Chapter 4

Anesthesia Management for Large-Volume Liposuction

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Additional information is available at the end of the chapter

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Abstract

The apparent easiness with which liposuction is performed favors that patients, young surgeons, and anesthesiologists without experience in this field ignore the many events that occur during this procedure. Liposuction is a procedure to improve the body contour and not a surgery to reduce weight, although recently people who have failed in their plans to lose weight look at liposuction as a means to contour their body figure. Tumescent liposuction of large volumes requires a meticulous selection of each patient; their preoperative evaluation and perioperative management are essential to obtain the expected results. The various techniques of general anesthesia are the most recommended and should be monitored in the usual way, as well as monitoring the total doses of infiltrated local anesthetics to avoid systemic toxicity. The management of intravenous fluids is controversial, but the current trend is the restricted use of hydrosaline solutions. The most feared complications are deep vein thrombosis, pulmonary thromboembolism, fat embolism, lung edema, hypothermia, infections and even death. The adherence to the management guidelines and prophylaxis of venous thrombosis/thromboembolism is mandatory.

Keywords: tumescent liposuction, large volume, anesthesia

1. Introduction

Tumescent liposuction is a cosmetic surgical procedure that consists of a suction-assisted lipoplasty that removes unwanted fat deposited under the skin. Liposuction has its beginnings in 1921, with the Parisian surgeon Charles Dujarrier who was interested in body shaping and fat removal. In 1970s, the technique evolved with various doctors such as Shrudde,

Kesserling and Meyer, the Fischers, and many more. The technique was again modified in 1977 by the French surgeon, Yves Gerard Illouz, who added hyaluronidase and saline solution to try to emulsify the fat and facilitate its aspiration, later called the wet technique [1–3]. It was not until the mid-1980s that the American dermatologist, Klein, described the tumescent technique, in which considerable amounts of sodium chloride solution, local anesthetic, epinephrine, and bicarbonate were infiltrated in the fatty tissue to expand and increase its turgor in order to create a level to facilitate the suction and reduce blood losses [4]. During tumescent liposuction a variable amount of crystalloid solution is infused, including dissolved epinephrine to thicken the subcutaneous fat layer in order to remove the highest possible amount of fat, thus decreasing blood loss to amounts as low as 1% of all the aspirated volume. Lidocaine can be added to the solution to produce local anesthesia during and after the procedure.

Although liposuction appears to be easy and harmless, it is not a trivial procedure because it can potentially involve serious complications like deep vein thrombosis (DVT), pulmonary embolism (PE), pulmonary edema, fat embolism, hypothermia, and even death [3, 5]. A painful recovery is also possible. Large-volume liposuction needs special care to avoid hypothermia, keep an appropriate fluid balance and DVT/PE prophylaxis.

This chapter focuses on large-volume liposuction done under general anesthesia, the most important technical aspects and literature data regarding risks, complications, and anesthesiological considerations.

2. Types of liposuction

According to the infiltration techniques for liposuction, this procedure can be classified into four categories [6]:

1. Dry technique: In which the aspiration cannula is inserted directly into the space from which the fat will be removed without any infiltration of the tissues. The estimated blood losses range from 20 to 45% of the aspirated volume.
2. Wet technique: In relation to the expected amount of aspirated volume, 200–300 ml of solution is injected in each area to be treated. Blood losses are calculated from 4 to 30% of the volume aspirated.
3. Super wet technique: The amount of infiltrated solution (calculated in 1 ml for each ml of the aspirated estimate) is equal to the amount of fat removed. Blood losses are calculated at 1% of the volume aspirated.
4. Tumescent method: A large amount of solution (estimated at 3–4 ml per ml expected to be aspirated) is injected into the fatty tissue, seeking to increase the space occupied by the fat, in addition to giving it a firm and turgid consistency (**Figure 1**). Blood losses are calculated at 1% of the aspirated volume.

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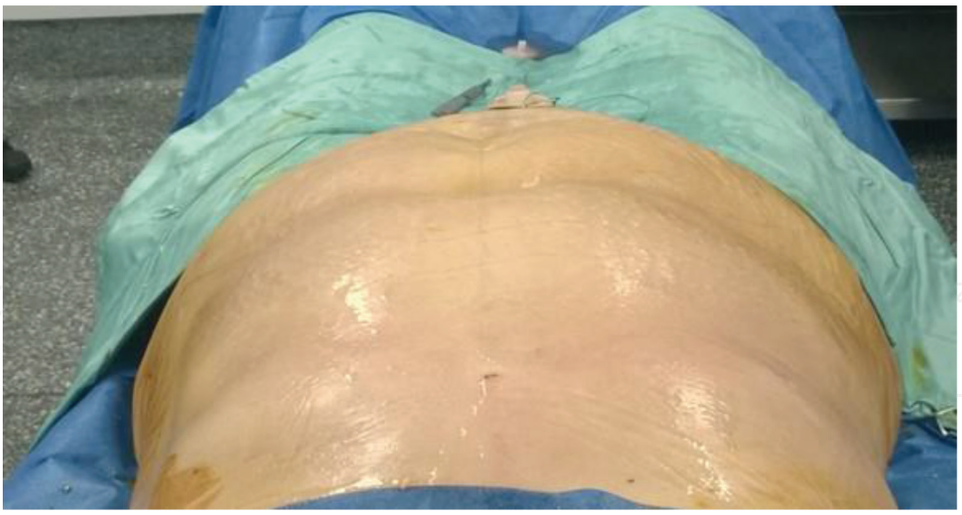

