



BAAPS Gluteal Fat Grafting Safety Review - and Recommendations:

Authors: Omar Tillo MD, MS, EBOPRAS, FRCS(Plast), Reza Nassab MBA FRCS(Plast),
Marc Pacifico MD FRCS(Plast)

Key messages / Abstract

- *Definition/description of procedure: **Superficial gluteal lipofilling (SGL)** is a fat grafting procedure that is performed to correct a trochanteric depression and buttock deflation.*
- ***Brazilian Butt Lift (BBL)** is gluteal lipofilling procedure traditionally associated with exaggerated appearance and intramuscular fat transfer. The exaggerated appearance or caricature of an hourglass shape is discouraged, especially when the boundaries of safety are crossed to achieve that goal.*
- *Previously, the risk of mortality from fat embolism in Brazilian Butt Lift (BBL) was reported as being 1:2500. The actual risk is estimated to be nearer 1:15,000, which is similar to the mortality risk in abdominoplasty.*
- *There is increasing evidence regarding the safety of subcutaneous gluteal lipofilling. This has principally been related to new technologies, surgical techniques and training being developed to avoid intramuscular injection of fat.*
- *The efficacy and benefits of using intraoperative ultrasound scan has been demonstrated in guiding the subcutaneous placement of fat and avoiding inadvertent deep lipofilling.*

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- *Other serious risks and complications must be considered in addition to mortality. These include hypothermia, sepsis, skin necrosis, and poor aesthetic results, as well as the much-publicised risk of fat embolism.*
- *Complications are better controlled and managed in strictly regulated healthcare settings. Patients seeking surgery abroad or in unregulated facilities are deemed to be at higher risk of being exposed to these serious complications and at risk of inadequate subsequent management.*

Introduction and background

Gluteal fat grafting has been performed over the last 3 decades (1) gaining widespread popularity in more recent years. It is currently the procedure with the biggest growth rate in plastic surgery worldwide, with an increase of around 20% year-on-year (2)(3). It has become the most popular means of buttock volume augmentation, overtaking gluteal augmentation with implants. In 2020, The Aesthetic Society statistics recorded 40,320 buttock augmentation procedures, which included both fat grafting and buttock implants (3).

In 2015, there were reports of intraoperative mortality related to pulmonary fat emboli associated with BBL surgery. These reports raised awareness of the mechanism of mortality associated with this procedure. Subsequently, the Aesthetic Surgery Education and Research Foundation (ASERF) formed the Gluteal Fat Grafting Task Force to study the mortality and

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complication rate of gluteal fat transfer. Around the same time, reports of death caused by fat embolism emerged (4)(5).

In 2017, the ASERF task force published a survey of 4,843 plastic surgeons reporting 32 fatal, and 103 nonfatal fat emboli in 198,857 BBL procedures. This was extrapolated to estimate the risk of death from this procedure being as high as 1:2,351 (6). This statistic resulted in significant measures being taken internationally as outlined below. However, as detailed later, it appears that this statistic was erroneously achieved and potentially misleading and inaccurate.

International Societies

In July 2018, The American Society of Plastic Surgeons (ASPS), American Society for Aesthetic Plastic Surgery (ASAPS), International Society of Aesthetic Plastic Surgery (ISAPS), International Society of Plastic Regenerative Surgeons (ISPRES) and International Federation for Adipose Therapeutics and Science (IFATS) distributed an urgent advisory in response to the alarming number of deaths occurring from BBL procedures. This Multi-Society Gluteal Fat Grafting Task Force made some suggestions, that include (7):

1. Stay as far away from the gluteal veins and sciatic nerve as possible. Fat should only be grafted into the superficial planes, with the subcutaneous space considered

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safest. If the aesthetic goal requires more fat than can be placed in the subcutaneous layer the surgeon should consider staging the procedure rather than injecting deep.

2. Concentrate on the position of the cannula tip throughout every stroke to assure there is no unintended deeper pass, particularly in the medial half of the buttock overlying the critical structures.
3. Use access incisions that best allow a superficial trajectory for each part of the buttock; avoid deep angulation of the cannula; and palpate externally with the non-dominant hand to assure the cannula tip remains superficial.
4. Use instrumentation that offers control of the cannula; avoid bendable cannulas and mobile luer connections. Vibrating injection cannulas may provide additional tactile feedback.
5. Injection should only be done while the cannula is in motion in order to avoid high-pressure bolus injections.
6. The risk of death should be discussed with every prospective gluteal lipofilling patient.

In August 2018, the Australasian Society of Aesthetic Plastic Surgeons (ASAPS) recommended any surgeons performing this procedure adhere to the above suggestions provided by the Task Force (8).

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In June 2019, the International Society of Aesthetic Plastic Surgery (ISAPS) published an advisory to its members and the public to approach this procedure with extreme caution (9). They cited the ruling from the Florida Board of Medicine that mandated fat may only be injected into the subcutaneous space and must never cross the gluteal fascia. Intramuscular or submuscular fat injections are prohibited (10).

However, the most publicised position statement was made by the British Association of Aesthetic Plastic Surgeons (BAAPS)(11). In October 2018, the BAAPS Council voted to recommend their members did not perform this procedure due to high reported mortality rate, until more was known and understood about the procedure, and there was evidence of an improvement in safety and mortality rates. This was deemed a ‘unique’ decision amongst other national and international plastic surgery societies. In the context of the time, Leah Cambridge, an English 29-year-old woman, had recently died following a BBL procedure in Turkey, resulting in widespread national publicity in the UK media. This publicity reached a peak shortly before the annual BAAPS scientific meeting in which a press conference was planned. Inevitably questions would be raised regarding the BAAPS’ view of this procedure in light of Leah Cambridge’s death. The BAAPS Council’s view was that a clear message needed to be provided regarding this reportedly unsafe procedure, until further investigation and evidence was produced.

