Anaesthesia for reconstructive free flap surgery for head and neck cancer

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Abstract

Head and neck cancer surgery presents significant challenges for the anaesthetist. A thorough multidisciplinary preoperative assessment and optimisation of the patient is essential, including nutritional and psychological evaluation. The incidence of a difficult airway is high, and the anaesthetist must be skilled in advanced airway techniques. Surgery is extensive, often requiring reconstructive surgery with either a pedicled or free flap. Detailed knowledge of flap physiology and anatomy is needed, and anaesthesia comprises careful management of mean arterial pressure, fluid administration, temperature control and oxygenation. The Enhanced Recovery after Surgery Society and the Society for Head and Neck Anaesthesia consensus recommendations provide guidance on current best practice. Despite continued debate, it now appears that this constitutes goal-directed fluid therapy, coupled with judicious vasopressor therapy sufficient to achieve an adequate mean arterial pressure. Emerging techniques such as prehabilitation and postoperative near-infrared spectroscopy flap monitoring provide hope of improved outcomes going forward.

Key words: Anaesthesia for head and neck cancer; Enhanced recovery after surgery; Free flap; Goal-directed fluid therapy; Vasopressors

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Introduction

The perioperative management of head and neck cancer surgery presents significant challenges for the anaesthetist. The incidence of encountering a difficult airway is higher, and airway access is limited. Patients frequently have significant medical comorbidities requiring preoperative optimisation and perioperative management. Surgery is typically long and extensive requiring reconstructive flap surgery. Detailed knowledge of flap anatomy and physiology is required by the anaesthetist. Careful regulation of oxygenation, haemodynamic support, temperature and fluid administration underpins anaesthetic management.

Background

Head and neck cancer

The incidence of head and neck cancer has increased by 37% in the UK since the early 1990s, and is now the eighth most common cancer (Cancer Research UK, 2018). Established risk factors include smoking (Brown et al, 2018), excessive alcohol consumption (Bagnardi et al, 2015), dietary intake (Chuang et al, 2012), and human papilloma virus (Mehanna et al, 2013). Many of these also constitute risk factors for developing cardiorespiratory comorbidities, creating challenges for the anaesthetist.

Reconstructive flap surgery

While most surgical procedures involve primary closure or healing by secondary intention, head and neck cancer surgery can be extensive, leaving large defects requiring reconstructive flap surgery. A flap is tissue that is mobilised and used to close a surgical defect. The tissue used depends on the type of surgery and nature of the defect, and ranges from a skin flap only, to more complex flaps involving skin, muscle and/or bone. Many different classifications of flaps exist (eg according to composition or geometry of the flap) (Wei and Mardini, 2016). The most important classification for anaesthetists relates to the flap's blood supply. There are two broad categories:

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1. Free flaps – tissue including its blood supply is harvested at a distal site and re-anastomosed at the surgical site using a microvascular technique. Examples of these include radial forearm or anterolateral thigh flaps
2. Flaps where the tissue is mobilised locally and used at the surgical site, but the blood supply remains uninterrupted. Often described as pedicled flaps, examples include deltopectoral or pectoralis major flaps.

Flaps used in head and neck cancer surgery

Head and neck cancer surgery typically involves significant dissection and removal of tissue, with more than 50% of resections requiring reconstruction of the resultant defect (Kanazawa et al, 2011). Flaps are typically used in cases where there is a large defect in the skin, or in locations such as the oral cavity, larynx, neck and oropharynx. In such cases, a pedicled flap or a free flap may be used, depending on the site and extent of the defect, and the patient's preoperative comorbidities.

Free flaps

Anatomy

Radial forearm free flap

The flap is raised from the radial and volar aspect of the forearm. The skin and fascia are harvested with the radial artery and the subcutaneous cephalic vein. If tendon or bone is required, palmaris longus or a segment of the distal radius may be used. Flap mobilisation is typically performed under tourniquet.

Anterolateral thigh flap

Anterolateral thigh flaps are used for larger defects. The anterolateral thigh is supplied by the descending branch of the lateral femoral circumflex artery, and typically has two accompanying veins that merge at the profunda femoral vein junction. If the quality of the deep perforators is a concern, then the tensor fascia lata flap can be used.