Figure 1. Abdomen infiltrated with 6 liters of tumescent solution. Note the pale coloration of the skin secondary to the effect of injected adrenaline.

Figure 2. The left image shows little blood compared to the image on the right with a large amount of blood in the liposuction container.

Liposuction can also be classified into two types according to the aspirated volume: large volume (>4 liters aspirated) and low volume (<4 liters aspirated). From here we must always keep in mind that the higher the volume aspirated, almost inevitably a greater amount of tumescent solution will have to be infiltrated in the dermoclysis. As this volume of infiltration increases, so does the risk of causing pulmonary edema, for which in these conditions the management of intravenous fluids must be very cautious, always tending to the restriction both in the transoperative period and in the first hours of postanesthetic recovery (**Figure 2**).

According to the surgical instruments used, liposuction is called power-assisted, laser-assisted, or ultrasonic-assisted lipoplasty. Manual liposuction using different sizes of syringes is a technique that is still used for small areas.

3. Tumescent solutions

Currently, the most used solution to generate the tumescence is the one described by Klein [4, 7], and a more reasonable variant—which we prefer to use but little is known—is the one proposed by Hunstad [8, 9], as seen in **Table 1**.

In the tumescent solution described by Klein, the local anesthetic was diluted in isotonic saline solution. However, when isotonic saline solution is used as a diluent, if the patient is not under anesthesia, a burn sensation will be reported as the solution is infiltrated. It is reasonably recommended that when using this solution, the acidic pH of the 0.9% saline solution should be neutralized with bicarbonate, which in addition reduces pain; by increasing the pH, it also increases the proportion of non-ionized lipid soluble lidocaine, which favors a faster entry into the nerve cell where lidocaine acts. When lactate Ringer's solution is used, this burning sensation does not occur upon infiltration, and the sodium load is reduced. It should be noted that the dose of lidocaine and epinephrine should be regulated according to the maximum doses to be considered as safe.

Regarding the local anesthetics used, there are reports with articaine or prilocaine. Liposuction done with up to 38.2 mg/kg bodyweight of articaine HCl produced plasmatic concentrations as high as 1719–7292 ng/mL, without symptoms of systemic toxicity which could be explained by the rapid hydrolysis through the plasmatic esterases. These data show that articaine is safe for infiltration during liposuction [10]. The groups that have reported the use of prilocaine have not detected elevated levels of it in plasma or methemoglobinemia [11, 12], although Yildirim et al. described a patient with 40% methemoglobinemia that developed 8 h after liposuction was performed with almost 1000 mg of prilocaine [13]. In our surgical facility, the most used local anesthetic is lidocaine, and even though for other applications when used in association with epinephrine, the maximum limit is established at 7 mg/kg. In the specific case of the tumescent solution for liposuction, the safety range is 35–55 mg/kg [14, 15]. We prefer to stay at the lower limit of 35 mg/kg in order to be more cautious, given that since the surgical team does not keep accurate control of the injected lidocaine or takes into consideration possible drug interactions or special conditions of the patient. The concentrations of lidocaine vary according to the vascularity of the area in which the liposuction is to be performed. In more sensitive or vascularized areas such as the chest and abdomen, the concentration or amount of local anesthetic mass can be increased and decreased in less sensitive areas such as the thighs.

Klein solution	Hunstad solution
1000 mL isotonic saline solution	1000 mL Ringer's lactate solution
50 mL, 1% lidocaine	50 mL lidocaine 1%
1 mL (1: 1000 epinephrine)	1 mL (1: 1000 epinephrine)
12.5 mL (8.4% sodium bicarbonate)	

Table 1. Tumescent solution.

Lidocaine toxicity is in function if the peak plasma concentration is reached, which will depend on several factors such as the total amount of mg/kg, as well as its rate of absorption and elimination, so that the peak levels of lidocaine and its active metabolite (monoethylglycinexylidide) occur in a period as variable as 8–32 h after infiltration has been done. For this reason alone, for patients who are treated with this procedure, it is not recommended to do it in an outpatient setting, because the maximum concentrations of lidocaine and its active metabolite will most often take the patient at home with little vigilance.