This stance succeeded in raising the international public and political awareness regarding this procedure. It has been reportedly responsible for raising the issue of safety of gluteal

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lipofilling and driving the investigation of the aetiology of complications, and the formulation of novel safer approaches

Time for a review

The development of the present guidelines and recommendations has been stimulated by the evidence that has emerged since 2018, based on scientific review and analysis. Other factors that have significantly contributed include:

- 1- An increasing number of UK based patients continuing to seek this procedure by non-board certified or equivalent doctors in the UK and abroad. As noted above, there is a concern regarding higher risk of exposure to risks and complications, such as sepsis, poor techniques, deep vein thrombosis (DVT), and pulmonary embolism (PE). The majority of BBL complications seen in the National Health Service (NHS) are related to sepsis, fat necrosis, and skin necrosis (11)(12).
- 2- Concerns and doubts have since been raised about the methodology and credibility of the ASERF survey statistics. This has been highlighted in the recent analysis by Del Vecchio et al (13).
- 3- Anatomical studies have since been published furthering understanding of the potential mechanisms for mortality from BBL. Furthermore, more recent published reports recommend specific standardised and new techniques that reduce the risks of this procedure (14)(15)(16)(17).

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Recommendation and Guidelines

This document aims to critically review the current evidence in the literature surrounding gluteal fat grafting. It is important to note that these recommendations are guidelines and are not rules nor are they standards. Their aim is to identify best practice where possible, to maximise the safety of patients in view of the previously reported morbidity and mortality associated with the procedure. The guidance is supported with evidence, where available, that is detailed in the Appendix below. There are varying levels of evidence to support these and we shall highlight areas where the evidence is considered strong or weaker.

Patient Assessment

Indication:

Patients typically describe a concern related to hip and buttock definition due to excessive fat tissue on the waist and lack of volume on the hip. This has frequently been referred to colloquially as the “hip-dip”. In addition, concerns are reported over a lack of projection of the posterolateral and posterior gluteal areas. Some patients express difficulties in clothes fitting, self-consciousness and psychological concerns over the appearance of their gluteal area.

Medical History:

A thorough medical history should be taken from the patient. This should include past medical history, previous surgery or anaesthesia, medications, family history, social history

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including smoking status. Gluteal fat grafting should not proceed or proceed with extreme caution if the following conditions are identified:

- Pregnancy (an absolute contra-indication)
- Unstable or untreated medical conditions that can be aggravated by surgery or anaesthetic such as diabetes, hypertension, anaemia or coagulopathies
- Significant organ dysfunctions such as cardiac, renal, hepatic, endocrine, and immune system
- Local conditions affecting the liposuction or fat transfer areas such as hernias, soft tissue malignancies, vascular malformations, lower limb vascular and neurological diseases
- Medications that can interact adversely with adrenaline (epinephrine) and lignocaine (lidocaine)
- Psychological and mental health problems such as body dysmorphic disorder, unstable mood disorders or psychosis
- Unrealistic expectations

Physical Examination:

A careful physical examination of the patient is required. This should include:

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General examination:

- Weight, height, body mass index (BMI)
- General distribution of body fat
- Skeletal anomalies such as scoliosis, pelvic tilts and lower limb length discrepancies

Potential donor sites:

- Volumetric assessment of the fat tissue
- Skin quality, laxity, elasticity, striae, overhang, scars
- Asymmetries
- Lumps, hernias, vascular malformations, or varicose veins

Recipient sites (Hips and gluteal areas):

- Frame type (A, V, Square, Round)
- Analysis of buttocks aesthetic units
- Gluteal volume analysis on posterior and lateral views
- Gluteal muscle height
- Gluteal attachment zones:

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- V-zone (upper inner cleavage)
- Infra-gluteal fold
- Lateral gluteal edge and trochanteric depression
- Gluteal ptosis
- Sub-gluteal folds (banana rolls)
- Skin laxities
- Scars, dents, cellulite, and striae
- Asymmetries
- Lumps, vascular malformations, or varicose veins

Donor area(s) Selection:

The choice of fat harvest site or sites is determined after listening to the patient's concerns followed by a careful clinical examination. The perceived volume of donor site fat is assessed along with the overlying skin quality, to determine the predicted post-liposuction skin retraction. The donor areas may include the abdomen, flanks, back, and thighs. The choice of donor site is agreed with the patient after discussion and examination, to ensure it is both suitable from a clinical perspective, as well as being acceptable to the patient. It is important

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to be mindful of the patient's preference, as tissue harvesting may result in unwanted effects to the donor site.

Aims, expectations and psychological assessment:

It is vital to carefully assess the patient's aims and expectations, their concerns, and their goals. An understanding of how their concerns affect their psychosocial well-being is also intrinsic to the pre-operative patient assessment. Consideration of psychological support or assessment needs to be entertained.

It is important to ensure the patient understands their anatomy, the limitations and the realistically achievable results. Establishing realistic expectations based on the patient's anatomy and limitations of surgery is crucial for their post-operative satisfaction. This is particularly important given the current widespread availability of material online, via social media and images on mainstream media that might exaggerate realistic outcomes.

Imaging:

Preoperative ultrasound or MRI scan imaging may be useful tools for the assessment of the subcutaneous fat tissue for clinical or academic purposes. Further discussion regarding the role of ultrasound imaging is included in the Appendix below.

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Consent:

Informed patient's consent must be taken by the surgeon prior to undertaking the procedure.

This should be completed before the day of surgery and patients should previously be provided with written educational material including a patient correspondence letter and/or procedural information sheet. The consultation process should include discussions regarding the following:

- Alternatives to gluteal fat grafting, such as improving the waist-to-buttock ratio by lower back liposuction alone, gluteal enlargement with silicone implants or body fillers
- Potential benefits of the procedure
- Patient journey and procedural information
- Potential risks or complications, including complications at donor sites
- Patient specific risks
- All potentially life-threatening complications
- Possible outcomes including poor cosmesis; fat loss; need for repeated procedures
- Experience and training of the surgeon performing the procedure
- Limitations due to donor site availability or skin laxity

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Cooling Off Period:

After a consultation, patients should be given a 'cooling off' period of at least 2 weeks before any procedure is performed. It is recommended that patients have a second consultation prior to their surgery.

Pre-Operative Anaesthetic Assessment:

For cases performed under a local anaesthetic the following should be assessed:

- History of tolerance, intolerance, or allergy to local anaesthetic
- Pre-existing medications that interact adversely with local anaesthetic or epinephrine

For cases performed under a general anaesthetic, a pre-assessment should be undertaken by a nurse or a trained registered practitioner, that includes:

- Anaesthetic health screening
- Escalating any concerns to the surgeon or the anaesthetist and arranging an anaesthetic review when required
- Full blood count, renal and liver function tests, clotting screen and other tests as deemed necessary.

