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Consecutive Cases Of Micro vascular Free Flap And Factors Affecting Its Viability: A Five-Year Single-Surgeon Experience In One Institution In A Developing Country

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Abstract— Microvascular free tissue transfer has gained popularity throughout the years. Many plastic surgery centers perform such challenging surgery on patients requiring extensive defect closure, including our center in the last five years. We will review our previous cases in order to achieve and assess our learning curve in a developing country. In this case series study, we looked at all patients who had a microvascular free tissue transfer conducted by a single operator (PA) in one institution between 2014 and 2018. Multivariate analysis was conducted to find out factors involved in free flap failure, which were age, gender, BMI, an indication of surgery, location of the defect, type of flap, number of veins anastomosed, vein graft usage, length of hospital stay, length of intensive care unit stay, and perioperative complications. Then, 203 microvascular tissue transfers were performed to reconstruct and close defects of various anatomic locations by a single operator. The patients' age ranged from 5.5 to 79 years. Most defects were due to tumor ablation, besides trauma and congenital deformity. The microvascular free flap reconstruction of various kinds of indications all over the body showed a viable flap rate of 90.6%. We concluded that to achieve a consistent high success rate, the parameters impacting the flap's viability must be evaluated regularly. This study found that the flap's viability can be affected by the number of veins anastomosed, BMI, length of hospital stay, and type of flap. As a result, the learning curve has been attained.

Keywords: Free tissue flaps, Microsurgery, Tissue survival

1. Introduction

The microvascular free flap has become the treatment of choice for complex reconstruction due to various etiologies [1-3]. This procedure allowed the harvesting of autologous tissue along with its pedicle and transferred to the site of the defect, followed by microsurgical vascular anastomosis to maintain its viability [4,5].

Our hospital has been amongst the most destined referral center for advanced cases of illness from all over Indonesia. These including cases of complex defects following tumor ablation or trauma, which require an advanced technique of defect closure using the microvascular free flap. Despite that microvascular free tissue transfer has been clinically reported since the early 1960s, it has just peaked its popularity in our center for the last five years [6-8].

Improvements in learning curves are in parallel with increment in the numbers of cases, leading to a better success rate and fewer perioperative complications. With improved reconstruction techniques, broad-spectrum defects resulting from the resection of pathological sites have become more acceptable and possible to be performed [1-4,8].

This study aims to review past cases of microvascular free flap procedures in our center. The patient's characteristics and factors assumed to contribute to the failure of free flaps are analyzed in order to achieve our learning curve, especially in a developing country.

2. Methods

2.1. Study Design

This article is a case series which a retrospective analysis was conducted. We reviewed all cases of the microvascular free flap performed in our institution from January 2014 until December 2018. Analysis was performed to find out patient's characteristics, and factors involved in free flap failure, including age, gender, Body Mass Index (BMI), location of defect, type of flap, disease entity, number of veins, vein graft usage, length of hospital stays, length of intensive unit stays, and viability result. Data were collected consecutively from the medical record of patients.

2.2. Surgical Technique

Cases included in this study were performed by a single operator (PA) and teams of plastic surgery residents. All flap harvesting and vasscular anastomosis were carried out by the operator himself, while residents in training perform donor site closures and flap inset. Patients were given heparin postoperatively, with an hourly evaluation of flap viability by clinical examination and handheld doppler in the first 24 hours.

Types of the flap are categorized into two groups; perforator and non-perforator. Perforator flap includes anterolateral thigh (ALT), deep inferior epigastric perforator (DIEP), and superficial circumflex iliac artery perforator (SCIP). While free fibular flap (FFF), proximal interphalangeal (PIP) flap, latissimus dorsi (LD) flap, vastus lateralis (VL) flap, and radial forearm free flap (RFFF), are categorized into the non-perforator group. Other data collected in this study are distinct enough, requiring no specific operational definition.

2.3. Data Assessment

Flaps considered viable were those with flap necrosis of not more than 50% area of the flap, whereas non-viable flaps were those with more than 50% flap necrosis. The area of flap necrosis was assessed by inspection. For the classification of BMI, we used the World Health Organization's (WHO) cut-off adjusted particularly for the Asian population, which is more appropriate for our subjects [9].

