Original Research Article

CORRELATION BETWEEN PERIOPERATIVE HEMODYNAMICS AND FLAP OUTCOME IN MICROVASCULAR FLAP RECONSTRUCTION

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ABSTRACT

Background: Aim: To analyse the impact of intraoperative hemodynamic stability and anaesthetic factors on the success of microvascular free flap reconstruction.
Materials and Methods: A retrospective study was conducted in a tertiary hospital in India, from March 2023 to April 2024 after the data was collected and its analysis was done. A total of 30 patients were included in the study who underwent microvascular free flap reconstruction in the Department of Plastic surgery. All the patients who fit into the inclusion criteria during the stated period of time form the sample population.
Results: The overall success rate of free flap reconstruction was 90%. No significant differences in intraoperative systolic and diastolic blood pressure were observed between the success and failure groups, except at the time of anastomosis (SBP: $p < 0.001$, DBP: $p < 0.001$) and postoperatively (SBP: $p < 0.001$, DBP: $p < 0.001$). Use of noradrenaline to manage intraoperative hypotension did not negatively affect flap survival. Excessive fluid administration was associated with flap edema and increased failure risk.
Conclusion: Perioperative hemodynamic stability is critical for successful microvascular free flap outcomes. Noradrenaline is a safe and effective agent for maintaining blood pressure without compromising flap viability. Careful fluid management and stable hemodynamic control are essential to optimize flap survival rates. Further studies with larger sample sizes are warranted to validate these findings.
Keywords: Plastic Surgery, FLAP, Noradrenaline, Retrospective study.

INTRODUCTION

Microvascular flap reconstruction is one of the greatest achievements in surgical field to achieve the closure of various tissue defects. These defects maybe caused due to various etiological factors such as trauma, oncology, chronic infection or wounds.[1]
Free tissue transfer, in contrast to conventional surgical techniques provide a reliable and wide range of donor sites, resulting in improved flap characteristics.[2] The advantages of free flap being early mobilisation, reduced hospital stay and cost. However, due to its complex surgical technique, problems of hypoperfusion and flap necrosis continue to be a major problem, despite improvements in surgical skills.[3]
Numerous non-surgical factors determine the survival of free flap, including age, comorbid condition, haemodynamic status, rheology, temperature regulation, anticoagulants and other vasogenic drugs. Maintaining the hemodynamic stability and regional blood flow in the intra – operative period with anaesthetic agents is an important determinant factor in the success of free flap.
The Hagen – Poiseuille's equation helps in understanding the factors that determine the blood flow of the newly vascularised tissue. The viability

of the free flap is majorly influenced by the haemodynamic stability of the patient in the perioperative period. The major determinant of the success of free flap includes the use of vasoactive drugs, changes in blood volume and the maintenance of microcirculation in the peri operative period.

Preoperative evaluation and optimisation of the current comorbidities of patient is at most important prior to surgery. Intraoperative Optimisation of blood pressure and fluid management to maintain high cardiac output and low systemic vascular resistance is crucial to ensure the success of the flap. Both hypotension and hypoperfusion can be harmful to the flap, hence it is important to maintain stable hemodynamic during the surgery and in the early recovery phase. Perioperative care in a multidisciplinary team – based approach could improve the results of microvascular flap surgery.

There are many literatures supporting the surgical factors influencing the viability of microvascular free flap, but there are very few studies regarding the influence of anaesthetic factors on the outcome of flap. Hence this retrospective study was conducted to analyse the hemodynamic changes and the free flap outcome.

MATERIALS AND METHODS

A retrospective study was conducted in a tertiary hospital in India, from March 2023 to April 2024 after the data was collected and its analysis was done. A total of 30 patients were included in the study who underwent microvascular free flap reconstruction in the Department of Plastic surgery. All the patients who fit into the inclusion criteria during the stated period of time form the sample population.

Inclusion Criteria: Patients in the age group 25-75years undergoing elective microvascular free flap reconstruction under General anaesthesia; ASA class I& II; Surgical duration less than 8 hours.