Physiology

Free flap surgery interrupts blood supply and requires careful microvascular re-anastomosis. Adequate flap perfusion is a complex interplay between surgical factors (such as the vessel calibre and quality of the anastomosis) and anaesthetic factors, and how they relate to flap perfusion and oxygenation. To understand the principles of anaesthetic management, one must consider the physiology of blood flow. The Hagen–Poiseuille equation states:

$$\text{Laminar flow} = \frac{\Delta P \times r^4 \times \pi}{8 \times \eta \times l}$$

where ΔP is the pressure difference across the tube, r is the radius of the vessel, η is viscosity and l is the length of the tube

Factors affecting flap perfusion include perfusion pressure, vessel radius and length, and blood viscosity. While initial vessel radius and length are determined surgically, the perfusion pressure, vessel radius and viscosity can be affected by anaesthesia. Consequently, oxygen delivery and flap survival may be impacted by anaesthetic management.

Flap harvesting

Forearm flaps are elevated and harvested under tourniquet. Tourniquet inflation time must be recorded, as this constitutes the start of ischaemic time. Anterolateral thigh flaps are typically performed without tourniquet and clamping of the vessels marks the beginning of ischaemic time. In both instances, this represents primary ischaemia, which is time critical. Following microvascular anastomosis the clamps are removed, and reperfusion injury can occur with the release of active metabolites, damaging the flap (Van den Heuvel et al, 2009).

Secondary ischaemia can occur as a result of several factors affecting perfusion and oxygenation of the flap. Anaesthetic management is therefore focused on maintaining adequate flap perfusion, oxygenation and the prevention or mitigation of secondary ischaemia.

Preoperative planning

Enhanced recovery after surgery and prehabilitation

All patients require extensive preoperative planning. The 2016 Enhanced Recovery after Surgery society consensus recommendations for optimal perioperative care includes preoperative carbohydrate treatment, pharmacological thromboprophylaxis, perioperative antibiotics, steroids and anti-emetics, goal-directed fluid management, opioid-sparing multimodal analgesia, frequent flap monitoring and early mobilisation (Dort et al, 2017). The role of prehabilitation is being investigated. A systematic review by Loewen et al (2021) found significant variability in the timing, duration and outcomes of prehabilitation. Further research is required in this area.

Airway assessment

The incidence of difficult airway is higher in these patients (Juneja and Lacey, 2009), as a result of physiological and anatomical features of the tumour and/or patient comorbidities. Salient features of airway assessment, important findings and potential implications are listed in Table 1.

General assessment

Smoking, poor diet, lack of exercise, and excessive alcohol consumption are known causative factors in head and neck cancer. Consequently, many patients will have significant cardiorespiratory comorbidities including chronic obstructive pulmonary disease, ischaemic heart disease, cardiac failure and obstructive sleep apnoea (Jones and Ahmad, 2019). Patients should have any existing conditions optimised where possible, including specialist referral where indicated. The 2020 European Society for Medical Oncology guidelines advise that

Table 1. Features of airway assessment

Assessment	Important findings	Potential implications
Mouth opening	Mouth opening <1.5 cm	Difficulty inserting video laryngoscopes and airway adjuncts. An awake tracheal intubation may be necessary Known risk factors for difficult intubation
Mallampati score	Mallampati 3–4	
Thyromental distance	Short thyromental distance (<6.5 cm)	
Neck movement	Limited movement or acute neck injury	
Mandible protrusion	Overbite	
Computed tomography or magnetic resonance imaging of the neck	Assessing the tumour site, size and extent of spread	Tumours may compress the trachea. Loss of muscle tone at induction of anaesthesia risks the development of total airway obstruction. May prompt an awake tracheal intubation
Flexible nasendoscopy	Tumours may be friable and bleed, or may obstruct the passage of an endotracheal tube	Obstructing tumours (eg a large glottic tumour) may require an elective awake tracheostomy
Ultrasound of the neck	Distorted anatomy	Distorted anatomy may render emergency front of neck access difficult or impossible
	Thyroid cancer	
Anaesthetic records	Difficulties with airway management (including bag–mask ventilation and intubation)	Previous documented difficulties may prompt an awake tracheal intubation
Medical records, history and clinical examination	Patient comorbidities (cardiac, respiratory, smoking, alcohol)	Patients may have limited functional residual capacity and desaturate quicker Significant cardiac comorbidities increase overall perioperative risk
	Radiation therapy	Can cause stiff, fibrotic tissues, making laryngoscopy difficult or impossible. May prompt an awake tracheal intubation

nutritional status be examined, and malnutrition addressed before treatment. Patients' psychological wellbeing should also be assessed (Machiels et al, 2020).