Lidocaine is eliminated from the body by diethylation in the liver by isoenzyme groups 1A2 and 3A4 of cytochrome p450. Thus, all drugs that inhibit isoenzyme 3A4 and cytochrome P450 can affect the metabolism of lidocaine. For this reason, lidocaine doses should be reduced in patients who use medications that interfere with the cytochrome P450 system or that affect the hepatic blood flow. The factors that can modify the systemic absorption of lidocaine need to be considered. Obviously, the reached concentration of the drug, the degree of vascularity of the infiltrated tissue, the concomitant use of vasoconstrictor drugs, and the infiltration rate [3] are very important.

The adequate use of epinephrine in the tumescent solution theoretically allows blood loss to be 1–2% of the total volume aspirated. The maximum recommended total dose of epinephrine is 0.07 mg/kg. Vasoconstrictors are used to reduce blood circulation in the tissues, which helps to slow the absorption of local anesthetics. Adrenaline is the most commonly used vasoconstrictor; the recommended concentration for the tumescent solution ranges from 0.25 to 1 mg/Lt, depending on the tissue vascularity in question. In more vascularized tissues, the recommended concentration is 1 mg/L to be decreased to 0.5 mg/L in body areas with less vascularization (**Figure 3**). If it is anticipated that this maximum dose will be exceeded, the procedure

Figure 3. Infiltrated back. Note the changes in skin circulation due to the tumescent solution, with a marked delay in capillary refill.

should be done replacing the adrenaline with other options such as 1-ornithine-8-vasopressin in concentrations of 0.01 IU/ml, with the disadvantage of having to use it in unheated solution with the consequent hypothermia of the patient.

4. Preoperative evaluation

Although it is well established that liposuction is not a treatment for obesity, more often than desired, the obese patient is programed for this type of procedure, and there are usually other associated comorbidities such as high blood pressure, diabetes mellitus, metabolic syndrome, ischemic heart disease, DVT, and obstructive sleep apnea. If despite recognizing that liposuction is not a reasonable treatment for obesity, if in any case it is decided to do this procedure, the minimum required is that, in the case of hypertension and diabetes, these conditions should be well controlled (it is advisable to postpone patients who have recently changed medications or doses in order to avoid unpleasant outcomes). If the risk of DVT, consider pharmacological thromboprophylaxis apart from mechanical prophylactic measures.

It is common that this type of patients is using recognized or unrecognized (natural remedies) medications and "herbal aids" to lose weight. This type of drugs ranges from amphetamines, thyroid hormones and ephedrine and a fairly large list of herbs and teas that if we take the care to inquire about it (identify them and look for their pharmacological effects), we will find that at least they alter the coagulation system or facilitate the interactions with epinephrine (see Chapter 1). Therefore, the patient should be instructed to suspend all this type of medications and naturopathic remedies at least 2 weeks before surgery. Needless to say, it is a contraindicated procedure in cocaine addicts.

With regard to laboratory tests, in our work center, it seems that it is exaggerated, but the type of patients and the procedures that are carried out have led us to request complete blood chemistry, basic metabolic panel, quantification of glycosylated hemoglobin (if the patient is diabetic), thyroid profile, coagulation times, liver function tests, pregnancy detection, serological detection of hepatitis A, B, and C, as well as detection of antibodies against HIV. If the patient presents some suspicious data, antidoping is added. All patients, regardless of their age, undergo ECG [6].

5. Preanesthetic medication

The preanesthetic medication in this group of patients is an important part of the preoperative management and should include not only sedative and hypnotic drugs but also an effective scheme that prevents the possibility of emesis and postoperative pain with neuropathic characteristics, which is secondary to multiple nervous fiber trauma of medium and small caliber. A typical preanesthetic scheme is lorazepam, dexamethasone, ondansetron, gabapentin, or pregabalin. A nonsteroidal anti-inflammatory analgesic can be added.

6. Anesthesia management

While liposuction of large volumes can be done with any anesthesia technique, we strongly recommend the use of general anesthesia. The anesthetic induction is done in the usual way, being propofol the most used drug. For muscular relaxation for endotracheal intubation, a non-depolarizing drug with rapid action such as rocuronium or atracurium, although vecuronium is probably the most used muscle relaxants due to its safety and low cost. For the maintenance of anesthesia, desflurane, sevoflurane or isoflurane alone or in combination with opioids can be used. Ketofol have been recommended by several authors. Muscle relaxation is optional during the surgery.