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Risks and complications of gluteal lipofilling

The following are specific and general risks and complications associated with gluteal fat grafting that should be discussed with all potential patients. There are some published articles that provide reported incidence of specific complications and further details of these are provided in the Appendix.

Major and Serious Complications

- Fat embolism
- Death
- Blood loss that may require transfusion
- Thrombosis DVT and PE
- Sepsis, septic shock and necrotising fasciitis
- Injury to the sciatic nerve
- Complications due to patients positioning and turning such as:
 - peripheral nervous system injury due to stretch or pressure
 - joint dislocations
 - ophthalmic complications due to direct pressure, corneal injuries, ischaemic optic neuropathy and blindness

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Minor Complications

- Mild infections
- Delayed wound healing
- Seroma
- Haematoma
- Visible scars
- Skin laxity
- Contour irregularities
- Numbness
- Skin necrosis
- Hyperpigmentations
- Pressure ulcers / sores
- Fat loss
- Fat necrosis
- Oil cysts



- Skin blow-out

Intra-operative Care and Techniques:

- Anaesthesia: Depending on the extent of donor sites, the patient's preference and the anaesthetist and the surgeon's experience, this procedure can be performed under a local anaesthetic with or without sedation or under a general anaesthetic
- The anaesthetist should be familiar with this procedure, type of anaesthetic and the intraoperative management of fluid balance and complications in relation to the liposuction and lipofilling
- Meticulous attention is paid to the patient's positioning and repositioning in supine, lateral or prone positions, with protection to the pressure points and eyes, and adequate airway control
- Measures for VTE prophylaxis are undertaken based on the risk assessment. These may include the use of TED stocking, intermittent calf compression and postoperative low molecular weight heparin (LMWH) or oral anticoagulants as appropriate
- Patient warming is extremely important in these procedures as severe hypothermia can occur with prolonged full body exposure, surface fluid evaporation and the use of high volumes of cold tumescent and IV fluid infiltrations. We recommend the use

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of warmed infiltration and IV fluids and the use of warming blankets or mattresses and monitoring patient's temperature during surgery

- Intravenous administration of tranexamic acid on induction has been shown to reduce blood loss in liposculpture procedures (18)
- The procedure should be done in an operating theatre with adequate ventilation and air exchange, under strict sterile conditions. The surgeon, assistants and scrub nurse should be in full sterile surgical gowns to reduce any risk of infection
- Fat harvesting, collection and processing devices and system that are least likely to cause damage to the fat tissue should be selected
- Instruments and devices that are least likely to cause fat contamination must be used, such as single-use instruments over reusable ones, closed collection systems over open ones
- Blunt and thick (4mm or more) lipofilling cannulas are used to reduce the risks of inadvertent intramuscular or intravascular penetration
- Fat should only be injected in the subcutaneous space avoiding intramuscular injections

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- Intraoperative ultrasound scan imaging must be performed to confirm the subcutaneous position of the cannula before lipofilling is initiated. Scanning images and video recordings should be saved
- The surgeon should be constantly aware of the 3-dimensional position of the lipofilling cannula
- Downward injection angles should be avoided
- If the aesthetic outcome requires more volume than can be transferred subcutaneously in a single session, due to graft-recipient capacity constraints, a staged procedure should be considered

Post-operative Care

- Adequate postoperative analgesia
- Some authors recommend the use of postoperative antibiotics, however, there is no evidence to support their use (19)
- Ensure adequate hydration and avoidance of hypovolaemia
- Encourage early mobilisation
- Continue VTE prophylaxis as indicated by the risk assessment
- Keeping pressure off the grafted area for the first 2 weeks (20)

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- Compression garments and Lymphatic drainage massages are often recommended by surgeons performing these procedures. However, there is lack of evidence on the safety and efficacy of both and no consensus on the duration or regimes of either
- Smoking should be prohibited for 4 weeks before and after surgery (21)

Documentation

The clinical records should meet the standards produced by the General Medical Council.

The following are specific information that are recommended for inclusion in the clinical records for patients undergoing gluteal fat grafting procedures:

- The patient's preoperative weight, height and body mass index (BMI)
- Clinical photographs using standardised views pre- and post-operatively
- Objective pre- and post-operative measurements such as waist and hips circumferences
- The composition of infiltration fluid used for the procedure and volume infused
- The volume of intravenous fluids infused during the procedure
- The total volume of fat aspirated
- The total volume of transferred fat and specific anatomical areas of injection. A diagrammatic representation of the grafted areas is recommended

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- The size of harvest and infiltration cannulas used during the procedure
- Use of ultrasound scan during the fat transfer
- Drains if used
- Post-operative compression garments used
- Complications encountered during the procedure
- The use of intra-operative or postoperative antibiotics
- The use of venous thromboembolic prophylaxis such as mechanical or chemical
- The use of body warming devices
- Discharge summary

Insurance

In the UK, a number of indemnity providers do not offer cover for gluteal fat grafting. There needs to be engagement with these insurers to identify measures that will allow them to provide provision of cover to surgeons and medical facilities. This may be based on evidence discussed above such as courses, logbook numbers, or certification.

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Training and CPD Recommendations

We propose that the safest approach would be to allow trained surgeons to perform this procedure, according to these recommendations and safety standards in a controlled environment that would allow:

- A. Patient education by providing them with up-to-date information about the risks of this procedure and allowing them to make their own fully informed decision.
- B. Providing the safest possible environment to perform this procedure by controlling all the known intrinsic and extrinsic risks
- C. Participation in research, auditing processes and monitoring the outcome-measures

Surgeons considering performing gluteal fat grafting should seek appropriate levels of training to ensure safe delivery of the procedure. There are a number of recommendations for training that include:

- Knowledge and skills in liposuction and fat grafting techniques. The literature and guidance from international societies have provided a number of technical operative interventions to reduce the risks of complications and mortality. These have been summarised in this document. Many surgeons will have prior experience in liposuction and fat grafting that will be used as evidence for technical ability in the area. They will have logbook evidence for experience in performing liposuction and fat grafting.

