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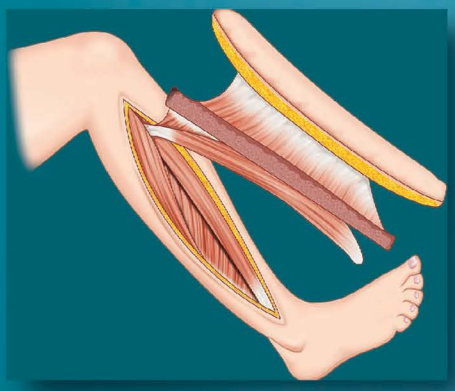
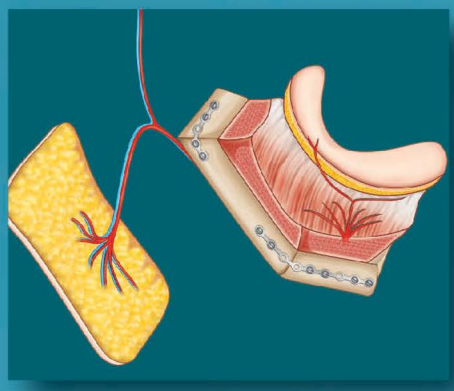
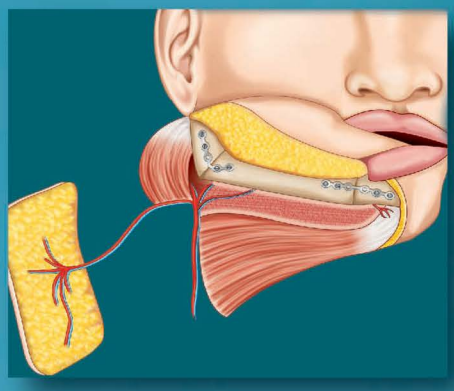

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Chapter 4

Anesthesia and Free Flaps

Vijaya Patil

INTRODUCTION

We the surgeons at Tata Memorial Centre are fortunate to have an excellent department of **Anesthesia**, **Critical Care and Pain**. The integrated services provides excellent peroperative care to our patients. Needless to say, the long hours of anesthesia and prompt response to a need for thrombotic exploration are a prerequisite for a microvascular unit. We can not thank enough our Anesthesia, Critical Care and Pain colleagues for providing relentless services and intellectual support to us.

Microvascular free flap for complex and extensive defects has revolutionized many surgeries, involving massive cancer resections.

The technique of free tissue transfer is complex. Initial flap failure rates reported in early '60s may have ranged as high as 40% to 50% but the overall failure rate quoted in recent literature is around 1–5 %. Despite improvement in surgical skills, loss of free flap represents major problems.

Anesthesia plays a major role in improving the success rate of this type of surgery by controlling the global hemodynamics and the regional blood flow. Many factors that an anaesthetist controls influence free flap microcirculation such as blood volume, vasoactive drugs usage, use of regional blocks, maintaining perioperative body temperature etc.

Free flap surgeries are different from other surgeries due to certain peculiarities of the flap.

- Usually only a single feeder artery and vein.
- Subject to warm ischemia during transfer making it susceptible to ischemia reperfusion injury on revascularization
- Denervated but responds to physical and chemical stimuli
- There is significant reduction in original blood flow in first 24-48 hours due to reperfusion injury
- No intact lymphatic drainage leading to increased risk of interstitial edema.

PHYSIOLOGIC CONSIDERATION

The guiding principle of anesthesia for free flap surgery is the maintenance of optimum blood flow to free revascularized tissue. The determinants of flow are summarized by the Hagen–Poiseuille equation

$$\text{Blood flow} = \Delta P \pi r^4 / 8 \eta l$$

Where ΔP = pressure difference between two ends of a tube, r = radius of the tube, η = viscosity and l = length of the tube.

From this we may deduce that the goals of anesthesia for free flap surgery are maintaining vasodilatation, good perfusion pressure and low viscosity.

ANESTHESIA MANAGEMENT

Preoperative Assessment

Principles of preoperative assessment and management remain same as for any other surgery. This includes proper history taking to assess functional status of patient, underlying pre-existing medical condition and eliciting relevant drug history followed by ordering for relevant investigations and finally optimizing for surgery.