Exclusion Criteria: (Deleted first criteria) Emergency surgeries and prior free flap failure; Coagulopathy (INR >1.5, platelets <100,000).; Surgery going beyond 8 hours; Severe vascular disease, pregnancy, chronic vasopressor/immunosuppressive use.

A qualified, experienced plastic surgeon performed the procedure. Pre induction standard ASA monitors, including ECG, NIBP, SpO_2, and capnography, were applied, and an arterial line was placed under local anesthesia (2% lignocaine, 1–2 mL) before induction for continuous blood pressure monitoring. Premedication included glycopyrrolate 0.2 mg IV, midazolam 1–2 mg IV, and morphine 0.1 mg/kg IV, followed by induction with propofol 2 mg/kg IV. Nasotracheal intubation using a nasal RAE tube was performed after administering vecuronium 0.1 mg/kg IV. Anesthesia was maintained with isoflurane at 1 MAC, and ventilation was set to volume-controlled mode with tidal volume 6–8 ml/kg, respiratory rate of 12–14/min and airway pressure targeted to P max of 15–25 cm of H2O, FiO_2 50% and $EtCO_2$ maintained between 35–40 mmHg. Intraoperatively, SBP was maintained between 100–130 mmHg, using intermittent boluses of propofol (20mg IV) if SBP exceeded 130 mmHg and fluid therapy was carefully titrated with balanced crystalloids (Ringer's lactate or Plasmalyte) to prevent excessive resuscitation and flap edema, if SBP dropped below 100 mmHg followed by noradrenaline infusion (0.03–0.05 mcg/kg/min) if the SBP did not respond to fluid resuscitation. The anaesthesiologist monitored and maintained the hemodynamic stability using fluids and inotropic agents and recorded the variation in vitals during the procedure and post procedure.

Postoperatively, the patient was shifted to the ICU for continuous hemodynamic monitoring and flap assessment. The patient remained paralyzed and sedated under controlled ventilation to optimize flap perfusion and minimize metabolic demand. Sedation was maintained with fentanyl (1–2 mcg/kg/hr) and midazolam (0.02–0.05 mg/kg/hr) infusions, while muscle paralysis was achieved with a vecuronium infusion (0.8–1.2 mcg/kg/min). Throughout the night, the patient was closely monitored for stable hemodynamics, adequate oxygenation, and flap viability, with regular assessments of temperature, capillary refill, ABG and flap glucose levels. The next morning, following a detailed flap assessment, sedation and paralysis were gradually tapered, the patient was weaned off mechanical ventilation, and extubated once stable. Post-extubation, the patient was provided supplemental oxygen and continued ICU monitoring to ensure optimal recovery and flap viability.

Data was collected on gender, age, Preinduction, post induction, intraoperative upto 6 hours, and post operative Blood pressure and heart rate, pre operative and post operative ABG reports.

All statistical analyses have been performed with SPSS version 23.0. Statistical significance was determined using independent t-test for continuous data. A p-value of ≤ 0.05 was regarded as statistically significant.

RESULTS

A total of 30 patients were included in the study. The average age among participants was 45.6±10.1 years old. The eldest participant was 62 years old, and the youngest was 25 years old. The average heart rate ranged from 75 to 95 bpm, with higher values seen during anastomosis. The comparison of average heart rate at specific intervals between successful and failed cases was not found to be statistically significant.

Table 1: Sociodemographic profile of participants

Variables	Sex		Re – exploration status		Flap Outcome		Blood Transfusion		Ionotropic Support	
	F	M	No	Yes	Successful	Failure	No	Yes	No	Yes
n	9	21	23	7	27	3	20	10	24	6
%	30	70	76.7	23.3	90	10	66.7	33.3	80	20

No significant differences ($p > 0.05$) in SBP and DBP between the Success and Failure groups was noted from pre induction to 6 hours post induction. Some borderline differences are noted at 2 hours (SBP, $p = 0.060$) and 5 hours (SBP, $p = 0.054$), but these are not statistically significant.

Post-Operatively, there is a significant increase in SBP ($p < 0.001$) and DBP ($p < 0.001$) in the Failure group, indicating a substantial rise in blood pressure. At Dissection, the Failure group had a significantly higher SBP ($p = 0.021$) but no significant DBP difference. At Anastomosis, there is a highly significant increase in both SBP ($p < 0.001$) and DBP ($p < 0.001$) in the Failure group compared to the Success group.

