

Hyperadiposity: Liposuction Applications in Weight Loss and Conditions Related to Excess Body Fat

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Abstract

Liposuction is a safe cosmetic procedure for body contouring that removes excess fat and reshapes the body parts. It is a well-known and helpful body contouring procedure that uses quick, safe, and minimally invasive techniques to remove unwanted fat deposits. The removal of excess fat reduces the risk of heart disease, stroke, diabetes, and other fat-associated health problems associated with fat while enhancing the patient's self-esteem. This review aims to investigate and summarize the historical, contemporary, and future vision of liposuction techniques, their application, benefits, and risks in weight loss and various health conditions. Also, this paper provides a concise overview of liposuction vs. bariatric surgery in weight loss.

Keywords: Adipose Tissue; Bariatric Surgery; Body Contouring; Cosmetic Procedure; Rapid Weight Loss Techniques; Removing Excess Fat

Abbreviations

HDL: High-Definition Liposculpture; GSADI-S: Sleeve Gastrectomy and a Single Anastomosis Duodeno-Ileal; LAL: Laser-Assisted Liposuction; PALL: Power-Assisted Liposuction; MD: Madelung's Disease; MSL: Multiple Symmetrical Lipomatosis; RFAL: RF-Assisted Liposuction; RYGB: Gastric Bypass Roux-En-Y; SAL: Suction-Assisted Liposuction; TCAL: Twin Cannula-Assisted Liposuction; TLC: Tumescant Superficial Liposuction with Curettage; UAL: Ultrasound-Assisted Liposuction; US FDA: United States Food and Drug Administration; VASER: Vibration Amplification of Sound Energy at Resonance; WAL: Water-Assisted Liposuction

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Introduction

At the beginning of the twentieth century, Dr. Charles Dujarrier used liposuction, a cosmetic surgery, to remove or curettage fatty tissue to improve the shape of the ankles and knees of a female ballet dancer [1]. However, the dancer's leg was amputated due to a femur injury during the procedure, which had a negative impact, lasting for decades, on the development of this technique.

In 1975, a father and son team, Drs. Arpad Fischer and Giorgio Fischer developed a new liposuction method by affixing a cannula to a suction device to lessen the risks associated with the technique employed by Dr. Dujarrier forty years earlier [2,3]. In 1977, the French surgeon Dr. Yves-Gérard Illouz modified the procedure by using a variety of smaller-diameter blunt-end cannulae, extending the application of the technique to the entire body [3,4].

Before suctioning, saline and hyaluronidase were injected into the targeted adipose tissue, enabling hydro-dissection and lessening trauma to adjacent tissues. This pre-suctioning preparation was known as the 'wet technique', and Illouz became the first physician to introduce the same.

The initial development of the liposuction technique focused on enhancing blunt-end cannulae, in which the procedure was carried out under general anesthesia and performed without injecting fluid to hydro-dissect. However, both of these approaches resulted in significant blood loss in the lipo-aspirate [5]. Nevertheless, anesthesia and the bolus composition have undergone several improvements over the past four decades, allowing the surgery to be performed with and without sedation (under local anesthesia).

To get high adipose volumes, Dr. Jeff Klein used large amounts of highly diluted local anesthetic during an experiment in 1987 [6]. Large amounts of highly diluted anesthetics significantly reduced total bleeding during the procedure. Klein's infusion comprised 10 ml of 8.4% bicarbonate, 0.05% lidocaine, and 1,000,000 IU of epinephrine in one IL of saline [6,7]. This liposuction procedure injects a large volume of Klein's solution subcutaneously. This technique, enhanced by microcannula aspiration under local anesthesia, is called tumescent liposuction.

Klein's technique requires less aggressive and manual fat extraction than the original liposuction procedure. As a result, the tumescent technique has been utilized for large volumes of lipo-aspirate, resulting in less patient risk, lower costs, reduced bleeding, adequate analgesia, and shortened hospitalization [7].

In 1988, Brazilian physicians Drs. Matsudo and Toledo began employing disposable syringes equipped with blunt-end needles instead of the vacuum pumps commonly used for liposuction. This method was more accurate and acceptable from the clinical and patient perspectives [8].

In 1992, Professor Michele Zocchi developed ultrasonic liposuction to replace traditional blunt cannula suction to reduce tissue damage, protect vital structures (e.g., neurovascular bundles), lessen surgical complications, accelerate the surgical procedure, and improve overall liposuction outcomes [9].