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- Observation of procedure - Direct observation in an operating theatre environment of the techniques used by experienced surgeons in gluteal fat grafting is a useful method of gaining knowledge about the technical aspects of performing this procedure safely. There are a number of key leaders who have published and assisted in the task forces related to this procedure. There are also some live surgery courses currently available globally. We recommend at least one attendance of direct intra-operative observation.
- Surgeons should be able to demonstrate competence in operating the intraoperative ultrasound scan by attending a relevant training course or workshop.
- It is suggested that the number of cases performed on an annual basis are in line with the recommendations in the UK's Cosmetic Surgery Certification Scheme.
- Attendance at educational courses - There are a number of international meetings where gluteal fat grafting is commonly featured. These are important means of staying up to date with the latest evidence on the procedure. We recommend attendance to at least one specialist meeting every 3 years and continual updates from the literature in the field evidenced in annual appraisals.
- Maintenance of logbook evidence - surgeons undertaking fat grafting to the buttocks must keep a logbook record of their cases. Experience in fat grafting to other areas of the body is advantageous for any surgeon starting fat grafting to the buttocks, and



should also be recorded. Logbook records form the basis for evidence supporting the experience of surgeons performing gluteal lipofilling.

- Audit - Surgeons undertaking gluteal fat grafting should undertake annual audits of their individual results including amount of fat harvested and injected; complications (major and minor); mortality; patient reported outcome measures and satisfaction. Participation in the BAAPS annual audit is recommended and this will include gluteal fat transfer as an index procedure in the future.

Technical Recommendations

The key technical recommendations include:

- Injection into the subcutaneous plane only - there is a plethora of evidence to suggest this significantly reduces mortality related to the procedure (5)(19)(22)(23)(15)(7)(24) (evidence level 4)
- Intraoperative ultrasound must be used during the placement of fat in the gluteal area to ensure that the cannula remains in the subcutaneous plane (25)(15)(24) (*Pasmíño, P. Article in press*) (evidence level 4 and 5)
- Avoidance of fatigue or distraction and limiting the number of cases to a maximum of three in a day is recommended. There is evidence to show increased risk of mortality when large numbers of cases are performed in a day or towards the end of the week (15)(24) (evidence level 4)

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- The patient is secured in a prone position. A mild jack-knife position, with less than 60 degrees of hip flexion, might help achieve a better control of the injection cannula (evidence level 5) (20). It is thought that hip flexion of 60 degrees or more should be avoided (26) (evidence level 4).
- Use of cannula over 4mm thick have been shown to improve fat viability and is thought to reduce the risk of inadvertent bending and displacement of the cannula (27)(20)(28)(15)(7) (evidence level 5). There is no significant evidence to show higher risk of death related to cannula size (22)
- The volume of fat transfer should be limited by the graft-to-capacity ratio to ensure optimal graft survival (20)(29) (evidence level 4)
- Harvesting techniques should be performed in accordance with previously published guidelines by BAAPS/BAPRAS on liposuction (30)

Future Directions and Suggestions

- **Certification of Gluteal lipofilling:** In the UK, the Royal College of Surgeons have introduced the Cosmetic Surgery Certification Scheme. This scheme has specialised areas of interest in aesthetic surgery, such as face, breast, body contouring, and, post massive weight loss surgery. Gluteal fat grafting may be considered as a further

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specialised area for certification. The certification scheme uses evidence such as attendance on educational courses, logbook evidence, case-based discussions, and, audit of results as evidence for eligibility for certification.

- **National Gluteal Fat Grafting Audit:** Consideration should be given to the introduction of a national audit to collate data from surgeons in the United Kingdom performing gluteal fat grafting. This data can be used to assess the safety of the procedure in a prospective nature. This can be used as a method of quality control and governance for those undertaking these procedures. The information and data collected should include, but not limited to:
 - Patient demographics - age, sex, BMI, comorbidity, ASA grade
 - Fat volumes - amounts harvested and transferred, areas, technique
 - Complications - major, minor, mortality
 - Outcomes - PROMs, patients' satisfaction, anthropometric measurements and ultrasound-scan assessment of adipose tissue thickness.

Future Research Possibilities

- Effect of donor site infiltration fluid composition on fat transfer survival

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- Effect of fat harvest, collection and preparation techniques
- Effect of local compression (sitting sleeping) on fat survival and outcome
- Safety and efficacy of postoperative use of compression garments
- Safety and efficacy of postoperative lymphatic drainage massages
- Prospective studies on outcome and complications - Most of the current literature and evidence is from surveys of surgeons. This method of data collection inherently has a number of potential issues such as recall bias, response bias, social desirability bias, data collection errors and ambiguity of terminology used between different surgeons.



APPENDIX 1 - Literature Review

Aesthetic Considerations

Mendieta described the classification of buttocks into 4 different shapes: A-shape; V-shape; round shape; and, square shape (31). Patients requesting gluteal lipofilling, often seek the A-shape or “hourglass figure” with an inward curved waist and an outward curved hip in a smooth and continuous S-shaped line. A waist-to-hip ratio of approximately 0.7 has been traditionally reported to the optimally attractive figure for a woman (32). However, this ideal ratio seemed to have moved toward a more exaggerated ratio of 0.6 or 0.5 possibly due to the influence of celebrities and social media (33). Cultural and racial variations and trends have been reported with hip to waist ratio of 0.70 in the most conservative patients and up to 0.65 (34).

Anatomy

The gluteal musculature can be grouped into either superficial and deep muscles. The larger muscles such as the gluteus maximus, medius, minimus, and tensor fasciae latae form the superficial group. The deep muscle group comprises the piriformis, obturator internus, gemellus superior, gemellus inferior, and quadratus femoris. The greater sciatic foramen is bounded by: the greater sciatic notch of the ilium anterolaterally; the sacrotuberous ligament posteromedially; and, the sacrospinous ligament and ischial spine inferiorly. The superior gluteal nerve, artery and vein pass through the greater sciatic foramen above the

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piriformis muscle. The inferior gluteal nerve, artery and vein pass through the foramen below the piriformis muscle.

The danger triangle of the buttock comprises the area between three points: superiorly, the posterior superior iliac spine; laterally, the greater trochanter; and inferiorly, the ischial tuberosity. Deep injection within this area increases the potential risks of injury to gluteal vessels and the sciatic nerve (20).

The subcutaneous plane is reported to be about 17mm thick in cadaveric studies and the gluteal muscle was 25mm thick (16). Anatomical studies have demonstrated that the deeper and more medial planes of the gluteal area house the large prominent vessels with the superior and inferior gluteal veins measuring 7.61 [2.24] mm and 13.65 [6.55] mm respectively with branches measuring 3.83mm. The subcutaneous vessels have the smaller diameters of 0.9 for arteries and 1.05mm for veins (16). Muresan et al. conducted cadaveric studies that showed the superior and inferior gluteal veins to be on average 3.28 and 1.25 cm away from the point a third the distance from the mid sacral edge to the greater trochanter (17).