Table 2: Comparison of Blood transfusion among successful and failed cases

Blood Transfusion	Successful		Failure		P – value*
	n	%	n	%	
No	18	66.7	2	66.7	0.223
Yes	9	33.3	1	33.3	

****Chi – square test***

No statistically significant difference was noted in the success and failure group, if blood transfusion was given or not given after the flap reconstruction.

Table 3: Comparison of SBP and DBP among successful and failed attempt cases at specific intervals

BP	SBP					DBP				
	Success		Failure		P value*	Success		Failure		P value*
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Pre induction	123.37	8.92	132	9.89	0.910	80.7	7.47	72.67	1.52	0.078
Post-induction	110.78	5.79	113.5	7.77	0.782	71.7	8.17	77.33	14.15	0.299
1 hour	124.56	10.1	127.5	16.26	0.428	80.81	6.08	80.67	9.5	0.970
2 hour	124.11	9.25	117	2.82	0.060	80.52	5.63	77.33	8.08	0.378
3hour	124.70	8.71	120	11.31	0.883	80.22	6.69	84.33	7.23	0.325
4hour	127.44	9.91	116.5	9.19	0.578	80.52	5.91	78.67	4.16	0.604
5hour	124.45	9.22	114	2.67	0.054	79.89	5.35	82.33	6.42	0.467
6hour	122.15	8.71	117.5	3.53	0.138	81.26	5.88	80.67	4.72	0.868
Post-op	125.52	8.32	164	6.98	<0.001	77.3	7.28	96	3.46	<0.001
At Dissection	122.26	10.52	131.5	0.71	0.021	80.52	6.32	77.67	9.86	0.486
At Anastomosis	121.52	6.42	168.67	3.05	<0.001	76.41	7.5	96	2	<0.001

****Independent T-test***

No statistically significant differences between Success and Failure groups for pH, CO_2, and HCO_3, indicating similar respiratory and metabolic conditions. Lactate levels tend to be lower in the Failure group pre- and post-operatively, but this is not statistically significant. The Failure group showed a slight post-op pH increase (alkalosis), which might suggest a physiological response to stress or interventions like hyperventilation.

Table 4: Comparison of ABG values among successful and failed attempt cases

ABG values	Success		Failure		P value*
	Mean	SD	Mean	SD	
Pre-operative values					
pH	7.39	0.03	7.37	0.02	0.332
CO2	40.05	2.83	38.63	3.03	0.419
HCO3	24.01	1.17	23.53	1	0.502
Lactates	1.35	0.5	1.44	0.15	0.774
Post-operative values					
pH	7.39	0.03	7.42	0.03	0.15
CO2	39.75	2.91	40.06	2.7	0.85
HCO3	23.88	1.17	23.7	1.68	0.8
Lactates	1.43	0.48	2.34	0.05	<0.05

Independent T - test

DISCUSSION

During microvascular free flap reconstruction, optimal blood pressure control during the perioperative period is crucial to minimise patient morbidity and maximize free flap survival.[4,5] However, during induction and intraoperatively period, the general anaesthetic agents tend to induce systemic hypotension which can result in hypoperfusion of critical organs and the flap itself. The overall success rate of free flap noted in our study was 90%, which was similar to the reported rate in most previously published studies.[3]

The effects of different anaesthetic agents on the microvascular parameter of the free flap and its fluid distribution remain unclear.[6,7] Studies have shown that the use of inhalational anaesthetics compared with intravenous anaesthetics such as propofol has shown beneficial effects on microcirculation, reducing the plasma leakage into interstitial space and decreasing oedema. There is evidence showing the beneficial effects of inhalational agents like Sevoflurane on different mechanisms of ischaemia–reperfusion injury and Isoflurane maintains microcirculatory flow [8-10,19]. In this study, all the patients were maintained with inhalational anaesthesia isoflurane with MAC of 1 and intermittent bolus dose of 20mg intravenous propofol to maintain the systolic blood pressure less than 130mmHg.