In 2006, the United States Food and Drug Administration (US FDA) approved a laser-assisted liposuction technique, 'laser lipolysis', that delivers energy, preferably to fat cells. The laser compromises the adipocyte membranes, releasing oil in the extracellular matrix. The oil material released during this process is aspirated using a vacuum pump and blunt-end cannulae [10]. Also, laser energy reorganizes the skin, forming and refining new collagen.

Liposuction technology was further advanced by combining ultrasonic energy with tumescent technology to achieve safer results with titanium probes and ultrasonic energy.

In 2020, Jewell reported for the first time the clinical application of a third-generation ultrasound device using high-efficiency VASER (vibration amplification of sound energy at resonance) technology to produce pulsed low-power ultrasound via titanium probes [11]. The energy delivered to the tissues is about one-quarter that of previous devices, and the pulsed mode reduced heat generation. Also, VASER lipolysis and liposculpture have expanded applications for the breast, face, neck, and fibrous body regions (the trunk and back) in men and women [12].

In 2018, Colombian plastic surgeon Dr. Alfredo Hoyos and colleagues introduced the world to an advanced high-definition liposculpture (HDL) method. Hoyos defined liposculpture as an artistic approach to sharpening the anatomy of muscles through the skin. Unlike mechanical liposuction, the VASER-assisted high-definition liposculpture technique minimizes blood vessel trauma, enhances results, and removes superficial fat. This advanced technology shapes the human body in three dimensions with better body muscle definition [13].

Effects of liposuction on health

Liposuction restores the contour of the body. The technique targets fat cells that are resistant to diet and exercise. It removes fat cells from the treated area and diminishes or improves the appearance of cellulite [1,3,5].

Liposuction has several health benefits associated with weight loss. Furthermore, liposuction is helpful for conditions such as lymphedema, gynecomastia, lipodystrophy syndrome, and lipoma. It also provides psychological improvements, such as improved confidence and self-esteem [14,15] (Figure 1).

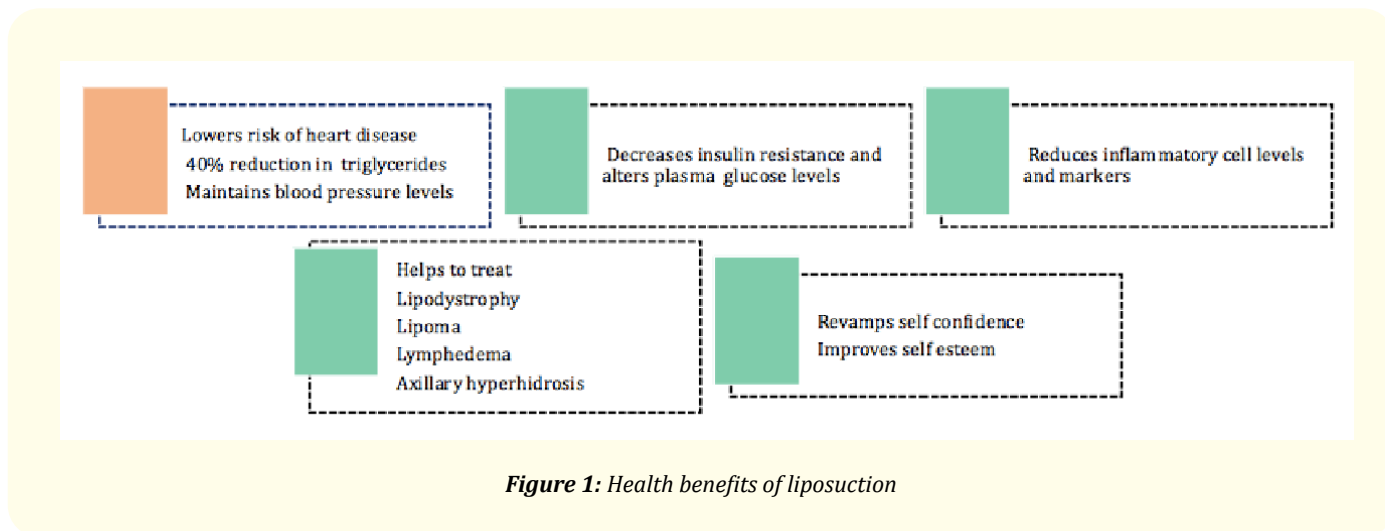


Figure 1: Health benefits of liposuction

Applications of liposuction

Lipomatosis

A metabolic disorder called multiple symmetrical lipomatosis (MSL), also known as benign symmetric lipomatosis, Madelung’s disease (MD), and Launois-Bensaude syndrome, is characterized by the formation of fatty masses in a minimal area on the face, back of the head, neck, upper arms, abdomen, back, and upper part of the leg [14,15]. Ultrasound-assisted liposuction approach can be used to treat multiple symmetric lipomatosis and is reported to be better than the traditional lipectomy technique in treating symmetric lipomatosis [15].

