Anaesthesia for plastic and reconstructive surgery

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Abstract

Plastic and reconstructive surgery aims to restore normal and functional anatomy following tissue destruction or impaired wound healing. The techniques required depend on the complexity of the wound, from simple closure to flap reconstruction. More complicated wounds with large skin defects may need free flap transfer for optimal functional and cosmetic results. Flap failure is a major potential complication and perioperative anaesthetic management plays an important role in successful surgery. Factors which may lead to vasoconstriction must be avoided, including pain, hypothermia and hypovolaemia. Blood flow is also improved by maintaining an adequate blood pressure, moderate haemodilution and normocarbia. Free flap failure occurs mainly during the first three postoperative days. Venous thrombosis secondary to congestion is more common than arterial obstruction. Prompt surgical re-exploration is the key to flap salvage.

Keywords Fluid management; free flap; haemodilution; microcirculation; reconstructive ladder; reconstructive surgery; vasopressor

Royal College of Anaesthetists CPD Matrix: 2A07

Learning objectives

After reading this article you should be able to:

- recognize the reconstructive ladder and the anaesthetic implications
- describe the physiology of the microcirculation in free flap surgery and factors which may affect it
- formulate strategies to improve flap survival in free flap surgery by promoting blood flow

Introduction

Plastic and reconstructive surgery aims to restore normal and functional anatomy following tissue destruction or impaired wound healing. The abnormality could be congenital, traumatic or as a result of a disease process such as cancer or infection.

In considering how to close a surgical wound, the plastic surgeon can ascend the 'reconstructive ladder' (Box 1), starting from the simplest option and ascending to a more advanced one depending on the complexity of the surgical wound and the clinical conditions.

The lower rungs of the ladder have limited implications for anaesthesia, and many simple elective plastic surgery procedures can be done in an office setting under local anaesthesia with little or no sedation. Strategies higher up the ladder require more intervention, in particular split skin grafts require good pain management for the donor site, preferably using regional anaesthesia, for example a lateral cutaneous nerve block in for the lateral thigh, from where split skin grafts are frequently harvested.

If there are no options for local wound cover, tissue can be harvested from elsewhere in the body, a technique known as a free flap transfer. Any tissue that can be isolated with a suitable vascular pedicle can be used, and this may include skin, fascia, fat, muscle, nerve, and bone. It offers the best functional and cosmetic results, but it also bears a higher risk of flap failure. Complications can arise due to primary ischaemia at the time of surgery, reperfusion injury or impaired postoperative blood flow causing secondary ischaemia.

Intraoperative and postoperative airway management can also be a concern in reconstructive ear—nose—throat and maxillofacial surgery. In the presence of an upper airway lesion, the anatomy could be distorted and increase the risk of a difficult airway. An airway management plan should be formulated with back-up plans in place. Often the plan may include awake fibreoptic intubation or even elective tracheostomy. Likewise the same attention to detail should be directed to extubation and the possibility of elective postoperative ventilation, particularly in the presence of oedema or intermaxillary fixation.[1] This should be well communicated with the patient and other members in the operating team.

Preoperative assessment

Perioperative medical complications increase the economic costs of microsurgery more than surgical complications. This highlights the importance of careful preoperative assessment, especially for free flap transfer, where the operating time can be prolonged (e.g. >6 hours).

Both high American Society of Anesthesiologists (ASA) grading and advanced Charlson grade have been reported as predictors of postoperative medical complications. Age alone is not an independent risk factor for postoperative medical or

The reconstructive ladder

9. Free flap transfer (e.g. latissimus dorsi myocutaneous flap)
8. Pedicled flap (e.g. pedicled transverse rectus abdominis myocutaneous (TRAM) flap)
7. Random pattern flap
6. Tissue expansion
5. Full-thickness skin graft
4. Split-thickness skin graft
3. Delayed primary closure
2. Primary closure
1. Secondary intention

Box 1

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surgical complications. However, medical co-morbidities are more common in the elderly and tend to increase postoperative medical but not surgical complications.[2] Ischaemic heart disease and alcohol abuse have been reported as independent predictors of overall complications following free tissue transfer.

Diabetes mellitus affects a substantial percentage of the population and increases overall postoperative complications. Although a large series of transverse rectus abdominis myocutaneous (TRAM) flap breast reconstructions showed no significant difference in flap survival or complications between those with or without diabetes mellitus,[3] it is prudent to maintain perioperative normoglycaemia.

Smoking, while not a significant risk factor for free flap failure,[4] is associated with an increase in wound complications. Three weeks of smoking cessation preoperatively is required to reduce wound complication rates. Obesity is associated with both increased medical and flap complications.