Baseline investigations

All patients should have bloodwork performed including full blood count, coagulation screen, urea and electrolytes, liver profile, type and screen, and a baseline electrocardiogram. A chest X-ray may not be required where patients have had a computed tomography, magnetic resonance imaging or positron emission tomography/computed tomography scan performed.

The need for arterial blood gas, pulmonary function tests or echocardiography should be guided by the patient's comorbidities. Cardiopulmonary exercise testing is an emerging tool in perioperative assessment. An anaerobic threshold of <11 ml/min/kg raises concern for significant perioperative morbidity, although this is not an absolute number (Older, 2013).

Risk stratification

Several established scoring systems exist to stratify a patient's perioperative risk, including modified Frailty Index and Revised Cardiac Risk Index. A systematic review by Mendes et al (2021) demonstrated a correlation between increased frailty and increased intensive care unit complications and 30-day mortality. Mascarella et al (2019) described the Head and Neck Surgery Risk Index, which has better sensitivity and specificity than the modified Frailty Index and Revised Cardiac Risk Index.

Intraoperative management

General anaesthetic considerations

Airway management

Choice of endotracheal tube: Endotracheal tubes may be inserted orally or nasally. Factors influencing the type of endotracheal tube used include the location of the tumour and surgical access required (eg nasal endotracheal tube for intraoral tumour), the postoperative plan (eg a reinforced endotracheal tube may be appropriate for surgery, but not for intensive care unit postoperatively)(Yoon et al, 2017), and the ability to safely change the endotracheal tube at the end of surgery (eg the procedure may predicably cause significant glottic swelling). Occasionally an awake tracheostomy is required.

Method of intubation: A thorough airway assessment should be performed as outlined above. Any doubts about the ability to safely bag-valve-mask ventilate the patient or secure the airway should prompt consideration of awake tracheal intubation (Healy et al, 2021).

The Difficult Airway Society has published guidelines on awake tracheal intubation (Ahmad et al, 2020). Successful awake tracheal intubation requires adequate topicalisation of the airway with local anaesthesia. Methods include nebulisers, mucosal atomiser devices, patient gargling and 'spray as you go' techniques. Regardless of the technique used, two important factors must be considered: the airway must be adequately topicalised, and the overall dose of local anaesthetic administered remain within safe dosing. Where the surgeon intends to use local anaesthetic, this must be factored into dose calculations (Ahmad et al, 2020).

Debate persists among airway experts regarding the use of sedation. When used, the patient's sedation level and respiratory rate must be closely monitored by a second anaesthetist. High flow nasal oxygenation may be used during awake tracheal intubation.

Intravenous access

Large bore intravenous access and invasive arterial blood pressure monitoring are a minimum requirement (Healy et al, 2021). The need for central venous access will depend on patient and surgical factors. Femoral vessels are used as the internal jugular and subclavian veins lie within the surgical field and may be required for flap anastomosis. Potential flap donor sites must be kept free of vascular access and monitors. It is important to liaise with the surgical teams before siting arterial and venous access.

Positioning

Patients are typically positioned supine with a shoulder roll and head ring. The neck must be well supported and not overextended (Nosan et al, 1993). Careful positioning of the arms and shoulders is paramount to avoid brachial plexus injury. Pressure areas should be carefully protected to avoid nerve and compression soft tissue injury. Patients should have thromboembolic deterrent stockings and pneumatic compression devices.

Neuromuscular blockade

The need for nerve monitoring requires consideration of the use of muscle relaxant. Surgery requiring intraoperative nerve monitoring includes:

- Thyroid surgery – recurrent laryngeal nerve
- Parotid and middle ear surgery – facial nerve.

Safe induction of anaesthesia requires optimal intubating conditions, and muscle relaxants should be used where indicated. Where reversal of blockade is required, agents such as rocuronium or vecuronium may be used, as these can be reliably reversed by suggamadex. The presence or return of nerve function should be documented using quantitative train of four ratio.