Dercum's disease

Dercum's disease can be identified by symptoms such as painful adiposity, sleep disturbance, memory impairment, shortness of breath, constipation, and fatigue. According to Kucharz., *et al.* (2019) [16], Dercum's disease can be classified into generalized diffuse, generalized nodular, localized nodular, and juxta-articular adiposity. Women are more affected than men, and symptoms typically appear between the ages of 30–50. The differential diagnosis includes familial lipomatosis, multiple symmetric lipomatosis, adipose tissue tumors, panniculitis, lipoedema, and fibromyalgia. Dercum's disease is diagnosed based on a patient's medical history and physical examination results. Liposuction was successfully used to treat juxta-articular adiposis dolorosa [17]. However, few convincing studies have supported the treatment of Dercum's disease using liposuction. At the same time, most of the existing treatment methods are based on case studies [16].

Subcutaneous lipoma

Lipoma is the most common benign soft tissue tumor composed of adipose tissue. Lipomas are typically soft to the touch, movable, painless, and small (less than one centimeter in diameter), but they can grow larger than six centimeters. Lipomas are most commonly seen in adults between the ages of 40 and 60 but can also occur in younger adults and children [18].

Elkhatib., *et al.* (2014) successfully treated subcutaneous capsulated giant and moderate-sized lipomas with traditional liposuction. At the end of the procedure, the capsule was surgically extracted using the same small stab used for liposuction [19]. There was no recurrence, and the cosmetic result was phenomenal.

Trauma-induced lipomas

The pathogenetic relationship between soft tissue trauma and lipoma formation is still being debated. The first possibility is that the adipose tissue prolapsed through the fascia defect caused by direct impact. However, according to Fotiadis., *et al.* (2021) [20], the second explanation is the formation of adipose tissue as a result of pre-adipocyte differentiation and proliferation mediated by cytokine release following trauma and hematoma formation.

Chronic lymphedema

The physiological discrepancy in blood flow and slow lymphatic drainage results in impaired lipid clearance and subcutaneous adiposity. The exact cause of primary lymphedema is unknown. However, lymphatic vessel injury, lymph node dissection, surgery, radiation therapy, and cancer treatment (most notably breast cancer) are some of the main secondary causes of lymphatic system damage, leading to lymphedema [21]. The prominent cases of lymphedema have been noticed to come from secondary pathways and are more common in the upper extremities of women after breast cancer treatment and lymph node dissection. Bosompura., *et al.* (2002) first reported using liposuction to reduce the size of extremity lymphedema in a patient [22]. Schaverien., *et al.* (2018) documented a refined process of the same technique [23].

A 5-year prospective study by Holfner., *et al.* (2018) reported that liposuction is effective in treating chronic, nonpitting arm lymphedema resistant to conservative treatment following breast cancer treatment [24]. In addition, several studies show significant and sustainable results of the liposuction technique in treating lymphedema in the upper and lower extremities and in treating acquired and congenital lymphedema [25-30].

Axillary hyperhidrosis

Excess sweating under the arm is a medical condition called axillary hyperhidrosis, and profuse sweating in the armpit is one of the symptoms of this condition. All deodorants and other odor-controlling drugs are only partially effective against this sweat. A person may

also have hyperhidrosis affecting other body parts, such as the hands, feet, and face. People with axillary hyperhidrosis have an overactive sympathetic nervous system; anxiety, stress, and other emotional stimuli directly trigger the sympathetic nervous system. Hsu and Wang (2019) reported that of 43 patients treated with superficial liposuction and curettage, 31 (72.1%) patients showed excellent results, while transitional ecchymosis, one of the most common complications after surgery, was treated in 2 weeks [31].

Tumescent superficial liposuction with curettage (TLC) is one of the most efficient and secure methods to treat axillary bromhidrosis. In a study of 88 patients, TLC was performed in 47 patients, and intradermal Botox injections were administered to 41 patients. Follow-up data revealed that in 91% of patients who underwent TLC, sweat volumes had decreased significantly from 78 ± 87 mg/min to 52 ± 41 mg/min [32].

