REVIEW & SPECIAL ARTICLE

Perioperative Anesthetic Considerations for Head and Neck Free Flap Reconstructions: A Narrative Review

Sasima Dusitkasem, MD[1], Thiothong Sirimusika, MD[1], Rojnarin Komonhirun, MEd[1]

[1] Department of Anesthesiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

Microsurgical free flap reconstruction remains the primary standard of care for managing complex defects, following advanced head and neck cancer resections. Although success rates have improved substantially, these complex procedures represent a major challenge to achieve the optimum patient and flap outcomes. Recent advances in preoperative evaluation and anesthetic management focus on patient optimization and perioperative care to maximize free flap survival and reduce complications.

Keywords: Head and neck surgery; Free flap reconstruction; Flap survival; Anesthesia management; Perioperative care

Received 30 June 2025 | Revised 6 January 2026 | Accepted 12 January 2026

J Med Assoc Thai 2026;109(2):162-74

Website: http://www.jmatonline.com

Head and neck free flap microvascular reconstruction is widely considered the standard of care for repairing large defects following tumor removal or trauma. Depending on the complexity of the defect, surgeons may use osteocutaneous flaps to provide tissue similar in type and volume to the resected defect. For example, the fibula free flap (FFF) or the iliac crest flap is used for mandibular reconstruction. The first microvascular free flap was performed in 1958, when a jejunum segment was used in an esophageal reconstruction[1]. Since then, success rates have improved substantially from 40%-50% to 90%-99%[2,3]. Reported flap failure rates remain a major concern for the patient and the medical teams as they range from 0.8% to 10.6% of cases[4]. Anesthetic-related factors including hemodynamic control, fluid therapy, and the use of vasopressors may influence blood flow in the flap and subsequently flap survival. The aim of the present literature review was to provide an update on recent advances in preoperative evaluation and anesthetic management, which is essential for optimizing surgical outcomes in these patients.

Correspondence to:

Dusitkasem S.

Department of Anesthesiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, 270 Rama VI Road, Ratchathewi, Bangkok 10400, Thailand.

Phone: +66-2-2011513

Email: sasima1308@gmail.com

How to cite this article:

Dusitkasem S, Sirimusika T, Komonhirun R. Perioperative Anesthetic Considerations for Head and Neck Free Flap Reconstructions: A Narrative Review. J Med Assoc Thai 2026;109:162-74.

DOI: 10.35755/jmedassocthai.2026.2.03222

Preoperative evaluation

The preoperative assessment for flap surgery should include a comprehensive evaluation of the patient's medical history, physical condition, and specific risk factors to optimize outcomes. Moreover, recognizing patients with potentially challenging airways and optimizing their physiological status prior to major surgical procedures are critical components of safe perioperative care. Preoperative assessment of risk factors for flap complications should include:

- Co-morbidity and preoperative nutritional status
- History of smoking
- Preoperative anemia
- Preoperative radiotherapy
- Surgical technique
- Clinical and physical examination and laboratory testing

Patients with head and neck cancer (HNC) are frequently elderly, with significant histories of tobacco and alcohol use. These patients are highly susceptible to cardiorespiratory disease and malnutrition. A retrospective study from 2016 found that diabetes, peripheral artery disease, kidney failure, prior radiation, and a duration of anesthesia greater than 18 hours are associated with higher rates of flap failure[5]. Preoperative malnutrition has been associated with impaired wound healing, increased risk of infection, and a higher incidence of postoperative complications[6,7]. According to

Nesemeier et al.'s review, individualized nutritional optimization in HNC patients can reduce the length of hospital stay by several days, compared to standard care. Perioperative nutritional support can also significantly lower the incidence of infectious complications and reduce rates of wound dehiscence by supporting metabolic demands for healing[8].

Tobacco use significantly exacerbates cancer-related cachexia and sarcopenia in HNC patients through several biological mechanisms that directly impair wound healing[9]. In a study of 2,193 patients, Crippen et al. found that smokers undergoing head and neck free-flap reconstruction have a significantly higher risk of postoperative wound disruption (OR 1.74) and unplanned reoperation within 30 days (OR 1.50)[10]. Smoking cessation three weeks prior to surgery diminishes airway sensitivity during anesthesia, reduces cardiopulmonary adverse events, and mitigates complications related to wound healing consistent with the time needed for mucociliary and macrophage recovery[11].

