VILNIUS UNIVERSITY
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Clinic of Rheumatology, Orthopaedics Traumatology and Reconstructive Surgery
Institute of Clinical Medicine

Liv Emilie Klemm, VI Year, Group 5

INTEGRATED STUDY MASTER'S THESIS

Postoperative Complications of Abdominoplasty: Etiology, Risk Factors, Diagnostics, Treatment Options and Methods of Prevention

Supervisor Lecturer Indrė Sakalauskaitė

Head of the department or clinic Prof. Irena Butrimiene MD, PhD

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liv.klemm@mf.stud.vu.lt

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1. Abstract

1.1 Introduction

Complications in abdominoplasty are notable, with an overall rate of up to 15%, which can even rise to 34.3% among patients with comorbidities. This paper examines various complications, which can be categorized into local and systemic. Local complications include seromas, hematomas, wound infections, and skin necrosis, while systemic complications encompass deep vein thrombosis and pulmonary embolism.

1.2 Method

This literature review was performed focusing on postoperative complications of abdominoplasty. This overview highlights the importance of understanding the risk factors, diagnostic methods, and treatment options for complications in abdominoplasty to enhance patient outcomes and minimise risks associated with surgical interventions among 44 clinical, retrospective studies or case studies from the last 10 years.

1.3 Results

The results of this thesis focus on the etiology, risk factors, diagnosis approaches, treatment and prevention of local and systemic complications such as seromas, hematomas, wound infections, skin necrosis, other local complications and venous thromboembolism.

1.4 Conclusion

In conclusion, the complications associated with abdominoplasty, particularly in patients undergoing massive weight loss, underscore the importance of thorough preoperative assessment and careful management. Highlighting the need for vigilance in detection and treatment. Understanding the preoperative optimisation is essential for effective intervention.

2. Keywords

Abdominoplasty, abdominoplasty techniques, postoperative complications, adverse effects.

3. Methodology

This paper investigates postoperative complications of abdominoplasty. It is organised as a literature review based on the latest literature and publications from articles, books, and journals, especially from plastic and reconstructive surgery resources such as “Plastic and Reconstructive Surgery – Journal of the American Society of Plastic Surgeons”. The publications investigated were mainly found on the following online publication websites: PubMed, Google Scholar, Elsevier, Clinicalkey, ScienceDirect, Sage Pub, UpToDate, and Access Medicine. To limit the extent of the review and select the most relevant data, the inclusion criteria include language, English, and a date range of 10 years between 2014 and 2024. To ensure that selected literature is from primary resources, the selection criteria include clinical trials, double-blind and single-blind studies, randomised controlled trials, cohort studies, retrospective studies, and case studies. Keywords that were entered in the different search engines include “abdominoplasty,” “postoperative complications,” “adverse effects,” “intraoperative complications,” and “abdominoplasty outcomes.” The specific complications were respectively incorporated in the search for references. Exclusion occured for publications published more than 10 years ago to ensure the selection of the most recent literature.

An example of application is the PubMed search with the keyword “postoperative complications”. Under the search in MeSH in PubMed, 1351 articles were suitable. However, applying the exclusion criteria, 35 remained. From these 35, each was individually assessed for potential use in this literature review, and only seven were selected. The algorithm can be visualised in Figure 1. Most studies were approached in an observational or retrospective design.

In total, 44 studies from various search engines and journals were included in this literature review to assess complications of abdominoplasty.

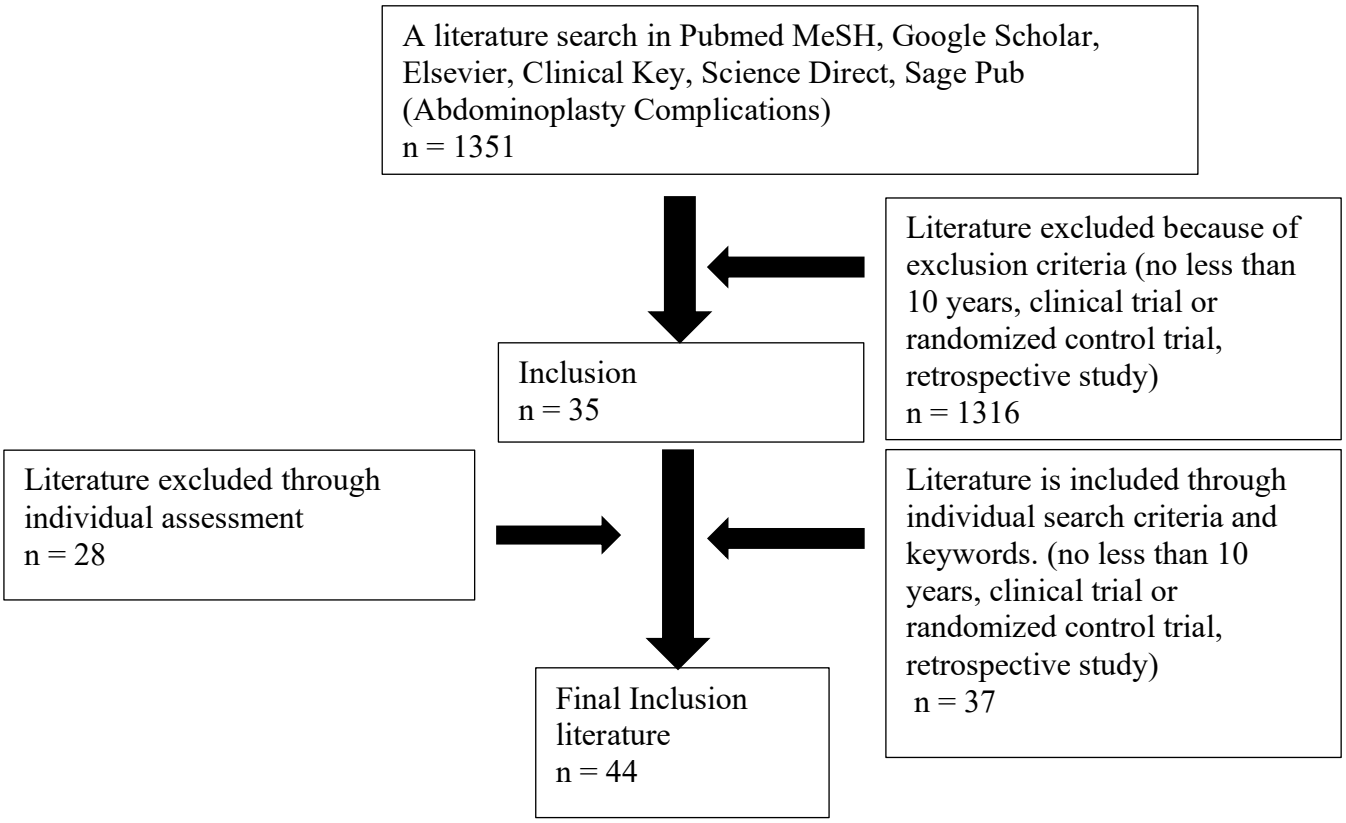

Figure 1 Diagram of search inclusion and exclusion for the literature review

4. Introduction

This paper investigates the postoperative complications of abdominoplasties and intends to provide insight into their etiology, risk factors, diagnosis, treatment, and method of prevention. It is organised as a literature review based on publications from the last 10 years. In fact, abdominoplasty is one of the most common techniques to reshape body contours. It is especially popular among women who have had children and experienced the physical changes of pregnancy. These changes include rectus diastasis, excess abdominal connective tissue, and skin laxity in both the abdominal wall and breast tissue. Another population group that commonly undergoes abdominoplasties are individuals with significant weight loss, especially after bariatric surgery. Like multipara patients, these, too, often want to address excess, loose skin from the massive weight loss. The procedure aims to improve the appearance of the abdomen by removing excess skin. Many patients seek abdominoplasty to achieve a more youthful and trim figure. In addition to pregnancy and substantial weight loss, other factors contributing to the decision to undergo abdominoplasty include a history of previous abdominal surgeries, age-related changes in skin laxity, and the desire to regain a more youthful physique.

Patients often aspire to achieve a lean and toned silhouette, and abdominoplasty is recognized as an effective means to help them attain their desired physical appearance. Furthermore, it is not uncommon for abdominoplasty to be combined with complementary cosmetic procedures such as liposuction to further refine body contours or breast augmentation to achieve a more balanced overall appearance.

Ultimately, the impact of this elective surgical procedure extends beyond aesthetic enhancement, with many patients reporting a significant improvement in their quality of life by regaining confidence in their appearance and enjoying a more positive self-image.

This literature review will initially focus on some background information, such as the anatomy of the anterior abdominal wall and some techniques that are used to perform abdominoplasty. The main section of this paper will discuss postoperative complications of abdominoplasty. These complications are composed of both local and systemic issues. The local complications include seroma, infection, skin necrosis, hematoma, and other local complications. The systemic complication covered in this literature review is limited to thromboembolism.

4.1 Anatomy

In the following, the anatomy of the anterior abdominal wall will be described from the external to the internal layers. The skin is the outermost tissue of the human body and serves various functions, such as providing a physical barrier for protection, reducing water loss, regulating temperature, and facilitating sensory and immune responses. It consists of three layers: the epidermis, dermis, and subcutaneous tissue. The epidermis, the outermost layer, acts as a physical barrier and is composed of stratified squamous epithelium. Its thickness and level of keratinisation vary depending on the body location. The dermis provides structural support primarily through collagen fibres and elastin. Additionally, it houses blood vessels, nerves, hair follicles and glands. The subcutaneous layer, also known as the hypodermis or panniculus, consists mainly of fat, adipocytes, nerves, and blood vessels. Adipocytes are arranged into lobules, separated by fibrous septae containing fibroblasts, fibrous tissue, and nerves. These lobules, separated by the septae, are referred to as cellulite in contemporary culture.

Skin tension lines are crucial for incision placement on the surface and may be described as a geographical map of the skin. It dictates the direction of the incision by a surgical blade to minimise scar formation after surgery. Figure 2 shows the skin tension lines on the body; the most commonly used map is known as the Lander lines, discovered in 1861 by Karl Langer. Other tension lines include cleavage lines, wrinkle lines, and biodynamic excisional tension lines. These lines are formed by internal tension from the connective tissue, the dermis, which, through external forces, is superimposed. Due to the collagen fibrils becoming aligned parallely. These lines vary for each

individual and are of importance since optimal surgical incision decreases wound contraction and scarring. However, it is not clear yet which technical map is best suited; some sources suggest following the biodynamic excisional tension lines, and others suggest that they prefer the relaxed lines. Yet others suggest that simply following striae densa may be most promising. (2)

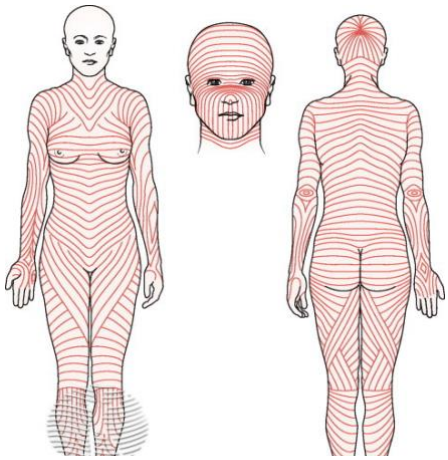

Figure 2 Skin tension lines by Dermnet (2)

The abdominal wall is composed of multiple fascia and muscle layers, which are innervated by nerves, veins, and arteries. The superficial fascia is the outermost structure, following the skin. The superficial fascia may be divided into two structures: the external layer, the Camper's fascia, and the internal layer, the Scarpa's fascia. The external Camper's adipose layer is innervated by the superficial epigastric veins. These veins drain into the femoral and paraumbilical veins. The Scarpas layer is mainly composed of collagenous connective tissue, as can be seen in Figure 3.