Physiology of blood flow to free flap

If the flow in a blood vessel is laminar, the flow can be predicted by the Hagen–Poiseuille equation, which states that flow is directly proportional to the pressure difference (ΔP), and the fourth power of the radius (r), and is inversely proportional to the length of the vessel (L) and the dynamic viscosity (μ).

$$\text{Blood flow} = \frac{\Delta P \pi r^4}{8 \mu L}$$

The systemic blood pressure is the main driving force for blood flow through the flap, therefore the adapted mean arterial pressure for the patient should be maintained. The vessel radius also has a significant impact on the blood flow, and vasoconstriction should be avoided. Hypovolaemia, hypocapnia, hypothermia and pain can cause vasoconstriction and should be treated accordingly.

Hyperventilation resulting in respiratory alkalosis is associated with peripheral vasoconstriction, but hypoventilation resulting in respiratory acidosis can also reduce erythrocytes deformability and increase catecholamine release, which can also cause vasoconstriction.

The use of vasopressors to treat hypotension is controversial, and is generally unpopular among plastic surgeons. Animal studies have shown that the use of vasopressors can lead to vasoconstriction in the microcirculation of the free flap but clinical studies show the use of vasopressor have no effect on flap survival. One study showed that dobutamine and norepinephrine both improve the flap skin blood flow with maximal improvement with norepinephrine.[5] Dobutamine may improve blood flow by increasing cardiac output.

Blood viscosity is determined by the haematocrit, in which a balance is struck between oxygen carrying capacity and blood flow. The optimal haematocrit is thought to be about 30%. If the haematocrit increases above 40%, viscosity increases considerably in the microcirculation which offsets the increased oxygen carrying capacity and increases the risk of thrombosis. A recent study on the appropriate transfusion trigger in free flap transfer surgery suggested that a lower haematocrit of 25% in contrast to a trigger of 30% reduced the number of patients requiring blood transfusion, while not increasing the rate of postoperative complications.[6] Thus the haematocrit target could be as low as 25–30% but further studies are required.

Perioperative management for free flap surgery (Table 1)

The perioperative care goal should be to improve free flap survival and prevent of complications. The exposed skin area can be large as multiple surgical sites may be involved. This, compounded with the loss of thermoregulation after induction, and an increase in evaporative water loss from the surgical field, can lead to the rapid development of hypothermia. The importance of normothermia in promoting free flap blood flow mandates the use of body temperature monitoring. Active warming device such as forced air warming device and/or warming mattress should be used, and the theatre temperature should be controlled to reduce the temperature gradient for heat loss. Intravenous and irrigation fluids should be pre-warmed.

Careful patient positioning and protection of pressure points is mandatory. Endotracheal intubation is usually preferred for head and neck procedures, although supraglottic airway devices can also be used with controlled ventilation for body surface surgery. Head and neck lesions can distort the airway anatomy and fibreoptic intubation may be necessary. The nasal route may be preferred if the presence of an oral tube is likely to obstruct surgical assess. Reinforced endotracheal tubes are useful if patient positioning and draping may subject the tube to kinking.

Invasive arterial pressure monitoring can be useful due to the importance of maintaining the perfusion pressure to the free flap, and for checking the haematocrit and blood gas analysis. Central venous assess may be necessary depending on patient's cardiovascular status and the anticipated need for vasopressor and inotropic support.

Cardiac output monitoring can be considered to help direct intraoperative fluid management and vasoactive drug use. The placement of oesophageal Doppler may not be practical in head and neck surgery due to interference with the operating site. In such cases, alternative non-invasive cardiac output monitoring such as using pulse contour analysis is feasible.

Individual risk assessment venous thromboembolism (VTE) prophylaxis should be undertaken according to the National Institute for Health and Care Excellence (NICE) guidelines. Thigh length anti-embolism stockings can be given upon admission to hospital. Intermittent pneumatic compression is started once the patient is positioned in the operation theatre. Pharmacological therapy, subcutaneous low-molecular-weight heparin (LMWH) prophylaxis can be used if the risk for major bleeding is low. Evidence from a plastic surgery series showed LMWH significantly reduced the rate of venous thromboembolism without a significant increase in bleeding or haematoma formation versus mechanical prophylaxis alone.

Volatile anaesthetics as sevoflurane and opioids may attenuate ischaemia-reperfusion injury which is hard to avoid completely in free flap transfer. On the other hand, propofol has antioxidant and free radical scavenging properties so there is not enough evidence to support the use of any particular agent.

Metaraminol, phenylephrine and noradrenaline are common first- and second-line choices to maintain the systemic arterial