Preoperative anemia is a critical, modifiable risk factor in microsurgery, significantly influencing both flap viability and systemic recovery. A retrospective study in 2012 found that anemia, with a hematocrit (Hct) cut-off of less than 30%, increases the risk of free flap failure[12]. A 2017 meta-analysis of 4,984 patients confirmed that preoperative anemia increases the risk of free flap failure and post-operative transfusion, which is also associated with increased flap complications[13].

Prior radiotherapy is a known contributor to increased postoperative wound issues and correlates with flap failure at irradiated recipient locations[14,15]. A history of radiotherapy can also affect the patient's airway. Mandibular osteoradionecrosis (ORN) remains one of the most debilitating late-stage complications of radiotherapy for HNC, primarily due to radiation-induced damage to the bone's microvasculature[16]. Preoperative evaluation should also include assessing the size of the tumor and the severity of trauma for trauma cases. A thorough history of any prior head or neck surgeries, along with imaging such as computed tomography (CT) and magnetic resonance imaging (MRI), and endoscopic evaluations are also important. As each patient's disease and pathological presentation are different, intubation planning may vary.

Vessel anastomosis has a profound influence on flap success, with venous anastomosis being a particularly critical factor. A 2025 prospective cohort study by Hennocq et al., examining 307 free flaps, indicated that surgical technique and decisions are more significant prognostic factors for free flap failure in head and neck reconstruction than patient characteristics. This study concluded that patient age, cardiovascular risks, and radiotherapy history did not show a statistical link to failure risk, while the venous anastomosis site and intraoperative revisions were identified as significant risk factors[17].

Recommended preoperative investigations include a complete blood count, coagulation profile, electrolyte and renal function assessments, blood glucose levels, chest X-ray, and electrocardiogram (ECG). Additional tests such as echocardiography, pulmonary function testing, or blood gas analysis may be warranted based on the patient's clinical condition. Blood typing and preparation of blood reserves are essential[18].

Intraoperative monitoring

Free tissue transfer surgery is typically prolonged and linked to significant blood loss, hypothermia, electrolyte imbalances, and hemodynamic instability, necessitating careful monitoring to guide resuscitation and ensure adequate free flap perfusion. Effective monitoring for this patient group involves standard American Society of Anesthesiologists (ASA) monitors, core temperature monitoring, and Foley catheter insertion for urine output tracking. In addition to standard monitoring, the implementation of invasive monitoring is determined by both pre-existing patient conditions and surgical complexity. Incorporating an arterial line facilitates serial laboratory testing and enables the use of goal-directed fluid therapy (GDFT), which allows for more precise fluid management, thereby reducing the volume of crystalloids needed to maintain optimal hemodynamics and mitigating the risks associated with fluid overload and flap edema.

Fluid management

Perioperative fluid administration significantly influences flap viability and patient outcomes following head and neck free flap reconstruction. Several lines of evidence suggest that free tissue is particularly vulnerable to the negative consequences of interstitial fluid accumulation and venous stasis[19-21]. A 2021 retrospective study found that excessive fluid administration during surgery was associated with increased flap complications, necessitating the use of diuretics to manage fluid overload, which was also associated with increased surgical revisions[22]. A study by Clark et al. also found

that the administration of more than 130 mL/kg per 24 hours of crystalloid was a predictor for medical complications, including heart failure, pulmonary edema, and cardiac arrhythmia[23]. It was also noted that intraoperative crystalloid administration exceeding seven liters was correlated with a 2.75-fold increased risk of flap complications[19]. However, fluid under-resuscitation may put patients at risk for unstable hemodynamic status during surgery and can also cause flap thrombosis[24].

Numerous studies have evaluated tailoring fluid administration to individual needs. The goals are to ensure adequate cardiac output and oxygenation for the patient and to prevent tissue hypoperfusion. There is increasing evidence to support the use of GDFT compared to conventional fluid management (CFM) for appropriate fluid management in patients undergoing microsurgery of the head and neck. GDFT involves administering fluids based on patient fluid responsiveness by monitoring cardiac output, stroke volume variation (SVV), or pulse pressure variation (PPV). It also enables the utilization of vasoactive drugs and inotropic support to optimize hemodynamic objectives. A retrospective study by Lahtinen et al.[25] evaluated GDFT using SVV with a Vigileo FloTrac® device in patients undergoing free flap surgery for HNC. The protocol included administering a 250 mL Ringer acetate bolus if SVV exceeded 10% or increased significantly from baseline, and using dobutamine to maintain a target cardiac index (CI) greater than 2 L/min/m². The authors concluded that SVV-guided strategies reduced fluid requirements and hospital length of stay without causing a statistically significant change in postoperative complications. An observational study by Tapia et al.[26] evaluated the effectiveness of GDFT in HNC patients undergoing microvascular surgery with free flap reconstruction. The study utilized SVV via FloTrac® to optimize volume status, aiming to maintain a CI of 2.5 L/min/m² or greater and mean arterial pressure (MAP) greater than 70 mmHg. Results showed that GDFT was associated with a significantly lower free flap necrosis rate of 13.6% and a reduced hospital length of stay compared to CFM at 37.1%.