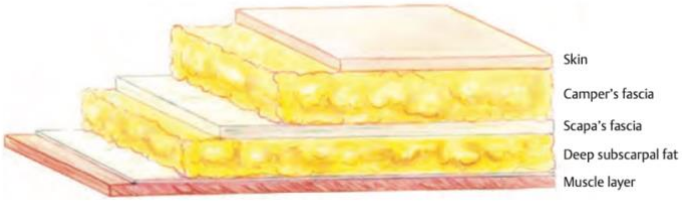

Figure 3 Visualization of the superficial and deep fat layers, separated by the Scapas fascia. (3)

Below the fascia, muscles contribute to the next layer of the abdominal wall. There are five muscles located in the abdominal wall. These muscles include the *external* and *internal oblique muscles*, *transverse abdominal muscle*, *rectus abdominals*, and *pyramidal muscles*. The anterior muscle, the *external oblique muscle*, attaches both to the *iliac crest* and the lower ribs and inserts into the *Linea Alba* as well as into the *Linea Albicans* anteriorly to the *musculus rectus abdominals* through the *external oblique aponeurosis*. Inferiorly, its *aponeurosis* inserts into the *inguinal ligament* between the *superior iliac spine* and the *pubic tubercle*. The *internal oblique muscle* inserts into the *Linea albea* as well and splits around the *rectus abdominalis*. It forms attachments with multiple structures,

including the *iliac crest*, the *inguinal ligament*, the *thoracolumbar fascia*, and the lower ribs. Inferiorly, it attaches to *pubic crest* and *pectineal line*. The deepest anterior muscle of the abdominal wall, *musculus transversus abdominis*, attaches similarly to the *internal oblique muscle* to the lower ribs, *thoracolumbar fascia*, *iliac crest* and *inguinal ligament*. Anteriorly, the muscle continues as *transverse abdominal aponeurosis* inserts into *Linea Albicans*, *pubic crest* and *pectineal line*. Intercostal and lumbar nerves, arteries and veins are located between the internal oblique muscle and the transverse abdominal muscle. The vertical muscle, *rectus abdominis*, attaches anteriorly to the *xiphoid process* and inferiorly to the *pubic bone* and *symphysis*. The three previously mentioned muscles, the *external* and *internal oblique* and *transverse abdominal muscles*, form through their *aponeurosis*, the *rectus sheath*. It encloses the superior part of the rectus abdominis muscle. These three muscles form the *Linea Albicans*. This structure may be described as a vertical midline that separates the abdominal rectus muscles.

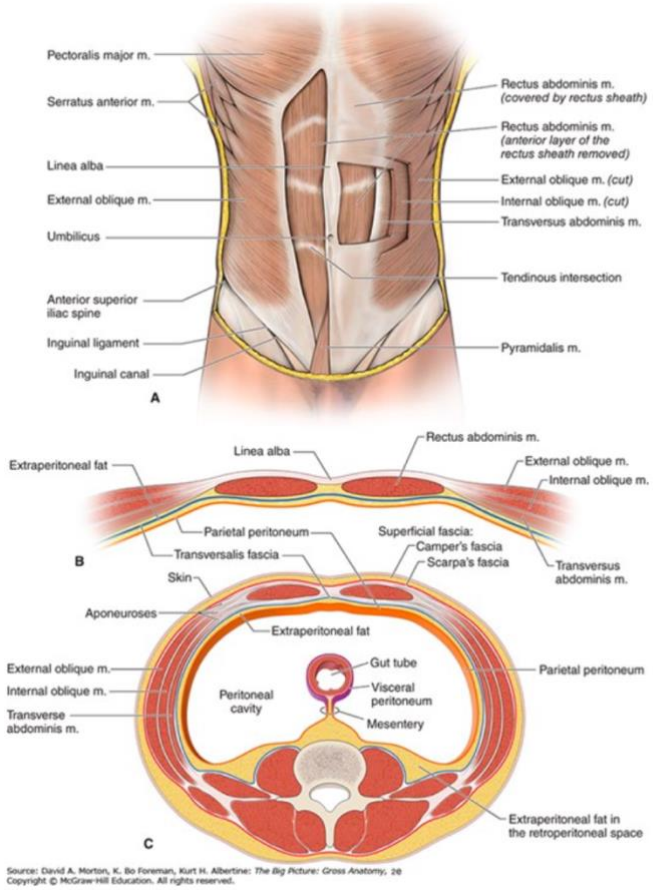

Figure 4 Fascia and muscles of the abdomen (3)

The *pyramidal* muscle is located in the lower quadrants of the abdominal wall and lies anterior to the abdominal rectus muscle. It attaches both to the *Linea Albicans* and *the pubic bone*. Posterior to the muscle layer lie three deep fascial layers. These include the *transversalis fascia*, *extraperitoneal fat*, and *parietal peritoneum*. The transversalis fascia is made from aponeurotic tissue posterior to the *transversus abdominis muscle*. Extraperitoneal fat, however, is constructed from both connective tissue and fat can be found in abundance posteriorly, especially around the kidneys and pelvic floor. The last component of the deep layer, the parietal peritoneum, is made from a serous membrane. It forms the mesentery, which suspends the visceral peritoneum. It is innervated by abdominal wall structures. (4)

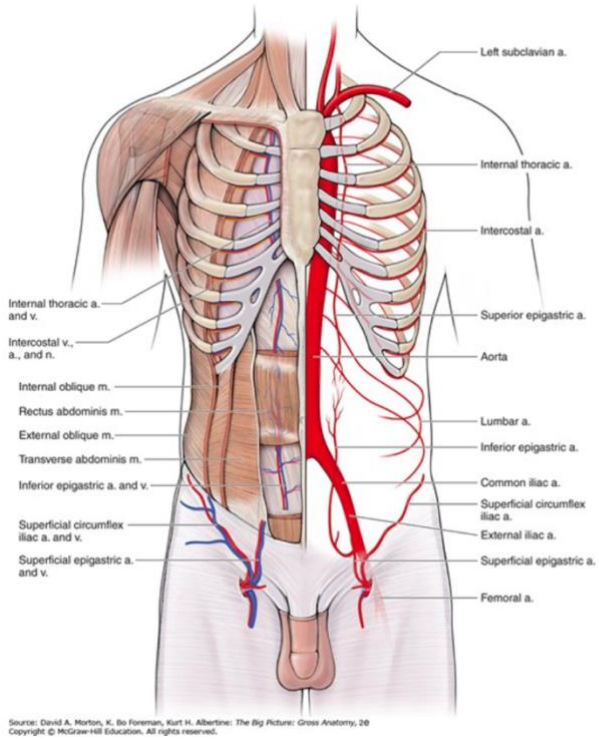

Figure 5 Vascular supply of the anterior abdominal wall (3)

Figure 5 represents the supply of the anterior abdominal wall. It is supplied by intercostal, epigastric, and lumbar arteries. The intercostal and lumbar arteries arise from the descending aorta and supply the lateral part of the anterior wall. The epigastric arteries are divided into the superior and inferior epigastric arteries. The superior epigastric artery arises from the internal thoracic artery and anastomoses with the inferior epigastric artery in the rectus abdominalis muscle. The inferior epigastric artery arises from the external iliac artery. Through the anastomosis of the superior and inferior arteries, a collateral circulatory supply is established between the arteries external iliac and subclavian. It is innervated by the spinal nerves T6-L1. The nerves move through the second and third layers of the muscle sheets through the internal oblique muscle and the transverse abdominal muscle. Other nerves innervating the abdominal wall are the subcostal and intercostal nerves and the bifurcations of the first lumbar nerve, the ilioinguinal and iliohypogastric nerves. (4)

4.2 Abdominoplasty technique and procedure

Abdominoplasty, also known as a tummy tuck, can be performed using various techniques, traditional abdominoplasty, lipo-, mini-, and reverse abdominoplasty, fleur-de-lis, and penectomy. The techniques described in the following were selected based on the techniques utilised in the primary publications reviewed in this paper. Other techniques are also used in practice, such as the *high lateral tension* abdominoplasty or the 360° abdominoplasty; however, since these are not in the selected studies, their descriptions are not included. Moreover, there is a possibility to combine multiple procedures, such as abdominoplasty and mastopexy, with or without implants, known as the "mommy makeover". Other combinations include the deep inferior epigastric perforator (DIEP) flap for breast cancer patients.

Regardless, the preoperative procedure is similar. The patient is informed about the procedure and its risks, and preoperative optimisation, such as smoking cessation, may commence. Preoperative markings are drawn on the patient's abdomen in a standing position; during the marking, the midline

is identified, and the lower incision is identified and placed in the natural lower suprapubic crease. The scar design may be determined based on the patient's preference. (5)

The anaesthesiologist initiates the anesthesia, which is general anesthesia or spinal/epidural anesthesia. Typically, the operating field is injected with *super wet* anesthesia, 1 L ringer solution, 20 ml of 1% lidocaine, and epinephrine (1 ml 1:1000). This facilitates hemostasis and minimizes bleeding during the surgery. (6)

It is important to adhere to the Surgical Care Improvement Protocol (SCIP) guidelines, which specify the administration of antibiotics for pre-surgical prophylaxis. It is administered within 1 hour before the first incision, and discontinued after 24 hours. For elective cases, it is crucial to ensure that the patient's conditions are optimal before and during the surgery. With a haemoglobin more than 7, good glucose control, preventing hypothermia and removing the Foley catheter within 24 hours. (7)

Commencing with the traditional approach to abdominoplasty. Primarily, the circular periumbilical incision is performed, from hip to hip. Dissecting with scissors, separate the subcutaneous fat from the umbilicus down to the rectus sheath. The umbilicus is marked with a traction suture, according to the surgeon's preference. After the dissection of the umbilicus, the bilateral inferior incision is performed through the Scarpa's fascia. The excess layer of fat and skin is lifted from the fascia up to the xiphoid process and costal margin via undermining from the umbilicus superiorly. If the inspection reveals the presence of rectus diastasis, it may be addressed through surgical repair with long-acting resorbable sutures or permanent sutures. To avoid unnecessary scarring in the mons pubis, drains should be inserted through the lateral incisions and fixed with sutures to the exit sites. The table is then flexed to the "beach chair position" of approximately 30°, followed by marking excess skin and fat, which can be removed while ensuring a tension-free closure. The marked tissue is resected, and the wound is irrigated and tacked closed. Vicrfyl 2-0 interrupted progressive tension sutures are applied to close the wound, and the umbilicus level is marked in the abdominal skin. The umbilicus is repositioned by a diamond-shaped incision on the marking and oriented according to the marking stitch; it is set and sutured. Then, through interrupted sutures, the superficial fascia is sutured, and dermal and subcuticular layers are closed separately. During my time at Charing Cross Hospital (London, UK), I observed deep dermal interrupted and running subcutaneous sutures. After cleaning them with wet and dry swabs, surgical glue, cyanoacrylate glue, is applied to the wounds. The patient's wound is covered with dressings and remains in a flexed position. (3) (8)