In our experience, which is worth taking into consideration, since in the last 8 years, we have accumulated an average of 200 large-volume liposuctions per year (with the peculiarity that it is the same surgeon and the same anesthesiologist). We usually premedicate patients with ranitidine, metoclopramide, ondansetron, and the prophylactic antibiotic of the surgeon's choice. Induction is with fentanyl 3–4 mμ/kg and vecuronium to facilitate orotracheal intubation (usually 4–6 mg) and propofol 2 mg/kg. We continue with inhalatory anesthesia with low flows, in general terms only use oxygen 350 to maximum 400 mL/minute, and desflurane given its faster response to modify the desired CAM. As approximately 60–70% of the time, the procedure will be done with the patient facing down, more when it includes lipoinjection in the buttocks. The patient is intubated orotracheally with a spiral reinforced cuffed tracheal tube (like Sheridan Spiral-Flex®) properly fixed. We never relied on a laryngeal mask; no matter the discussion, it will never approach the security provided by an endotracheal tube. Due to the situation of changes in the patient's position, experience is necessary in turning the patient from supine to the ventral position and ventral to the supine, protecting the cervical spine and ensuring that the endotracheal tube does not move. It is necessary to have protection devices for pressure points, which allows us to keep the patient upside down, taking care of pressure points on the nose and eyes fundamentally (**Figure 4**) [16].

The patient scheduled for liposuction at least qualifies as a moderate thromboembolic risk, so all of them must have compression stockings and intermittent pneumatic compression systems installed, both during surgery and during all the time that they remain in the clinic or at least until they start ambulation. In special cases of higher risk, pharmacological thromboprophylaxis with low-molecular-weight heparin is necessary.

As for the monitoring equipment, beyond the required pulse oximetry, ECG with automated analysis of the ST segment, noninvasive blood pressure measurement every 5 minutes, capnography, and analysis of inhaled and exhaled gases, if available. As for temperature monitoring is useful to keep the record in two channels, central and peripheral temperature, since the isolated reading of the peripheral is of little use, it is more advisable to have both readings and be aware of the gap between the two. Although we have neuromuscular relaxation monitor, given the type of surgery, the low doses of the neuromuscular blocking agents injected for the tracheal intubation and its pharmacokinetic profile, at the end of the surgery, have no residual effects. BIS or entropy monitor can be very useful, given that the hemodynamic variations of the patients are not rare as a result of the adrenergic stimuli due to the infiltrated

Figure 4. Proper mechanical thromboprophylaxis by compression stockings and intermittent pneumatic compression system in lower limbs.

Figure 5. Hyperemia is seen in the areas of the face where the device for protecting the nose and eyes rested, as well as adequate eye occlusion.

epinephrine and that they do not necessarily have to do with the need of changing the anesthetic depth (**Figure 5**).

One of the reasons to use general anesthesia is because through endotracheal intubation and mechanical ventilation, it is easy to control the respiratory function more efficiently. In this sense, spirometry has great importance. If you do not use spirometry with these types of procedures, you could say that you ventilate blindly, considering the almost obliged obesity of many of

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these patients, in which their thoracic dynamics differ with just the change to ventral position. Normally, we ventilate the patients with volume-controlled mode, calculating their tidal volume between 6 and 7 mL/kg, and always keep a sequential record of the peak pressure reached with these volumes. In many patients, with only the change to ventral position, the peak pressure increases between 2 and 4 cm H_2O, values that increase even more when the tumescence is completed either from the back or the abdomen. The vast majority of patients tolerate it adequately, but between 5 and 10% present a peak pressure increase that forces us to consider that all the extra effort that the ventilator is generating is what helps meet those required volumes. A patient with upper spinal block, in ventral position, sedated and with a nasal cannula, definitely cannot meet the required ventilatory work. Sometimes it is better to change to a pressure-controlled mode, usually lowering to maximum pressures of 18–20 cm H_2O, but always observing the expiratory volume, so that it is sufficient to maintain an adequate reading of CO_2ET, maintaining adequate alveolar ventilation without the significant increase in airway pressure that can be generated in volume-controlled mode (**Figures 6** and **7**).

As mentioned before, it is mandatory to supervise the cumulative dose of lidocaine to avoid systemic toxicity; it must be taken in mind that although it is being used within the limits recommended as safe, it must be considered that its enzymatic metabolism depends on cytochrome P450, which is also responsible for the metabolism of other drugs. This could cause the 3A4 subfamily of cytochrome P450 to be saturated and alter the metabolism of lidocaine. Midazolam competes in its metabolism in this subgroup, which could decrease the elimination of lidocaine, and with its effects, midazolam may mask the toxicity symptoms of lidocaine up until the onset of cardiovascular collapse. Other drugs that inhibit the 3A4 subfamily of cytochrome P450 are listed in **Table 2** [17, 18]. As it is observed, the list is quite extensive, making it difficult to have in mind all these possible interactions, the reason why we recommend the online use of the system of detection of interactions and undesirable side effects "epocartes."

Figure 6. Observe the adequate anesthetic depth (entropy readings) despite the rise in blood pressure secondary to epinephrine infiltration.