According to a study by Hand et al.[27], a GDFT protocol utilizing FloTrac/Vigileo monitoring was shown to significantly improve outcomes for patients undergoing head and neck free tissue transfer. While the control group received crystalloids and colloids to maintain a MAP above 70 mmHg or within 20% of baseline, the GDFT group utilized vasopressors for fluid non-responders when MAP fell below 75 mmHg or decreased by more than 10% from baseline. This approach resulted in a significantly reduced intensive care unit (ICU) length of stay, averaging 24.6 hours, and a shorter duration of mechanical ventilation compared to the control group at 0.81 versus 1.72 days. In a study by Kim et al.[28], a GDFT protocol for head and neck free flap surgery utilized FloTrac® monitoring to maintain SVV below 12% via colloid boluses. Hemodynamic stability was further supported by the administration of dobutamine, ephedrine, or norepinephrine to sustain a CI of 2.5 L/min/m² or greater and a MAP of 65 mmHg or greater. This approach was associated with improved flap survival rates and reduced ICU length of stay compared to standard care, though overall hospital stay did not significantly differ. Taylor et al. found that a GDFT protocol incorporating vasopressors is safe and does not adversely affect free-flap survival or complication rates[29].

Most findings indicate that the GDFT protocol primarily utilizes enhanced monitoring with a Flo Trac®/Vigileo® to effectively guide intraoperative fluid management while preventing fluid overload during free flap transfer procedures. Nevertheless, other outcomes such as postoperative complications, duration of mechanical ventilation, and total ICU and hospital length of stay demonstrate inconsistency across various clinical studies[25-30]. These inconsistent findings may be attributable to the heterogeneity of protocols and standards across the included studies. Several studies were retrospective and non-randomized in design. In addition, the application of GDFT protocols varied across studies, with techniques and variables differing among anesthesiologists. Furthermore, the low incidence of major flap complications, at 3.3%, can statistically obscure the relationship between excessive fluid administration and flap survival. Considering the potential for adverse effects from excessive intraoperative fluid administration, the implementation of GDFT could offer benefits and is suggested in tailoring fluid management to individual patient needs, potentially reducing a contributing factor to free flap complications.

Vasopressor administration

Overall, hypotension in free flap surgery is caused by patient conditions, anesthetic agents, and blood loss. Microvascular surgeons have traditionally avoided vasopressor use during free tissue transfer due to concerns about vascular pedicle vasospasm.

Table 1. Commonly used vasopressors in free flap surgery

Vasopressor	Pharmacologic target	Physiologic effect	Adverse effect	Flap survival and major outcomes
Phenylephrine[41-46]	α-1 adrenergic agonist	Vasoconstriction (↑SVR)	Reflex bradycardia, hypertension, arrhythmia	No difference in major flap complications
Ephedrine[41-46]	β-1 and α-1 adrenergic agonist Moderate β-2 agonist	Vasoconstriction, ↑ endogenous NE, ↑ inotropic chronotropic effect	Tachycardia, arrythmia	No significant differences in flap outcomes
Norepinephrine[40,47,48]	Strong α-1 and β-1 adrenergic agonist	Vasoconstriction (↑SVR), ↑CO	Reflex bradycardia, arrhythmia	↑ flap skin blood flow, no difference in flap survival
Dopamine[39,40]	Moderate D1 agonist Dose dependent β-1 and α-1 agonist	Low dose: vasodilation (↓SVR) Intermediate dose: ↑CO, ↑SV High dose: vasoconstriction (↑SVR, ↑CO)	Tachycardia, hypotension, arrythmia	No significant differences in flap failure or major complications
Dobutamine[27,28,39]	Strong β-1 and moderate β-2 agonist	Vasodilation (↓SVR), ↑CO due to chronotropic and inotropic effect	Tachycardia, arrythmia	↑ flap survival rates in treatment group, no difference in reoperation rate
Epinephrine[29,39]	Strong β-1 and α-1 agonist Moderate β-2 agonist	Low dose: ↑CO High dose: ↑CO and ↑SVR	Tachycardia, arrythmia, splanchnic vasoconstriction	↓ flap skin blood flow, no difference in flap-related complications