The mini abdominoplasty is not very common due to the limited number of patients with the proper indication for this procedure. It is limited to patients who have isolated fat and skin access infraumbilically. The restricted superior margin for undermining arises from the limitation of the umbilical level. Compared to the traditional abdominoplasty, the scar is shorter, with a length of 12

to 16 cm. Furthermore, the umbilicus is not dissected from the anterior abdominal wall, and in case of a rectus diastasis, it is repaired by long-acting resorbable sutures. Similar to the traditional abdominoplasty, excess fat and skin are resected in this procedure. Due to the remaining attachment of the umbilicus, it will move 2 cm inferiorly. This procedure may be combined with liposuction to improve the abdominal contour. (3) (8)

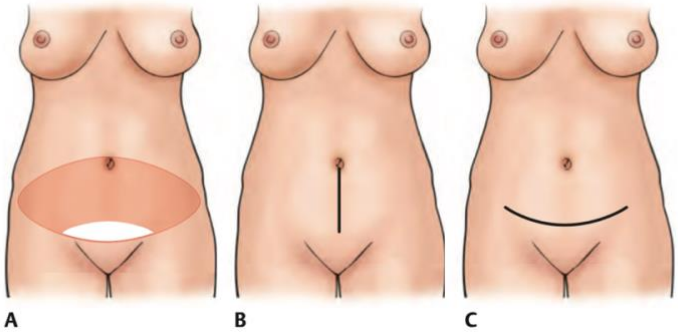

Figure 6 Mini-abdominoplasty. A, Skin elevated and skin cut out. B, Musculofascial repair C. Scar (7)

Lipoabdominoplasty, as the name suggests, is the previously mentioned combination of liposuction and the excision of abdominoplasty. During this procedure, it is of the utmost importance to preserve the blood supply to the flap, according to the "Hugers Zones", as can be seen in Figure 17 (page 22). Therefore, it is important to maintain the lateral blood supply in Zone III, which may be disrupted during liposuction. Thus, undermining of the upper midline is avoided and restricted to areas that plicate. Thereby, allowing persistant perfusion from Zone I. Furthermore, either ultrasonic or traditional suction-assisted liposuction can be used. Preserving the lymphatic system is essential. Thus, some fat tissue remains on the abdominal wall since only 17% of the lymphatic drainage occurs underneath the Scarpa's fascia. (3) (8)

A very popular procedure in patients with a lot of excess fat and skin in both horizontal supraumbilical and interior abdominal areas is the Fleur-de-lis abdominoplasty. This allows a rather drastic modification to the patient's abdominal contour. A midline incision is performed vertically. It may be initiated superiorely until the xiphoid process and inferiorly until the mons pubis, as seen in Figure 7. This, however, depends on the patient's skin laxity. Compared to the traditional abdominoplasty, the skin remains attached to the fascia to increase vascularization unless excised during the procedure. The remaining steps of the procedure are the same as those for traditional abdominoplasty. (3) (8) (9)

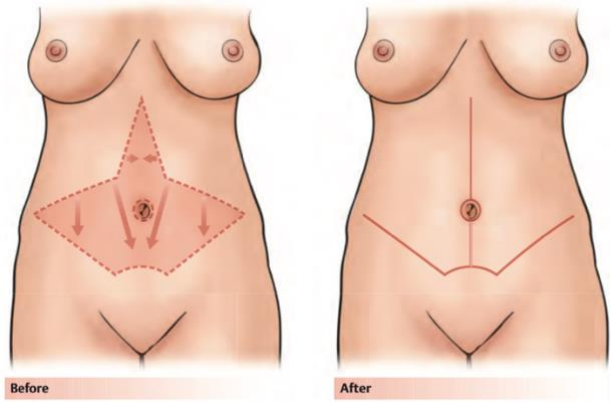

Figure 7 Fleur-de-lise abdominoplasty (7)

The panniculectomy is described as a "functional excision of a large, symptomatic apron of skin and fat" by Key Notes on Plastic Surgery. This procedure usually does not have the same aesthetic outcome as the traditional abdominoplasty since it removes excess skin and fat. Patients who require this type of tissue removal are not able to complete daily activities or are expecting a bariatric surgery later and require this intervention to allow easier access for the second surgery. Another indication is a constant infection of the skin fold. It is necessary to suspend the pannus from the ceiling with either hooks or a crane. The tissue apron is removed, without undermining or plicating the tissue of the rectus sheath. The wound closure varies from patient to patient and upon the surgeon's choice. If possible, it is closed directly. Sometimes the wound cannot be closed; either negative pressure wound therapy or packing of the wound may be required. Due to the state of the patient and the accompanying comorbidities, patients usually suffer from infections of the wound. (8)

Another procedure is the reverse abdominoplasty. As the name suggests, reverse abdominoplasty is advised after a previous lower abdominoplasty. It is usually performed to correct disposable tissue remaining in the superior abdominal wall after the previous abdominoplasty. The incision occurs superior under the fold of the breast, called the inframammary incision. The excess abdominal tissue is excised after being pulled upwards, and the remaining tissue meets the line of incision and is closed, as is demonstrated in Figure 8. (3) (8)

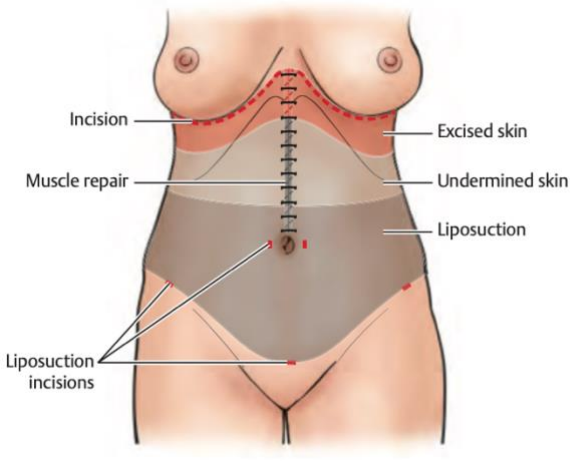

Figure 8 Reverse abdominoplasty (7)

Table 1 below provides an overview of techniques described in this paper and their indications according to Janis's textbook, Essentials of Plastic Surgery, 3rd Edition. However, not all techniques have been enumerated, including the Panniculectomy.

PROCEDURE	EXCESS FAT	EXCESS SKIN	SKIN TONE
TRADITIONAL OR LIPOABDOMINOPLASTY	Significant, not condined to infraumbilical region	Significant, not condined to infraumbilical region	Fair / Poor
MINI-ABDOMINOPLASTY	Infraumbilical	Infraumbilical	Good
FLEUR-DE-LIS	Mild / Moderate	Extending to the back	Fair / Poor
PANNICULECTOMY	Vastly Significant	Vastly Significant	Fair / Poor
REVERSE ABDOMINOPLASTY	Mild / Moderate	Upper Abdomen	Fair / Poor

Figure 9 Table 1 according to Janis, Adjusted and Addition of Panniculectomy (7)

5. Postoperative Complications of Abdominoplasty

Generally, abdominoplasty is considered a safe surgery with a high success rate. The complication rate in patients undergoing abdominoplasty is up to 15%. This number increases, however, for exclusively massive weight loss patients. In massive weight loss patients, the number increases to 34.3% to 50% (10). In the following, I will discuss post-operative complications associated with abdominoplasty by elaborating on their etiology, risk factors, diagnosis, treatment, and methods of prevention. Complications may be classified into local or systemic. Local complications include seroma, hematoma, wound infection, skin necrosis and other local complications such as dog ears and wound dehiscence. Systemic complications elaborated include deep vein thrombosis and pulmonary embolism, also known as venous thromboembolism. (3)

5.1 Seroma

5.1.1 Etiology

Seromas are one of the most common complications in plastic surgery. In abdominoplasty, the incidence of this complication is as high as 5 to 15%. The etiology of seromas can be described as an accumulation of serous exudate that collects underneath the abdominal flap in the anatomical “dead space,” resulting from the abdominal flap's detachment during the abdominoplasty. The serous fluid usually appears clear since it is mainly composed of proteins, neutrophils, cholesterol, and lactate dehydrogenase, which are higher than in lymphatic fluid. Seromas appear to be closer to inflammatory exudate than to lymphatic fluid. Not only because of the previously mentioned components but also because proinflammatory cytokines, tumour necrosis factor-alpha, and interleukin-6 may be found, indicating that it stems from tissue destruction rather than solely from the lymphatic system. (11) (12) (13)

5.1.2 Risk Factors

Risk factors for developing seroma include multiple factors, one being the location. Especially the abdomen, increases the risk for developing seromas. However, other locations, such as the upper arms and thighs, are heavily affected as well. Other risk factors for developing seromas besides abdominoplasty include breast reconstruction, hernia repair, and removal of a mass, e.g. tumour, liposuction and abdominal wall repair.

5.1.3 Diagnosis

During my internship at the plastic and reconstructive surgery department at Charing Cross Hospital, the use of drains for abdominoplasty was a frequently discussed topic. The removal of drains usually followed after the output was less than 30ml/day. The process of removing the drains may allow further clues into detecting seromas early and deciding on a clinical diagnosis of seroma

formation. Typically, in cases of seroma, there was a visible or palpable fluid wave observed after the removal of the drains. However, the imaging diagnosis usually occurs with an ultrasound or computer tomography. These imaging techniques allow for a proper description of the location of a collection and more accuracy during diagnosis, as described in the study by Di Martino et al. In the following diagram, Figure 10, the diagnostic accuracy is visualized clinically vs. image (ultrasound). (11) (14)

	Seroma			%	
Diagnosis	**Yes**	**No**	**Total**	**Seroma**	***p***
Clinical	5	16	21	23.3	0.024*
Ultrasound	8	13	21	38.1	

*Statistical significance ($p < 0.05$, McNemar test).

Figure 10 Di Mario's comparison of clinical vs. Ultrasound diagnostics (12)

5.1.4 Treatment

There are different treatment options for seromas. It may be treated through a conservative approach, which is usually the first step. It is essential to differentiate between a seroma and a lymphocele. A lymphocele is a collection of lymph fluid that reaccumulates despite treatment. It is however, a rather small and firm collection of lymphatic fluid, not located in the lymphatic system. The treatment of a lymphocele requires surgical intervention in the form of removing the lymphocele and its capsule. This conservative management of seroma is composed of percutaneous needle aspiration, as can be seen in Figure 11, however, in clinical practice this is usually performed while the patient is standing, in an ambulatory setting. The percutaneous aspiration must be performed after disinfecting the area of aspiration and using clean utensils. A follow up after 1 to 2 weeks is necessary to reassess the location and rule out the remaining or recurring fluid collection. In the event of a return of collection, it is crucial to reaspirate the area. Ideally, the amount of aspirate will decrease with each attempt. If not, placing a seroma catheter is indicated. The placement may be performed in the outpatient department and secured with a suture at the exit site. The catheter serves as drainage as well as a medium for injection. The injections can include agents with sclerosing properties, such as doxycycline or bleomycin. An example of the use of doxycycline is 500mg of tetracycline diluted in 50 ml of saline mixed with 10 ml of 1% lidocaine. This mixture may be injected into the seroma catheter via a 60 ml syringe. The drain is clamped, and turning the patient four times an hour in 15-minute intervals allows for better distribution of the sclerotherapy with doxycycline. If this does not decrease the output, the

Figure 11 Drainage of a seroma of serohematic fluid, three weeks post-operative, during aspiration (20.)

next approach is marsupialization of the seroma, which is similar to removing a cyst. The wound is packed, and secondary healing may take place. In the event of the marsipulaztion failure, removing the seroma cavity in the theatre is necessary. (14)

5.1.5 Preventative methods

One preventative measure is simply dissecting the abdomen in the correct planes. Other factors that help prevent seromas are the so-called quilting sutures, the use of appropriate instrument: scalpel vs diathermalcoagulation, and fibrin glue.

