Original Research

COMPARATIVE ANALYSIS OF CAPILLARY BLOOD GLUCOSE LEVELS IN FLAP AND FINGERTIP AS PREDICTORS OF POST-SURGICAL VENOUS THROMBOSIS IN PEDICLED FLAP: AN OBSERVATIONAL COHORT STUDY

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ABSTRACT

Background: Early diagnosis of venous thrombosis after surgical intervention is crucial for fruitful retrieval of pedicled flaps. Clinical evaluation remains the gold-standard conventional monitoring method, but it requires technical interpretive expertise. This study evaluated the diagnostic efficacy of the mean capillary blood glucose difference between the fingertip and pedicled flap as a principal determinant of venous thrombosis after surgery.

Methods: A cohort study involving 90 adults was conducted on pedicled flap reconstruction at a tertiary care facility between November 2022 and December 2024. A portable glucometer was used to measure capillary blood glucose levels from both the fingertip and the flap over up to 5 days at specific postoperative intervals. The difference in glucose levels was calculated and examined in relation to venous thrombosis, which was confirmed through clinical evaluation. The diagnostic abilities were systematically assessed using receiver operating characteristic (ROC) curve analysis.

Results: Within the first 18 post-surgical hours, venous thrombosis was detected in eight patients (8.9%) with a significantly higher (p<0.001) mean fingertip-to-flap glucose difference in normally perfused flaps (39.18 ± 7.93) in comparison to congested flaps (3.80 ± 5.62 mg/dL). ROC curve analysis shows outstanding diagnostic performance, with an AUC of 1.00. At this threshold, 100% sensitivity and 100% specificity were shown to be the ideal cut-off values for detecting venous thrombosis in the study population.

Conclusions: The capillary blood glucose difference is an easy, cost-efficient, reliable, and primary additive for Postsurgical monitoring of pedicled flaps. It may increase flap salvage and facilitate earlier diagnosis of venous thrombosis when combined with standard clinical examination techniques, especially in resource-limited settings. Confirmation of these findings requires larger multicenter studies.

Keywords: Venous Thrombosis, Pedicled Flap, Perfusion Flap (PF), Congestive Flap (CF).

INTRODUCTION

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Reconstruction via Pedicled flap has been used as the most conventional method for the Management of post traumatic complex defects like Diabetic foot, ankle wounds, Exposed tendon / bones, tissue loss after infection, and Chronic non-healing ulcers (1). The success rate of pedicled flap surgery is

found to be nearly 95% or higher (2). The most important flap reconstructive problem that ultimately leads to flap failure is vascular compromise. Venous thrombosis is the main cause of flap loss, but arterial insufficiency, venous thrombosis, or hematoma formation can all result in vascular compromise (3). With a longer time gap between initiation and detection of vascular impairment, the chance of flap retrieval reduces. According to several studies, flap salvage rates might increase from 30% to over 70% when previous identification is followed by timely re-exploration (4). Clinical evaluation— of flap colour, capillary refill, turgor, temperature, and pin-prick — remains the cornerstone of flap monitoring despite the availability of numerous monitoring techniques (5).

Systemic blood glucose levels frequently fluctuate in the early Post-surgical period, especially in patients hospitalised to the intensive care unit. Additionally, a microdialysis system has shown an ischemia decrease in the flap glucose concentration within the flap has been demonstrated using a microdialysis system (6). Nevertheless, no research has yet been done on the relationship between flap glucose concentration and patients' systemic blood glucose.

The present study evaluated a new index test designed to monitor flaps after surgery by analysing the difference in capillary blood glucose readings taken from a patient's fingertip compared to those collected from a reconstructed pedicled flap. Additionally, we aimed to establish standard cut-off values that could serve as a primary tool for the early identification of potential flap failure, even in the hands of less-experienced healthcare providers working in resource-limited settings. The main objective of this study was to assess the diagnostic accuracy of the index test, focusing on its sensitivity and specificity in detecting vascular compromise during the post-surgical monitoring of free flaps. Thus, the study aimed to evaluate the utility of capillary blood glucose monitoring in predicting venous thrombosis in pedicled flaps following surgery.