CO=cardiac output; SVR=systemic vascular resistance; ↑=increase; ↓=decrease

This practice is reinforced by animal model studies suggesting caution with vasopressor use in free flap surgery[31-33]. A 2007 animal study[32] demonstrated that local phenylephrine application decreased pedicle artery blood flow. Conversely, another study[34] indicated that systemic administration of the agent resulted in relatively stable flap perfusion. Epinephrine was shown to improve cardiac output and subsequently increased flap blood flow[33]. In a comparative analysis of inotropic agents, dopamine does not significantly alter total blood flow to island musculocutaneous flaps, despite markedly increasing cardiac output. In contrast, dobutamine administration resulted in significantly enhanced pedicle flow[31].

Despite animal studies advocating for cautious human application, high-quality clinical data suggests a different outcome in human patients. Most studies reveal that perioperative use of vasopressors does not adversely affect free flap survival in head and neck reconstructive surgeries. In a study comparing GDFT to conventional management, Philteos et al.[35] observed a significantly higher administration of vasopressors and inotropic agents within the GDFT group. Nonetheless, this approach did not significantly change the rates of postoperative flap or medical complications compared to conventional management. A large multi-institutional database study involving 10,699 patients confirmed that vasopressor use in HNC patients is not linked to a higher risk of free flap complications or failures[36]. Moreover, a 2023 meta-analysis by Michelle et al. demonstrated that perioperative vasopressor use in head and neck reconstruction was safe and significantly improves outcomes, reducing flap-specific complications by 31%[37].

Different studies utilized a variety of vasopressor agents such as phenylephrine, ephedrine, dopamine, and norepinephrine. Most studies indicate that vasopressors do not exhibit a negative influence on free flap outcomes in head and neck surgeries, regardless of dose, timing, or administration method[37,38]. A study by Eley et al.[39] compared the effects of four different agents on blood flow in free flaps at varying infusion rates in random order. They concluded that norepinephrine was the optimal pressor, as it produced the greatest increase in free flap skin blood flow. In contrast, infusions of dopexamine and epinephrine were found to decrease blood flow in the free flaps without compromising the flap. A study by Raittinen et al.[40] suggests that the use of norepinephrine and dopamine did not result in a significant difference in the free flap failure rate, complication rate, or clinical variables among groups managed with different hemodynamic protocols. A retrospective study of 4,888 patients undergoing head and neck, breast, and extremity free flap reconstruction between 2004 and 2014 found that the use of phenylephrine, ephedrine, and calcium chloride decreased intraoperative fluid requirements, with no difference in flap complications observed between vasopressor and non-vasopressor groups, nor among the three types of vasopressors[41]. Further support was provided by a 2016 meta-analysis[42] of four cohort studies, including 933 head and neck free tissue transfer patients, which demonstrated that vasopressor use, primarily with ephedrine and phenylephrine, did not lead to a statistically significant difference in flap complications. The timing of administration also had no effect on the flap outcomes. Table 1 demonstrates commonly used vasopressors in free flap surgery[27-29,39-48].

The physiological benefits of increased systemic perfusion pressure in patients receiving vasopressors likely outweigh the theoretical risks of pedicle vasospasm. In a multivariate analysis of 445 patients, Kass et al. established that intraoperative hypotension and aggressive fluid resuscitation independently increase the risk of free-flap failure[49]. Traditional approaches to intraoperative hemodynamic management in free flap surgery prioritize colloid and crystalloid administration over vasopressors, which could result in complications from fluid overload and tissue edema. The use of vasopressors may offer benefits in tailoring fluid management to individual patient needs, potentially reducing a contributing factor to free flap complications. Moreover, the denervated flap vessels may respond differently to circulating vasopressors than the innervated recipient vessels at the anastomosis site. Surgical adventitiectomy, however, immediately prevents vasoconstriction induced by alpha-adrenergic agents at the recipient site[32,50-52].

