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Liposuction and anaesthesia

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Introduction

The demand for plastic surgery procedures has increased globally.[1] Liposuction is the second most common cosmetic procedure performed with over 1.6 million procedures performed annually in the United States of America.[2] Liposuction is simplistically described as suction-assisted lipoplasty that removes fat deposits from beneath the skin.[3,4] The increasing demand for body contouring procedures and associated costs of in-hospital care has motivated for more procedures to be performed in the office-based and ambulatory settings.[1]

Although a seemingly minor procedure, a complication rate of between 1.2–5%[5,6] has been described, with a mortality rate of between 0.003–0.02%.[3] It is prudent for the anaesthesiologist to be familiar with the techniques used to facilitate liposuction, the options for anaesthesia, and the recognition and management of complications in order to provide safe care to patients.

History

The first reports of body shaping and surgical fat removal are from 1921 by a Parisian surgeon, Dujarrier.[4] Liposuction was formally introduced into clinical practice only in the 1970s by Giorgio Fischer using a blunt curette, known as the dry technique.[3,5] Complications as a result of this technique include marked postoperative bruising, swelling and pain; and blood loss of up to 25% of the aspirated volume.[7]

Wet liposuction techniques then emerged where hyaluronidase and 200–300 ml of saline were injected into each area, limiting blood loss to 4–30% of the aspirated volume, with more aesthetically pleasing results.[2-4] Super-wet techniques increased the saline injected to match the volume aspirated and further limited blood loss to 1% of the aspirated volume.[3,4]

In the 1980s, Jeffrey Klein, a dermatologist, introduced the concept of tumescent local anaesthesia (TLA), revolutionising medical care related to liposuction. This technique uses a large volume of a dilute formulation of a local anaesthetic agent and other additives, approximately 3–4 times the volume of that aspirated, infiltrated into tissues making it firm and turgid in order to achieve adequate anaesthesia to facilitate liposuction while minimising blood loss.[5] This technique has become the standard of care.[7,8]

Tumescent local anaesthesia technique

The TLA technique is routinely used during liposuction and its application has expanded to include other procedures, including vascular, breast, ENT and other plastic surgical cases.[7] In its original description of use, TLA is used as a sole anaesthesia technique without general anaesthesia[1] both in the office or hospital environment and is suited to day-case surgery.[7]

TLA has proven to be safe[7] and efficacious and has a number of other potential benefits, namely:[5,7]

- Low incidence of postoperative complications
- Reduction in blood loss from adrenalin-induced vasoconstriction and hydrostatic compression of blood vessels from the tumescent effect
- Potential anti-inflammatory and bacteriostatic properties of local anaesthetic agents limiting infections
- Pain on infiltration limited by the alkaline component of the solution
- Relative long-lasting anaesthesia postoperatively
- Cost effective as a sole anaesthetic when compared to general anaesthesia

Liposuction can be classified according to the volume aspirated into large (high) volume (> 4 L) or small (low) volume (< 4 L).[4] The volume of tumescent solution used is invariably greater with high volume liposuction and with this comes the increased risk of complications related to fluid management.[3,6]

Tumescent solutions

Two types of tumescent solutions used are detailed in Table 1. The most commonly used local anaesthetic agent is lignocaine.[3] A maximum dose of between 200–300 mg is recommended without adrenalin and 500 mg with adrenalin.[1]

The final composition of lignocaine in Klein's solution is 0.047%.[2] Various additives can be used which are described below.

Table I: Constituents of tumescent solutions[3,4]

Klein solution	Hunstadt solution
1 000 ml isotonic saline	1 000 ml Ringer's lactate
50 ml, 1% lignocaine	50 ml, 1% lignocaine
1 ml, 1:1 000 adrenalin	1 ml, 1:1 000 adrenalin
12.5 ml, 8.4% sodium bicarbonate	

Local anaesthetic agents

The choice of local anaesthetic agent and its pharmacokinetic properties, the pH adjustment and addition of vasoconstrictors to the tumescent solution affect the overall plasma levels and efficacy. Lignocaine is the most commonly used agent and will be discussed in more detail.

