Author contributions

Investigation: Gang Wang.

Validation: Wei Gang Cao.

Conceptualization: Tian Lan Zhao.

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