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ORIGINAL RESEARCH

# Aspects of perioperative management and outcomes of flap surgery at Charlotte Maxeke Johannesburg Academic Hospital

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**Background:** Perioperative outcomes of specialised surgeries, such as flap surgery, provide valuable information about the performance and capacity of the unit and facility to provide quality care to patients presenting with conditions that require the abovementioned intervention. Reconstructive flap surgery involves the transfer of tissue from the site of origin to other sites to restore the shape and function of tissue that has been lost. Success rates of 90–99% have been reported worldwide. An audit of the perioperative outcomes at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) has not been described. Therefore, an audit of this nature will reveal standards and practices at the facility.

The incidence of flap failure is also unknown. The study aimed to provide an overall description of patients who have undergone flap surgery and to describe the perioperative management and outcomes of patients presenting for flap surgery at CMJAH.

**Methods:** A retrospective research design was followed in this study, where records of patients who had undergone flap surgery at CMJAH were reviewed. The study population included all patients who presented for and underwent flap surgery from 1 January 2015 to 31 December 2019.

**Results:** Our analysis included a total of 87 cases. The flap failure rate was 14.9%. Older age and diabetes mellitus were univariably associated with flap failure. Perioperative factors had no influence on flap survival rate. Multivariable regression analysis revealed significantly increased risks of flap failure related to revision surgery ($p = 0.017$, odds ratio [OR] 9.42).

**Conclusion:** Flap surgery plays an important role in reconstructive surgery, and the outcomes of these procedures greatly affect patients' quality of life. The results of our study did not demonstrate the effect of anaesthetic techniques on the outcomes of flap surgeries.

**Keywords:** anaesthesia, audit, flap surgery

## Introduction

Reconstructive flap surgery aims to restore the shape and function of tissue lost due to trauma, infection, oncological surgery, congenital defects, or burns. Flaps used in reconstructive surgery can be categorised into local/pedicle flaps and free flaps.[1] Free flap surgery involves tissue transfer to distant sites, whereas pedicle flaps involve tissue movement near the area of origin without severing the vascular supply.[1,2]

Complication risks for flap surgery include infection, excessive bleeding, poor wound healing, haematoma formation, unfavourable scarring, persistent swelling, tissue necrosis, loss of sensation, flap failure, and risks concerning the anaesthesia itself.[3,4] These complications result in a higher cost and increased hospital stay. Flap failure rates have improved significantly from earlier rates due to the evolution of techniques for microvascular tissue transfer.[3]

The goal of anaesthesia is to maintain optimal blood flow for the revascularised flap by increasing the circulatory blood flow and maintaining a normal temperature to prevent peripheral vasoconstriction.[1,3] Hypothermia also increases plasma viscosity, with erythrocyte and platelet aggregation.[1,5] A retrospective study of 156 free flaps showed a correlation between intraoperative hypothermia < 35 °C and recipient site infections.[3] In addition to infectious complications, hypothermia has also been reported to adversely affect wound healing via temperature-mediated vasoconstriction that induces tissue hypoxia.[5]

Fluid therapy to maintain optimal blood flow is guided by urine output, central venous pressure (CVP), haematocrit (Hct) measurement, blood lactate concentration, and the increasing difference between core and peripheral temperature (Δt).[2] Preoperative haemoglobin values below 10 g/dl are a significant predictor of flap failure and thrombosis. A recent retrospective review demonstrated that intraoperative blood transfusion was associated with higher rates of overall surgical complications, medical complications, postoperative transfusion, reoperation, and head and neck cancer recurrence in free flap construction.[4] This association may be caused by the immunomodulatory effect of blood transfusions.[4]

Inotrope and vasopressor use to prevent and treat hypotension assist in maintaining global perfusion, but may have varying effects on the microvasculature, thereby affecting flap survival. Catecholamines are usually avoided despite little evidence to show that systemically administered catecholamines adversely affect flap blood flow.[2] Fang et al.[6] suggest that the intraoperative use of vasopressors does not increase the incidence of flap pedicle compromise or flap failure.

Patient comorbidities, such as chronic obstructive pulmonary disease, complications of diabetes, a smoking history, a high American Society of Anaesthesiologists (ASA) status, and malnutrition, have a negative influence on flap survival.[7] Surgical factors to be considered include operative duration, experience/expertise of the surgical team, type of flap, and perioperative radiotherapy.[7,8]

## Methodology

Approval to conduct the study was obtained from the Chief Executive Officer of Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), the Head of the Department of Anaesthesia, and the Head of the Department of Plastic and Reconstructive Surgery. Ethical approval was granted by the University of the Witwatersrand Human Research Ethics Committee, and the study was registered with the National Health Research Database. The study is a retrospective review of the medical records of patients who underwent free or pedicle flap surgery from 1 January 2015 to 31 December 2019. A data collection sheet was utilised to record the data.