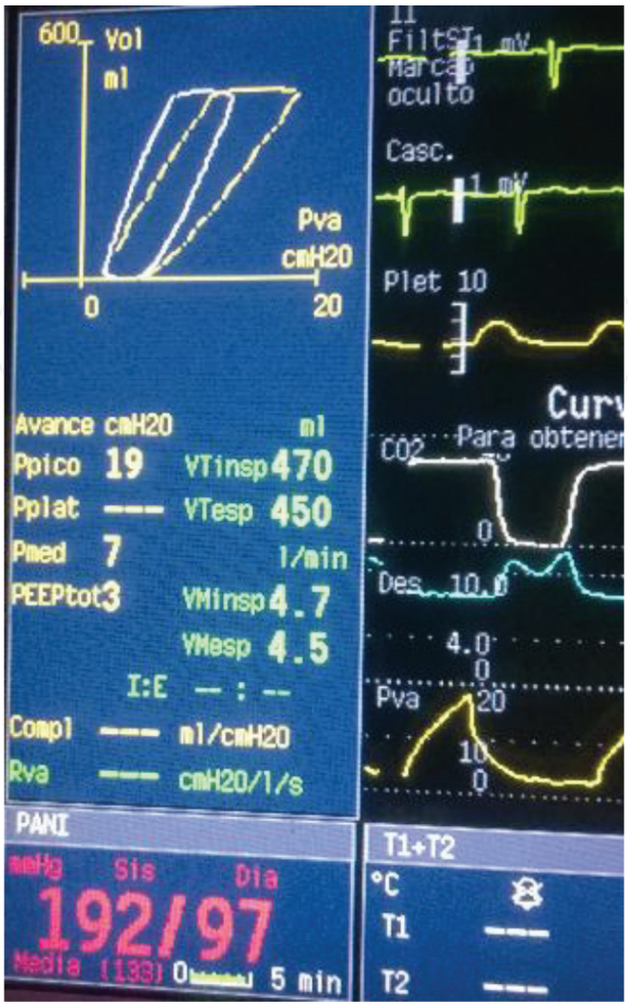

Figure 7. Increase of blood pressure during the infiltration of the solution for tumescence in a hypertensive patient. In the upper part of the figure in yellow, we can see the current loop of spirometry, produced by the decrease in thoracic compliance, compared with the reference white loop before infiltration.

Propofol	Methylprednisolone	Amiodarone
Flunitrazepam	Dexamethasone	Verapamil
Diazepam	Itraconozole	Atenolol
Triazolam	Ketoconazole	Labetalol
Paroxetine	Miconazole	Pindolol
Carbamazepine	Fluconazole	Propranolol
Fluoxetine	Isoniazid	Metoprolol
Sertraline	Clarithromycin	Diltiazem
Nefazodone	Chloramphenicol	Nicardipine
Terfenadine	Erythromycin	Timolol
Methadone	Tetracycline	Nadolol
Danazol	Cimetidine	Nifedipine
Thyroxine	Quinidine	Pentoxifylline

Table 2. Drugs that inhibit the 3A4 subfamily of cytochrome P450.

7. Management of perioperative intravenous fluids

For safety reasons, tumescent liposuction of large volumes is a surgery in which patients must stay at least 1 night hospitalized in an environment that guarantees their monitoring and safety. Often, there are patients who want extensive liposuction that can be as much as 30% of their total body surface, the remaining 70% will stay on the infiltrated tissues, and from there it will be reabsorbed, with the potential for fluid overload. Although the perioperative management of liquids during liposuction remains an unresolved controversy, especially in liposuction of large volumes, the current trend is to decrease the administration of liquids and sodium to avoid fluid overload, pulmonary edema, and congestive heart failure.

A recent study was done in China by Wang et al. [19], who retrospectively reviewed 83 medical records of patients who underwent extensive liposuction under intravenous monitored sedation with propofol 1–2 mg/kg/h and remifentanil 1–7 μg/kg/h. The intraoperative fluid ratio was 1.66 for extensive liposuction. These authors did not find cases of pulmonary edema, congestive heart failure, or other important complications. The average diuresis in the operating room, the recovery room, and in the surgical floors was 1.35, 2.3, and 1.4 mL/kg/h, respectively. The administration of intravenous fluids during liposuction decreased approximately 300–500 mL. The total volume of intravenous injection was also reduced to less than 1500 mL when the patient was in the recovery room and on the floor of the hospital. The Colombian Consensus recommends to consider the effect of dermoclysis of the tumescent solutions that are injected to the patients [20].

The liposuction removes approximately 30% of the infused tumescent solution, so for each liter of infiltrated tumescent solution, 700 mL are absorbed, so they should be considered as part of the fluids administered to the patient.

Another piece of information that can be used as a guide is to administer intravenous crystalloid solutions from 0.1 to 0.25 mL per mL of aspirate [21, 22].