MATERIALS AND METHODS

The observational cohort study was carried out between November 2022 and December 2024 in the Department of Surgery at a tertiary care facility in Shahjahanpur and Cygnus Cosmetic and Health Clinic in Shahjahanpur. A total of 90 patients, aged 18 years and above, undergoing reconstructive pedicled flap surgery for traumatic, oncologic, or post-infective lesions were assessed and recruited in the study. Patients suffering from uncontrolled diabetes mellitus, peripheral vascular disease, and those receiving vasopressor therapy that can alter peripheral circulation were excluded from the study. Furthermore, Flaps observed with immediate post-surgical arterial insufficiency were also excluded. The study protocol was approved by the Institutional Ethics Committee (Ref.No.IEC/VAMC/BC/004/MAR2023).

Confidentiality of all the information was maintained strictly, and prior informed written consent was obtained from all participants included in the study.

Data Collection Procedure

Readings taken from Capillary blood glucose levels of the patient's fingertip served as the reference standard, and from the reconstructed free flap following surgery for flap monitoring. Blood samples were taken using a sterile lancet and evaluated using a calibrated glucometer (Model No. GLM-77, NiscoMed Blood Glucose Monitor, Surescreen). Data were collected at predetermined intervals following surgery, such as every hour for the next twenty-four hours, and then every two hours for the next twenty-four hours, and then every four hours until post-surgical day five or flap stabilization. The difference between fingertip and flap blood glucose readings was computed and noted for every observation. The Gold standard clinical evaluation approach was used to assess flap congestion in order to diagnose venous thrombosis.

RESULTS

A total of 90 patients who underwent reconstruction with pedicled flap techniques were included in the study. The reverse sural artery perforator flap was the most common procedure, utilized in 20 cases (22.22%) for lower limb reconstruction. Distally based fasciocutaneous transposition flaps were second, used in 18 patients (20%), followed by abdominal flaps in 14 patients (15.55%) for upper limbs. Nasolabial flaps were performed in 12 cases (13.33%) for facial and oral defects. Pedicled groin flaps were used in 10 patients (11.11%), and Singapore flap reconstructions in 9 patients (10%) for perineal and genital areas. Tensor fascia lata flaps were reserved for 4 cases (4.44%), while cross-leg flaps were the least common, used in only 3 cases (3.33%) for complex lower limb defects, as shown in Table 1.

Table 1: Distribution of Various Types of Pedicled Flaps Performed Among Patients

Types of Pedicled Flap used in reconstruction	Total Numbers N=90	Percentage (100%)
Pedicled groin flap	10	11.11%

Reverse sural artery perforator flap	20	22.22%
Abdominal flap	14	15.55%
Singapore flap / Pudendal thigh flap	09	10%
Tensor fascia lata flap	04	4.44%
Distally bored faciocutaneous transposition flap	18	20%
Nasolabial flap	12	13.33%
Cross-leg flap	03	3.33%

Capillary blood glucose monitoring is the easiest, most reliable, and economical approach for assessing flap perfusion after reconstructive surgery. A normal range of flap glucose levels to fingertip blood glucose levels is suggestive of adequate vascular perfusion and tissue viability. On the contrary, drastically lowered blood glucose may signal restricted blood flow due to vascular insufficiency. By serially monitoring flap glucose levels, clinicians can gain pivotal insights into the viability of the flap over time and facilitate the early detection of any vascular issues. This method can be frequently used in conjunction with standard clinical evaluations, enhancing the overall accuracy of post-surgical flap monitoring (Figure 1).

Fig 1: Illustration Of A Portable Glucometer Configuration For Blood Glucose Measurement In Monitoring And Evaluating Perfusion In Pedicle Flaps.

Failed pedicled flap reconstructions induced by venous thrombosis were discovered in eight individuals, as illustrated in Table 2. The re-exploration duration following surgery varied from 6 to 18 hours, demonstrating that venous impairment progresses during the initial post-surgical phase. The most recent re-exploration occurred 18 hours after surgery for a distally based fasciocutaneous transposition flap, while the earliest was performed after 6 hours for a reverse sural artery perforator flap. These results underscore the significance of careful post- surgical flap blood glucose value recording to detect early signs of venous thrombosis and facilitate prompt intervention, which is essential for improving flap survival.