Post-ablative surgery

The safety and effectiveness of autologous fat grafting in the breast for aesthetic and reconstructive purposes are still debatable. The best method for fat graft harvesting is believed to be liposuction. Although general anesthesia is preferred for removing most fat, local anesthesia is frequently used. Another helpful method is the “one-step harvest modification” [33]. It is a convenient and efficient technique that can simplify routine procedures in high-volume replacement lipofilling.

In addition, manual methods with a Luer-Lok syringe preserve more intact and viable lipocytes for transfer than traumatic methods with low negative pressure drainage. They are undoubtedly more effective than continuous active suction machines. In liposuction procedures, fat tissue is considered a better filler. Fat is biocompatible, self-growing, and generally causes fewer complications. The widespread use of fat as a filler led to the development of specific protocols and guidelines for its use [34].

Radiation dermatitis

Radiation dermatitis is a skin condition linked to repeated exposure to ionizing radiation. Most radiation therapy patients, either with or without chemotherapy, experience some degree of radiation dermatitis [35]. Radiodermatitis can be successfully treated by implanting a fat graft obtained through liposuction.

Costantino, *et al.* (2012) reported the use of liposuction in patients who had undergone lateral lymph node dissection and subsequent chemo and radiation therapy. Four years later, due to recurrence, the patient underwent a subcutaneous mastectomy and immediate reconstruction, including a subcutaneous muscle implant. Seven years later, the patient reported radiodermatitis and a fracture around the implant and received lipophilic treatment. The treatment was effective as the surface tissue was clear and thick during follow-up, and the skin had reduced pigmentation and tension [36].

Flap debulking

In 2010, Reuben reported the effectiveness and safety of power-assisted suction lipectomy to debulk fasciocutaneous flaps in the upper and lower extremities [37]. Hallock, *et al.* (2022) described the success of conventional liposuction to debulk muscle flaps with perforator bases [38].

General considerations and complications

When treating the lower extremities, the best practice is to avoid the 5 adhesion zones located in the fascia of the underlying muscle connected to the superficial subcutaneous tissues. The adhesion zones include the lateral gluteal depression, the medial compartment of the thigh, the distal posterior thigh, and the inferolateral iliotibial tract. Furthermore, extra care should be taken during the procedure to avoid damage to the gluteal crease. One way to achieve this is not directly suction the gluteal crease to prevent deformation [39,40].

Weight gain after liposuction procedures is mainly due to the patient not following the necessary postoperative instructions to maintain body weight. Some practical ways to maintain body weight after liposuction are following the post-procedure instructions provided by the surgeon, reducing caloric intake, following a healthy diet focusing on protein and healthy carbohydrates, and staying hydrated [41].

Cosmetic and noncosmetic indications for liposuction are listed in Figure 2.

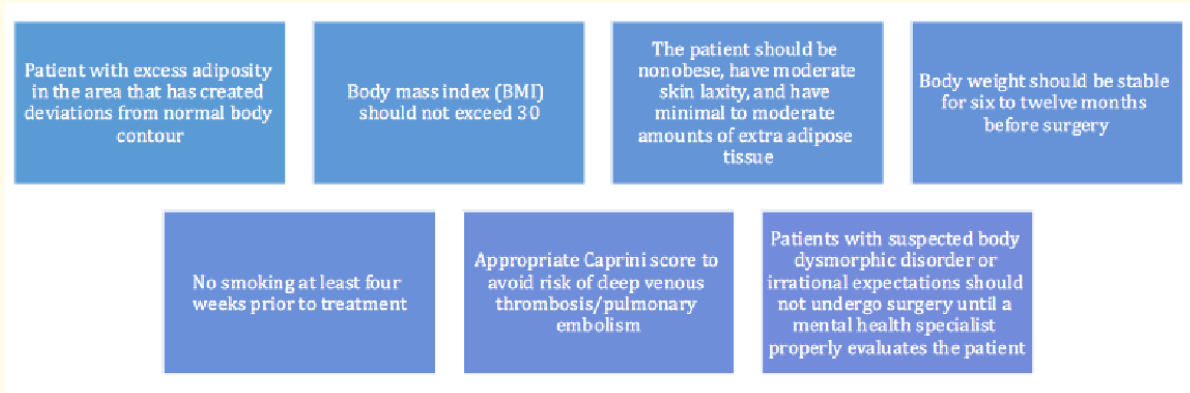


Figure 2: Cosmetic and noncosmetic indications of liposuction

The primary conditions a patient should satisfy for successful liposuction are listed in Figure 3 [42]. Although liposuction is generally considered a weight reduction procedure, it is not; it is a fat-removing process and should not be performed on people who are obese with BMI > 30.