In addition, different subsets of patients will have different set of problems peculiar to that patient population. Patients with head and neck malignancies are often elderly, poorly nourished, heavy smokers and drinkers and may have significant underlying cardiac and respiratory dysfunction. They are likely to have difficult airway due to primary malignancy or secondary to radiotherapy.

Postoperatively these patients are likely to have urinary catheters, nasogastric tubes and many a times endotracheal tube or tracheostomy. Preoperative counseling should include explanation of all these devices otherwise

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inability to talk or void urine can lead to agitation and irritation, excess movements and uncooperative state.

Conduct of Anesthesia

Balanced general anesthesia with adequate analgesia to reduce the stress response and catecholamine release is technique of choice. Since most of these surgeries are prolonged duration surgeries many anesthetists choose to avoid N_2O and use oxygen air mixture.

Volatile anesthetic agents remain preferred agents for maintenance of anesthesia. Almost all inhalational agents lead to decrease in blood pressure due to their effect on peripheral vascular resistance and myocardial contractility.

Studies using laser Doppler flowmetry to measure total flap flow in Guinea pigs have showed that during normovolemic conditions flap flow remains well maintained in both with halothane and isoflurane anesthesia; however, during mild to moderate hypovolemia flap flow decreases markedly with halothane anesthesia while it remains unchanged with isoflurane suggesting superiority of isoflurane.[1] Sevoflurane and Desflurane are probably the volatile agents of choice due to a combination of relatively stable cardiovascular conditions and rapid offset after prolonged surgery. In addition, the preconditioning effects of sevoflurane can protect endothelial cells against ischemia-reperfusion injury and become agent of choice in free vascular tissue transfers.[2] Also it has been demonstrated that sevoflurane, when compared with intravenous anesthetics such as Propofol, could have beneficial effects on the microcirculation by decreasing extravasation of plasma into the interstitial space, and thus limiting flap edema.[3]

Opioids constitute major part of anesthetic management as they are potent analgesic, minimize stress response to intubation, reduce requirement of volatile anaesthetic agents and have minimal effect on myocardial contractility or peripheral vascular resistance. Fentanyl, remifentanyl or alfentanyl are preferred drugs of choice due to their shorter half-lives allowing better titration and rapid recovery.

One can also use nonsteroidal anti-inflammatory agents that would maintain postoperative analgesia as well as will have opioid sparing effects.

The majority of patients can be extubated at the end of surgery. Emergence and extubation can be very challenging. At the time of extubation one should aim to have awake cooperative patient but at the same time care should be taken to minimise haemodyanamic responses and avoid movements at operative site. This is especially true in head and neck surgery and it is vital to ensure optimal analgesia before discontinuing the anesthetic.

Fluid Management

Traditional teaching has been to use hypervolemic hemodilution during anesthesia for free tissue transfer to maintain good flap flow by decreasing viscosity, increasing cardiac output and avoiding vasoconstriction.

However, studies do not support this assumption, rather almost all studies looking at fluid therapy in free flap surgeries have shown increased complication rates associated with more fluids. As free flaps have no lymphatic drainage they are prone to interstitial edema and so excessive fluid administration may in fact be detrimental.[4,5]

Achieving a balance between flap perfusion and prevention of hypervolemia is a major task of anesthetist. Maintenance of an adequate mean arterial blood pressure (MAP) and cardiac output is crucial. Combination of crystalloids and colloids to maintain good blood pressure and urine output of 0.5 mL/kg/hr can be used as a goal for fluid therapy. Retrospective analysis of 241 head and neck reconstruction has shown that more than 7 liters fluid infusion in entire intraoperative period was associated with increased flap complications.[6]

Crystalloid volume greater than 130 mL/kg/24 hrs was an independent predictor for medical complications in retrospective evaluation of 185 patients undergoing free flap reconstruction following ablation of head and neck cancer.[7] Another study showed increased complications of flap when patients received >6 mL/kg/hrs fluids.[8] All these findings suggest excess fluid is harmful and caution should be exerted while infusing fluids for these surgeries.