Another method of prevention, which has been proven to decrease the formation of a seroma, are drains. The use of drains remains controversial since some investigations suggest a solid link to the reduction of seromas through the use of drains. Yet, there are multiple studies indicating no difference in seroma rates with or without the use of drains. (13) (14)

However, if drains are used, removing them at the optimal time is impertinent. In the 2018 randomized control trial "Early drain removal improves quality of life and clinical outcomes in patients with breast cancer," Vos et al. divided 106 patients into two groups: early removal and output-based removal. This study attempted to find the optimal approach to removing drains post-operatively to increase the quality of life. Patients in Group 1, the out-put-based group, had their drains removed when the output was less than 30ml per 24 hours. In group 2, the early removal group, the drains were removed while being discharged from the hospital on day 4 or 5 post-operatively. The quality of life questionnaire was significantly better in Group 2 due to less home care and restriction. The time of seroma formation varied by 9 days. It appeared earlier in Group 2. (15)

Quilting sutures are a preventative measure for seromas as well. In the 2023 prospective, single-blind, randomized controlled clinical trial by the Amiens Picadie University Hospital in France, (breast cancer) patients were split into two groups, quilting closure Group and control Group, with conventional wound closure. The study's primary focus was the presence of seroma 15 days after surgery. Additionally, the study evaluated the operating time, hospitalization, number of draining procedures, the seroma volume drained, postoperative pain, complications, and esthetic outcome. The results concluded that the operating time was approximately 15 minutes longer. Of the 87 patients, 37.9% (33 patients) developed seromas 15 days postoperatively. However, the number of patients developing seromas with quilting closure was statistically significantly lower than in the controll Group ($p < 0.05$). 30.8% of the quilting suture Group had seromas, and 52.5% of the control Group had seromas on postoperative day 15. (16)

Another study from 2019 by *Alhussini et al*. performed a study including abdominoplasty and hernioplasty patients. The researchers split 370 patients into two groups, Group A and Group B. Group A being the control group, with conventional suturing and Group B closure using quilting sutures. Both groups were monitored postoperatively, and the drains were removed according to

output. This allowed clinical assessment and diagnosis of seroma formation, during the removal. Furthermore, at weeks 1, 2, and 4, postoperative patients were inspected for seromas, again. After week 1, 2.6% of quilting suture Group patients developed seromas, whereas 11.7% of controll group developed seromas. The quilting closure patients remained stable at a rate of 2.6%, whereas in week 2, the controll group decreased to 6.1%. Lastly, in week 4, the percentage of patients from the quilting suture group dropped to 1.1% and the control group to 2.2%. Thus, statistically significantly indicating that quilting is a preventative measure of seroma formation in patients with abdominoplasty. (17)(18)

Figure 12 Picture of interoperative marking of quilting sutures (16)

Lastly, evaluating the appropriate utensils. The usage of a scalpel for dissection versus electronic dissection. In a prospective study from 2015 by Valenca-Fillipe et al., 119 female patients underwent abdominoplasties. The patients were split into Group A, operated by one surgeon, and Group B; where every 20 surgeries, the surgeon changed, with a total of four changes. Additionally, in Group A, the surgery was performed with a steel scalpel, and in Group B, a diathermocoagulation device. The results were quite impressive. The local complication rate in Group A was 10.26%, and in Group B, the local complication rate was 26.25%. Furthermore, there were no reports of seromas in the patients who underwent steel scalpel-conducted surgeries. Yet, 15 patients in Group B, roughly 19%, experienced seromas. It may be concluded that since seromas resemble inflammatory exudate, the dissection method may very well play a role in the formation of this fluid collection. Due to the increased damage of tissues with diathermocoagulation, an increase in seroma rates occur. (19)

5.1.6 Summary

To sum up, seromas are complications that are highly probable after abdominoplasty and is described as the accumulation of serous fluid, which is composed of inflammatory and lymphatic fluid and resembles exudate. Seromas occur postoperatively in the dead space created after surgery. Risk factors include the use of electron dissection and the removal of any tissue that causes dead spaces. They are mostly diagnosed either clinically or using an ultrasound. The management of seromas depends on recurrence. Usually, it is possible to treat seromas conservatively by aspiration of the serous collection, injecting sclerosing agents, or performing marsupialization. However, surgery will be necessary if they recur frequently and the volume does not gradually reduce by removing the seroma and its capsule. The preventative techniques for avoiding seroma formation include properly

dissecting anatomical planes using a scalpel and applying quilting sutures intraoperatively. Postoperatively, it is beneficial to consider early drain removal or removal according to the output, this will be a topic for the discussion.

5.2 Infection

The second most common postoperative complication of abdominoplasty is infection. According to Hunecke's study, 3.3% of patients who underwent abdominoplasties developed infections, which can be either wound infections or infective seromas. Infections can occur locally or systemically. Nevertheless, I will focus on wound infections (local). (20)

5.2.1 Etiology

According to the United States Centres for Disease Control and Prevention, infection of the surgical site, or surgical site infection, is defined as an infection occurring within or around the surgical site within 30 days of the initial procedure or within 90 days of procedures involving implants. The classification of surgical wounds is as follows: clean, clean-contaminated, contaminated, and infected. Since abdominoplasty is an elective surgery, this paper focuses on clean and clean-contaminated wounds, as the operating field is well-controlled, clean, and not an emergency situation. (21)

The etiology of clean wounds of elective surgeries such as abdominoplasty is usually composed of microbes found on the skin. In a study from 2022 by Gupta et al., the physicians took samples from two sites on the skin of the same patients. The first site, also the control, was a microbe swab from non-infected, intact skin. The second swab site is a wound. The physicians repeated this process throughout a week to see the different microbe species. This allowed for comparison between the microbiomes found on intact skin and a wound. Bacteria such as *Cutibacterium, Staphylococcus Epidermidis* and *Staphylococcus Capitis* were found more abundant in normal skin than surgical wounds, seen in Figure 13. *Staphylococcus aureu*s, on the other hand, accounts for the majority of infections in elective surgery. However, *Escherichia coli* and *Enterococcus feacalis* have also been reported. These two are probably attributed to poor hand hygiene by the patients. (23) (24)

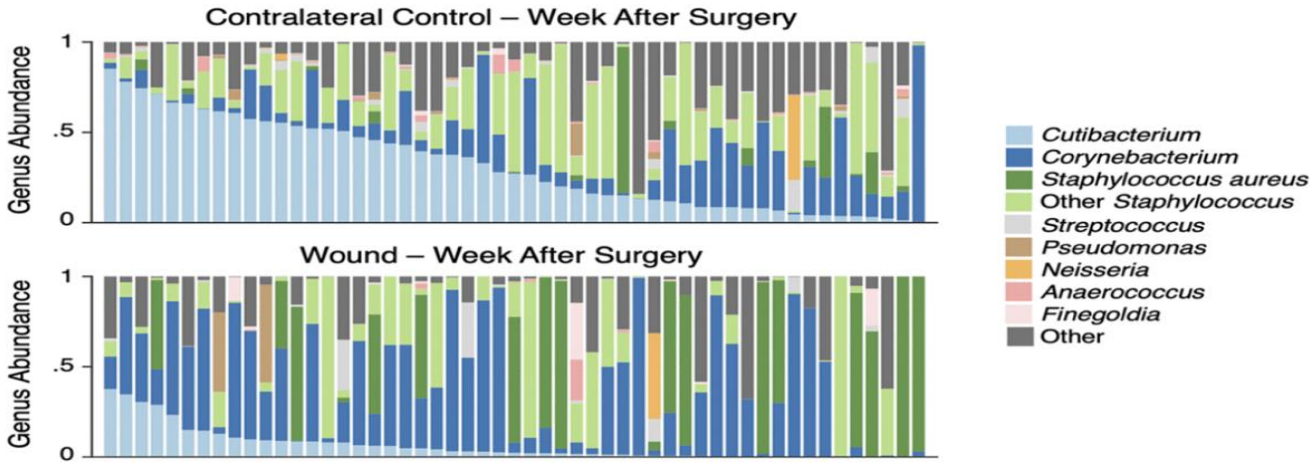

Figure 13 Species Genus in Operating site Group and Control Group within one week after incision. (21)

5.2.2 Risk Factors

Not everyone undergoing a surgical intervention develops wound infections. Therefore, it is important to note risk factors for developing surgical site infections. These infections include obesity, immunosuppression, malnutrition, and prolonged operating time. Another highly determining lifestyle habit is smoking. Smokers are more likely to develop surgical site infections following abdominoplasty, with a morbidity of 12.7%. Nonsmokers, on the other hand, have an incidence of 5%. (23)

5.2.3 Diagnosis

The infection is usually diagnosed seven or more days postoperatively; however, according to the nomenclature previously described, within 30 days postop. Clinical signs of infections of the operating site, similar to other infections, present with these five main symptoms: erythema, edema, elevated temperature, tenderness, and pain. An example of this can be seen in Figure 14. In case of severe wound infections, it is possible to have exudate from the site. Additionally, the output into drains may change their appearance and become more turbid. (14)

Figure 14 Wound infection (20)

5.2.4 Treatment

The treatment is based on The NICE criteria used in the United Kingdom and functions as guidelines for physicians. According to the NICE guidelines of infection, the recommendations include an antibiotic treatment that covers the most probable causative agents. Microbiological testing is essential in determining the causative agent and assists in

guiding the proper selection of antibiotics. Interactive dressing, a dressing that promotes wound healing by maintaining a warm and moist environment underneath the dressing, is indicated as well. (26)

5.2.5 Methods of Prevention

Methods of prevention can be separated into preoperatively, such as avoiding malnutrition and smoking cessation, and intraoperatively, assuming proper aseptic technique. The wound-healing process is a high-energy process. Hence, avoiding malnutrition prior to the surgery is essential in the form of proper nutrition of macro-nutrients such as Carbohydrates, fats, proteins, and fluids, and micro-nutrients such as amino acids, vitamins, and minerals. Unfortunately, there is still a lack of evidence to support which minerals and vitamins are statistically significant for the wound healing process. Yet, Zinc and Vitamin A have been linked to increased epithelialisation and angiogenesis which may aid this process. (27)

Smoking is a major risk factor. Stopping smoking one month before elective surgery helps reduce the risk of post-operative infection. It's unclear if quitting one day before or two months prior is necessary to reduce complications in smokers. Smokers generally face more wound-healing issues than non-smokers. Thus, smoking cessation before elective surgery is a preventive measure against wound infections. (21)

Other preoperative considerations include eliminating previously existing infections, such as in the umbilicus or genitals, and showering twice with 4% chlorhexidine detergent. Surgical site preparation is performed with either iodine or chlorhexidine in alcohol, avoiding unnecessary damage to the site and avoiding dead spaces to avoid infected seromas. Furthermore, there is no evidence to support postoperative use of antibiotics. Thus, preoperative prophylactic antibiotics are sufficient, which are administered within 1 hour prior to the incision and stopped 24 hours after surgery at the latest. In practice, the most commonly used antibiotic is cefazolin or ceftriaxone, which are both second-generation cephalosporins. In patients with suspicion of methicillin-resistant staphylococcus aureus, or MRSA, additional antibiotics may be necessary, such as vancomycin or teicoplanin. (28) (29)