8. Risks and complications

Liposuction risks and complications are undervalued and underreported. When analyzing the medical literature related to the subject, it is always necessary to take into consideration the context from which the experiences are taken, since it is very different to perform liposuction of low volumes than liposuction of high volumes. In this way, there are interesting publications [23] but refer to cosmetic surgery performed in the office, for which the following possible contraindications are mentioned:

- Liposuction >5 liters
- Tumescent solution >5 liters
- Liposuction of large volumes with a second procedure
- Multiple procedures including abdominoplasty
- Anticipated blood loss >500 mL in adults
- Duration of surgery >6 h

Risks associated with tumescent infiltration and liposuction include DVT/PE, fatty embolism, anemia, perforation of the abdominal wall, pleural perforation, infection, fluid overload, pulmonary edema, hypothermia, and toxicity by local anesthetics and epinephrine. It is quite important to consider the necessary care during changes in position (ventral decubitus to prone decubitus) to minimize hemodynamic changes when patients are turned around and protect certain areas to avoid pressure injuries, corneal injuries, neural damage, and even blindness after anesthesia surgery. A recent report [24] mentioned the five more frequent serious complications of liposuction: thromboembolic disease, fat embolism, pulmonary edema, lidocaine intoxication, and intraabdominal visceral lesion. These events are easily preventable by simple measurements and safety protocols. The literature is full of reports of complicated patients during or after liposuction, and it is enough to mention some of these complications to encourage specialized care and stay within the recommended guidelines.

8.1. Deep vein thrombosis and embolism

Abdominoplasty is the plastic surgery procedure with the highest incidence of death secondary to PE. In addition, it must be considered that if the abdominoplasty is associated with liposuction of large volumes, the risk of PE increases. It is estimated that the rate of thromboembolism if these procedures are combined increases 6.6 times. The rate of nonlethal PE was 8.8% in patients who had an abdominoplasty with wide resection, combined with liposuction with surgical times of more than 140 minutes [25]. The causes that increase the risk of PE are the mechanical factors that favor blood stagnation in the lower extremities, such as the surgical position, abdominal compression, and the use of bandages and garments in the postoperative period [26]. In a survey conducted by the American Society of Plastic and Esthetic Surgery, a mortality of 1 for 47,415 liposuctions was reported, 1 for 7314 if liposuction was combined with other procedures, and 1 for 3281 when liposuction had been combined with abdominoplasty; this is 14 times greater than with liposuction alone [27]. Ibarra et al. [20] contributed to the elaboration of the Consensus of the Colombian Society of Anesthesiology and Resuscitation (SCARE) and of the Colombian Society of Plastic Surgery on the recommendations for the management of low-risk elective patients. Within this consensus, the following measures are mentioned: prevention of DVT, comfortable position (legs in partial flexion of knees and extremities), intermittent pneumatic compression during surgery and until discharge. Elastic compression stockings from the preoperative period until ambulation are mandatory (**Figure 8**).

Consider the use of low-molecular-weight heparin every 12 h until ambulation is normal. The following should be considered for patients with increased risk of DVT: patients with a history of previous episode of DVT, patients undergoing procedures lasting more than 5 h, patients with liposuction of large volumes (>5 liters), patients who undergo combined procedures that include abdominoplasty, patients who arrive in cities of high altitude (>2000 m asl) 2 or less days before surgery, patients traveling in the immediate preoperative or aspire to travel with a duration of 4 h or more within the first week of the postoperative period, and the patients who undergo gluteal lipoinjections.

Morales and his group studied the prophylactic effect of rivaroxaban and apixaban in patients undergoing liposuction of large volumes and other body contouring procedures, finding