Intraoperative hypotension may be dealt with by reducing the dosage of anaesthetic agents or increasing the volume of intravenous fluids. Reducing the dosage of anaesthetic agents is not feasible as a certain depth of anaesthesia needs to be maintained intraoperatively. Overzealous use of intravenous fluids may cause pulmonary oedema with resultant cardiopulmonary decompensation. Intravenous fluid infusion is associated with flap oedema and surrounding tissue oedema, which progressively impair flap microcirculation by mechanical compression of the microvasculature or pedicle vessels.[11,12] The free flap lacks lymphatic drainage and denervation of the free flap decreases interstitial fluid reabsorption, causing the free flap more prone to graft oedema, contributing to adverse flap outcomes.[13,14] Perioperative overzealous use of fluids is also associated with increased anastomotic thrombosis, flap complications and medical complications.[11,14]

The use of vasopressor may be necessary in certain situations to maintain an acceptable mean blood pressure. Spectral analysis of laser Doppler blood flow signals in free flap reconstruction patients has demonstrated that the use of norepinephrine, and control of blood flow shifted towards low-frequency vasomotion where blood flow depended mostly on an average blood pressure. Hence, the use of noradrenaline could be considered the most suitable agent following free flap reconstruction.[15]

In this study, the success group had stable blood pressure throughout the surgery, but on the contrary, the failure group had a drop in blood pressure post-induction. The blood pressure in the failure group was increased by giving intraoperative fluids and starting the patient on noradrenaline inotropic agents. There were 3 cases in the success group, where the use of noradrenaline inotropic agents to increase blood pressure had no adverse flap outcome.

The use of noradrenaline is noted to increase the free flap skin blood flow more when compared to other vasopressor agents, making it the most suitable inotropic agent during hypotension in patients undergoing free flap reconstruction. The noradrenaline acts on both alpha – 1 and alpha – 2 adrenergic receptors to cause vasoconstriction and thereby increase blood pressure.

In a retrospective review by Kelly et al., on the impact of intraoperative vasopressor use in free tissue transfer during the head, neck, and extremity reconstruction, it was found that the frequency of vasopressor use was 53.2% with no significant difference in flap outcome in patients who received vasopressors and those who did not.16 Another randomized controlled trial in patients undergoing ablative and reconstructive head and neck surgery with microvascular flap also showed noradrenaline to be safe and effective for use in the postoperative period when used to maintain MAP between 80 and 90 mmHg.[17]

The common cause of flap failure seen in the literature is multifactorial such as arterial (arterial thrombosis, vasospasm), venous (venous thrombosis, vasospasm, mechanical compression), flap oedema (overzealous use of fluids, hemodilution), generalised vasoconstriction (hypothermia, pain, respiratory alkalosis), hypotension (hypovolemia, myocardial depressants) and prolonged ischemia of the flap.[18] Venous thrombosis is noted to be the most common cause of flap failure followed by arterial obstruction.

CONCLUSION

This study emphasizes the critical role of perioperative hemodynamic stability in optimizing free flap survival during microvascular free flap reconstruction. A stable hemodynamic profile was noted in the success group, whereas the failure group exhibited intraoperative hypotension that required intravenous fluids administration and use of noradrenaline inotropic support.

Despite concerns regarding vasopressor use, our findings, along with evidence from previous studies, indicate that noradrenaline is a safe and effective agent for maintaining adequate mean arterial pressure (MAP) without compromising flap viability. Inhalational anesthesia, isoflurane, appears to offer beneficial effects on microcirculation, potentially reducing flap edema and ischemia–

reperfusion injury. However, excessive intravenous fluid administration should be avoided due to its association with flap edema and increased risk of anastomotic thrombosis.

Flap failure is multifactorial commonly attributed to venous thrombosis, arterial thrombosis, vasospasm, and mechanical compression a comprehensive approach involving meticulous intraoperative monitoring, judicious fluid management, and appropriate vasopressor use is essential for improving free flap survival rates. Future studies with larger sample sizes and randomized controlled trials are warranted to further refine perioperative management strategies and optimize surgical outcomes.

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