The pKa of lignocaine is 7.9, while that of commercial lignocaine is 6.5. The addition of adrenalin reduces the pKa to 6.4. The addition of sodium bicarbonate raises this pH to a more basic solution. Infiltration of the TLA solution into a basic environment in the tissues results in more nonionised molecules able to exert a physiological effect. Lignocaine is lipophilic with a high volume of distribution and its use in TLA solutions results in slow absorption from subcutaneous tissues. The addition of adrenalin further reduces this. Furthermore, between 65–75% of lignocaine is protein bound. Plasma levels are dependent on redistribution of lignocaine from the peripheral to the central compartment. Absorption of lignocaine into the central compartment occurs at a constant rate ("zero-order absorption") despite large doses without high peak plasma levels.[7] In practice, peak levels can be measured between 8–18 hours after TLA infiltration.[2]

Lignocaine has a high hepatic extraction ratio, and the liver can metabolise up to 150 mg/hr. Lignocaine is metabolised by the CYP3A4 isoenzyme of the cytochrome P450 system to monoethylglycinexylidide (MEGX), which is further hydrolysed and renally excreted. MEGX, which retains 80–90% potency of the parent compound, and glycine xylidide, another metabolic product, can both exert adverse central nervous system effects. Hepatic elimination, although efficient, may become dependent on blood flow when saturated. This is more likely to occur in elderly patients or in those with liver disease. Administration of agents that affect hepatic blood supply or metabolism may alter these pharmacokinetic effects.[7]

A maximum cumulative dose of lignocaine with adrenalin is 500 mg.[1] Due to the nature of the TLA technique, lignocaine doses (with adrenalin) of between 35–55 mg/kg have been described.[2,7] Between 7–30% of lignocaine is removed during liposuction limiting systemic absorption,[7] and more recent literature recommends doses up to 45 mg/kg during liposuction with lower doses (up to 28 mg/kg)[9] recommended for other procedures utilising TLA.[2,5] The American Society of Plastic Surgery recommends a maximum dose of 35 mg/kg when diluted lignocaine is used (0.05–0.1%).[7]

Other factors can also affect peak plasma levels. Upper body injection results in higher and earlier peak levels than lower body injection. Male patients have a lower body fat content placing them at greater risk for local anaesthetic systemic toxicity (LAST). Doses are reduced by 10% for this reason.[7]

Use of other local anaesthetic agents has been described including prilocaine, ropivacaine, levobupivacaine, bupivacaine and articaine.[3,7,8] Prilocaine has been used for TLA, as it displays similar pharmacokinetics to lignocaine. Production of O-toluidine during metabolism can result in methaemoglobinaemia at doses of 2.5 mg/kg[7] but this is not commonly seen.[3,4] Ropivacaine and bupivacaine are both longer-acting local anaesthetic agents with more cardiotoxicity potential than lignocaine. Ropivacaine and bupivacaine have been safely used for TLA, however the use of bupivacaine is not recommended by the American Society of Plastic Surgeons and American Academy of Dermatology.[2,8] The duration of action of bupivacaine is marginally prolonged when compared to lignocaine with adrenalin, with a far greater toxicity profile.[7]

Crystalloid

Isotonic crystalloid, saline or Ringer's lactate is used to dilute the local anaesthetic agent.[3] The advantage of using Ringer's lactate as the diluent is the lack of burning sensation on injection and the reduction of the sodium load.[4] Infiltration of excessive volumes may lead to fluid overload or hyperchloraemic metabolic acidosis (saline).[7]

Vasoconstrictors

Adrenalin is the most commonly used vasoconstrictor[3] and confers several advantages to the TLA solution: it is a potent vasoconstrictor limiting blood loss, it prolongs the duration of action of the local anaesthetic agent, and it limits the rate of absorption allowing for higher maximum dose thresholds.[7] The recommended concentration is 0.25–1 mg/L depending on the vascularity of the tissue.[3] A dose of 50–70 µg/kg of adrenalin should not be exceeded to limit systemic effects.[3,7] Ornithine-vasopressin has been used as an alternative vasoconstrictor but the tumescent solution cannot be heated if it is used.[1,3]

Buffers

The addition of sodium bicarbonate adjusts the pH of the TLA solution closer to physiological pH, quickening the onset of action of lignocaine by increasing the nonionised fraction; it also reduces the uncomfortable burn on injection.[3,7] Concentrations of 10 mEq/L of sodium bicarbonate are usually used.[7]

Anti-inflammatory agents

Steroids can be added to tumescent solutions for their anti-inflammatory effect.[3]

Anaesthesia considerations

Preoperative assessment[3,4]

Patients presenting for liposuction will often be obese with other metabolic diseases. Patients with HIV infection may develop

lipodystrophy as a result of antiretroviral therapy and may necessitate surgical management for aesthesis.[10] Assessment and optimisation of comorbid diseases must be performed.

Severe cardiovascular disease, pregnancy and coagulation disorders are contraindications to liposuction. A thorough history of medication and herbal product use should be sought. Anticoagulants and medications that may interfere with the metabolism of lignocaine must be discontinued. Perioperative pharmacological and mechanical thromboprophylaxis should be considered in high-risk patients.