While current evidence largely supports the administration of vasopressors in free flap procedures, determining clear guidelines for vasopressor use during head and neck free flap surgery remains challenging. There is significant variability in the definition of intraoperative hypotension and the decision to use intraoperative vasopressors reported in the literature. Data from a retrospective medical record review by Gardner et al.[53] showed that the goal of maintaining a MAP of 80 mmHg with continuous vasopressors was not associated with an increased rate of unplanned reoperation. Nevertheless, studies on free flap surgery employ various GDFT strategies that use vasopressors. These strategies often use SVV monitoring to guide fluid administration, while the MAP targets in these studies typically range from 65 to 75 mmHg[25-30]. Moreover, heterogeneity across existing studies remains a significant limitation. Consequently, the development of definitive, evidence-based clinical guidelines and protocols for the application of vasopressors in free flap surgery necessitates further investigation through high-powered randomized controlled trials.

Colloid administration

Aggressive fluid resuscitation during free flap reconstruction was found to be a predictor of both significant general medical issues and specific flap-related complications[19]. In theory, colloids may be preferred over crystalloids for achieving hemodynamic stability because they require a smaller infused volume, potentially reducing the risk of fluid overload and tissue edema. The use of colloids in free flap surgery remains a subject of ongoing debate, largely due to a paucity of specific literature on the topic. A retrospective study by Xu et al.[54] found that perioperative albumin supplementation in patients who underwent microvascular free flap reconstruction following oral and maxillofacial tumor resection was associated with a reduction in local complications, shortened hospital stays, and decreased crystalloid requirements. However, the authors proposed that these positive outcomes were likely attributable to the correction of underlying malnutrition rather than merely the fluid-resuscitation effects of the albumin. A triple-blinded randomized controlled trial by Arellano et al.[55] found that large-dose 10% hydroxyethyl starch (HES) impaired coagulation and led to significantly more allogeneic red blood cell transfusions compared to 5% albumin during major reconstructive surgery.

Current practice emphasizes GDFT using either fluid type to maintain optimal hemodynamics and tissue perfusion. A 2019 randomized controlled trial by László et al.[56] comparing goal-directed 6% HES with Ringerfundin in free flap surgery, found that the crystalloid group required significantly more fluid volume, 1.5 times more, to maintain hemodynamic stability. Despite the difference in volume administered, Doppler flowmetry detected no differences in microcirculation within the control or flap areas between the two groups. This result was corroborated by a meta-analysis of 15 randomized controlled trials, with 2,956 patients, by Niu et al., which concluded that colloids offer no general benefit over crystalloids in non-cardiac surgery under GDFT protocols, regarding overall postoperative complications or mortality[57].

While the use of colloids is common and theoretically advantageous for minimizing edema, evidence from direct free-flap studies suggests they offer no clear benefit over crystalloids in terms of flap survival when used within a monitored GDFT protocol. Moreover, general meta-analyses in critically ill patients have raised safety concerns regarding synthetic colloids, specifically HES, linking them to a significant increase in the risk of renal injury requiring renal replacement therapy[58]. Future research with larger sample sizes is necessary to provide evidence that balances the theoretical benefits of colloid administration against safety concerns raised in general critical care populations.

Perioperative blood transfusion (PBT)

Major HNC free flap surgeries are often accompanied by significant blood loss, which frequently necessitates PBT. However, PBT is an independent risk factor associated with increased general patient morbidity and potentially negative long-term oncologic outcomes[59,60]. Therefore, determining the appropriate hemoglobin (Hb) threshold requires a delicate balance between ensuring adequate oxygen-carrying capacity for the microcirculation to maintain flap viability and minimizing exposure to the inherent complications associated with blood transfusions.

Several studies have investigated the impact of different Hb and Hct thresholds, and the results mostly support a restrictive transfusion strategy. A study by Rossmiller et al.[61] concluded that lowering the transfusion trigger from a liberal Hct of less than 30% to a restrictive Hct of less than 25% significantly reduces the number of units transfused without increasing flap-related complications. Flap loss rates were similar between the two groups at 2.3% versus 6.7%, which was not statistically significant. Skoog et al.[62] demonstrated the safety of a restrictive transfusion threshold of Hb of less than 7 g/dL compared to a liberal threshold of Hct of less than 26% in head and neck free flap surgery, reporting no statistically significant difference in flap failure rates at 5.31% versus 6.70% (p=0.67). On the other hand, in a 2018 retrospective study of microvascular reconstruction involving the head and neck, breast, and extremities, Kim et al.[63] found that PBTs did not correlate with flap complications. Instead, patient age and the minimum perioperative Hb level served as significant predictors of failure, with a suggested transfusion threshold of 8.75 g/dL, with a sensitivity of 73% and specificity of 67%.