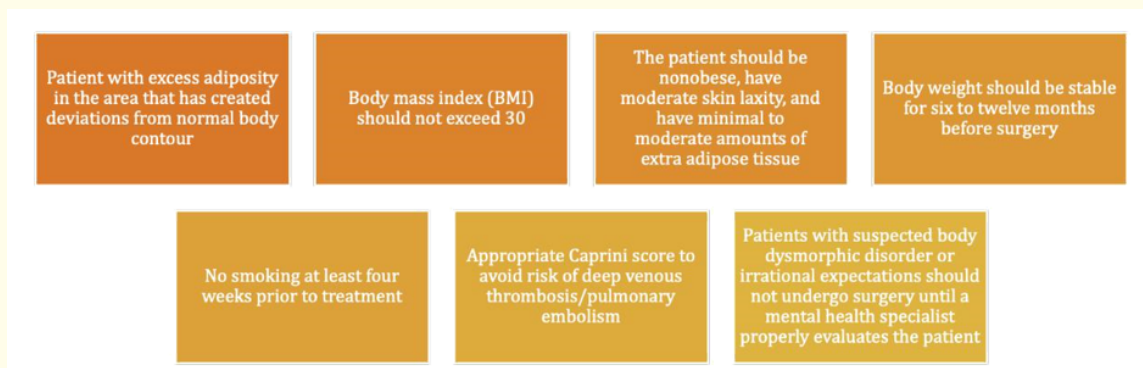


Figure 3: Requirements for successful liposuction

Liposuction is contraindicated in pregnancy, women within 6 months of childbirth, and patients with psychological disorders, cardiovascular diseases, clotting disorders, and allergies. The detailed list is provided in Figure 4 [42].

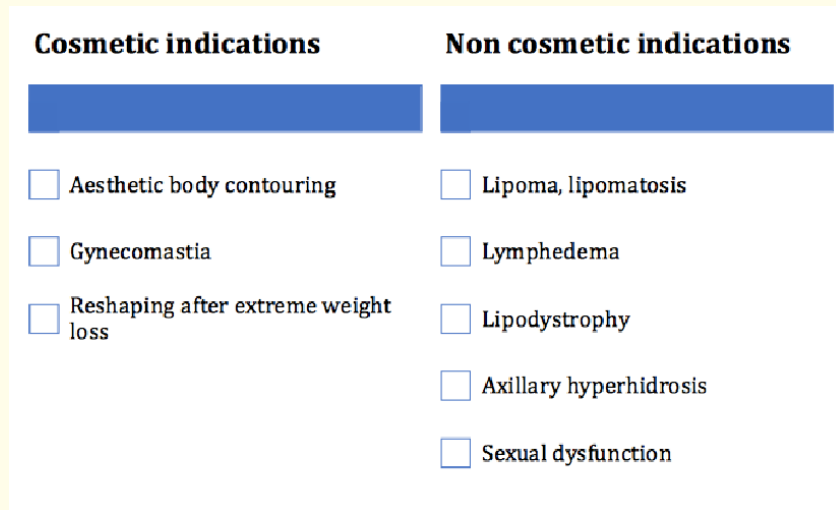


Figure 4: Contraindications of liposuction

Complications of liposuction

Severe side effects such as pulmonary embolism, necrotizing fasciitis, toxic shock syndrome, and organ perforation were reported. These complications were mainly due to poor patient selection, overuse of local anesthesia during mega liposuction (tumescent technique), and insufficient postoperative monitoring. The prevalence of complications generally indicates a lack of medical expertise [43].

Most adverse effects and risks, such as skin infection, fluid accumulation, and numbness in the area of the procedure, are related to the way the procedure is performed. However, liposuction may cause renal and cardiac problems, internal bleeding, fat embolism, and anesthesia poisoning. Common side effects and risks of liposuction are listed in Table 1 [44].