Categorical variables were described using frequencies and percentages. Continuous data were summarised using mean and standard deviation (SD) if normally distributed or median and interquartile range (IQR) if not normally distributed. To test for association between categorical variables and flap outcome, we used the chi-square test or Fisher's exact test as an alternative if at least 20% of the expected values in cells were < 5. To test the effect of continuous variables on flap outcome, we used the t-test for normally distributed data or the Mann–Whitney U test for non-normal data. A univariable logistic regression analysis of factors associated with flap survival was performed. Factors with a *p*-value ≤ 0.1 were then used in a multivariable regression analysis. Comparisons were made based on a 95% significance level, and a *p*-value < 0.05 was considered statistically significant.

## Results

The study included 87 flap surgeries (Table I). The surgeries were performed on 53 male and 34 female subjects. The median age was 44 years (range 30–58 years).

In total, 17 patients (19.5%) had a history of hypertension, seven patients (8.0%) had diabetes mellitus, 31 (35.6%) had a history of smoking, and nine (10.3%) had undergone radiotherapy before surgery. The duration of surgery was less than six hours for 22 surgeries (25.3%), between six and 10 hours for 44 (50.6%), while 21 (24.1%) exceeded 10 hours. The anaesthetic used for most cases was volatile-based compared to total intravenous anaesthesia (TIVA) techniques (Supplementary Table I). Different types of analgesics, including opioids alone, opioid-ketamine, opioid-Perfalgan, opioid-ketamine-Perfalgan, and opioid-Perfalgan-ketamine-nonsteroidal anti-inflammatory drug (NSAID) combinations, were used. A total of 74 flaps (85.1%) survived.

There was a significant relationship between flap failure and advanced age, a history of diabetes mellitus, and surgical revision (Table II). The type of anaesthetic, analgesia, and use of vasopressors did not show a significant relation to flap outcome (Supplementary Table II).

Advanced age, diabetes mellitus, and revision surgery were univariably associated with flap failure (Table III). Surgical revision was the only independent predictor of flap failure.

**Table I:** Descriptive statistics

| **Variable** | | ***n* = 87** |
|---|---|---|
| Demographic information | | *n* (%) |
| Age (years) | Median (IQR) | 44 (30–58) |
| Gender, *n* (%) | Female | 34 (39.1) |
| | Male | 53 (60.9) |
| ASA status, *n* (%) | I | 20 (23.0) |
| | II | 46 (52.9) |
| | III | 21 (24.1) |
| Smoking, *n* (%) | Yes | 31 (35.6) |
| | No | 56 (64.4) |
| Hypertension, *n* (%) | Yes | 17 (19.5) |
| | No | 70 (80.5) |
| Diabetes mellitus, *n* (%) | Yes | 7 (8.0) |
| | No | 80 (92.0) |
| Preoperative Hb (g/dl) | < 7 | 0 (0.0) |
| | 7–10 | 10 (11.5) |
| | > 10 | 77 (88.5) |
| Preoperative platelet count per microliter | Median (IQR) | 316 (262–416) |
| Type of flap, *n* (%) | Free | 73 (83.9) |
| | Pedicle | 14 (16.1) |
| Flap site, *n* (%) | Radial forearm | 18 (20.7) |
| | ALT | 37 (42.5) |
| | DIEP | 9 (10.3) |
| | Fibula | 8 (9.2) |
| | Latissimus | 6 (6.9) |
| | PEC | 4 (4.6) |
| | Other | 5 (5.8) |
| Indication for flap, *n* (%) | Trauma | 62 (71.3) |
| | Malignancy | 25 (28.7) |
| | Congenital defect | 0 (0.0) |
| Previous radiotherapy, *n* (%) | Yes | 9 (10.3) |
| | No | 78 (89.7) |
| Surgery type, *n* (%) | Primary | 79 (90.8) |
| | Revision | 8 (9.2) |

ALT – anterolateral thigh, ASA – American Society of Anaesthesiologists, DIEP – deep inferior epigastric perforator, Hb – haemoglobin, IQR – interquartile range, PEC – pectoralis major flap

## Discussion

This study retrospectively audited the perioperative management of flap surgeries and their outcomes at a central hospital in Johannesburg over five years. A total of 87 flaps (both free and pedicle flaps) were performed. The significant risk factors for flap failure were found to be a history of diabetes