Anaesthesia technique

Liposuction can be performed under local, neuraxial or general anaesthesia with no technique proven to be superior.[3] The choice of anaesthesia is dictated by the patient profile, areas of surgery and volume of liposuction planned, as is the choice between day-case and inpatient surgery.

Day-case surgery[11]

Day-case surgery is advantageous due to the avoidance of general anaesthesia and its inherent risks, autonomous patient positioning and lower costs. However, there is a limitation to the aspirate volume when limited postoperative monitoring is possible. Consideration for day-case surgery can be given for localised, small volume liposuction. Large volume liposuction carries the risk of late manifestations of LAST and haemodynamic changes, necessitating inpatient monitoring.[3]

Sedation

The use of sedation with TLA solution infiltration can be considered, as TLA limits bleeding and provides analgesia.[1,3] It has the advantage of shorter recovery time, earlier ambulation and discharge, and lower costs.[3] Sedative agents that can be used include midazolam, propofol, ketamine, clonidine or dexmedetomidine.[1] Fentanyl or remifentanil can also be used but the primary analgesia to facilitate the procedure is provided by the TLA infiltration.[1]

Neuraxial anaesthesia

Liposuction has been performed under spinal, epidural and combined spinal-epidural anaesthesia.[1,3] The quality of analgesia achieved is superior to the use of TLA only.[3] The choice between the neuraxial techniques will be determined by the surgical site and duration. Local anaesthetic agents used for neuraxial techniques include lignocaine, ropivacaine, levobupivacaine and bupivacaine with or without additives (opioids or α_2 agonists).[1] For neuraxial techniques using infusions of local anaesthetic agents, cumulative doses with that used in the TLA solution must be considered to avoid toxicity. Epidural anaesthesia has the additional advantage of less thromboembolism.[1,12]

General anaesthesia

General anaesthesia is recommended for large volume liposuction[3] and is the modality of choice in some centres.[4] Either volatile-based or inhalational anaesthesia can be used. The airway can be maintained with a supraglottic airway or endotracheal tube depending on the duration of the surgery and positioning of the patient.[3] Muscle relaxation is not required for the surgery but may be needed to facilitate intubation.[4] TLA infiltration is sufficient for intraoperative analgesia.[3]

Monitoring[3,4]

Standard ASA monitoring including temperature monitoring, is mandatory regardless of the anaesthesia technique chosen. Where sedation is used, capnography must be monitored. Based on the anticipated haemodynamic changes, high-risk patients undergoing large volume liposuction may require invasive monitoring. A urinary catheter is inserted for long procedures and can be useful to assess overall fluid status.

Patient positioning[3,4]

Depending on the area of surgery, the patient may be placed in a non-supine position. Careful padding of pressure areas and protection of the eyes is warranted during prone positioning. Pneumatic compression devices should be used for large volume liposuction and prolonged surgery.

Hypothermia[3,4,13]

Large volume liposuction carries a risk of hypothermia for multiple reasons. Infiltration of large volumes of TLA solution, exposure of a large surface area of the body, cold ambient temperature, prolonged surgery and impaired thermoregulation during general anaesthesia all contribute to a drop in body temperature. Active measures to maintain adequate temperature must be taken, especially where prolonged surgery is anticipated, including warm tumescent solutions (38–40 °C), warm cleaning solutions, forced air warmers, warm intravenous fluids, cover of exposed areas where possible and warmer theatre temperature (> 24 °C).

Haemodynamic effects[3,4]

Large volume liposuction is associated with haemodynamic consequences as more than 4 L (approximately 4 kg) of fat and fluid is removed. A decrease in mean arterial pressure and systemic vascular resistance is seen, while cardiac index, stroke volume index, heart rate, mean pulmonary pressure and right ventricular stroke work increase. Patients may require haemodynamic support in the form of vasopressors or inotropes to maintain acceptable physiological parameters.

Fluid management

Intraoperative fluid management is unique in this patient group. The total fluid intake is considered intravascular fluid administered and the volume of the tumescent solution

injected.[3] The total output is calculated as the urine output and the aspirated volume which contains fluid, blood and fat.[3] The residual volume is the difference between the intake and output.