Low preoperative Hb of less than 10 g/dL is a strong predictor for requiring PBT. Indeed, a recent systematic review and meta-analysis confirmed that patients with preoperative anemia were significantly more likely to receive a blood transfusion at 47.62%, than patients with normal Hb levels, at 13.92%[64]. These findings suggest that by identifying and treating anemia before surgery, clinicians can potentially minimize the need for PBT and its associated risks in current clinical practice.

Limited data are available to determine the optimal Hb thresholds for transfusion initiation in patients undergoing free tissue reconstructive surgery, despite research in critically ill and trauma patients demonstrating associations between blood transfusions and adverse outcomes. Significant heterogeneity exists in PBT practices across centers performing this type of surgery. PBT exposure varies widely between institutions, between 19% and 85%, as do the transfusion triggers between 7 and 10 g/dL[64]. Current evidence suggests that a restrictive transfusion threshold of Hb 7 to 8 g/dL is safe for the majority of free flap recipients and does not elevate the risk of flap failure or postoperative morbidity. Ultimately, clinical judgment, informed by patient-specific variables such as hemodynamic stability, cardiovascular reserve, and clinical symptoms of anemia, remains crucial in determining the appropriate trigger for transfusion.

Anesthetic maintenance

General anesthesia continues to be the established standard for head and neck free flap reconstructions due to the extreme duration and technical complexity of these procedures. Although success rates are high, flap failure occurs in 0.8% to 10.6% of cases[4], often precipitated by ischemia, reperfusion injury, and infection. The ischemia-reperfusion (IR) injury occurs following anastomosis, when the reintroduction of blood flow triggers the release of proinflammatory factors and oxygen-derived free radicals. The administration of volatile anesthetics, such as sevoflurane, desflurane, and isoflurane, offer potential pharmacological preconditioning against IR injury while simultaneously influencing microvascular resistance.

Animal studies have demonstrated a protective effect of volatile anesthetic preconditioning. Dohar et al. suggested that the choice of anesthetic may impact the survival rate of random skin flaps, with isoflurane demonstrating the greatest increase in mean skin flap survival area in pigs when compared to nitrous oxide, euoxemic, and hyperoxygenated groups[65]. In 1994, another animal study found that isoflurane with nitrous oxide reduced peripheral vascular resistance and increased blood flow to musculocutaneous flaps four times compared to ketamine and xylazine[66]. In clinical research, isolating the impact of volatile anesthetics on microvascular flap outcomes remains inherently complex. This difficulty is attributed to the multifactorial nature of flap survival, where the specific anesthetic agent is frequently obscured by dominant surgical and patient-specific variables. A study by Claroni et al. concluded that sevoflurane preconditioning provides transient benefits against IR injury during microvascular flap transfer, but its long-term clinical impact is limited, and flap survival

rates remained comparable between the anesthetic cohorts[67].

Total intravenous anesthesia (TIVA), primarily using propofol and short-acting opioids, is a common alternative to inhalational anesthesia for head and neck free flap surgery. Evidence from clinical trials indicates that TIVA offers advantages in reducing postoperative complications. A 2016 retrospective study by Chang et al. compared TIVA with inhalational anesthesia in 156 patients undergoing head and neck free flap surgery. The results indicated that the TIVA group required less fluid for hemodynamic stability and developed significantly fewer pulmonary complications[68]. These findings were confirmed by a 2022 randomized clinical trial, which demonstrated that TIVA significantly reduces the rate of postoperative pulmonary complications (PPCs), such as pneumonia and atelectasis, compared to inhalational anesthesia at 14.3% versus 40.0%[69]. Furthermore, TIVA provides a more stable hemodynamic profile, exhibiting less hourly fluctuation in MAP and systemic vascular resistance relative to volatile agents. Importantly, both the 2016 retrospective study and the 2022 randomized clinical trial demonstrated that flap outcomes were comparable between the two cohorts, with no statistically significant variance observed[68,69]. Research continues to support dexmedetomidine as a safe and effective adjuvant in microvascular free flap surgery. While dexmedetomidine was previously avoided due to potential vasoconstrictive risks, a 2024 study by Bista et al. concluded that dexmedetomidine is more effective than fentanyl as an adjuvant for managing hemodynamics during complex head and neck free flap surgeries[70]. Moreover, Goswami concludes that it effectively manages postoperative agitation and ensures hemodynamic stability without detrimental effects on microvascular free flap outcomes[71].