**Table II:** Relationship between demographic factors and flap outcome

| Demographic information | | Failure | Survival | *p*-value |
|---|---|---|---|---|
| Age (years) | Median (IQR) | 59 (39–71) | 43 (29–57) | 0.042 |
| Gender, *n* (%) | Female | 6 (17.6) | 28 (82.4) | 0.57 |
| | Male | 7 (13.2) | 46 (86.8) | |
| ASA status, *n* (%) | I | 3 (15.0) | 17 (85.0) | 0.39 |
| | II | 5 (10.9) | 41 (89.1) | |
| | III | 5 (23.8) | 16 (76.2) | |
| Smoking, *n* (%) | Yes | 7 (22.6) | 24 (77.4) | 0.14 |
| | No | 6 (10.7) | 50 (89.3) | |
| Hypertension, *n* (%) | Yes | 4 (23.5) | 13 (76.5) | 0.27 |
| | No | 9 (12.9) | 61 (87.1) | |
| Diabetes mellitus, *n* (%) | Yes | 3 (42.9) | 4 (57.1) | 0.031 |
| | No | 10 (12.5) | 70 (87.5) | |
| Preoperative Hb (mmHg) | 7–10 | 1 (10.0) | 9 (90.0) | 0.64 |
| | > 10 | 12 (15.6) | 65 (84.4) | |
| Preoperative platelet count per microliter | Median (IQR) | 322 (276–358) | 315 (262–437) | 0.72 |
| Type of flap, *n* (%) | Free | 11 (15.3) | 61 (84.7) | 0.92 |
| | Pedicle | 2 (14.3) | 12 (85.7) | |
| Flap site, *n* (%) | Radial forearm | 3 (16.7) | 15 (83.3) | 0.24 |
| | ALT | 7 (18.9) | 30 (81.9) | |
| | DIEP | 0 (0.0) | 9 (100) | |
| | Fibula | 1 (12.5) | 7 (87.5) | |
| | Latissimus | 0 (0.0) | 6 (100) | |
| | PEC | 2 (50.0) | 2 (50.0) | |
| | Other | 0 (0.0) | 5 (100) | |
| Indication for flap, *n* (%) | Trauma | 3 (12.0) | 22 (88.0) | 0.63 |
| | Malignancy | 10 (16.1) | 52 (83.9) | |
| Previous radiotherapy, *n* (%) | Yes | 3 (33.3) | 6 (66.7) | 0.10 |
| | No | 10 (12.8) | 68 (87.2) | |
| Surgery type, *n* (%) | Primary | 9 (11.4) | 70 (88.6) | 0.004 |
| | Revision | 4 (50.0) | 4 (50.0) | |

ALT – anterolateral thigh, ASA – American Society of Anaesthesiologists, DIEP – deep inferior epigastric perforator, Hb – haemoglobin, IQR – interquartile range, PEC – pectoralis major flap

mellitus, advanced age, and revision surgery. Furthermore, flap revision was independently predictive of flap failure. None of the perioperative factors related to anaesthetic conduct were associated with flap failure.

Flap failure is most often attributed to a microvascular aetiology. A threatened flap often prompts rapid surgical intervention with surgical exploration and possible revision of the pedicle.[9] Data suggests that the need for revision to the anastomosis predisposes free flaps to an increased risk of failure.[9] A study by Mücke et al.[10] also showed that the main risk factor for the loss of the microvascular transplant was a previous attempt at microvascular reconstruction. Similarly, we found this factor to be predictive of flap failure.

Previous studies have suggested that the age of the patient alone is not considered to be a contraindication for surgery or a risk factor for postoperative morbidity and flap failure.[3,7] In contrast, our study found a higher risk of flap failure with increasing age. Comorbidities such as diabetes mellitus, a smoking history, a high ASA status, and malnutrition had a more negative influence on flap survival.[7] Similarly, we found those with diabetes mellitus to be at risk of flap failure. Diabetes mellitus causes microangiopathy and immunodeficiency that may adversely affect the outcome of a free flap.[8,10,11]

Experimental studies on mice demonstrated an impaired self-repair ability in the vessel intima of diabetic patients and, therefore, a higher likelihood of microvascular anastomosis failure. These studies suggest that uncontrolled hyperglycaemia predisposes the development of vessel thrombosis.[11] Diabetes mellitus increases the occurrence of postoperative complications, including thrombosis, fistula, infection, and necrosis of the free flap.[11]

Surgical experience is often described as a critical factor for free flap success. Surgical experience can be extrapolated to surgical time. A prolonged operative time has been identified as an independent risk factor for failure of head and neck free flaps.[10,12] However, in our study, most surgeries had a duration of more