Liposuction removes approximately 30% of the tumescent solution; thus for each litre of tumescent solution infiltrated, 700 ml will be absorbed intravascularly over time.[4,6] Additional fluid administered as maintenance, especially in large volume liposuction, can easily result in fluid overload which can cause morbidity and mortality.[3,4] Conversely, aspirates of more than five litres or greater than 5% of body weight can cause hypovolaemia from bleeding.[1]

The recommendation is to limit maintenance fluid and to use clinical markers to guide fluid therapy.[4] Balanced crystalloids are recommended for maintenance and replacement.[6] A recommended fluid replacement strategy for large volume liposuction suggests replacement of 0.25 ml of crystalloid per ml of aspirate greater than 4 L.[1,3] No replacement fluid is recommended for small volume liposuction; fluid intake is limited to maintenance fluid and TLA infiltration only.[1]

Analgesia

The local anaesthetic in the tumescent solution provides adequate analgesia in the intra- and early postoperative periods.[3] Limited research suggests that the analgesic effect from TLA solutions is negligible, but it is still widely used.[2] Nonsteroidal anti-inflammatory drugs, paracetamol and mild opioids are sufficient to manage pain postoperatively.[1]

Complications of liposuction

Major complications can result from liposuction with higher incidences reported when performed out of a hospital setting.[3] The commonest complications are thromboembolism, fat embolism, lignocaine toxicity, pulmonary oedema, and intraabdominal visceral perforation.[4,6]

Thromboembolism

The incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) following liposuction is reported as between 0–1.1%,[13] with a higher incidence when liposuction is combined with other procedures such as abdominoplasty[4,13] and during large volume liposuction.[4] PE accounts for up to 23% of deaths from liposuction and is among the leading causes of mortality.[3,13] Preventative measures should be taken to avoid this complication.

The Caprini/Davison score is a validated method of risk stratification for thromboembolism and has been adapted specifically for plastic surgery.[12] A score of three or more indicates a high risk for thromboembolism[12,13] mandating non-pharmacological prophylaxis measures and consideration for pharmacological prophylaxis.[12] Intermittent pneumatic compression devices are recommended intraoperatively and graduated compression stockings postoperatively until ambulating.[4] Pharmacological prophylaxis with low molecular weight heparin can be commenced 6–12 hours postoperatively and continued for between 7–10 days.[13] Prolonged prophylaxis for 30–35 days can be considered in patients who are deemed very high risk.[13] Novel oral anticoagulants have been used safely as prophylaxis but their use is not routine.[12]

Fat embolism syndrome

Fat embolism syndrome is characterised by hypoxaemia, respiratory failure, neurological deterioration and petechiae, in the context of fat embolisation.[4] Lipid microfragments are produced during liposuction and can reach the venous circulation via ruptured blood vessels leading to the clinical effects.[14] Liposuction volume of 900 ml or greater places patients at risk[13] and concomitant lipoinjection carries a higher risk.[4,13] Fat embolism syndrome is a clinical diagnosis and management is supportive.[4,14] Although the exact incidence is not known, the mortality is high.[14] Preventative measures include ensuring an adequate intravascular volume status, performing gentle infiltration, using cannulas greater than 3 mm in diameter and avoidance of deep intramuscular injection such as into the subgluteal crease.[13]

Lignocaine toxicity[7]

Lignocaine has a narrow therapeutic index (1–5 µg/ml). Subjective symptoms of toxicity become apparent at plasma level of greater than 3 µg/ml, however, patients can complain of early symptoms at lower plasma levels. These include light-headedness, tinnitus, euphoria, blurred vision, digital paraesthesia, drowsiness, and restlessness. Objective symptoms appear above levels of 5 µg/ml including nausea, vomiting, tremors, circumoral numbness, muscular fasciculations and excitatory central nervous system effects (confusion, excitement, psychosis). At 8–12 µg/ml, seizures result with ensuing cardiorespiratory depression and coma which may progress to arrest.[2,7]

Risk factors for LAST include higher concentrations of local anaesthetic agent, perivascular injection, rapid injection, and removal of adrenalin from the TLA solutions.[2]

Based on the pharmacokinetics of lignocaine in TLA, toxicity may appear hours after infiltration and recognition and prompt management of this complication is mandatory. The American Society of Regional Anesthesia and Pain Medicine has published a practice guideline summarising the management of LAST (Figure 1).[15]

Pulmonary oedema

Fluid overload and pulmonary oedema result from the slow absorption of the tumescent solution in addition to intravascular fluid administration.[3,4] This occurs more frequently with large volume liposuction and can result in morbidity and mortality.[3,6]

Intraabdominal perforation

Traumatic injury to intra-abdominal viscera has been described.[4,13] Inherent patient factors that may predispose patients include