Donor sites selection

A variety of areas can be chosen for the harvest of the fat tissue. The choice is often made based on the contribution of that harvest to the buttocks and body contouring, patient's preferences, volume of tissue available and the volume needed for the enhancement.

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The most common areas for the harvest are the lower flanks, lower back and the upper thighs which contribute to the contouring of the hips and buttocks. These are followed by the abdomen, upper flanks, and lower thighs for additional body contouring and more fat harvest.

There is no evidence to favour one donor site over another in terms of adipocytes viability and graft take (35)(36). Some evidence suggests higher adipose-derived stem cells in fat harvested from the lower abdomen and inner thighs (37), and possibly a higher viability of graft taken from these areas in young age groups (38).

Patient Position During Lipofilling

Some authors recommend the jack-knife prone position to allow greater control of the cannula position and potentially safer transfer (20). It is also believed that it causes reduction in the calibre and volume of the gluteal veins. However, this position reduces the skin to muscle surface distance when compared to the prone position. A comparative radiological study between the prone position and the jack-knife position, at a flexed angle of 60 degrees has showed that the muscle surface was on average 2.5cm beneath the skin in jack-knife position at 60-degrees flexion; compared to 3.2cm in the standard prone position. The authors of this paper suggested that the jack-knife position may make veins more vulnerable to an avulsion injury from fat migration to the piriform space (26). They suggested further studies are required to further evaluate the safety or dangers of the jack-knife position.

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Anaesthesia

General anaesthesia is most commonly used in gluteal lipofilling especially when the procedure involves harvesting fat from multiple sites. This reduces or eliminates the use of local anaesthetic and its related toxicity, and ensures a secure airway in the prone position.

Local anaesthetic with conscious sedation has been reported as an option (39), however, safety and efficacy concerns related to airway management and unsatisfactory outcome should be carefully considered (15).

Cannula Diameter

The use of a large-bore (4 to 5 mm) blunt-tip cannula is thought to minimise the risk of venous injury or the inadvertent penetration into the deeper musculature (20). It is argued that the large-bore cannulas are more rigid, provide more control of the position and, therefore, are less likely to bend or cause “flexibility misguidance” (28)(15). Some evidence suggests an improved fat viability with larger cannulas (27).

A survey of Brazilian plastic surgeons did not show any significant decrease in risk of death with use of a 4mm or greater blunt cannula (22).

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Mechanism of Mortality

There are a number of causes and postulated mechanisms of mortality related to gluteal fat grafting. The most discussed cause of death is fat embolism. However, a variety of other complications can lead to mortality if not treated promptly such as sepsis, thromboembolism, visceral perforation, cardiovascular collapse, allergic reaction and local anaesthetic toxicity. We will focus here on pulmonary fat embolism.

It is crucial to differentiate between two variants of fat embolism, microscopic and macroscopic, because the clinical presentation, treatment, and prognosis of each condition are completely different.

- 1- Microscopic fat embolism occurs when small droplets of fat and fatty acids are released into the circulation causing an inflammatory reaction leading to pulmonary oedema, central nervous system depression, acute respiratory distress syndrome and possibly death in 10-30% of the cases occurring after trauma. This is one of the known but rare complications of liposuction (40). Signs and symptoms can start 24 hours postoperatively.
- 2- Macroscopic fat embolism is caused by an abundance of adipocytes forming large emboli 1-8 cm in diameter that cause mechanical obstruction of the pulmonary circulation resembling pulmonary thromboembolism and acute heart failure with very high mortality rate (41). Most cases of fatal fat embolism after gluteal lipofilling

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are due to macroscopic fat embolism (5). The signs and symptoms usually occur intraoperatively or within a few hours postoperatively (42).

Intravascular adipocyte migration occurs via a laceration in the gluteal veins. It is postulated that this laceration can be the result of a direct-hit by the cannula (the Direct-Hit Theory), or via traction on the gluteal vein plexus caused by the posterior expansion of the gluteal muscle due to deep submuscular fat migration (the Venous Traction Theory) (23).

The intravascular fat migration can possibly occur via direct vein cannulation and direct fat injection into it, however, it is more probable that large fat particles migrate from the high pressure extravascular space into the low pressure venous system through the venous injury (6) or the so called syphoning mechanism (23).

Fat transfer Plane

Fat transfer in the highly vascularized Intramuscular beds was historically widely recommended to enhance volume maintenance and improve the adipose tissue integration. The majority of pioneering surgeons and authors recommended multiple plane lipofilling to include the intramuscular and submuscular transfer to help fat integration and this continued to be the common acceptable practice until recent years (19)(43)(14)(44).

The analysis by Cárdenas-Camarena *et al*, of 22 cases of death caused by fat embolism in gluteal lipofilling found that intramuscular gluteal lipofilling is associated with higher

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mortality due to blood vessels damage allowing the fat embolism. They recommended avoiding injections into deep muscle planes (5).

A systematic review by Condé-Green et al documented the planes of fat transfer into the following areas: intramuscular and subcutaneous planes (46.7%), intramuscular only (26.7%), subcutaneous only (20%), or subfascial and subcutaneous planes (6.7%). The incidence rate of fatal and nonfatal pulmonary fat embolism was higher with deep muscle injections. In a total of 4084 patients, there were fewer complications in subcutaneous fat injection (4.1%) in comparison with the intramuscular transfer alone or combined with subcutaneous planes (28.7%); however, these results did not achieve statistical significance ($p = 0.059$) (19).

A survey of Brazilian board-certified plastic surgeons, reported a 16-fold increase in risk of death when the fat was injected intramuscularly (22).

Anatomical studies have demonstrated that the deeper and more medial planes of the gluteal area house the large prominent vessels with the superior and inferior gluteal veins measuring on average 7.61 [2.24] mm and 13.65 [6.55] mm respectively with branches measuring 3.83mm. The subcutaneous vessels had the smaller diameters of 0.9 for arteries and 1.05mm for veins (16). The subcutaneous and intramuscular veins were mostly venae comitantes to perforating vessels. These veins measure 1.05mm in the subcutaneous plane and increase to 1.3mm in the intramuscular plane. On the deeper layer of the muscle tributaries start to merge giving veins of calibre between 3.5-3.85 (16). The authors of this



study suggest that the subcutaneous planes may represent the least risk with regards to vascular complications as they contain the smallest calibre vessels. The intramuscular central and lateral planes may represent an intermediate risk. The submuscular plane throughout its length and the medial intramuscular plane represent perhaps the greatest risk to vascular sequelae due to the possibility of penetrating the superior and inferior gluteal vessels or branches.