Given the limited data available from current studies, it is difficult to determine the impact of specific anesthetic agents on flap outcomes. Instead, research indicates that meticulous hemodynamic management is a more critical factor than the specific selection of anesthetic agents. Consequently, current anesthetic management employs a balanced approach of inhalational and intravenous agents, with selection tailored to the specific surgical requirements and patient profile according to established safety profiles.

Enhanced recovery after surgery (ERAS)

ERAS for HNC with free flap reconstruction utilizes a multimodal, multidisciplinary framework focused on preoperative optimization, intraoperative stress minimization, and postoperative rehabilitation. Key preoperative recommendations include the administration of immunonutrition, mandatory smoking and alcohol cessation for at least four weeks prior to the procedure, and the reduction of fasting periods via carbohydrate loading two hours before anesthetic induction. During the intraoperative phase, protocols emphasize GDFT to prevent fluid overload, the maintenance of normothermia, and the use of opioid-sparing multimodal analgesia (MMA). Recommendations for the postoperative phase include continuing antibiotic prophylaxis for up to 24 hours, initiating early mobilization, typically within 24 hours, and conducting intensive clinical flap monitoring[72].

The integration of ERAS protocols into general anesthesia frameworks has been shown to reduce hospital length of stay without increasing the incidence of minor or major postoperative complications[73-76]. Recent evidence from study published in 2025 further emphasizes that high compliance with these multidisciplinary protocols significantly improves clinical outcomes while maintaining surgical safety[77]. Currently, the most consistent benefit of ERAS implementation remains a substantial reduction in both general hospital and ICU length of stay[73-76].

Despite its benefits, ERAS presents significant clinical and institutional limitations. While these protocols effectively mitigate medical complications, such as pneumonia, pulmonary edema, and delirium, they typically demonstrate no significant impact on surgical outcomes, including flap survival or reoperation rates. Furthermore, the multifaceted nature of ERAS, which often incorporates 15 or more concurrent elements, makes it technically difficult for researchers to isolate the efficacy of individual interventions. The inherent clinical heterogeneity of HNC patients also suggests that standardized protocols may not always be safe or feasible, particularly for those with advanced diseases or significant comorbidities. For example, surgeons often remain cautious regarding early oral intake following the reconstruction of the oral cavity or pharynx due to theoretical concerns over suture line dehiscence, and fistula formation. Consequently, while standardization is a core tenet of the ERAS framework, the complexity of head and neck surgery necessitates highly individualized management that can be challenging to integrate into a rigid, protocol-driven system.

Perioperative pain management

Regional anesthesia induces vasodilation, which may theoretically enhance blood flow and flap survival. However, its overall impact on free flap outcomes remains controversial. On one hand, Habib et al.[78] found that continuous thoracic paravertebral blocks at the T1-T2 levels favorably influence maxillofacial flap survival by improving tissue perfusion. Conversely, Jayaram et al.[79] identified regional anesthesia, alongside preoperative hemodynamic instability, as an independent risk factor significantly associated with flap failure. This discrepancy may be explained by the 'steal phenomenon,' wherein the RA-induced sympathetic blockade diverts blood flow away from the denervated free flap toward the surrounding innervated tissue, potentially precipitating flap ischemia. Furthermore, the risk of profound hypotension associated with neuraxial techniques remains a critical concern, as it may further compromise systemic and flap-specific perfusion.

Routine pain management for HNC surgery patients has traditionally relied on opioid medications. However, opioids are associated with a variety of adverse effects, ranging from gastrointestinal dysmotility, dose-dependent respiratory depression, and postoperative nausea to the potential for drug dependence and addiction[80]. A 2023 study by Ferreira et al. concluded that opioid-free anesthesia (OFA) significantly improves outcomes in head and neck microvascular free-flap reconstruction compared to traditional remifentanil-based approaches. OFA protocols were found to reduce overall postoperative complications from 78.9% to 53.3% and offered additional benefits such as shorter ICU stays, reduced duration of mechanical ventilation, and a decreased need for postoperative vasopressors[81].

MMA strategies, encompassing different combinations of preoperative and intraoperative interventions such as paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs), and gabapentin, have proven capable of reducing or eliminating opioid consumption in numerous surgical settings. A meta-analysis of 1,253 patients by Go et al.[82] demonstrated that MMA significantly reduces postoperative opioid requirements in head and neck free flap reconstruction without increasing surgical or systemic complications. The most commonly utilized agents included gabapentinoids, at 72.9%, NSAIDs at 44.6%, and corticosteroids at 25.1%. These findings confirm that MMA protocols, which prioritize non-opioid adjuncts, effectively optimize pain management while maintaining safety profiles comparable to standard regimens.