Side effect	Description
Fluid buildup	Seromas, temporary pockets of fluid, can form under the skin. This fluid is removed with the help of a needle.
Contour abnormalities	The skin may appear bumpy, wavy, or withered due to uneven fat removal, lack of skin suppleness, and unusual healing.
Numbness	The area of liposuction may experience either temporary or permanent numbness and transient nerve irritation.
Skin infections	Skin infections are rare, but they are reported.
Internal bleeding	Rarely a cannula can puncture an internal organ during the liposuction procedure, which may require immediate intervention.
Fat embolism	Fat embolism is a severe medical condition in which bits of unfastened fat can detach, enter the bloodstream, and travel into the brain.
Renal and cardiac disease	The injection and suction of fluids might alter fluid levels, potentially leading to kidney, heart, and lung problems.
Lidocaine poisoning	Lidocaine is routinely injected with fluids during liposuction to lessen discomfort. While lidocaine is ordinarily safe, it can cause severe damage to the heart and central nervous system.

Table 1: Side effects and risks of liposuction

The future of liposuction

The global liposuction industry is expected to grow at a 6.8% CAGR between 2022 and 2032, reaching a market value of approximately US \$ 9.1 billion. Power-assisted liposuction procedures accounted for about 41.5% of the global market in 2021. The aesthetic device market is poised for rapid evolution to meet changing patient demands [45]. It is reported that the worldwide liposuction device market will be USD 6.1 billion by 2029, with an expected CAGR of 11.35% [46].

The devices commonly used in liposuction procedures are based on the following technologies: ultrasound-assisted liposuction (UAL), twin cannula-assisted liposuction (TCAL), laser-assisted liposuction (LAL), power-assisted liposuction (PAL), suction-assisted liposuction (SAL), tumescent liposuction, RF-assisted liposuction (RFAL), water-assisted liposuction (WAL) and aspirator devices.

Aesthetic treatments are currently receiving increasing interest from young and male patient groups, which is expected further to promote the growth of the global liposuction market. According to a 2018 International Association of Cosmetic Plastic Surgery report, the United States, Brazil, Mexico, Germany, and India are the 5 leading countries performing cosmetic procedures. The main players in aesthetic therapy design new devices and processes to improve the results of liposuction therapy by focusing on secretion management, minimally invasive procedures, and overall cost-effectiveness. In 2019, Möller Medical introduced a PAL device Vibrasat® Pro which can separate fat at a rate of 5 strokes/minute and up to 6 strokes/ minute with a power boost function [45].

The following companies invest and develop innovative devices for liposuction: Solta Medical, Cynosure Inc., Invasix Ltd, Alma Lasers Ltd, YOLO Medical Inc., InMode Ltd., Sciton Inc., Wells Johnson, Bausch Health, Inmode Group, MicroAire Surgical Instruments, LLC, Jull Surg, Cutera, Inc., and Vaser Lipo.

The main factors guiding this remarkable growth are the popularity of liposuction surgery and the increasing consciousness of self-image. In addition, the increase in obesity, the increase in disposable income, and the increase in medical tourism are considered opportunities for further growth [46].

Other weight loss surgeries

Bariatric or metabolic surgery is widely practiced for weight loss. Bariatric surgery is usually performed when other weight reduction methods, such as diet and exercise, do not affect weight, adversely affecting health. Bariatric surgery helps reduce weight by changing the digestive system, such as restricting food intake and reducing the body's ability to absorb nutrients [47,48].

Potential life-threatening health conditions from obesity in which bariatric surgery can be considered are high blood pressure, type 2 diabetes, non-alcoholic fatty liver disease, cardiovascular disease, and sleep apnea. In addition, bariatric surgery can also be considered for extreme obesity, in which BMI > 40 [48].

The short-term complications of bariatric surgery are primarily related to the nature of the procedure, including gastrointestinal leakage, infections, anesthesia complications, uncontrolled bleeding, blood clots, and respiratory problems. Long-term complications include dumping syndrome, hypoglycemia, malnutrition, vomiting, acid reflux, ulcers, revision surgery, intestinal obstruction, gallstones, hernias, and death in rare cases. After surgery, patients should follow some guidelines for the surveillance of diet and existing health conditions. There are multiple types of bariatric surgeries. After a detailed evaluation, the surgeon selects one of the following options [47,48] (Figure 5).