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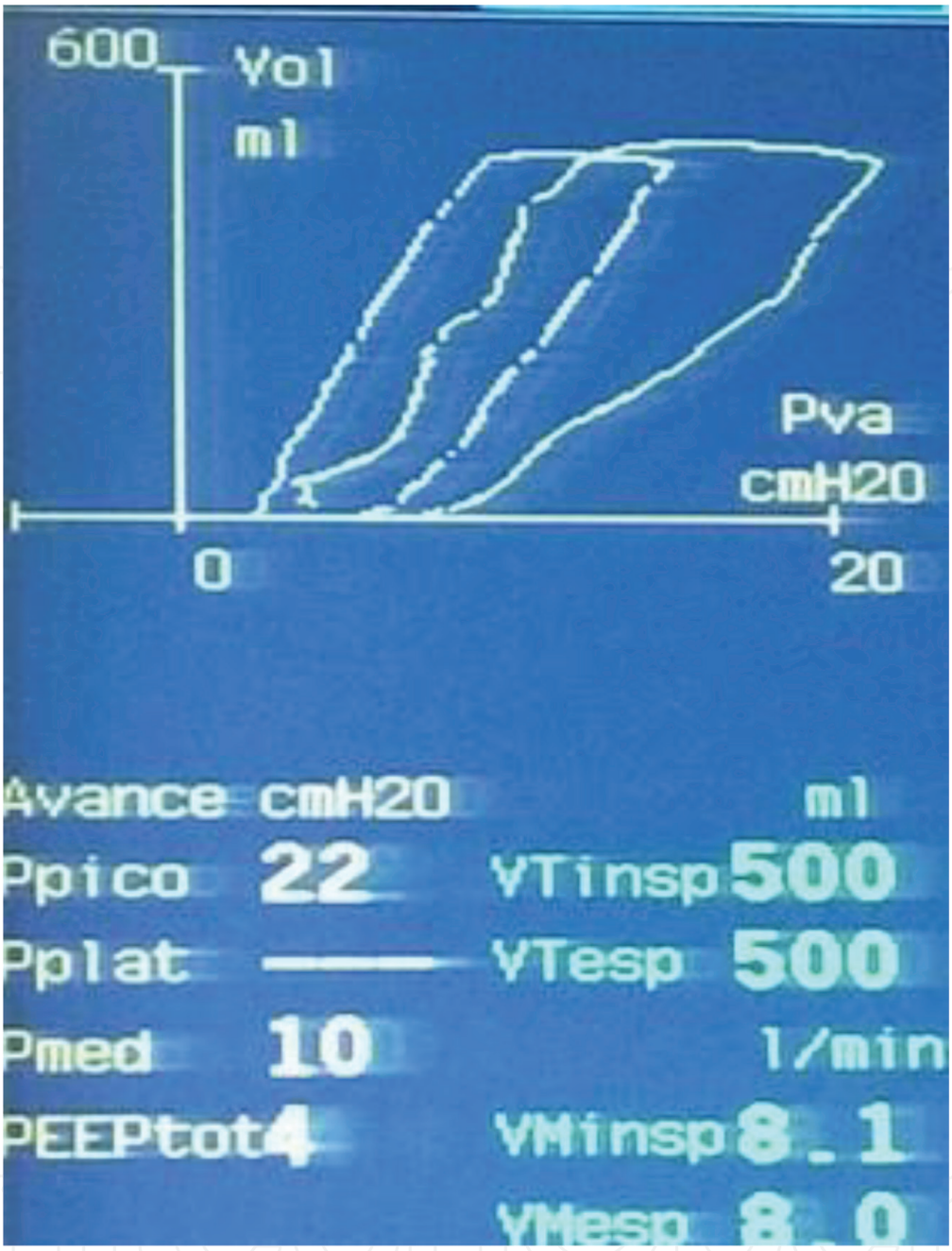

Figure 8. Comparison of spirometry loops, the basal with a peak pressure of the airway of 15 cm of water, and the second obtained once the patient's back has been infiltrated, rising to 22 cm of water.

that their thromboprophylactic effects and side effects are similar to each other and to low-molecular-weight heparin [28].

8.2. Anemia

Anemia is a frequent postoperative complication in patients undergoing liposuction, especially in liposuction of large volumes. The use of vasopressors in the tumescent solutions that are injected into the fatty tissue at the beginning of this procedure decreases bleeding due

to vasoconstriction, although there are some areas such as the torso and neck where bleeding is usually more abundant. Cansancao et al. [29] administered 10 mg/kg of intravenous tranexamic acid preoperative and postoperative vs. placebo in patients undergoing liposuction. The volume of blood loss for every liter of lipoaspirate was 56.2% less in the tranexamic group compared with the control group ($p < 0.001$). Hematocrit levels at day 7 postoperatively were 48% less in group 1 compared with group 2 ($p = 0.001$). Furthermore, a 1% drop in the hematocrit level was found after liposuction of 812 ± 432 ml in group 1 and 379 ± 204 ml in group 2. The authors concluded that tranexamic acid could allow for aspiration of 114% more fat, with comparable variation in hematocrit levels. Although erythropoietin has been used to improve anemia after liposuction and decrease the frequency of hemotransfusions, its usefulness has not been demonstrated [30]. It is advisable to check the hematocrit value before discharging the patient; in our patients, the hemoglobin values obtained by co-oximetry have a good correlation with the values obtained by the laboratory.

8.3. Drug interactions

Take care of possible drug interactions including natural products and anabolic steroids. Clarify in informed consent the high risk of interaction of substances such as cocaine, amphetamines, ecstasy, and other recreational drugs, with anesthetic and vasoactive medications. In suspected cases, antidoping and toxicology tests can be done [20].

Liposuction of large volumes is associated with important hemodynamic alterations: an increase in the cardiac index, heart rate, mean arterial pressure of the pulmonary, ejection volume index, and right ventricular work index are observed as well as a decrease in mean arterial pressure. Epinephrine, which is usually used at considerable doses during liposuction, may be responsible for tachycardia and increased cardiac index. The decrease in mean arterial pressure and systemic vascular resistance is probably due to the effects of general anesthesia and opioids in the transoperative period, but also the reduction of peripheral vascular resistance may be due to the dominant action of the epinephrine on the beta2 receptors of skeletal muscle vessels, where an increase in blood flow is observed.