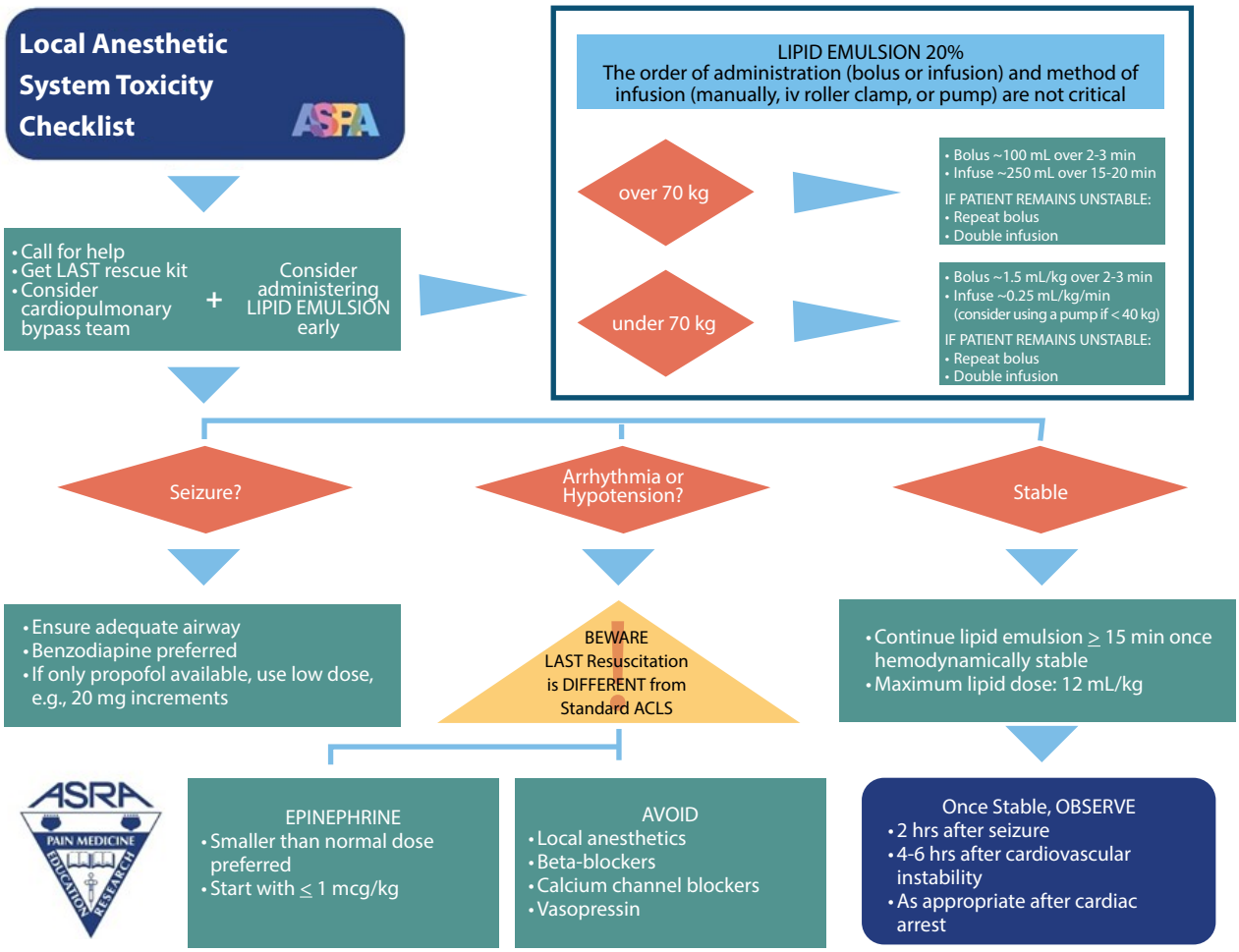

Figure 1: ASRA Local Anesthetic Systemic Toxicity checklist
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obesity, previous surgery, hernias and diastasis. A high index of suspicion must be maintained when abdominal symptoms and pain are reported postoperatively. Early radiological imaging must be done, followed by emergency laparotomy when an injury is identified.

Blood loss[4]

Bleeding is a frequent complication associated with liposuction. The use of tumescent solutions with adrenalin aims to reduce this but some areas such as the neck and torso are more prone to bleeding. Intravenous tranexamic acid administration (10 mg/kg) has shown a reduction in blood loss per litre of aspirated fat volume.

Other complications include pleural and lung injury, acute respiratory distress syndrome, anaesthesia-related complications and sepsis.[3,4]

Conclusion

Liposuction is a common aesthetic procedure performed globally. Large volume liposuction poses a number of challenges and anaesthesia for this procedure requires careful understanding of the physiological effects, meticulous monitoring and fluid management. Knowledge of the potential complications allows preventative measures to be instituted to ensure good outcomes.

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