Another key to lowering the risk is reducing operating time. Prolonged time in surgery has been linked with an increased risk of infection. The general increase of developing surgical site infections per 10 minutes of prolonged surgery time is approximately 5%. Moreover, there was a 37% increase in developing surgical site infections per every 60 minutes of operating time. Therefore, another measure to ensure limiting the risk of developing surgical site infections is keeping the operating time as short as possible. (30) (31)

A retrospective study from 2024 by Skorochod and Wolf advertised single drain insertion. The outcome are fewer surgical site infections. The average drain removal occurred after 5 days; the drain remained only if there was more than 50ml per 24-hour output. This study included 743 patients who

were split into three groups: 45% of the patients did not get drains, 20.6% had a single drain, and 34.4% got 2 drains. The outcome of the study was that no intra-operative drain insertion led to increased incidents of surgical site infection, as well as wound dehiscence, hematomas and overall increased rate of post-operative drain insertion. Patients with a single intraoperative drain insertion show a lower incidence of surgical site infection; however, according to this study, it was associated with a higher rate of seroma. (32) (15)

5.2.6 Summary

In conclusion, wound or surgical site infections in the case of abdominoplasty occur within 30 days postoperatively. Given that proper surgical hygiene technique is used, most of the aetiology stems from the patient's own skin microbiome. The most common agent causing these infections is *Staphylococcus Aureus*. In other cases, however, species such as *Escherichia coli* or *Pseudomonas aerogenosa* have been identified. Necrotising fasciitis due to *Pseudomonas aerogenosa* is a rare but life-threatening condition and requires immediate and appropriate treatment with susceptible antibiotics. Risk factors for developing infections include patients with immunosuppression, malnutrition and prolonged operating time. Furthermore, smoking and obesity play a major role in developing infections. Infections are usually diagnosed clinically through observation of the surgical site. Typically, the incision site presents with inflammation signs such as erythema, edema, elevated temperature, tenderness, and pain. However, a change in the drains' output may also be observed. The treatment depends on the pathogen and the susceptibility, according to the NICE criteria. Hence, a diagnostic swab is necessary to evaluate the correct treatment. Prevention includes preoperative lifestyle modification such as proper nutrition, smoking cessation and proper showering technique before surgery. Intraoperatively, it is necessary to use proper aseptic techniques and limit operating time as much as possible. Preoperative antibiotics with second-generation cephalosporins are sufficient up to 1 hours before surgery and discontinued after at the latest 24 hours. Lastly, single drain use and early removal, according to output, are beneficial in preventing infections at the surgical site.

5.3 Skin Necrosis

Another significant complication of abdominoplasty is skin necrosis. According to Hunecke, the incidence of developing it, is 1.6%. (20)

Figure 15 Postoperative wound healing complications following abdominoplasty and mastopexy (Rangaswamy)

5.3.1 Etiology

The majority of etiology of skin necrosis after abdominoplasty occur due to insufficient perfusion. This may occur due to severing perforators through dissection of the abdominal wall or other techniques, such as liposuction techniques. Therefore, depending on the severity of perfusion loss, the symptoms may vary, such as prolonged capillary refill time or diminished temperature at the location. A mild variant of the loss of perfusion is epidermolysis; luckily, this mild scenario usually recovers spontaneously due to re-epithelialization. In more severe cases, when necrosis develops in the skin and subdermal tissue, the outcomes are less favourable since aesthetically acceptable results accompanied by this complication are less than 1%. (23)

On the other hand, some infective agents may cause skin necrosis as well, such as necrotising fasciitis due to *Group A Streptococcus bacteria* or, *Pseudomonas Aeruginosa*.

5.3.2 Risk Factors

Risk factors for developing skin necrosis include smoking or combining surgeries such as abdominoplasty and liposuction. As previously discussed in infections, smoking decreases perforation, thus limiting perforation to the skin flap, which was dissected and relies primarily on the perforation through vessels in the dermal and some remaining subcutaneous layer.

5.3.3 Diagnosis

The diagnosis of necrosis usually depends on the clinical signs, these include a delay in capillary refill time and a local temperature.

5.3.4 Treatment

Usually, skin necrosis treatment depends on the necrotic area's size. The treatment process typically lies in observation and secondary intention due to spontaneous re-epithelialization. Regular follow-ups with debridement and dressing are necessary. Dressing the wound with negative pressure wound therapy has been shown to increase neovascularisation, which is essential in the healing process of skin necrosis. Therefore, the healing period may take anything from weeks to months.

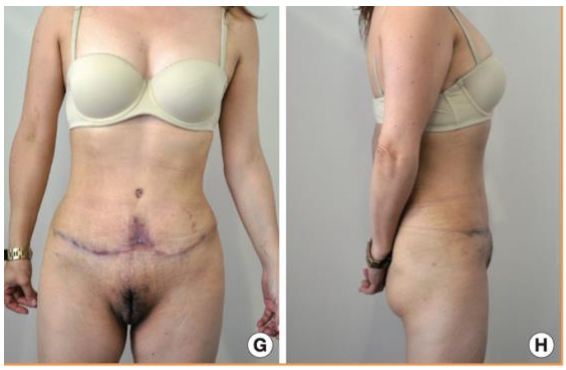

Figure 16 Wound healed after skin necrosis, 3 months after abdominoplasty (20)

5.3.5 Methods of Prevention

Methods of prevention include cessation of smoking, prior to the surgery, since smokers have a 3 fold higher chance of developing necrosis. Especially lipoabdominoplasty poses a risk of developing skin necrosis. (23)

Keeping perforation according to Huger's zones is essential in avoiding the destruction of perforators, leading to skin necrosis.

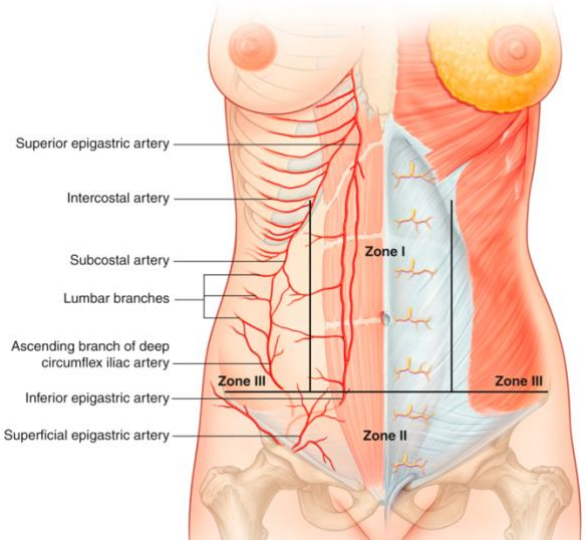

Figure 17 Huger's zones I,II,III (8)

In order to maintain a safe surgery and limit complication rates, the three distinctive Huger's zones are essential to avoid devascularizating the abdominal wall. As visualized in Figure 17, Zone I ranges from the xiphoid to the pubis and is supplied by perforators from the deep and superior epigastric vessels. Laterally, it is bound by the rectus sheath. The lower abdominal wall in the Hugers zone refers to the lower abdominal wall. Inferior to the anterior superior iliac spine and bound by the inguinal crease of the pubis, this zone is supplied by the superficial circumflex femoral artery, the superficial inferior epigastric artery, and the external pudendal artery; all three are branches of the femoral artery. The third zone refers to the anterior lateral abdominal wall above the anterior superior iliac spine margin. The first and second zones are separated by the linea semilunaris. Zone three is vascularized by the intercostal arteries, subcostal arteries, and lumbar vessels. During the procedure of abdominoplasty, Huger's zone I and most parts of zone II are usually resected, leaving zone III as the main vascular supply for the anterior abdominal wall. (9)

Another preventative measure is the progressive tension suture. They are applied in various types of abdominoplasty. The flap is advanced, and each 2-0 Vicryl interrupted suture is stitched into the musculofacia. The tension gets progressively higher the further away from the incision the stitch is placed. This can be seen in Figure 18. The closer the stitch is to the incision, the less tension must be

applied due to necrosis and hypertrophic scar prevention. This procedure allows for closing an anatomical dead space, which further decreases the formation of seroma, which will be discussed in more detail later. (3)

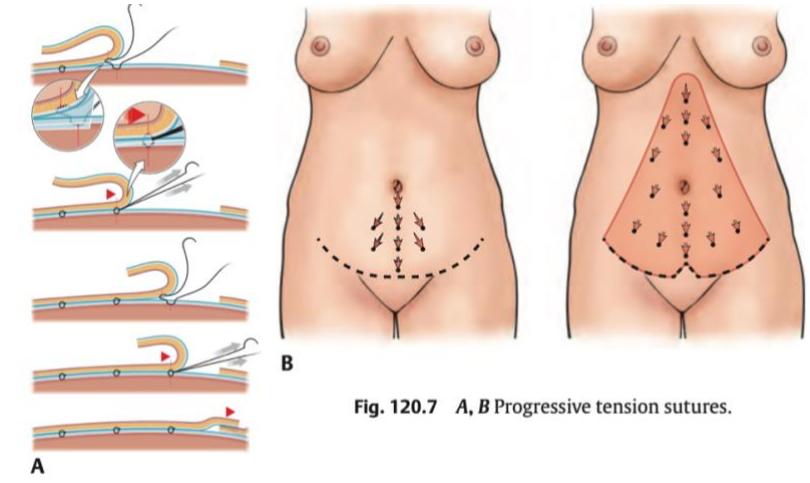

Figure 18 progressive tension suturing technique (7)

The 2022 published clinical study by Martins et al. focuses on improving the understanding of fixation points on the abdominal flap to adjust flap tension and to discover if quilting sutures may contribute to decreasing the tension on the distal end of the flap. The tension force was adjusted before applying the quilting suture, as seen in Figure 19. Thus, with quilting sutures, the flap was attached to the scarpas fascia and other myoneurotic layer structures. Thus reducing the tension on the advancing flap. (33)

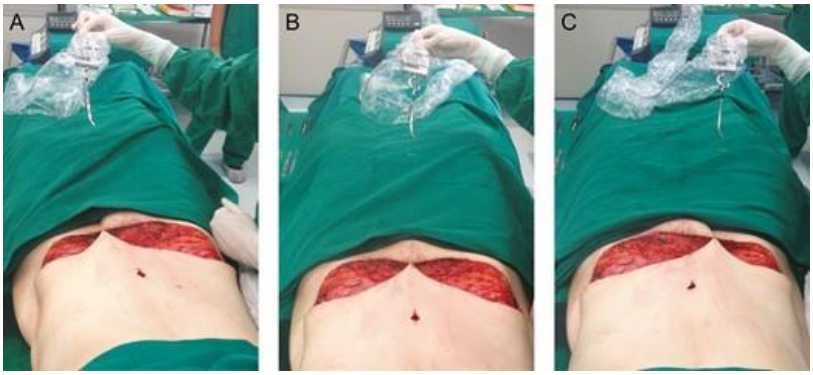

Figure 19 Estimation before applying quilting sutures in the 2022 study by Martins et a l(33)

As previously discussed, *pseudomonas aeriginosa* causes surgical site infection and may lead to tissue necrosis. Thus making it necessary to perform a tissue swab and microbiology to rule out the presence of this pathogen in wound infections, especially in immunocompromised patients to prevent the development of tissue necrosis from this source.