Table2: Illustration of the Failed Pedicle Flap Reconstruction Due to Venous Thrombosis

Pedicle Flap Types	**failed flaps (N=08)**	**Time of Re-Exploration**
Pedicled groin flap	1	12 hrs
Reverse sural artery perforator flap	1	12 hrs
Reverse sural artery perforator flap	1	10 hrs
Reverse sural artery perforator flap	1	6 hrs

Pedicle Flap Types	failed flaps (N=08)	Time of Re-Exploration
Pedicled groin flap	1	12 hrs
Abdominal flap	1	8 hrs
Distally based faciocutaneous transposition flap	1	18 hrs
Distally based faciocutaneous transposition flap	1	10 hrs
Distally based faciocutaneous transposition flap	1	12 hrs

Figures 2 & 3 demonstrate the intraoperative and post-surgical phases and appearance of reconstruction in the same patient undergoing covering of a soft tissue defect in the lower limb. The flap in Figure 1 appears nicely vascularized with an intact pedicle. Figure 3 shows how flap viability can be preserved by properly placing and covering exposed defects.

Fig 2: Surgical Reconstruction using a Pedicled Flap

Fig 3: Post-surgical view After Flap Transfer

The mean difference in glucose between the Perfusion flap (PF) and Congestive flap (CF) groups is displayed in Table 3. The total number of observations was 1620 in the PF group and 14 in the CF group, respectively. The mean of sugar difference in the PF group (n=1620) was 3.80 ± 5.62, whereas the mean of sugar difference in the CF group (n=14) was 39.18 ± 7.93. Comparison between the groups was done by applying an independent t-test, which was found to be highly significant. ($t=16.64$, $p<0.001$).

Table 3: Comparative Analysis of Mean Capillary Blood Glucose Levels between Perfusion Flap (PF) and Congestive Flap (CF) Groups

Parameter	PF Group (n=1620)	CF Group (n=14)	t-value	p-value	Significance
Mean ± SD	3.80 ± 5.62	39.18 ± 7.93	16.64	<0.001	Highly Significant

The predictive and diagnostic ability of flap glucose difference in distinguishing between the Perfusion flap and Congestive flap groups was evaluated using the Receiver Operating Characteristic curve (Fig.4). With the curve area, i.e., AUC of 1.000 at 95% CI, the ROC curve demonstrated exceptional discriminating power and complete separation between the two groups. At this threshold, 100% sensitivity and 100% specificity were shown to be the ideal cut-off values, accurately categorising all positive and negative classes. These results imply that the difference in flap glucose levels is a good screening marker for distinguishing between the Perfusion Flaps and Congestive Flaps groups in this investigation.