Despite potential benefits, surgeons may be reluctant to implement MMA techniques involving NSAIDs due to concerns regarding potential coagulopathy and hematoma formation, particularly in the highly vascular and anatomically sensitive head and neck region. A retrospective analysis by Chen et al. of 293 head and neck free tissue transfers revealed a significant association between preoperative NSAID use and increased hematoma formation at 26.2% versus 7.6%. Patients developing hematomas were more likely to experience flap compromise necessitating emergent re-exploration, although final total and partial flap failure rates remained comparable[83]. Kaplan et al.'s review of 126 cases also demonstrated comparable results, finding that NSAID intake within one week of surgery was a major predictor of postoperative hematoma formation (OR 6.73)[84]. In contrast, three independent investigations evaluating postoperative MMA protocols involving NSAIDs reported no statistically significant increase in hemorrhagic complications compared to traditional analgesic regimens[85-87]. Recently, a retrospective cohort analysis of 226 microvascular head and neck cases validated the safety of NSAID-inclusive MMA. The study found no significant variance in postoperative hemorrhage, reoperation rates, 30-day mortality, or total flap failure when compared to traditional pain management[88]. This discrepancy may be attributed to the use of MMA allowing for a more balanced and effective pain management strategy, which can result in lower overall NSAID consumption. The timing of NSAID administration may also be a factor. While preoperative use may induce a state of systemic anticoagulation, deferring administration until the postoperative period effectively reduces the duration of hematological exposure.

Comprehensive evidence confirms that MMA, including the routine administration of NSAIDs such as ketorolac, does not increase the risk of flap failure, hematoma formation, or other surgical complications in head and neck reconstruction. However, recent research suggests potential long-term limitations to this approach. A 2021 study by Hinther et al. demonstrated that MMA protocols effectively reduce perioperative opioid consumption without compromising pain control. Nevertheless, emerging evidence suggests that while MMA provides superior analgesia during the initial postoperative period, during the post operation day one to five (POD 1-5),

its efficacy may equalize with traditional management by the time of discharge, typically between POD 6-10[89]. Furthermore, a 2024 study by Wagoner et al. indicates that although MMA is highly effective in the acute phase, it may not significantly alter opioid prescription rates or pain scores at six weeks post-discharge compared to standard care[90].

While MMA protocols are highly effective at decreasing perioperative opioid requirements, their implementation presents clinical challenges. Non-opioid adjuncts carry specific side-effect profiles. As example, gabapentinoids may induce dizziness, sedation, and visual disturbances, which can potentially complicate early postoperative mobilization. Furthermore, significant heterogeneity exists in MMA protocols across different institutions. More extensive, multicenter randomized controlled trials are necessary to refine these strategies and definitively establish optimal pharmacological combinations for free flap patients.

Conclusion

Head and neck free flap microvascular reconstructive surgery involves anesthetic factors that may significantly affect the outcome. Anesthesiologists play a crucial role in preoperative assessment, airway management, perioperative monitoring, fluid administration, blood transfusion, anesthetic, and pain management. This review of recent literature provides evidence to optimize the management of physiological considerations and patient care of head and neck flap reconstruction.

What is already known about this topic?

Free flap reconstruction is the gold standard for head and neck surgery, with anesthetic management being critical for flap survival. Excessive fluid administration is detrimental, leading to tissue edema and venous congestion, while a historical reluctance to use vasopressors exists due to concerns over pedicle vasoconstriction. The optimal strategy for intraoperative management of hemodynamic stability and tissue perfusion remains to be defined, as no best-practice recommendations currently exist.

What does this study add?

This review provides a practical update by synthesizing recent evidence on key evolving topics. It clarifies the safe use of vasopressors, which challenges traditional practice, examines the application of GDFT, and assesses MMA strategies to reduce opioids. This serves as a contemporary guide for clinicians to optimize anesthetic management for head and neck free flap surgery.

Authors' contributions

SD supervised the project, drafted the manuscript, provided critical revisions to intellectual content, integrated diverse perspectives, and ensured the overall thematic consistency of the review. TS conducted the literature search and contributed to writing and editing process. RK provided general oversight of the project and refined the writing throughout all sections of the manuscript. All authors participated in the literature search, critically reviewed, and approved the final version of the manuscript.

Funding disclosure

The authors received no external financial support for the preparation of this review.

Conflicts of interest

The authors declare no conflict of interest.

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