5.3.6 Summary

In summary, necrosis of the skin mainly occurs due to the destruction of perforation during abdominoplasty. Risk factors may be lifestyle or surgical technique related. The diagnosis usually occurs clinically, with prolonged capillary refill time and low local temperature. The treatment and healing process is very tedious and long. In mild cases, re-epithelialization may occur; in severe cases,

debridement over an extended period and dressing with negative pressure wound therapy may be beneficial. Pre-operative cessation of smoking is a strong preventative initiative. Intra-operatively, while conducting lipo abdominoplasty, it is necessary to respect the Huger's zones. Furthermore, the quilting technique and correctly placed tension sutures are essential to avoid the tension on the distal flap beein too great.

5.4 Hematoma

5.4.1. Etiology

Hematomas are less frequent than seromas, but they still occur in 3.31% of cases (Hunecke, 2019). The origin of hematoma, especially in the case of rectus sheath hematoma, lies in the damage to vascular vessels in the muscles posterior to the rectus sheath. Ergo, resulting in an accumulation of blood subcutaneously. This complication is associated with abdominal wall trauma in abdominoplasty, most likely through the damage created during the dissection of the tissue. The vessel associated with abdominal wall hematoma complication is either the epigastric artery or one or more of its branches. As previously described, there are two epigastric arteries, the superior and inferior epigastric arteries. The superior is supplied by the internal thoracic artery, and the inferior arises from the external iliac artery. The superior epigastric artery travels caudally and anastomoses with the inferior epigastric artery at the rectus sheath. (34)

5.4.2. Risk factors

Besides the trauma caused by the surgery itself, other risk factors for developing hematomas include the therapeutic use of anticoagulation or conditions such as haemophilia. In the research by Sheth et al., 77.4% of patients who developed hematomas were using either antiplatelet or anticoagulation medication, or both, indicating a strong link for this complication.

Another major risk factor for developing hematomas postoperatively is emesis. In a recent study published in 2024, Scharfetter et al. discuss the complications arising after postoperative emesis. The emesis process increases intraabdominal pressure, blood pressure, and mechanical friction exerted on the abdominal wall. In this retrospective study, 189 patient data were collected, and the patients were separated into two groups: vomiting and nonvomiting. Non-vomiting being the control group. Between the two groups, there was a significant difference in developing hematomas and surgical reintervention. The group that experienced postoperative vomiting had a complication rate for developing hematomas of 62.5% and a surgical reintervention rate of 43.75%. On the other hand, the control group had a hematoma rate of 9.25% and a surgical reintervention rate of 8.67% Thus, indicating a strong statistical significance with $p < 0.000001$. Furthermore, the statistical significance for reintervention between the two groups was $p = 0.0007$. The p-value is an indicator used in statistics to determine whether two values correlate by suggesting whether they are statistically significant. If

the p value is less than 0.05, it is considered statistically significant and thus a correlation. This retrospective study shows the risk factors for vomiting and developing a hematoma. (35) (36) (37)

5.4.3. Diagnosis

The diagnosis of hematomas may be rather complex since blood collection may be very evident or quite subtle. The clinical picture typically is distinct in the case of evident hematomas. Clinically, the patients may have increased output in their drains, and the symptoms may include hypotension, in 7.9% of patients, syncope in 1.6% of cases, decrease in urine output, and tachycardia, present in 13% of cases. A palpable or visible bulge or swelling is likely present, usually painful and asymmetrical. The bulge may be accompanied by ecchymosis. This could be observed in 17% of patients. Oozing and bleeding may be present surrounding the incision and drain sites, see Figure 21. Furthermore, dark liquid in the drain may indicate that a clot is present. Yet, the most common symptom of hematoma remains abdominal pain, which could be observed in 71.4% of patients. (14) (34) (35)
While the clinical picture is tremendously important, laboratory investigations also provide insight. The haemoglobin and coagulation studies may suggest bleeding and coagulation time. A decline of haemoglobin greater than 0.4 g/dL is a strong indicator of bleeding. A coagulation study is imperative for making an informed decision about further management. For example, if a patient uses therapeutic warfarin, the INR should be evaluated. The outcome of the coagulation study may influence the decision to administer reversal agents to allow coagulation.

In addition to clinical and laboratory investigations, imaging studies such as ultrasound and computer tomography are highly sensitive. The sensitivity and specificity for ultrasound in the investigation of hematomas in the abdominal wall are 80%, yet this depends on the skills and experience of the doctor performing the ultrasound. The ultrasound allows for the evaluation of the size of the hematoma, and Doppler flow can establish whether it is active bleeding. An alternative to ultrasound is computer tomography imaging. It is highly sensitive to these hematomas. Typically, this imaging-resource finds a mass that is spindle-shaped. Depending on the intravenous contrast used, the density may vary. Using a contrast allows the physician to see if the leakage is active, as visible in Figure 20. On top of that, edema in the soft tissue of the surroundings may be present. (34)

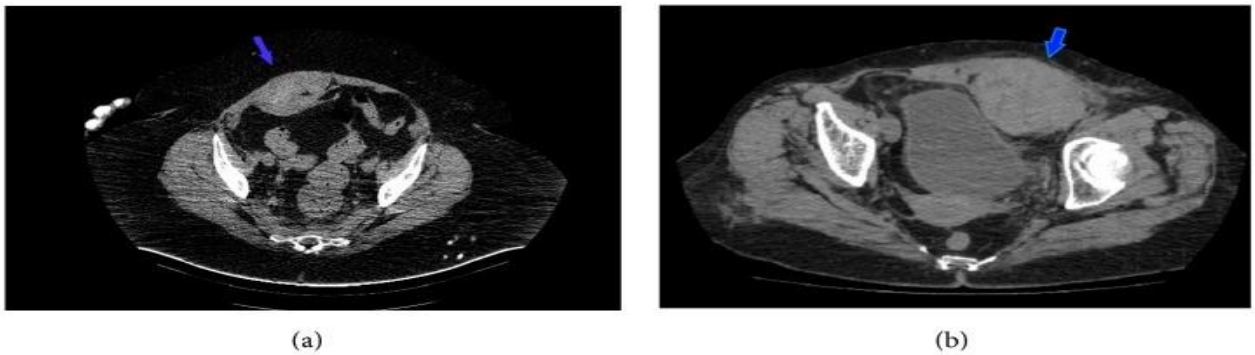

Figure 20 Computer Tomography of the abdomen, blue arrows indicating hematomas, B showing a spindle-shaped mass (33)

5.4.4. Treatment

The treatment of hematomas depends on their volume. Small hematomas may be managed conservatively by leaving the drains that have already been placed for an extended period. Initially, hematomas can be considered rather solid. It might take weeks for them to liquefy and be evacuated, and it may take up to three months for them to resolve. The longer they last, the more likely they are to leave a permanent deformity. Therefore, drainage by incision may result in a more desired and aesthetically pleasing outcome.

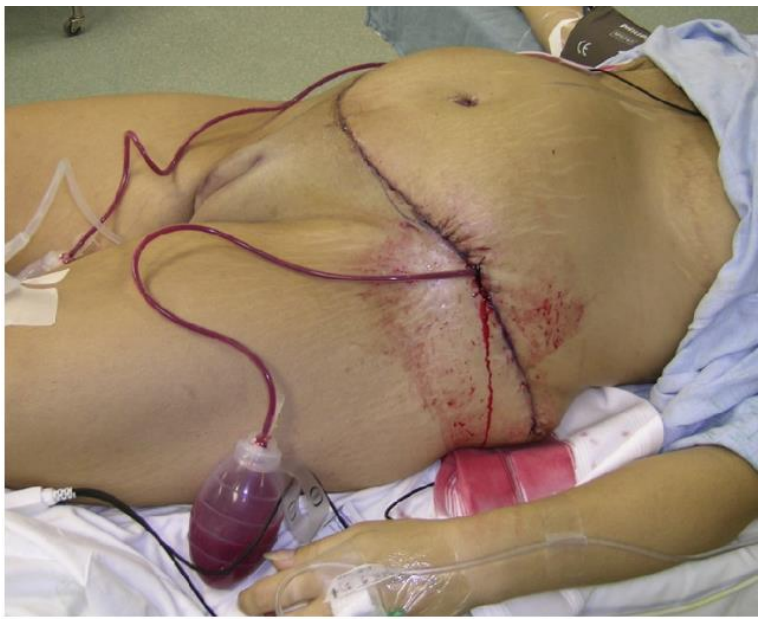

Figure 21 Postoperative hematoma, emergency drainage (12)

Large and life-threatening hematomas are indications for emergency surgery. Patients who show hemodynamic changes, such as tachycardia and hypotension, are usually associated with a 15 to 30% blood volume loss. Thus, blood transfusion with packed red blood cells is essential. During the site's reopening, it is necessary to identify and control bleeders. Furthermore, hemostatic agents may be necessary in oozing wound beds due to their clotting properties. After controlling the bleeders, it is imperative to place new drains. Resuscitation approaches are discussed among the surgical and anesthesiology teams.

5.4.5. Methods of prevention

The preventative approaches to avoiding hematoma formation are quite elementary. The measures prior to surgery include the evaluation of bleeding risk factors. Patients who are prescribed heparin or low-molecular-weight heparin need to be made aware of the risks of bleeding and should be informed about blood transfusion and other resuscitation methods. However, since this procedure is considered an elective surgery, it is necessary to weigh the possible risks against the possible outcomes, also known as the risk/benefit ratio, and assess patients on a case-by-case basis. It is essential to avoid any unnecessary risks.

Generally, hemostasis intraoperatively prevents hematomas postoperatively. This can be achieved by electrocautery, clips, and sutures. Furthermore, the intraoperative use of epinephrine and lidocaine solution, as well as the previously mentioned super wet technique, may be useful to reduce bleeding as it causes hemostasis.

Postoperatively, compression may aid homeostasis. This can be achieved by applying abdominal. (14)

5.4.6. Summary

Recapitulating hematomas, the collection of blood results from intraoperative damage to the vessels, especially epigastric vessels, and their branches. Risk factors other than trauma through surgery include the use of therapeutic antiplatelet or anticoagulation treatment, such as heparin or low-molecular-weight-heparin. Another risk factor for developing postoperative hematoma is emesis because of the increased intraabdominal pressure during vomiting. The diagnosis of hematomas occurs either clinically and might as well be seen in haemoglobin levels in laboratory studies or through imaging, such as ultrasound or computed tomography. The treatment of hematomas depends on their volume. Mild hematomas may be treated conservatively by simply leaving in the already-placed drain for a prolonged time until the solid hematoma liquefies. If the hematoma is very large, on the other hand, it is necessary to reopen the operation site and control bleeders. Additionally, lost volume needs to be re-established by volume resuscitation and red blood cell transfusion. Large hematomas are associated with a 15% to 30% blood loss, and symptoms such as tachycardia and hypotension are important clinical indicators. Preoperative prevention of hematomas includes a detailed history of medications and evaluating the risk/benefit ratio since it is an elective surgery. Intraoperative prevention includes the identification and control of bleeders through the use of adrenaline and lidocaine and the use of electrocautery, clips, and sutures. Lastly, postoperatively, the application of compression is associated with a reduction in hematoma formation.

5.5 Other Local Complications

Due to the space limitation in this literature review, the other local complications are compressed into this section. These complications include umbilical complications, scars and sensitivity, pain, subcutaneous lymphedema, suture extrusion, and “dog ears”.