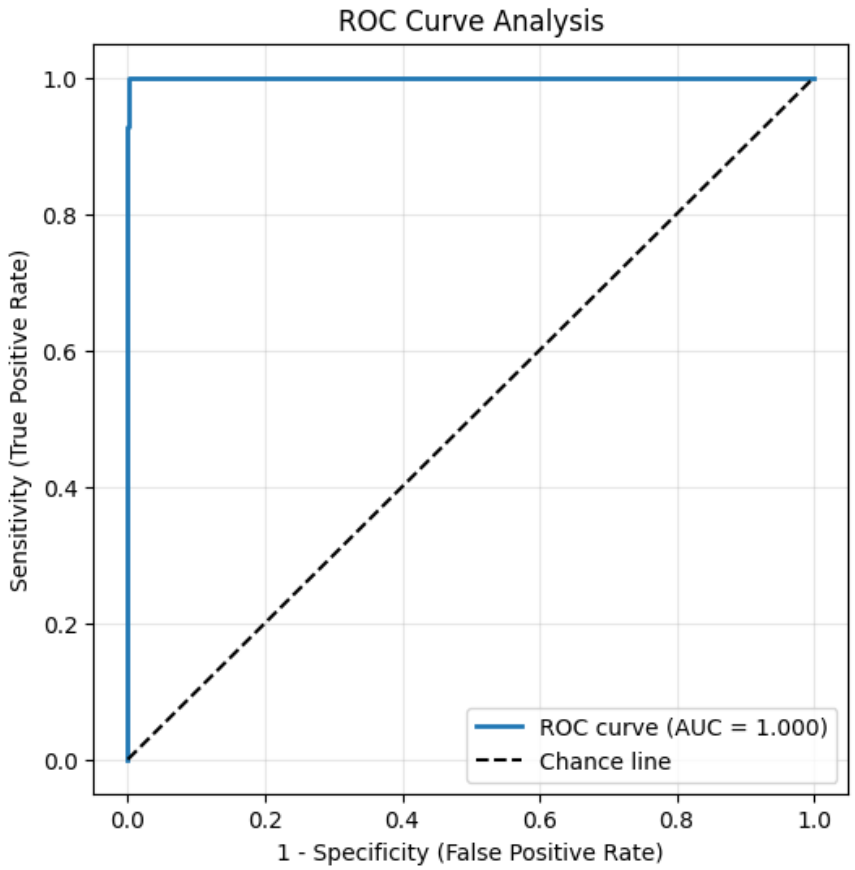

Fig 4: The Receiver Operating Characteristic (ROC) curve

DISCUSSION

Despite advances in reconstructive surgery, post-surgical vascular compromise remains the leading cause of flap failure. The rate of Flap retrieval decreases rapidly with increasing ischemic time; thus, early detection of venous thrombosis is necessary. Consequently, there is an ongoing search for cost-efficient, determinant, and easily reproducible monitoring techniques to augment routine clinical examination. The present study evaluated the role of capillary blood glucose difference between fingertip and flap as a primary screening method of venous thrombosis in pedicled flaps with excellent diagnostic power.

Venous thrombosis after flap surgery remains the most common cause of failure of both pedicled and free flaps. Prompt diagnosis of venous thrombosis is important as flap salvage diminishes with prolonged ischemic time. As such, there is still interest in identifying simple, objective, inexpensive, and reproducible adjunctive monitoring modalities to routine clinical evaluation. The current work analysed the role of capillary glucose difference as a measure of venous thrombosis in pedicled flaps, showing promising results.

Within the first eighteen hours following surgery, 8.9% (8/90) of patients in the current study had venous thrombosis. Other research supports this finding that the majority of vascular problems happen in the first 24 to 48 hours after reconstructive surgery, emphasising the necessity of close supervision in this crucial time. Recent reviews have stated that early diagnosis followed by timely re-exploration remains the leading decisive factor of flap salvage, irrespective of flap type (7,8).

The major finding of our study was the highly significant ($p < 0.001$) difference in capillary blood glucose levels between regularly perfused and congested pedicled flaps. For well-perfused flaps, the mean blood glucose difference was observed to be 3.80 ± 5.62 mg/dL, and for congested flaps, it was 39.18 ± 7.93 mg/dl. These results corroborate the physiological and biochemical theory that venous congestion lowers the concentration of glucose in the flap by causing tissue hypoxia, anaerobic glycolysis, poor microcirculatory perfusion, and rapid local glucose use. Similarly, work conducted by Setälä et al. (6) using the microdialysis technique also found a decline in the glucose, lactate, and pyruvate levels after flap congestion.

Despite the availability of various advanced monitoring techniques like implantable Doppler probes, laser Doppler flowmetry, hyperspectral imaging, near-infrared spectroscopy (NIRS), and tissue oximetry to detect vascular compromise, recent evidence indicates that the gold standard method of clinical evaluation is irreplaceable due to expenses, availability, and technical expertise-related limitations. Several recent studies have found that none of the single monitoring strategies alone is better, and it is beneficial to perform objective monitoring and clinical evaluation together to get the best results (9,10). Thus, based on our research. Early detection of vascular compromise and prompt referral for surgical exploration are made possible by handheld glucometers, which are inexpensive, readily available, minimally intrusive, and repeatable by nursing staff or junior residents at the bedside. Therefore, this is a promising strategy to enhance post-surgical surveillance in resource-limited situations and healthcare set-ups.

An AUC of 1.00, with 100% sensitivity and specificity respectively at the ideal cut-off, was further shown by receiver operating characteristic analysis. These results show good discriminatory power; they should be interpreted with caution and need external confirmation in larger multicenter cohorts.