Del-Vecchio et al studied and demonstrated the “deep intramuscular migration” that occurs with intramuscular fat transfer. The fat migrates into deeper planes and other compartments by following the path of least resistance (23).

Fat Harvesting Technique

Various methods of fat harvest, collection and transfer may be used depending on the surgeon’s personal experience. There is currently a paucity of evidence regarding the superiority of one method over the other.

- Fluid infiltration: various infiltration regimens have been described; wet (200ml-300ml per area), super-wet (1 ml infiltrate:1 ml of aspirate) and tumescent (3-4ml infiltrate:1ml aspirate). Various fluid infiltration formulae have been used containing adrenalin with or without local anaesthetic. The choice of regimen and fluid composition depends on various factors and is determined by the surgeon. The goals are: reducing the soft tissue and vascular trauma during liposuction, easing the harvesting of fat, and reducing



bleeding and post-operative pain. There is little evidence to suggest the benefit of one fluid formula over another. The volume of infiltration fluid and the specific formula used is decided by the surgeon and anaesthetist with consideration of fluid balance, fluid overload, and the effect of epinephrine on the cardiovascular system.

- Type of liposuction: various instruments and devices are used for the fat harvest including manual syringe liposuction, vacuum-assisted liposuction, power-assisted liposuction (PAL), ultrasonic-assisted liposuction (UAL), and LASER assisted liposuction. Studies on cell viability show that mature adipocytes are fragile cells with low resistance to trauma (45). It follows logically that gentle handling of the fat graft must be very important (46). Therefore, it is necessary to consider the use of instruments, energy and suction pressures that are least likely to cause damage to the harvested fat tissue.
- Fat collection systems: a variety of fat collection systems is used ranging from syringes, reusable open systems, and single-use closed systems. The selection of a suitable collection system is decided by the surgeon and should allow the harvest of the required amount of fat tissue and maintain its sterility.
- Fat preparation by decantation is most commonly used for the preparation of relatively large volumes of fat tissue. Filtration and centrifugation have also been used; however, these may be time consuming, and carry the risk of contamination and damage to the fat tissue.



Fat Transfer Technique

- The use of mobile luer syringe connections is not recommended due the risk of flexibility misguidance. This is a phenomenon that occurs when the direction of the penetrating cannula is diverted off the direction of the syringe due to bending at the cannula-syringe interface which can potentially lead to deeper penetration of the cannula tip than intended (28)(7).
- Access: it has been suggested that a cranial buttock approach, via an incision in the antenatal cleft or superior gluteal area is safer than access via the inferior gluteal crease. This is based on anatomical observations that penetrating the gluteal muscle and causing a “direct hit” to the gluteal vessels is more likely to occur via inferior gluteal access (20).
- Plane of lipofilling: Gluteal lipofilling should only be performed in the superficial and deep subcutaneous fat tissue (under and above the superficial facial system), above the deep fascia and gluteal muscle. The current evidence discussed above suggests that any intramuscular lipofilling; being superficial or deep, in danger zones or the so-called “safety” zones as described previously; should be avoided due to the possible risk of deep intramuscular fat migration via the path of least resistance.
- Attention and awareness: it is essential that the surgeon maintains a constant 3-dimensional awareness of the cannula position throughout the whole period of lipofilling. This stage warrants the surgeon’s full concentration and the anaesthetist’s

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complete attention to any changes in the patient's vital signs, with the absolute avoidance of any distractions in the operating room.

- Ensure the dispersion of the grafted fat throughout the recipient tissue plane to improve the graft take. Large concentrated boluses of fat should be avoided as this can lead to lumps of fat necrosis, oil cysts and in extreme cases blow-out phenomenon. The blow-out phenomenon occurs when large volumes of fat do not survive in one large region resulting in skin detachment over a lake of necrotic tissue and a subsequent contour deformity (47).
- Intraoperative ultrasound imaging has been shown to be reliable in confirming the position of the cannula during the lipofilling which may help the surgeon avoid the inadvertent intramuscular penetration. Further discussion on the role of ultrasound is found below.
- Expansion Vibration Lipofilling (EVL) is thought to expand the subcutaneous space and to improve the volume capacity in the receiving sites (48).
- It is advised to avoid aggressive and wide subcision of subcutaneous fascial bands which can lead to the blow-out phenomenon, especially when combined with large accumulations of fat graft (49).



Ultrasound Guided Gluteal Fat Grafting

Ultrasound is a useful tool in the assessment of thickness of subcutaneous fat and fat survival in gluteal fat grafting (50). Cansanco et al. used ultrasound to assess fat survival in patients at 12 months following their procedure. They recorded the adipose tissue thickness in the gluteal region preoperative, immediately postoperatively and at 12 months postoperatively. They showed that there is an average increase of 56.51% immediately following fat grafting This decreased by an average of 18.16% at 12 months postoperatively (51). In another study by Cansanco et al., they demonstrated the real time use of ultrasound assisted gluteal fat grafting to identify the plane of injection. They reported disadvantages of this technique included: the cost of the device; increased surgical time; learning curve; and, need for assistants to follow the cannula and probe continuously (25).

The use of ultrasound scan in gluteal fat transfer is becoming increasingly recommended by authors (15) and enforced by some health authorities (24).

Angle of Injection

Two anatomical studies investigated the optimal angles of the injection that would have the least risk of neurovascular complications.

One study involving ten dissections in 5 cadavers, evaluated the relation between the gluteal vessels and a colourant that was injected at 30 compared to 45 degrees. They concluded that the injection at 30 degrees can decrease the chance of damage to the vessels. The

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injection at 45 or more degrees angles were more likely to contact the vessels and the sciatic nerve. The authors also identified the medial quadrant of the buttocks as the highest risk area of fat embolism due to the location of the gluteal vessels in that area (52).

Another study investigated the risk of reaching the gluteal vessels and sciatic nerves using 3 different approaches, upper medial intergluteal sulcus, middle lower gluteal sulcus, peri-trochanteric at various angles of 0, 10, 15 and 30. They studied the occurrence of complications in each group. They defined a complication as the graft being in contact with the gluteal vessels or the sciatic nerve. The majority (73%) of middle lower gluteal sulcus application techniques, at any angle, encountered complications.