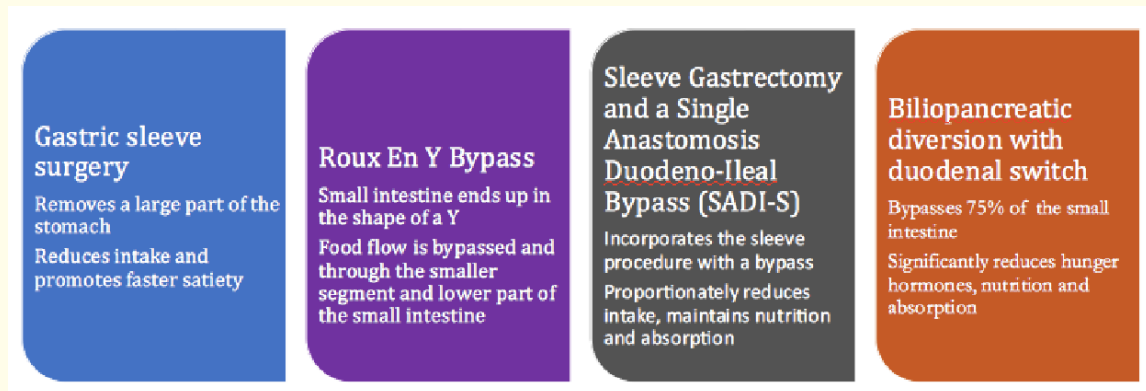


Figure 5: Types of bariatric surgery

Gastric bypass surgery

The gastric bypass is performed in a variety of ways. As with many bariatric surgeries, the newly constructed stomach pouch is smaller and can retain less food, resulting in fewer calories consumed. In addition, fluid injections through a port beneath the skin can be used to modify the size of the opening. Food usually passes through the stomach, but the band's smaller hole limits its passage. As a result, it is less effective against type 2 diabetes and has only minor effects on metabolism [47].

Roux-en-Y gastric bypass (RYGB)

The Roux-en-Y Gastric Bypass, also known as the "gastric bypass," has been carried out for over 50 years. Since 1993, the laparoscopic technique has been improved and is now one of the most popular and successful procedures in treating obesity and diseases related to obesity. The name is a French expression that means "in the shape of a Y".

The stomach is first separated into a top pouch, a little smaller size than an egg, during this procedure. Since the most considerable portion of the stomach is bypassed, food is no longer digested in the stomach. Next, the small intestine is divided and joined to the new stomach pouch to allow food to pass through. This results in a bowel connection resembling the letter Y, and the newly formed stomach pouch is smaller and can hold less food, leading to fewer calories ingested. Finally, the small intestinal segment empties the bypassed or larger stomach and is connected to the small intestine approximately 3 - 4 feet downstream [49].

BPD/DS, or biliopancreatic diversion with duodenal switch

The Biliopancreatic Diversion with Duodenal Switch, also known as BPD-DS, starts with creating a stomach pouch in the shape of a tube, much like the sleeve gastrectomy. It is comparable to gastric bypass in that more of the small intestine is not utilized. Instead, the first segment of the small intestine is separated from the stomach after the stomach is created to resemble a sleeve. When the patient eats, the food passes through the sleeve pouch and into the later part of the small intestine after being brought up and connected to the outlet of the newly formed stomach. As a result, the absorption of calories and nutrients is significantly reduced [50].

Sleeve gastrectomy and a single anastomosis duodeno-ileal bypass (GSADI-S)

Following the stomach, the first section of the small intestine is separated. The length of the intestine is measured from one end to the other and then joined to the stomach. In this procedure, only one intestinal connection is made. When the patient eats, food passes directly through the pouch and into the last part of the small intestine that mixes with the digestive juices. The procedure enables optimal absorption along with satiety, controlled hunger, and maintaining blood sugar levels. Patients can eat less food because the stomach is shaped like a banana [51].

Conclusion

The advent of liposuction has revolutionized health by combating the health risks associated with obesity. Along with aesthetic concerns, today, liposuction is used as a surgical measure to treat various conditions, sometimes in combination with other procedures. The global liposuction market is evolving by developing new methods and devices to provide better results and cost-effective benefits. Liposuction may have a slight advantage compared to other weight reduction procedures, such as bariatric surgery, due to the complexity of the procedures involved in bariatric surgery compared to simple liposuction procedures. However, more clinical and relevant case studies are needed to discover newer technologies and weigh their potential benefits and risks.

Conflict of Interest Statement

The authors declare that this paper was written without any commercial or financial relationship that could be construed as a potential conflict of interest.

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