Using the sugar difference between fingertip glucose and flap glucose instead of only flap glucose is a key component of this investigation. Surgical stress, intravenous glucose supply, insulin therapy, corticosteroid use, and nutritional assistance all regularly produce fluctuations in post-surgical systemic glucose concentrations. Using the patient's fingertip glucose as a standard internal reference reduces the impact of these systemic changes and offers a more accurate evaluation of flap perfusion in our study. The evaluation utilises mean sugar difference in pedicled flaps; hence, the current study could be a novel input to monitor flaps following reconstructive surgery. (11,12)

The majority of recent investigations are performed primarily using free flaps, but the present study evaluated a variety of pedicled flaps, including reverse sural artery perforator flaps, distally based fasciocutaneous flaps, tensor fascia lata flaps, abdominal flaps, groin flaps, Singapore flaps, nasolabial flaps, and cross-leg flaps. The results have significant practical implications as pedicled flaps are still the principal reconstructive option in many underdeveloped nations and peripheral healthcare facilities.

Due to its single-centric design and limited sample size (only eight cases of venous thrombosis), the current study has several limitations. Its relevance to these high-risk circumstances was further limited by the exclusion of patients with peripheral vascular disease, arterial insufficiency, vasopressor medication, and uncontrolled diabetes mellitus. Additionally, only venous thrombosis was assessed in this investigation; additional testing is necessary to ascertain the effectiveness of mean glucose variation in distinguishing venous congestion from arterial insufficiency. Thus, despite the high accuracy of the diagnosis, before generalised implementation, its verification is necessary in multiple centres.

Overall, our findings imply that the capillary blood glucose difference between fingertip-to-flap is a basic, affordable, dependable, and highly precise metric for post-surgical monitoring of pedicled flaps. This bedside methodology may reduce reconstructive failures in healthcare facilities without sophisticated perfusion monitoring technologies by providing early detection of venous thrombosis followed by prompt flap salvage when combined with meticulous routine clinical evaluation methods.

REFERENCES

1. Charles H. Thorne. *Grabb and Smith's Plastic Surgery*. 8th ed. Philadelphia: Wolters Kluwer; 2020.
2. Smit JM, Zeebregts CJ, Acosta R, Werker PMN. Advancements in free flap monitoring in the last decade: a critical review. Plast Reconstr Surg. 2010;125:117e85.
3. Qian Y, Li G, Zang H. A systematic review and meta-analysis of free-style flaps: risk

analysis complications. Plast Reconstr Surg Glob Open. 2018;6(02):e1651.
4. Yang Q, Ren Z H, Chickooree D et al. The effect of early detection of anterolateral thigh free flap crisis on the salvage success rate, based on 10 years of experience and 1072 flaps. Int J Oral Maxillofac Surg. 2014;43(09):1059-63.
5. Chae MP, Rozen WM, Whitaker IS, Chubb D, Grinsell D, Ashton MW et al. Current evidence for post surgicalmonitoring of microvascular free flaps: A systematic review. Ann Plast Surg. 2015;74:621-32.
6. Setälä LP, Korvenoja EM, Härmä MA, Alhava EM, Uusaro AV, Tenhunen JJ. Glucose, lactate, and pyruvate response in an experimental model of microvascular flap ischemia and reperfusion: a microdialysis study. Microsurgery 2004;24(03):223–231.
7. Paro J, et al. Current concepts in post surgicalfree flap monitoring. *Journal of Reconstructive Microsurgery.* 2022.
8. Ghanem AM, Myers SR. Advances in free flap monitoring and early detection of vascular compromise. *Plastic and Aesthetic Research.* 2023.
9. Power DM, et al. post surgicalmonitoring of microvascular reconstruction: an evidence-based review. *Journal of Plastic, Reconstructive & Aesthetic Surgery.* 2024.
10. Newton E, Butskiy O, Shadgan B, Prisman E, Anderson DW. Outcomes of free flap reconstructions with near-infrared spectroscopy (NIRS) monitoring: A systematic review. *Microsurgery.* 2020;40(2):268-275. doi:10.1002/micr.30526.
11. Vikal S, et al. Near-infrared spectroscopy (NIRS) versus hyperspectral imaging (HSI) to detect flap failure in reconstructive surgery: A systematic review. *J Clin Med.* 2022;11:531.
12. Festa BM, Costantino A, Pace GM, Spriano G, De Virgilio A. Near-infrared spectroscopy for continuous noninvasive monitoring of free flap in head and neck reconstruction: Systematic review of the literature and personal experience. *Otolaryngol Head Neck Surg.* 2023. doi:10.1177/15533506231209128.

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