Analgesia

Opioid-sparing multimodal analgesia regimens are preferred (Healy et al, 2021). Ultra-short acting opiate infusions such as remifentanil are frequently used. Long-acting opiates such as oxycodone (0.05–0.15mg/kg/intravenous) and paracetamol are administered towards the end of surgery. Non-steroidal anti-inflammatory drugs are often relatively contraindicated as a result of patient comorbidities such as existing cardiac or renal disease. Other potential pain adjuncts include clonidine, magnesium, ketamine and intravenous lidocaine.

Specific anaesthetic considerations

The anaesthetist must be aware of anaesthetic considerations specific to flap surgery. The primary goal of anaesthetic management is to ensure adequate flap perfusion and oxygenation. This is founded on the principles of the Hagen–Poiseuille equation.

Maintenance of perfusion

Perfusion to any organ is determined by the pressure gradient between the arterial inflow and venous outflow. Low mean arterial pressure results in a low perfusion pressure. Similarly, high venous pressure, even with normal mean arterial pressures, results in lower perfusion pressures which can threaten the flap.

Mean arterial pressure is maintained or increased in two ways:

1. Increasing cardiac output – typically by administering intravenous fluids
2. Increasing total peripheral resistance – by using vasoactive drugs such as phenylephrine or noradrenaline.

In addition, there is a complex interplay at the microvascular level between interstitial and colloid oncotic pressure forces, which can affect perfusion and oxygen delivery. Free flaps may have reduced lymphatic drainage initially, rendering them prone to oedema, although lymphatic drainage can return (Slavin et al, 1997).

Vasopressors

Vasopressors such as phenylephrine and noradrenaline are commonly used in free flap surgery. While vasopressors increase the mean arterial pressure effectively, there have been concerns regarding potential vasoconstriction, which could decrease blood flow to the flap. However, animal studies by Cordeiro et al (1997) and Lecoq et al (2008) demonstrated improved flap flow with increased mean arterial pressure compared to normal tissues. This may be a result of increased mean arterial pressure, coupled with a denervated flap reducing the local sympathetic mediated vasoconstrictive effects (Goh et al, 2019). A meta-analysis by Naik et al (2020) examining vasopressor use (including phenylephrine, ephedrine and noradrenaline) in head and neck flap surgery concluded they were not associated with flap failure or morbidity, and may even be beneficial. Inodilators such as dobutamine have shown improved flap blood flow in experimental studies (Cordeiro et al, 1997; Eley et al, 2013), but adrenaline has demonstrated conflicting results (Massey and Surgery, 2007; Eley et al, 2013). Studies to date have been heterogenous and no single vasopressor has demonstrated superiority.

Fluid therapy

Free flap surgery is long with multiple exposed operative sites, and potentially significant fluid losses, including blood. While it is important to replace these losses, over-administration of fluid can result in flap oedema. This may increase the pressure within the flap, decreasing the perfusion pressure and blood flow, which can impair oxygen delivery and lead to flap failure. Small studies to date show that goal-directed fluid management reduces intraoperative fluid administration and may reduce intensive care unit length of stay (Hand et al, 2016) and hospital length of stay (Jandali et al, 2020), as well as decreasing flap complications (Gupta et al, 2021). However, large, multicentre trials are required to verify this. Nevertheless, enhanced recovery after surgery (ERAS) Society guidelines recommend goal-directed fluid management as best practice (Dort et al, 2017). Several minimally invasive cardiac output monitors are available, as are more invasive methods. They all have limitations, and are best used and interpreted in conjunction with the overall clinical picture (Kobe et al, 2019). Indeed, the trends may be more helpful than any specific value. There is insufficient evidence to support advanced cardiac output monitors over systolic pressure variation aimed at goal-directed fluid therapy (Healy et al, 2021).

Fluids vs vasopressors?

There has been significant debate surrounding fluid management and vasopressor use, and their potential role in flap failure. Goal-directed fluid management results in better outcomes, whereas excess administration of fluid has been associated with increased flap failure (Lin et al, 2019). Despite concerns regarding vasopressors, multiple studies, systematic reviews and meta-analyses consistently fail to demonstrate a link between vasopressor use and flap failure (Fang et al, 2018; Goh et al, 2019; Naik et al, 2020). Indeed, based on current evidence, one could argue that judicious use of vasopressors may result in decreased intravenous fluid administration, and potentially mitigate against excess fluid administration, which has proven deleterious effects (Naik et al, 2020).