The application through the upper medial intergluteal sulcus, at -10 or 0 degrees, and the cannulation via peri-trochanteric access at the level of the femur head at +10 degrees, and the access at the middle of the buttock at the level of the iliac crest at -30 degrees did not involve the vascular or nervous bundles (53).

Expansion Vibration Lipofilling (EVL)

EVL is a lipofilling technique where a wide, reciprocating exploded-tip injection cannula (Flared Mercedes / Basket , 4 or 5 mm in diameter), is used for transferring the fat into the recipient area. The exploded tip of the cannula is thought to widen the space (expansion). This space is further enhanced by the cannula reciprocation (vibration) and simultaneously

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filled by the fat being transferred through the cannula. The fat is often propagated via a peristaltic pump, at a controllable rate (48).

It is thought that EVL provides the following advantages:

- 1- The mechanical expansion of the donor tissue improves its compliance to receive fat tissue with less interstitial pressure
- 2- The use of a peristaltic pump to advance the fat, eliminates the use of syringes which frees the surgeon's hands to concentrate on palpation or holding the ultrasound scan transducer for a real-time and constant awareness of the cannula tip location within the recipient tissue .
- 3- The large diameter cannula is less likely to bend causing flexibility misguidance and the wide blunt tip is less likely to penetrate the venous structures (see Fat Transfer Techniques above).
- 4- The cannula's wide diameter and large holes at the exploded tip reduces intraluminal flow pressure, drag and stress on adipocytes (48).

Volume of lipofilling

The volume of fat grafting has not been found to be associated or related to fatal or non-fatal pulmonary fat embolism (6). Cárdenas-Camarena et al in their study of 13 deaths caused by gluteal lipofilling, found the mean amount of fat injected to be 214 cc with a range of 120-300cc in those patients who had fatal fat embolisms (5). The survey conducted

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by Cansancao et al. revealed that just over 80% of Brazilian plastic surgeons grafted 200-399ml of fat per buttock with only 3% grafting more than 600ml per buttock. They also concluded that there was no significant evidence that the volume of fat injected was a factor in increasing mortality (22).

It is agreed that care should be taken to not overfill the recipient site with excessive graft pressure which would compromise the fat survival. It is difficult to objectively quantify the maximal fill volume. Some authors equate the feel of tissues similar to that achieved during tumescent infiltration as an indication of tissue saturation (20). The 'graft-to-capacity ratio' is the correlation between the volume of grafted fat to the volume of the recipient site. Higher volume maintenance was found when this ration did not exceed 1 to 1 value. i.e volume of transfer = volume of recipient area (29).

Fatigue and distraction

Long working hours and distraction have been shown to be associated with increased medical errors (54)(55). An independent audit of BBL mortalities in South Florida showed that more than half of the mortalities occurred towards the end of the week. Therefore, some authors and health authorities suggested limiting the number of cases to three in one day and avoiding sources of distraction during this critical procedure (15)(24).

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Complications

The overall reported incidence of complications varies from 7 to 10.5%, of which 95.5% are minor complications (56). However, there is a lack of high-level evidence in the literature.

The majority of articles are based on surveys of surgeons performing such procedures. This level of evidence will inherently have responder or reporting biases that may not be reliable compared to prospective studies.

Fat embolism

Fat embolism is a serious and potentially fatal complication associated with gluteal fat grafting. The proposed theories for occurrence of fat emboli during gluteal fat grafting include direct intravascular injection and/or fat migration into deeper muscle. This has been supported by anatomical cadaveric studies that revealed fat tissue into and under the gluteal muscle despite some alleged superficial injections. The recommendations from these data suggest that any breach of muscular fascia should be considered unsafe.

In 2017, the survey conducted by ASERF Task Force reported 135 cases of pulmonary fat emboli in 198,857 cases with 32 fatalities. The calculated risk of pulmonary fat emboli was 1 in 1472 or <0.07% (6).

In 2019, a survey of ISAPS and ASAPS members was conducted (57). This survey revealed some trends in gluteal fat grafting such as significantly fewer surgeons performing the procedure. The technique had changed significantly since the 2017 ASERF report with the majority (85.7%) injecting into subcutaneous fat only compared to 39.8% in 2017. The

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number surgeons performing deep muscle injections dropped significantly from 13.1% to 0.8%. Consequently, reported risk of any pulmonary fat emboli incidence was 1 in 2492 (57).

Another survey in 2019 reported the incidence of non-fatal fat embolism being 1 in 9530 cases (22)

Death

One study analysed 14 deaths following patients undergoing liposuction and gluteal lipoinjection in Columbia and Mexico from 2005 to 2014. In this study, autopsy confirmed cause of death as fat embolism in 13 cases, and myocardial infarction in one. In the 13 cases due to fat embolism 61.5% death occurred during surgery and the remainder within the first 24 hours (5).

In the ASERF Task Force 2017 study, the reported mortality risk was 1 in 3448 (0.03%) (6).

The 2019 survey reported a significantly lower fatality rate of 1 in 14952 (57).

A recently published analysis by Del Vecchio et al raised serious questions regarding the credibility of the 2017 ASERF statistics (13). This new analysis suggested that the actual mortality risk should have been reported as 1 in 13,000 which falls into line with the second ASERF survey, that reported a risk of 1 in 14,921; and the Brazilian survey by Cansancao et al that reported a risk of 1 in 20,117 (22). Del Vecchio et al. have estimated an annual mortality reduction rate of 25% with forecasted mortality of 1 in 45776 for the year 2026. This is in comparison to a predicted mortality of 1 in 19123 for abdominoplasty (13).

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The survey of 853 certified Brazilian plastic surgeons reported that 1.5% of them had experienced a mortality during their career. In the 11 plastic surgeons that reported death, the aetiologies were: fat embolism (54.55%); pulmonary embolism (18.18%); infection (18.18%); and, unknown (9.09%) (22).

Based on the most up-to-date studies, the mortality risk from superficial buttock fat grafting appears to be similar to that for abdominoplasty.

Deep Venous Thrombosis and Pulmonary Embolus

The survey by Cansancao reported that 2.13% and 1.88% of surgeons encountered pulmonary embolism and deep venous thromboembolism respectively (22). They suggest avoiding bending the patient's knees while in the prone or jackknife position, to reduce venous stasis and risk of DVT.