5.5.1. Umbilicus

The navel, or umbilicus, is the point on the abdomen that draws our eyes in first. Hence, it is aesthetically important in abdominoplasty since it can single-handedly change abdominal beauty. In 2017, a retrospective study investigated complications of the umbilicus. The results show an 18% total complication rate of the umbilicus. The umbilical complications include minor scab, wound dehiscence, partial necrosis and total necrosis. The study further focuses on differences in patients

with and without complications to find statistically significant (p =/< 0.05) factors for developing umbilical complications. The researchers found that patients with complications are older and have a higher body mass index. Measured through computer tomography, these patients had a thicker abdominal wall and increased umbilical stalk height. Additionally, the umbilical complications patient group had a higher percentage of smoking history, previous surgeries, radiotherapy and diabetes. (38)

5.5.2. Scars

Scar quality and cutaneous sensitivity were evaluated by Novais et al. by conducting a randomised controlled trial. The researchers yielded to understand whether preserving the Scarpa's fascia improves scar quality and tactile sensitivity in abdominoplasties. 160 patients were split into 2 Groups: Group A performing traditional abdominoplasty, and Group B performing abdominoplasty with Scarpa's fascia preservation. Novais et al. concluded that there was no significant difference in scar quality. Group B showed an improvement regarding recovery of sensibility in the supraumbilical region. (39)

5.5.3. Pain

Pain management remains a significant aspect of any postoperative period. In 2023, Beaton et al. investigated a new approach to achieve post-operative analgesia. In this double-blind study, patients either received three placebo implants or three 100 mg bupivacaine implants, implanted intraoperatively. Of course, patients still received post-operative pain management. The patients were followed for 30 days. The investigation results show that the medicated Group had a statistically significant lower pain intensity for the first 24 hours than the control Group (placebo), with a p-value of 0.002. However, the pain intensity after 48 hours and 72 hours did not show a statistically significant difference. The physicians concluded that the use of 100 mg bupivacaine implants is efficient in providing postoperative analgesia for the first 24 hours and that there is no evidence of systemic toxicity or impaired wound healing. (40)

5.5.4. Lymphedema

Lymphedema, a local complication after abdominoplasty, was investigated by Zimmermann et al.. This recent primary and randomised study from 2023 evaluates whether there is a difference in the accumulation of subcutaneous lymphedema by comparing the effect of compression garments post-abdominoplasty. Surgeons usually indicate that wearing compression garments decreases dead space postoperatively. Thirty-two patients were included in the study, all with a normal BMI, healthy and non-smoking. These patients were equally split into the garment group and the non-garment group. The waist circumference and body water were measured using a bioimpedance analyser. The data analysis over a 56-day period showed that there is a statistically significant decrease in waist circumference in patients without compression garments. However, there was an increased incidence

in patients without compression garments and seroma formation. The researchers concluded that there is a correlation between wearing a compression garment and increased edema formation. Furthermore, the observation indicates a statistically significant decrease 3 weeks postoperatively in subcutaneous edema formation. (41)

5.5.5. Suture extrusion

Suture extrusion or "splitting a stitch" refers to a physiological process that occurs as a result of intradermal and subcuticular incision closure. Hence, there is a small opening in the closed wound that is not healing. Depending on various factors, patients may present with suture extrusion, including suture material, wound edge devascularisation, inflammatory response to suture material, and response in reabsorbing the material. The inflammatory response around the knot in the skin occurs rapidly, and the resulting small abscess, similar to a pimple, may be visible on the suture line and drain. Luckily, the treatment is very straightforward: removal of the suture. Slow absorbable barbed sutures are associated with a higher incidence of developing suture extrusion, although these are not interrupted but continue. Barbed sutures induce wound closure by having filaments that are directed away from the needle. It is the same principle as in a hook. Thus, it is not necessary to knot this type of suture as it is another absorbable monofilament. Barbed sutures are both available in absorbable and non-absorbable. Due to the technique in which the barbed suture closes the incision, it is not necessary to know. Hence, less suture extrusion due to the lack of a knots. Yet, exactly the opposite applies, especially the slowly absorbable barbed sutures, which have a significantly higher incidence of suture extrusion. (42)

5.5.6. Dog Ears

Lastly, the local complication discussed is "dog ears". They refer to a defect that can be described as the bulging end of the incision during closure due to excess skin after a circular or asymmetric incision. In 2018, Hosseini et al. published an article on "correcting flank skin laxity and dog ear" in obese Middle Eastern women. During this clinical trial, 25 bariatric female patients received lipoabdominoplasties and dog ear correction. The new technique in correcting dog ears was applied by removing large parts of the dog ear, thus creating a new incisional apex in the medial border of the iliac crest, as seen in Figure 22. At 2 and 4 months postoperatively, the patients were asked about their aesthetic satisfaction levels. 68% of the patients were satisfied, 12% were highly satisfied with the results at 2 months, and only 20% were moderately satisfied. 4 months postoperatively, the number remained quite similar at 12% being highly satisfied and the remaining 64% being satisfied

Figure 22 new technique in removing dog ears (41)

and 24% being moderately satisfied. The complication rates postoperatively aligned with the classic abdominoplasty rates. Thus providing a safe and new technique for correcting dog ears. (43)

5.5.7. Summary

Summarising various local complications associated with abdominoplasty, including umbilical issues, scars and sensitivity, pain management, subcutaneous lymphedema, suture extrusion, and "dog ears."

A 2017 study found an 18% complication rate concerning the umbilicus, identifying older age, higher body mass index, and specific medical histories (e.g., smoking, prior surgeries, diabetes) as significant risk factors. Scar quality and sensitivity were compared in a 2020 randomized controlled trial, which revealed no significant difference in scar quality but improved tactile sensitivity in patients with preserved Scarpa's fascia during abdominoplasty.

The efficacy of subcuticular suturing for minimizing scarring is discussed, highlighting its use of sutures beneath the skin surface. A 2023 study examined postoperative pain management, showing that bupivacaine implants significantly reduced pain intensity for the first 24 hours after surgery but had no effect afterward.

Research on subcutaneous lymphedema indicated that compression garments could correlate with increased edema formation, although they decreased waist circumference over time. Finally, suture extrusion is described as a complication resulting from insufficient healing of closed wounds, often influenced by various factors such as suture material and inflammatory responses.

5.6 Thromboembolism

Venous thromboembolism, also known as VTE, collectively describes deep venous thrombosis and pulmonary embolism and is a systemic complication of abdominoplasty. Generally, the incidence of VTE in surgical specialities is approximately 1%. Fortunately, the risk of developing venous thromboembolisms in abdominoplasty is lower than the general incidence. The incidence of abdominoplasty is 0.2%. Venous thromboembolism is a collective condition from both deep venous thrombosis and pulmonary embolism. A clot forms, usually in the lower extremities, and disembarks from the venous wall into the bloodstream, which travels toward the pulmonary system. VTEs can lead to serious complications such as death.

5.6.1. Etiology

The etiology of venous thromboembolism is blood clot formation in veins, typically in the lower limbs. This is the thrombosis part of a VTE. The pulmonary embolism aspect of this condition is the travelling of this previously formed clot into the pulmonary system via the veins.

5.6.2. Risk factors

Risk factors overall include major surgery, prolonged operating time under general anesthesia, massive weight loss greater than 22 kg, and extensive tissue resection. Furthermore, patient factors such as age, obesity (BMI > 30), use of contraceptives or hormone replacement or smoking are significant risk factors as well. Therefore, evaluating the probability of developing a VTE using the Caprini risk assessment score, ranging from 2-8, is essential. This tool estimates the risk according to lifestyle factors such as body mass index, BMI, or use of contraception, and predisposing factors such as history of deep vein thrombosis. Keyes, however, in 2017, showed that 89.5% of patients who developed VTE had a Caprini score of <6. Concluding that most VTEs occur in patients with low Caprini scores. Furthermore, according to the 2022 observational study by Pannucci et al., the 2005 Caprini score needs to be adjusted for patients in aesthetic surgery. Summarising this study, most patients, 96% of patients who develop VTEs among plastic and reconstructive surgeries have a Caprini score of < 6. Hence, adjustments for these patients must be reconsidered, because; according to this study, 28% of low-risk patients would benefit from a more thorough risk assessment. This study concludes that patients with a score of > 7 have a 5.96-fold risk.

Additionally, the sensitivity of the Caprini score is only 52.4%. Thus, experience and intuition are important tools. (44)

Intraoperatively, the risk of developing this complication increases in lipoabdominoplasty compared to the non-liposuction approach. Additionally, the removal of 1500 grams of pure fat increases the risk as well. (45) (46)

PUBLICATION	OUTCOME
1. **KEYES ET AL 2018**	Increased risk of VTE among patients with lipoabdominplasty
2. **PANNUCCI ET AL 2022**	Increased risk of VTE in the Caprini low risk group
3. **CHATTHA ET AL 2018**	Increased risk of VTE among oral contraception and hormonal replacement therapy patients
4. **SWEETLAND ET AL 2013**	Increased of VTE risk among smokers

Figure 23 Table summarising literature regarding outcomes from studies

5.6.3. Diagnosis

Typically, the diagnosis of venous thromboembolism is concluded by Doppler Ultrasound imaging. The sensitivity of Doppler ultrasound is 97% in patients who experience symptoms such as lower extremity pain and swelling. Color Doppler allows physicians to see the veins of the lower extremities. Thus, the diagnosis of a clot is established if present. This method is highly efficient in terms of both cost and time. Another possibility for detecting a clot is the D-Dimer in laboratory investigations. The specificity for this diagnostic test is low, and the results require more time. A

positive result does not confirm DVT, a negative result rules out a DVT. Thus, it is not used to diagnose deep vein thrombosis. (47)

If the clot has dislodged from the lower extrimities, the patient presents with clinical symptoms of chest pain and sudden shortness of breath. X-ray is indicated to confirm the suspicion.

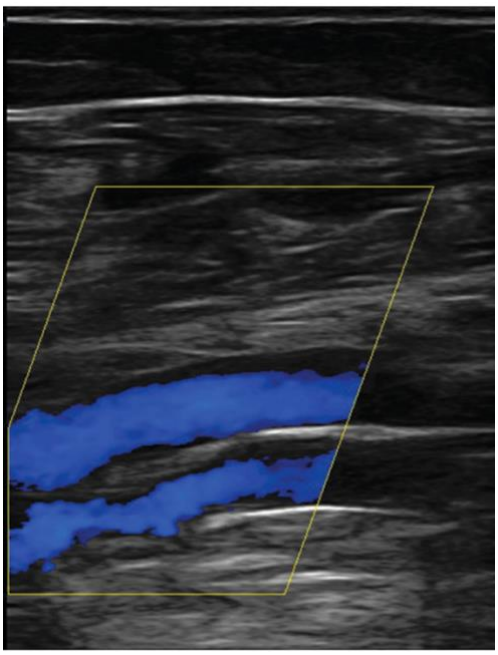

Figure 24 Colour Doppler Ultra Sound of the right popliteal vein in longitudinal view (45)

5.6.4. Treatment

The treatment of venous thromboembolism is based on the NICE criteria, previously discussed in Section 5.2.4. According to NICE, there physicians should consider either the thrombolytic or the mechanical intervention methods. Patients with suspicion of a deep venous thrombosis include a catheter-directed thrombolytic therapy of a therapeutic dose of heparin through a peripheral catheter. X-ray-guided venographic assessment in the area of thrombosis is used, and a multi-lumen infusion catheter is passed into the vein. An ultrasound transducer is used to assist in placing recombinant tissue plasminogen activator (rt-PA), a thrombolytic drug, directly into the thrombus. (26)

The treatment of pulmonary embolism is mainly managed through anticoagulation. The oral anticoagulant frequently used is apixaban; it inhibits factor x directly. The initial administration is 10 mg twice a day for 7 days. This is further followed by a 3-month period of taking 5 mg apixaban twice a day.