Temperature management

Hypothermia results in vasoconstriction, coagulopathy, increased risk of surgical site infection, decreased oxygen availability, and increased length of stay or prolonged recovery (Rauch et al, 2021). Nasal, pharyngeal and oesophageal temperature recording is impractical. In free flap surgery, skin and core temperature (via urinary catheter or the rectum) should be monitored.

Choice of anaesthetic technique

The choice of anaesthetic has been debated. Volatile agents cause vasodilation and may enhance blood flow, whereas propofol causes a reduction in platelet aggregation potentially aiding microvascular flow. To date, there is no definitive evidence that either technique is superior, although some evidence suggests a possible benefit with total intravenous anaesthesia in cancer outcomes in general (Soltanizadeh et al, 2017).

Postoperative considerations

The extent of surgery and the patient's comorbidities will determine the location of postoperative care. This may be in a post-anaesthesia care unit, high dependency unit, intensive care unit or a ward experienced in treating ear, nose and throat patients undergoing extensive dissection and reconstructive flap surgery (Varadarajan et al, 2017). General adverse outcomes include major adverse cardiac events, infection and bleeding, so vigilance is required. Flap failure is a specific and significant risk in the postoperative period. Regular flap monitoring is vital and constitutes best practice.

Causes of flap failure

1. Decreased arterial flow – causes include issues with the anastomosis, low mean arterial pressure, microvascular thrombosis, vasospasm. Regular assessment of flap arterial supply with Doppler monitoring is important

Key points

- Head and neck cancer surgery with free flap reconstruction presents significant challenges for anaesthetists.
- Thorough medical preoperative assessment should also include nutritional and psychological evaluation.
- Detailed knowledge of flap anatomy and physiology, and skills in advanced airway techniques are essential.
- Debate remains regarding the use of fluids and vasopressors in free flap surgery.
- Currently, best practice constitutes goal-directed fluid therapy, with judicious use of vasopressors to maintain an appropriate mean arterial pressure, avoiding over administration of fluids.

2. Decreased venous flow – causes include issues with the anastomosis, vasospasm, microvascular thrombosis, compression. Regular assessment of colour and capillary refill is required, ensuring dressings are not causing venous compression
3. Oedema – oedema increases pressure within the flap, decreasing blood flow and impairing oxygen delivery. Free flaps can have reduced lymphatic drainage and are prone to developing oedema.

Several studies have attempted to identify predictors of flap failure, often with conflicting results. Potential predictors include overadministration of fluid, the reason for surgery, duration of surgery and anaesthesia, and existing comorbidities such as coronary artery disease (Hand et al, 2015; Burkhard et al, 2021).

General considerations

It is vital to ensure adequate perfusion and oxygenation in the postoperative period. Strategies include maintaining a mean arterial pressure close to the patient's baseline, careful fluid management to prevent oedema, temperature control (typically the patient is placed in a heated room), and adequate analgesia to reduce the stress response and catecholamine release. A meta-analysis by Newton et al (2020) demonstrated the potential role of near-infrared spectroscopy monitoring and improved flap outcome. However, numbers were small and further research is required.

Postoperative delirium is common post extensive head and neck surgery. A study by Booka et al (2016) found an incidence of 17%, occurring most frequently between 1 and 3 days postoperatively. Multivariate analysis demonstrated age >70 years to be a significant risk factor.

Conclusions

Anaesthesia for head and neck cancer surgery with flap reconstructive surgery requires specific knowledge and skills. Detailed preoperative assessment and expertise in advanced airway management techniques are essential. A thorough understanding of flap physiology and a tailored anaesthetic approach can be crucial to flap survival. Recommendations and consensus statements offer guidance on current best practice. While the vasopressor vs fluid debate continues, goal-directed fluid therapy appears to improve outcomes and vasopressors have consistently shown no harm. New risk stratification scoring systems are emerging, prehabilitation offers the hope of further improving outcomes into the future, and near-infrared spectroscopy monitoring may have an emerging role in postoperative flap monitoring.

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Conflicts of interest
The authors declare that there are no conflicts of interest.

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