Statistical analyses used in this study is the Statistical Package for the Social Sciences (SPSS) version 20. A descriptive analysis was conducted to obtain patients' characteristics. Each of these characteristics was then analyzed using bivariate analysis, with flap viability being the dependent factor. Independent factors with $P< 0.20$ were further analyzed using logistic regression to find out how much these factors affect flap viability. We chose $P < 0.20$ to minimize error in assessment for multivariate analysis.

3. Results

A total of 203 patients between January 2014 and December 2018 were analyzed. Subjects were evenly distributed between males and females (103 and 100 subjects), mostly aged between 20-59 years. The BMI trends of the patients are mostly underweight to normal, with an overall range from 15.0 kg/m^2 to 26.8 kg/m^2.

Common cases encountered for the past five years were head and neck cases (81.8%), mostly caused by a tumor (64.5%) and trauma (20.7%). The most popular flap is the anterolateral thigh free flap (47.3%), followed by a free fibular flap (29.6%), and a radial forearm free flap (14.8%). Other types of the free flap were practiced less than ten times during the past five years, which were latissimus dorsi flap, deep inferior epigastric perforators flap, vastus lateral flap, superficial circumflex iliac artery perforator flap, and proximal interphalangeal flap.

The result of the microvascular free flap shows a 90.6% success rate (n=183) with a 9.4% non-viable flap found on follow-up. A single vein was mostly used and rarely perform vein grafting. Our patients were mainly discharged after 7-13 days of hospital stay and treated in the intensive unit for less than three days.

Out of ten independent factors, only type of flap was statistically proven significant to have an independent association with the viability of free flap ($P < 0.05$). However, three other factors were eligible to be further analyzed using the logistic regression model ($P < 0.20$). These factors are described in Table 2. The number of veins anastomosed, BMI, length of hospital stays, and the type of flap chosen were shown to act as factors associated with flap viability.

The four included predictors were further analyzed using the logistic regression model. We examined the reliability of the obtained regression with Nagelkerke r2. We discovered that the number of veins anastomosed, BMI, length of hospital stays, and types of the flap have 36.8% (Nagelkerke r2 = 0.368) role in determining the flap viability. The remaining 63.2% is determined by other factors that are not analyzed in this study. This statement is supported by a significant Hosmer and Lemeshow Test ($p > 0.05$). This indicates good compatibility between predicted and observed outcomes.

This analysis obtained an equation for predicting the probability of a viable flap with 97% accuracy. The equation is as follows:

$$\text{Logit (viable flap)} = -3.948 + 0.506\ \text{BMI} + 0.263\ \text{NUMBER OF VEINS} + 0.085\ \text{LENGTH OF HOSPITAL STAY} - 2.275\ \text{TYPE OF FLAP}$$

The trend of total free flap cases and their viability rate year by year were observed (Figure 1, Figure 2). A somewhat unstable trend was visible in the first three years of practice. The year 2015 was the highest number of free flap but a declining overall flap viability rate compared with the previous year. An opposite trend is observed in 2016, with a much smaller number of total free flap cases. However, the success rate was increased from 79.1% to 92.9%. The number tended to stabilize in the last two years, with a slight decrease. In 2018, we noticed that the increase of flap failure (from 7.5% to 9,7%) was parallel with the decreased number of total free flaps.

4. Discussion

Previous retrospective studies reviewing the clinical experience of the microvascular free flap in a single center were compared to this study (Table 3). We limit our comparison to studies in the last ten years to reduce any technological bias. These centers experience viability rates ranging from 89.0% to 96.8% [8,10-14]. The two most similar reviews in Thailand and Kenya even conducted less microvascular free flap reconstruction, respectively, 153 and 132 cases [8,10]. With a smaller number of total cases, however, Thailand can reach a better success rate (92.8%) than our center, although only by less than 2%. A higher success rate may be due to the long practice of microvascular free flap reconstruction in their center. Nevertheless, we managed to present the largest data of microvascular free flap reconstruction ever assembled from a single surgeon in Indonesia, with up to a 5-year follow-up.