Mechanical interventions include inferior vena caval filters, elastic graduated compression stockings, and percutaneous mechanical thrombectomy. An inferior vena cava filter should be considered in patients in whom thrombolytic therapy is contraindicated. This application may be described as a small umbrella-shaped filter that is placed in the inferior vena cava to trap thrombi and prevent them from entering the pulmonary system. This filter should be removed within 6-12 weeks. Elastic graduated compression stockings are used to manage symptoms of deep venous thrombosis; they are not used as treatment for the underlying cause, the clot.

Percutaneous mechanical thrombectomy may be considered as well. (26)

5.6.5. Methods of prevention

Methods that help reduce the risk of developing venous thromboembolisms are highly important.

In moderate to high Caprini scores (>3), chemoprophylaxis with low-molecular-weight-heparin or unfractionated heparin is recommended.

Five hundred forty-six patients who underwent massive weight loss, which increases the risk of thromboembolism, were enrolled in the study by Michaels in 2015. The VTE prophylaxis in Group 1 was composed of sequential compression devices (SCD) and early ambulation. Group 2 received SCDs, early ambulation, and low-molecular-weight-heparin chemoprophylaxis, 30mg Enoxaparin was administered subcutaneously 6 hours postoperatively, every 12 hours until discharge. On top of that, patients undergoing panniculectomies received temporary inferior vena cava filters. The SCDs were placed preoperatively in both groups. This investigation focuses on whether it is safe to practice chemoprophylaxis due to the adverse effects of increased bleeding risk, which results in hematoma and transfusion. Micheals et al. concluded that there is no significant increase in developing hematoma or transfusion complications from the use of chemoprophylaxis and that postoperative low-molecular-weight-heparin is an excellent medium that balances VTE prophylaxis and bleeding complications. (48)

In 2018, researchers Pannucci et al. explored the impact of the administration of Enoxaparin once versus twice a day regarding relevant bleeding risk. This study divided patients into two groups: Group 1 received 40mg of Enoxaparin once daily, and Group 2 received Enoxaparin twice daily. The results showed that Group 1 was much superior to Group 2 regarding thromboembolism prophylaxis in a 90-day period. The anti-factor Xa levels were monitored. According to statistical evaluation, the p-value was 0.012, concluding a statistical significance. Additionally, the increase in bleeding was not statistically significant regarding relevant bleeding, $p = 0.25$. Thus, the investigation concluded that twice daily administration of Enoxaparin is superior to once. However, they made further suggestions about the possibility of adjusting the dosage according to the patient's weight. Hence, 0.4 or 0.5 mg/kg twice daily. (49)

After his efforts in 2018, Pannucci published another paper in 2021. In this investigation, his team attempted to answer whether a weight-adjusted dose of 0.5 mg/kg is superior to a twice-daily administration of 40mg Enoxaparin, thus avoiding over- or under-coagulation. The parameters were similar to those in his previous study. Patients were randomly assigned a treatment protocol of either approach and after 90 days, the results were concluded. The study concluded that there was statistical significance in improving pharmacokinetics by both avoiding over and under-coagulation in the weight-adjusted group. Additionally, there was no statistically significant difference in the groups regarding bleeding risks. Therefore, the authors of the publication suggest that a weight-based Enoxaparin administration of 0.5 mg/kg twice daily is superior to 40mg twice daily.
(50)

In order to decrease the risk of developing a thromboembolic event, it is necessary to promote smoking cessation, as well as discontinuing oral contraception. Smokers have a positive association with VTE, as can be seen in a cohort study by the NHS (National Health Service in the United

Kingdom), which found that Women smokers have a 40% higher incidence of developing VTE than non-smokers who underwent surgery. According to Charrha, however, only 24.5% of surgeons recommend pre and post-operative cessation of oral contraceptive use. (51) (52)

5.6.6. Summary

Summarizing venous thromboembolism. It is a collective condition from both deep venous thrombosis and pulmonary embolism. A clot forms, usually in the lower extremities, and disembarks from the venous wall into the bloodstream, which travels toward the pulmonary system. Risk factors typically involve smoking, hormone therapy and obesity. Major surgery, prolonged operating time, and large tissue removal play key roles in abdominoplasty patients. The diagnosis is confirmed by ultrasound of the lower limbs during the venous thrombosis stage. The pulmonary embolism stage presents with chest pain and shortness of breath. This is confirmed by an x-ray. The treatment is based on the NICE criteria from the United Kingdom. The initial treatment approach to deep venous thrombosis is thrombolysis via a catheter-directed thrombolytic therapy of a therapeutic dose of heparin. Pulmonary embolisms are treated with an anticoagulation regimen. Mechanical intervention is administered if the initial thrombolytic approach fails or is contraindicated. These include inferior vena caval filters, elastic graduated compression stockings, and percutaneous mechanical thrombectomy. Prevention is based on the Caprini score. However, it needs to be adjusted for patients in plastic and reconstructive surgery since there is a higher incidence in patients with low scores that develop VTEs. According to Pannucci's multiple studies, chemoprophylaxis twice daily according to the patient's weight is the safest measure.

6. Discussion

This literature review explores findings about common postoperative complications in abdominoplasty and their etiology, risk factors, diagnosis, treatment, and method of prevention. Abdominoplasty is a safe procedure which can be beneficial for the patient regarding aesthetic outcome and quality of life. Nevertheless, the complication rate is 15%, with some complications proving to be potentially fatal. Hence, a benefit-risk evaluation is very important for every patient. In addition, it is vital to take all the preventative measures applicable to the patients. Since prevention metho may be contradictory depending on the complication, the surgeon chooses the method he or she prefers after evaluating the situation. In the following, I will attempt to highlight the controversial situations.

Drains have been frequently discussed in the results section. Some research suggests that optimal timing for drain removal is essential. In the 2018 randomized control trial "Early Drain Removal Improves Quality of Life and Clinical Outcomes in T Patients with Breast Cancer," Vos et al. divided

106 patients into two groups: early removal and output-based removal. The aim was to identify the best approach to drain removal post-operatively. Patients in the output-based group had drains removed when output was less than 30ml per 24 hours, while Group 2 had drains removed on day 4 or 5 post-operatively. Quality of life was significantly better in Group 2 due to less home care and fewer restrictions, although seroma formation occurred earlier in this group; however, no significant difference was noted between groups regarding seromas. This leads to the question: do drains effectively prevent seromas? According to this study, they do not (15).

Other studies suggest a single drain may be optimal. A 2024 retrospective study by Skorochod and Wolf favoured single drain insertion to minimize surgical site infections. Average drain removal occurred after 5 days when output exceeded 50ml per 24 hours. This study examined 743 patients divided into three groups: 45% had no drains, 20.6% had a single drain, and 34.4% had two drains. Results showed that not using drains increased surgical site infections, wound dehiscence, and hematomas. Patients with a single intraoperative drain showed lower surgical site infection rates but higher seroma rates, contrasting with the early removal approach based on output ((32); (15)). This controversial topic is an interesting opportunity for more research and possibly a clinical study. Hence, some questions arise: Do drains really decrease seroma formation? Does early drain removal prove beneficial for quality of life and decrease in surgical site infection? What is the ideal time for drain removal, considering quality of life, surgical site infection, and seroma prevention?

Another topic for discussion is the choice of the proper instrument for dissection. It is the surgeon's choice, of course. I cannot help but wonder which instrument I would choose if I were asked. The Diathermocoagulation tool does provide better homeostasis control. However, as mentioned in the seroma section, there is a correlation between using a diathermocoagulation device and seroma formation. Thus, should this tool be applied in patients with bleeding problems, such as on permanent anticoagulants or haemophilia, and should scalpels be used in patients without homeostasis issues? Continuing with this paradigm, does the scalpel use prolong the surgery by more than 10 minutes, which would increase the chance of developing thromboembolism and infection?

One risk factor associated with complications in abdominoplasty that I came across multiple times during my reading is smoking. Further highlighting the importance of smoking cessation prior to surgery. Other risk factors that were frequently emerging include massive weight loss, obesity, and diabetes.

The limitations for this literature review include biases during the primary source selection process and the multiple retrospective studies evaluated. Another complication is the use of variable surgical techniques and patient groups. In one study, the surgeon performs a lipoabdominoplasty; the next study references a traditional technique. In some instances, the methods of operation are not mentioned at all. Another limitation is the heterogenicity of the studies reviewed. Additionally, due

to the selection criteria, I selected English studies only. Establishing a language bias. Many foreign institutions publish in English, as it is considered a global language in the field of medicine, yet not all. Despite that, this means that there might be relevant publications in other languages that have not been reviewed or included in this thesis.

Nevertheless, the strengths of this literature review include a comprehensive analysis of the findings, highlighting clinical relevance. Primary sources for this literature review include 44, one of which is a case study. The selection process includes clinical and retrospective studies from the last 10 years that are randomized, controlled, double or single-blind studies, allowing for an in-depth analysis of complications.

Clinical Recommendations based on the literature review are divided into the following sections:

1. Preoperative Optimization: Prior to the surgery, it is necessary to ensure that patients are adhering to smoking cessation, weight management, and diabetes control.
2. Patient-specific Risk Assessment: Adjusting the Caprini score system to be tailored specifically to plastic and reconstructive surgery patients. Additionally, being critical of patients who are not in optimal condition for surgery, according to their smoking habits, diabetes control, and INR scores, since it is an elective surgery.
3. Improving surgical techniques: Finding a careful tissue dissection technique while still achieving coagulation and applying quilting sutures. Furthermore, Huger's zones should be respected regarding tissue perforation.
4. Enhancing Recovery Protocols: Finding the optimal drain application and timing of removal and improving the thromboembolism prevention protocol through the Caprini scoring system. Furthermore, infection control will benefit from a patient-specific antibiotic selection depending on the most probable infections.

Abdominoplasty is such a widely performed surgery to enhance aesthetics and function. It is very important to fully understand the risk factors, management and methods of prevention associated with its postoperative complications. Therefore, large-scale studies should be undertaken to provide unbiased results and better understanding. Different sources describe different incidences of post-operative complication rates. Thus, a large-scale prospective study may be beneficial in properly evaluating which complications occur at which rate in specific techniques. Another study should focus on preventative measures. I recommend more prospective studies to be carried out in the future that evaluate techniques to prevent complications, such as ideal drain removal and placement. Findings on complication rates and their etiology, risk factors, diagnosis, treatment and mode of prevention are consistent with previous research, though variations in reported rates across studies highlight differences in surgical techniques, patient demographics, and operative protocols.

8. Conclusion

1. Abdominoplasty can lead to both local and systemic postoperative complications.
2. Seromas are the most common local complications, while thromboembolism is the most dangerous systemic complication.
3. Prioritising preoperative optimisation is of the utmost importance, including lowering BMI below before surgery, quitting smoking, ensuring adequate nutrition, and keeping Hb at healthy levels.
4. A recurring risk factor highlighted in this literature review is smoking. Nicotine causes inadequate tissue perfusion, leading to complications like skin necrosis and infections.
5. Ultimately, abdominoplasty enhances the quality of life regarding functional activity and aesthetic reasons.

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