Role of Regional Anesthesia

Most of the studies in this field are done using epidural analgesia. Epidural analgesia provides good analgesia and by blocking sympathetic system induces vasodilatation, both of which should be beneficial in flap surgery. However, one has to take precautions so as to maintain normal blood pressure otherwise hypotension associated with sympathetic blockade will produce MAP dependent fall in flap blood flow.

A 'steal phenomenon' has also been proposed with blood flow diverted away from the denervated free flap to

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vasodilated vessels. Study done in human patients have shown that epidural block did not cause any change in microcirculatory flow in the intact skin and muscle, however, it resulted in a 20–30% decrease in microcirculatory blood flow in all the free flaps studied along with significant decrease in MAP.[9] However a recent case series has reported successful use of epidural anesthesia for gracilis free flap suggesting epidural anesthesia can be used in carefully selected patient.[10] Use of upper extremity blocks have been found to be effective over plain GA both regarding postoperative pain relief and microvascular flow in flap for microvascular surgeries in upper limb.[11,12]

Achieving Specific Goals of Microvascular Surgery

Maintaining Vasodilatation

1. **Avoid hypothermia**: Temperature control is very important for microvascular surgeries both during and after surgery. Hypothermia causes vasoconstriction and increases blood viscosity, both detrimental to flap perfusion. Minimize heat loss by keeping patient well-covered, using forced air warming blankets, warming mattresses and blood and fluid warmers. Many times preventing hypothermia is difficult task as multiple sites of surgeries or large operative fields increase heat loss and prevent application of effective warming measures. In such cases one can raise OT ambient temperature after discussion with surgeons.
2. **Maintain euvolemia**: Hypovolemia leads to vasoconstriction. In microvascular free flap surgeries there are more than one operating site that can increase insensible fluid loss. Also patients with faciomaxillary or intraoral malignancies tend to have difficulty in swallowing resulting in hypovolemic state preoperatively. Assessment of intravascular volume status and avoidance of hypovolemia is very important for good flap perfusion
3. **Good analgesia**: Pain is powerful stimulant for sympathetic stimulation leading to vasoconstriction. These patients need good analgesia in view of multiple incision sites, drains and sometimes awkward positions. Good analgesia reduces the level of circulating catecholamines and avoids the vasoconstrictor response to pain.
4. **Maintain normocapnea**: CO_2 is most potent systemic vasodilator. Hypocapnia commonly seen under anesthesia is not a benign clinical entity and leads to vasoconstriction and decrease in blood flow across various vascular beds including flap blood flow. There is increasing evidence that hypocapnia induces substantial adverse physiological and medical effects and should be avoided.

Maintaining Perfusion Pressure

The preservation of a good perfusion pressure is essential to flap survival. Appropriate anesthetic depth and proper fluid management are usually all that is needed.

During the dissection stages of surgery, especially for major tumor resection, surgeons might request for controlled hypotension to improve the surgical field and reduce blood loss which can be accomplished by increasing depth of anesthesia, infiltration of local anesthetic and vasoconstrictor, and optimum position to achieve unobstructed venous drainage.

After resection of primary site, during harvesting and anastomosis of the flap, mean arterial blood pressure should be maintained at a normal or slightly elevated level to ensure an adequate perfusion pressure through the graft tissue bed.

There is very little evidence to show that systemically administered catecholamines adversely affect flap blood flow. Almost all studies done are animal studies and have shown that blood flow to flap is directly proportional to MAP irrespective of the agent used.

In a study conducted on porcine model by Banic et al.[13] it was shown that systemic phenylephrine in a dose that increased the systemic vascular resistance and arterial pressure by 30% showed no adverse effects on blood flow in free musculocutaneous flaps.

Sodium nitroprusside, however, in a dose causing a 30% decrease in systemic vascular resistance and arterial pressure, caused a severe reduction in free flap blood flow despite maintaining cardiac output suggesting importance of perfusion pressure.

Suominen et al. compared dobutamine, dopamine and placebo on effect on blood flow in recipient and donor blood vessels in TRAM flap for breast reconstruction and concluded that if vasoactive agents are needed during microvascular surgery, dobutamine seems to be more advantageous than dopamine.[14] The recent study by Messy et al. in porcine model compared phenylephrine and epinephrine on their effect on blood flow across

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pedicled artery and microvasculature in flap. Results showed that epinephrine consistently increased both flows across the entire dose range whereas phenylephrine consistently decreased the pedicle artery blood flow and the microvascular perfusion. Furthermore, epinephrine-induced increases in cardiac output correlated well with the observed increases in pedicle artery blood flow and microvascular perfusion.[15]

Thus, the general recommendation is to use inotropes like dobutamine or adrenaline after ensuring that patient is not hypovolemic.