8.4. Hypothermia

There is an increased risk of hypothermia in patients of large volume liposuction since there are large areas of body surface exposed to temperature loss. If the anesthesiologist does not insist, the nursing staff tends not to adequately heat the dermoclysis solutions, or if the surgeon has no experience or does not care about hypothermia, he/she can make the procedure excessively long, without considering that regardless of the type of anesthesia, this will always help to facilitate hypothermia. It is necessary to maintain the temperature of the operating room, even in hot climates in no less than 25°C or 77°F, even if it goes against the surgeon's comfort and other operating room staff. We must bear in mind the complications that hypothermia can cause, such as cardiac dysrhythmias, coagulopathies, oliguria, and electrolyte imbalance and an important increase in the consumption of oxygen during the chill phase. Both the hemodynamic changes and the tendency to hypothermia persist at least in the first 24 h of the postoperative [31].

8.5. Fat embolism

Fat embolism and fat embolism syndrome are another serious complication whose incidence is not known, but apparently has increased [32]. Fat embolisms are fat drops that enter the circulatory system, typically after trauma, that may or may not lead to the development of fat embolism syndrome, a rare and ill-defined diagnosis that can cause multiorgan failure and death. Fat embolism syndrome is defined as the entry of fat into the blood circulation with a clinical pattern characterized by hypoxemia, respiratory failure, neurological deterioration, and petechiae that occur in the appropriate clinical context; it is a continuum of fat embolism [33–35]. A study in 30 Wistar rats showed that there was an increased risk of systemic fat embolism in the animals that underwent liposuction-lipoinjection compared to those who only underwent liposuction (3/10 vs. 6/10, respectively). Fat embolism was not detected in rats that were only anesthetized [36]. There is no specific treatment for fat embolism syndrome, therefore prevention is so important as well as prompt detection, and supportive therapy are critical. Most patients with fat embolism or fat embolism syndrome are undiagnosed or misdiagnosed, so their mortality is very high. Most of these cases are diagnosed at autopsy [34].

8.6. Miscellaneous complications

The literature is full of varied reports of complicated patients during or after liposuction, and it is enough to mention some of these complications to encourage specialized care and stay within the recommended guidelines. There is a wide spectrum on liposuction complications: pleural and lung injury, bilothorax, bowel herniation, hematoma, seroma, lymphedema, and abdominal wall injury with damage to intra-abdominal viscera such as the liver, biliary tract, intestinal, or bladder perforation necrotizing fasciitis, blindness, and coronary fat embolism [37–39].

The main risk factors for the development of complications are deficient standards of hygiene, infiltration of multiple liters of wetting solution, prompt postoperative discharge, and selection of unfit patients, lack of surgical anesthesia experience, and early identification of developing complications [40].

9. Postoperative analgesia and hyperbaric oxygen therapy

Postoperative analgesics are extraordinarily mandatory in the professional management and prevention of acute and chronic pain after liposuction. It is usually started from the beginning of the surgery with an infusion with 300 mg of ketorolac, 300 mg of tramadol in 100 mL/2 mL/h, considered as basal analgesic scheme. It is also valid to resort if necessary to some rescue strategies, in which the analgesic and anti-inflammatory effect of hyperbaric oxygenation therapy can be considered. This therapy is routinely provided to all of our patients in the next 4 to 5 days after their procedure [41, 42].

The use of hyperbaric oxygenation therapy (**Figure 9**) has also reduced the need for pharmacological thromboprophylaxis, since it has been shown that hyperbaric oxygen by the action of nitric oxide decreases the expression of intracellular adhesion molecules (ICAM-1),

Figure 9. Partial view of the Hyperbaric Center at Buenrostro Clinic of Plastic Surgery and Hyperbaric Medicine in Tijuana México.

a factor that participates in favoring thrombus formation [43]. In addition, another of the already proven actions of hyperbaric oxygen that contribute to diminish the possibility of venous thrombosis formation is its capacity to favor the expression of fibrinolytic factors [44]. In this way in the last 8 years, with an average of 200 liposuctions performed per year, we have only resorted to the use of low-molecular-weight heparin in 2 patients, one of them had a history of deep vein thrombosis 3 years before liposuction, and the other patient was an exceptional case, since for traumatic reasons the patient was paraplegic for 5 years before her surgery.

10. Conclusion

Currently there are many controversies in the selection and better management of patients undergoing liposuction, especially in tumescent liposuction of large volumes. Meticulous selection of each patient is the basis of success, as well as a strategy of prophylaxis of catastrophic events such as thromboembolism, fat embolism, anemia, fluid overload, and infections, among others. Anesthesia is a determining factor and although various anesthesia techniques can be used, we propose general anesthesia as a safe procedure. Hyperbaric oxygenation is an unexploited resource that requires further study in this field.

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Conflict of interest

None.

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