Four single-surgeon studies focusing on the reconstruction of head and neck defects showed a variable number of cases treated. These studies show a good trend of flap success rate, ranging from 92.0% to 96.8% [11-14]. For several years, such a high success rate is achieved by practicing microvascular free flap reconstruction in one area, in this case, head, and neck. This means repetition and, thus, practicing a smaller range of donor options by a single surgeon to similar defects. [15,16] By this matter, we understand that the learning curve is an essential aspect of achieving a viable microvascular free flap [17,18]. This corresponds to the constant high success rate (above 90%) in the last three years, shown in Figure 2.

Factors statistically proven to act as predictors towards the viability of microvascular free flap, including the number of veins anastomosed, BMI, length of hospital stay, and type of flap, are aligned with the data gained from previous studies.

A literature review study by Silverman et al. showed that the use of an internal jugular influenced the viability rate. However, theoretically, single vein-free flap transfer does not contribute to the viability of the flap, especially in head and neck defects, due to the benefit of gravity [19]. We might conclude that one might use one internal jugular or use two veins alternatively. Meanwhile, for lower extremity trauma, other studies show the significance of using dual-vein compared to single-vein flap in affecting a flap's viability. The studies state that dual-vein outflow can reduce the flap failure rate by 69%and reduce the complication rate by fourfold [19,20,21].

BMI, however, plays a different role in the success of microvascular free flaps. It is observed in a previous study that patients with low BMI show a higher risk of developing recipient-site infection and facial fistula [21]. This will impact the patients' morbidity, impairing the flap's viability.

Contradicting with other factors, we believe the length of hospital stay plays a different role in the viability of the flap. It is a consequence of undesired flap outcome rather than a predictor of flap viability. Previous studies show a higher hospitalization period ranging from 20.5 to 36.6 days [8,11-13]. However, most of the studies with more extended hospitalization show a higher success rate. Such an outcome may be due to the high rate of re-exploration and salvaging surgeries. Unfortunately, our study did not analyze data regarding re-exploration and salvaging surgeries. We recommend further investigation regarding this matter.

We acknowledge some limitations that may contribute to the conclusion of our study. The determination of flap viability was done by physical examination, which is a subjective form of measure. This results in a biased calculation of the result. We resolve this issue by measuring the flap using more than one interpreter. The use of objective measures is recommended in future studies. Aside from that, we cannot deny the weak documentation of our medical records, causing the unavailability of specific data in some patients.

5. Conclusion

The total number of 203 microvascular free flaps performed in one institution over four years by a single operator in a developing country is not insignificant. To achieve a consistent high success rate, the parameters impacting the flap's viability must be evaluated regularly. This study discovered that the number of veins anastomosed, BMI, length of hospital stay, and kind of flap can all affect flap viability, and as a result, the learning curve has been attained.

6. Table Legends

Table 1. Characteristics of subjects

Table 2. Factors associated with flap viability

Table 3. Comparison of flap viability rate across studies

Table 1.

Subject characteristics	n (%)
Age in years (n = 202)	
<20 years	25 (12.4)
20-39 years	76 (37.6)
40-59 years	80 (39.6)
≥60 years	21 (10.4)
Gender (n = 203)	
Male	103 (50.7)
Female	100 (49.3)
BMI (n = 69)	
Underweight	20 (29.0)
Normal weight	39 (56.5)
Overweight	9 (13.0)
Obese	1 (1.4)
Location of defect (n = 202)	
Head and neck	166 (82.1)
Esophagus	1 (0.5)
Extremity	25 (12.4)
Trunk	5 (2.5)
Breast	5 (2.5)
Types of flap (n = 203)	
Perforator	103 (51.0)
Non-perforator	99 (49.0)
Disease entity (n = 197)	
Tumor	131 (66.5)
Infection	19 (9.6)
Trauma	42 (21.3)
Parry Romberg	1 (0.5)
Congenital	4 (2.0)
Number of veins (n = 196)	
1	107 (54.6)
2	87 (44.4)
3	2 (1.0)
Vein graft usage (n = 134)	
Yes	20 (14.9)
No	114 (85.1)
Length of hospital stay (n = 118)	
<7 days	11 (9.3)
7-13 days	68 (57.6)
≥14 days	39 (33.1)

Length of intensive unit stay (n = 88)	
<3 days	59 (67.0)
≥3 days	29 (33.0)
Viable flap	
Yes	183 (90.6)
No	19 (9.4)

Table 2.