Sepsis, septic shock and necrotising fasciitis

The reported risk of septic shock was 0.02% (19). A meta-analysis by Oranges et al. found the incidence of sepsis to be 0.4%. The risk of infection may be reduced using prophylactic antibiotics preoperatively and postoperatively (43). The most common bacteria are gram negative such as *Escherichia coli*, *Enterococci*, *Bacteroides fragilis* and *Pseudomonas aeruginosa* (58).



Blood loss and Transfusion

The reported rate of symptomatic hypovolaemia is 0.05% and of anaemia anaemia is 0.12% following gluteal fat grafting (19). This is thought to be related to fat harvest rather than grafting. In this literature review, there is no clear definition of the amount of blood loss or blood count level.

Minor Complications

The overall minor complication rate was reported as 6.7 percent (19). The most common minor complication was seroma.

- Seroma – The published seroma rates are from 2.4% (19) to 17.75% (22)(59). Seroma formation usually occurs at the harvest site typically at the sacral triangle. Some report that suction drains may help reduce the rate of seroma formation (58).
- Contour irregularities – There is a large variation in the reported incidence of contour irregularities from 0.64% (19). In a survey of 853 surgeons, 36.35% of surgeons reported experiencing contour irregularities (22).
- Fat necrosis - Fat necrosis occurs following fat transfer and may be due to direct tissue damage due to handling during harvest and transfer; or lack of tissue perfusion. Reported rates from 0.56% have been published (19). The survey by Cansanco showed up to 23.63% of surgeons reported fat necrosis (22). The wide variation in reported rates may be due to the sensitivity of the method used to detect necrosis such as ultrasound, clinical examination or magnetic resonance imaging.

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- Oil cysts - Oil cysts of various sizes can form following fat transfer due to fat necrosis or high-volume injection. 11.25% of surgeons in a survey reported this (22)
- Pain or Numbness - Sciatic nerve axonotmesis or sciatalgia have been reported in up to 1.7% of patients (43). This usually presents with radiating pain from the posterior thigh to the calf. The survey by Cansancoo et al. revealed 5.13% of surgeons experiencing paraesthesia (22)
- Visible scars
- Mild infections
- Delayed healing
- Erythema – 1.3% (19)
- Haematoma: 9.38% of surgeons experienced a haematoma postoperatively (22).
- Skin laxity

Complications due to prone position:

Several complications are known to be related to the prone positioning. These have been presented in fine details in a review by Kwee et al (60)

Nerve palsies and neuropraxia

These can occur as a result of focal direct pressure on the nerves, or strain caused by to extreme levels of flexion or extension. It is generally recommended to: (60)

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- use supportive padding at bony surfaces where superficial nerves are known to travel such as the ulnar nerve at the elbow and the common peroneal nerve at the knee
- keep the joints in neutral position to avoid traction on nerves
- position the humerus anterior to the thoracic cage to prevent stretching of the brachial plexus

Pressure ulcers

These have been reported on the forehead, chin, nose, ears, chest and breasts. It recommended to: (60)

- use supportive soft padded headrests
- adjust the operating table inclination by elevating the head to minimise the weight pressure on the face
- Position the breasts medially to avoid traction injury

Ophthalmic injuries and loss of vision

Significant ophthalmic injuries and loss of vision can result from several causes such as:

- corneal and scleral abrasion, laceration and infection
- orbital compartment syndrome and ischaemic optic neuropathy due to increased intraocular pressure as a consequence of direct pressure on the orbit, acute angle-closure glaucoma, reduced orbital venous return due to low head position and increased intraabdominal pressure, or high-volume fluid replacement and soft tissue oedema

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- central retinal artery occlusion caused by hypotension or emboli
- cortical blindness due to severe hypotension or emboli to the posterior cerebral artery

The risk factors for ophthalmic injuries include:

- venous congestion due to head down positioning
- intraoperative hypotension, anaemia and blood loss
- surgical duration more than 6 hours
- some comorbidities such as glaucoma, obesity, peripheral vascular disease, hypertension, smoking, atherosclerosis, hyperlipidemia, diabetes hypercoagulability, sleep apnoea, polycythaemia, and renal failure.

It is recommended to: (60)

- elevate of the head above the heart in a neutral position to reduce the risk of venous stasis
- prevent direct pressure on the orbits by using appropriate headrests
- monitor the eye position frequently with a mirror attachment to the headrest
- maintain tight control of haemostasis, blood pressure and hypovolemia
- correct anaemia and hypotension
- obtain an ophthalmologic evaluation pre-operatively if the patient has personal or family history of glaucoma

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- obtain an early postoperative assessment of vision and early ophthalmologic intervention if new visual disturbance is reported post operatively

Limb compartment syndrome

Risks factors include peripheral vascular disease, obesity, the use of anabolic steroids, and long duration of surgery. It is recommended to:

- Position the limbs in neutral position
- Use of appropriate padding and avoid direct pressure on the limbs

Increased intra-abdominal pressure

The increase in the intra-abdominal pressure can lead to abdominal compartment syndrome and multi-organ failure due to the decrease organ perfusion. The jackknife position is thought to decrease the intra-abdominal pressure by relaxing the hips while supporting the chest

It is recommended to:

- use chest rolls to support the chest and allow the abdomen to hang freely
- Frequent checks for signs of multi-organ failure

Cardiovascular collapse, arrest and death

Prone position is associated with reduced stroke volume, cardiac index, raised central venous pressure and low blood pressure. These changes can trigger cardiovascular collapse.

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Risk factors include massive blood loss, hypothermia, fluid shifts, cardiac comorbidities, and anatomic deformities such as thoracic lordosis or pectus excavatum, which can aggravate hypotension.

It is recommended to:

- maintain euvolemia and monitoring fluid balance
- monitor high risk patients closely

Thrombosis and stroke

Reduced cerebral perfusion can occur due to vascular kinking at the neck, intimal injury, or thrombosis. Blood clotting can occur due to stasis associated with position-related occlusion of the blood flow. Carotid and vertebro-basilar artery dissection is associated with non-neutral neck positioning and movements. Stroke can also occur due to severe hypertension.

It is recommended to:

- maintain normal blood pressure
- stabilise the head and neck and avoid neck movements
- maintain the neck in neutral position



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