Prevention of Deep Vein Thrombosis (DVT)

Significant number of patients undergoing major surgery under general anesthesia develop DVT.[16] Though incidence of clinically relevant DVT is low, nonetheless if it happens it results in significant morbidity and mortality.

The eighth ACCP conference on antithrombotic and thrombolytic therapy make a strong recommendation for use of thromboprophylaxis to all major surgical procedures (procedures lasting for >1 hour) and prolong immobilization.[17]

One can use either unfractionated heparin 5000U SC bid or low molecular weight heparin once a day.

For patients at high bleeding risk one may consider using mechanical thromboprophylaxis. In surgeries, where bleeding can be a major problem, the surgeon should use Intermittent Pneumatic Compression devices both before and during the operation and in the early postoperative period. When it is deemed appropriate, anticoagulation should then be commenced.[18]

Maintaining Low Viscosity

The ideal hematocrit for patients undergoing free tissue transfer procedures are unknown.

For years physicians used the "10/30" rule (Hb of 10 and hematocrit of 30), but various[19] studies have shown that this is no longer a clinically useful value. There is a non-linear relationship between blood viscosity and hematocrit; viscosity rises steeply when the hematocrit exceeds 40%.

Studies have shown that most critically ill and surgical patients can tolerate much lower hemoglobin levels without adverse effects, but a safe threshold above which red cell transfusion is clearly unnecessary has not been established. Many observational studies have shown an association between red cell transfusions and infection[20,21] multiple organ failure,[22] increased ICU and hospital length of stay,[23,24] and mortality. In a pig model comparing partially well-perfused and partially ischemic flap, normovolemic hemodilution increased flap blood flow and increased oxygen tension in ischemic flap, with the optimum Hb being around 9 mg% and Hct just less than 30.[25] Recent observational cohort study done by Rossmiller and colleagues did not show increased flap failures by lowering transfusion threshold to hematocrit 25.[26]

Postoperative Care

Principles of postoperative care are same as for any other surgery which include keeping patients warm, pain free and hemodyanamically stable.

Coughing or vomiting can reduce flap flow by increasing venous pressure and should be avoided.

One can use intravenous patient controlled analgesia or continuous nerve blocks for analgesia.

In addition care has to be taken to maintain unobstructed venous flow by giving proper position and keep patient relatively immobile to avoid stress on vascular anastomosis. Since most of these patients remain immobilized or minimally mobilized for prolonged postoperative duration, thromboprophylaxis should be integral part of postoperative care in these patients. Patients requiring postoperative ventilation are generally admitted to ICU.

Glycemic Control

Perioperative period is a highly diabetogenic state due to hypermetabolic stress response which increases glucose production and causes insulin resistance.

In surgical patients, perioperative hyperglycemia has been shown to increase risk of postoperative mortality, and cardiovascular, respiratory, neurologic, and infectious morbidity.[27]

American Diabetes Association and the American Association of Clinical Endocrinologists currently recommend targeting blood sugar between 140–180 mg% with use of insulin infusion.[28]

Monitoring of Flap

Since microvascular flap depends on feeding artery and vein for its survival till development of collateral capillary circulation, flap needs continuous monitoring to identify problems of perfusion. The frequency with which flap observations should take place depends on individual practitioner and varies from as frequent as every 30 minutes to every 4–6 hours. The traditional methods of

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monitoring include mainly clinical observation of skin colour, capillary return and temperature of free skin flaps. However, the best of the currently available methods is laser Doppler flowmetry which allows more reliable and objective method of assessment of microcirculation of free flap. As the level of care required by patients of free flap surgery is, most centers prefer to admit them to high dependency unit (HDU).

CONCLUSION

Along with good surgical technique, good anesthesia technique and proper postoperative management are important contributors to outcome in free flap surgeries. Application of good physiological principles helps to attain these goals.

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