Predictors	Viable Flap Yes n (%)	Viable Flap No n (%)	Total	P	RR (CI 95%)	P	aOR (CI 95%)
Number of veins	-	-	-	0.195[a)]	-	0.832	1.30 (0.11-14.83)
BMI	-	-	-	0.18[a)]	-	0.128	1.66 (0.87-3.18)
Length of hospital stay	-	-	-	0.073[a)]	-	0.095	0.92 (0.83-1.01)
Type of flap							
Perforator	89 (90.6)	14 (13.6)	103	0.038[a)]	0.37 (0.14-0.99)	0.259	0.10 (0.00-5.33)
Non-perforator	94 (94.9)	5 (5.1)	99				
Total	183 (90.6)	19 (9.4)	202				

[a)]Logistic Regression

Table 3.

Author	Year	Number of flaps	Recipient site	Viability rate (%)
Current study	5-year	203	All area	90.6
Kamnerdnakta et al. (2015) [8]	5-year	153	All area	92.8
Nangole et al. (2015) [10]	5-year	132	All area	89.0
Pastars et al. (2018) [11]	8-year	157	Head and neck	96.8
Holom et al. (2012) [12]	9-year	143	Head and neck	92.0
Liang et al. (2018) [13]	8-year	93	Head and neck	90.3
Copelli et al. (2017) [14]	4-year	149	Head and neck	96.0

7. Figures Legends

Figure4. Total Free Flap Cases from 2014-2018

Figure 2. Accumulated Free Flap Success Rate from 2014-2018

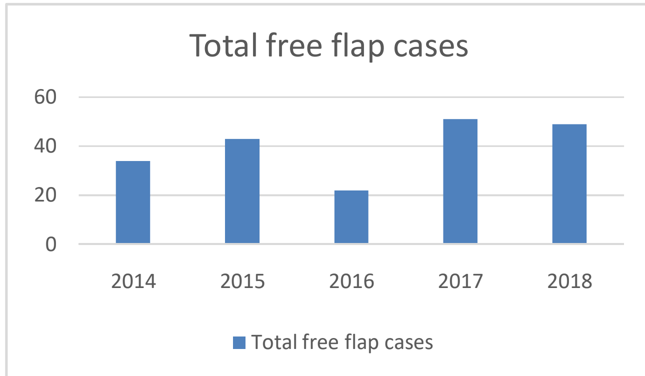

Figure1.

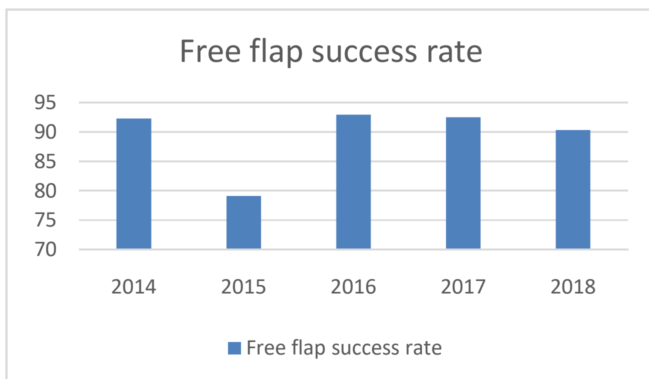

Figure2.

8. Declarations

Ethics approval and participation consent

The research was carried out according to the Helsinki Declaration. Participants in this study have filled in informed consent to be a part of this study.

Consent for publication

We authorize the journal for publication of identifying images or other personal or clinicaldetails of participants that compromise anonymity.

Data and material availability

All data and material are available upon request.

Conflicting interests

The authorsstate that the publishing of this paper does not involve any competing or conflicting interests.

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