Table III: Logistic regression analysis of factors associated with flap survival

| Variable | | Unadjusted OR (95% CI) | *p*-value | Adjusted OR (95% CI) | *p*-value |
|---|---|---|---|---|---|
| **Demographic information** | | | | | |
| Age (years) | | 1.04 (1.00 to 1.08) | 0.042 | 1.02 (0.98 to 1.06) | 0.388 |
| Gender | Female | 1 (Ref) | | | |
| | Male | 0.71 (0.22 to 2.32) | 0.572 | | |
| ASA status | I | 1 (Ref) | | | |
| | II | 0.69 (0.15 to 3.22) | 0.638 | | |
| | III | 1.77 (0.36 to 8.65) | 0.480 | | |
| Smoking | No | 1 (Ref) | | | |
| | Yes | 2.43 (0.74 to 8.02) | 0.145 | | |
| Hypertension | No | 1 (Ref) | | | |
| | Yes | 2.09 (0.56 to 7.82) | 0.276 | | |
| Diabetes mellitus | No | 1 (Ref) | | | |
| | Yes | 5.25 (1.02 to 26.98) | 0.047 | 5.37 (0.75 to 38.29) | 0.284 |
| Preoperative platelet count | | 1.00 (0.99 to 1.00) | 0.287 | | |
| Type of flap | Free | 1 (Ref) | | | |
| | Pedicle | 0.92 (0.18 to 4.7) | 0.924 | | |
| Indication for flap | Malignancy | 1 (Ref) | | | |
| | Trauma | 0.71 (0.18 to 2.82) | 0.626 | | |
| Previous radiotherapy | No | 1 (Ref) | | | |
| | Yes | 3.40 (0.73 to 15.81) | 0.119 | | |
| Surgery type | Primary | 1 (Ref) | | | |
| | Revision | 7.78 (1.65 to 36.6) | 0.009 | 9.42 (1.79 to 49.53) | 0.017 |
| **Perioperative factors** | | | | | |
| Duration of surgery (hours) | < 6 | 1 (Ref) | | | |
| | 6–10 | 2.22 (0.43 to 11.49) | 0.341 | | |
| | > 10 | 1.67 (0.25 to 11.13) | 0.598 | | |
| Fluid type and volume | Crystalloid | 1 (Ref) | | | |
| | Crystalloid and colloid | 1.65 (0.31 to 8.90) | 0.561 | | |
| Blood product use | No | 1 (Ref) | | | |
| | Yes | 0.67 (0.13 to 3.36) | 0.627 | | |
| Regional block | No | 1 (Ref) | | | |
| | Yes | 1.59 (0.16 to 15.58) | 0.690 | | |
| Lowest temperature | | 0.71 (0.18 to 2.75) | 0.618 | | |
| Estimated lowest systolic BP | | 1.00 (0.93 to 1.07) | 0.946 | | |
| Estimated lowest diastolic BP | | 0.97 (0.87 to 1.10) | 0.672 | | |
| Use of vasopressors | No | 1 (Ref) | | | |
| | Yes | 0.72 (0.21 to 2.45) | 0.600 | | |
| Postoperative Hb | | 0.79 (0.56 to 1.11) | 0.168 | | |

ASA – American Society of Anesthesiologists, BP – blood pressure, CI – confidence interval, OR – odds ratio

than six hours, which was not associated with flap failure. Our study did not have records of flap ischaemia time, which may have been a better predictor of flap outcome.[12]

Several perioperative factors are reported to adversely affect flap survival, such as:

- excessive intraoperative fluid administration;[12]
- anaemia with Hct levels < 30% and haemoglobin < 10 g/dl;[4]
- intraoperative blood transfusion;[4]
- catecholamine administration;[2]
- hypothermia < 35 °C and recipient site infections;[3] and
- type of anaesthesia.[13]

In our audit, there was no relationship between flap outcome and these parameters. The sample size in our study was small. Therefore, one cannot conclude that the mentioned parameters do not affect flap outcomes. In our data, most patients received between one and four litres of crystalloids. Vasopressors were used in 57% of the cases in our study, with ephedrine and phenylephrine predominantly used.

## Conclusion

Flap surgery plays an important role in reconstructive surgery, and the outcomes of these procedures greatly affect patients' quality of life. The procedures themselves can be affected by several variables that must be carefully considered and addressed when caring for these patients. Greater attention should be paid to patients who have a history of diabetes mellitus, are of advanced age, and are presenting for revision surgery when performing flap surgery. Risk stratification and analysis of the risk-benefit ratio for patients with diabetes must be done, including how well-controlled their condition is, to minimise the risk these patients face. The results of our study did not demonstrate the effect of anaesthetic techniques on the outcomes of the flap surgeries. However, the institution of a hyperdynamic circulatory state with vasodilation to maintain good flow through the flap, a good mean arterial blood pressure with a low CVP, maintaining a reduced blood viscosity of around 30%, and restricting crystalloids to 3.5–6 ml/kg/hr are sound principles to follow in the anaesthetic management of these patients.

### *Conflict of interest*

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### *Ethical approval*

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***Supplement available online***