Section: Plastic Surgery

Original Research Article

A PROSPECTIVE STUDY ON ANALYSING FLAP PERFUSION BY MEASURING INTRA FLAP GLUCOSE LEVELS IN FLAPS

Palli Shirin MCh, DNB[1], P.V. Sudhakar MCh, DNB, FAIS, FICS[2], Badugu Ratnabhushan MCh, DNB,[3] Kondamudi Srinivasu MCh[4]

[1]Senior Resident, Department of Plastic Surgery, ESI Medical College and Superspeciality Hospital, Sanath Nagar, Hyderabad, Telangana, India.
[2]Dean and Professor, Department of Plastic Surgery NRI Institute of Medical Sciences, Visakhapatnam, Andhra Pradesh, India.
[3]Associate Professor, Department of Plastic Surgery, Rangaraya Medical College, Kakinada, Andhra Pradesh, India.
[4]Senior Resident, Department of Plastic Surgery, ESIC Medical College and Superspeciality Hospital, Sanath Nagar, Hyderabad, Telangan, India.

Received : 11/07/2024
Received in revised form : 07/09/2024
Accepted : 22/09/2024

Corresponding Author:
Dr. Kondamudi Srinivasu,
Senior Resident, Department of Plastic Surgery, ESIC Medical College and Superspeciality Hospital, Sanath Nagar, Hyderabad, Telangan, India.
Email: vasumbbs12@gmail.com.

DOI: 10.70034/ijmedph.2024.3.149

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2024; 14 (3); 833-838

ABSTRACT

Background: Monitoring glucose levels in flap tissues can be a valuable indicator of flap viability and early detection of flap failure. This study aimed to analyze the utility of intra-flap glucose monitoring in predicting flap outcomes.

Material and Methods: A prospective study was conducted on 25 non-diabetic patients undergoing flap surgeries, excluding those with buried flaps or unwilling to participate. Age, sex, indications for surgery, body regions, and flap outcomes were recorded. Mean intra-flap glucose levels were measured at multiple time points up to 72 hours post-surgery and compared between survival and non-survival groups.

Results: The study population ranged from 5 to 62 years, with a mean age of 42.84 years. Males constituted 80% of the participants, with trauma being the most common indication for flap reconstruction (68%). Flaps were predominantly axial (68%), followed by random pattern flaps (32%). Complications occurred in 12% of axial and 12.5% of random pattern flaps. The mean glucose levels were significantly higher in the survival group (134.46 mg/dL) compared to the non-survival group (55.38 mg/dL). Glucose levels in the survival group remained consistently elevated, whereas they declined in the non-survival group. Statistical analysis showed a significant difference (p<0.001) between the mean glucose levels of the two groups. All flaps with complications exhibited changes in color, turgor, and pin prick bleeding.

Conclusion: Intra-flap glucose monitoring is a reliable method for predicting flap viability. Higher glucose levels are associated with flap survival, providing a potential tool for early intervention in cases of impending flap failure.

Key Words: Flap perfusion, glucose monitoring, flap viability, flap failure, trauma reconstruction, flap surgery outcomes.

INTRODUCTION

Flap reconstruction is a critical procedure in plastic and reconstructive surgery, commonly performed to repair defects resulting from trauma, burns, oncologic resection, or congenital abnormalities.[1] The success of these procedures heavily depends on the viability of the transplanted tissue, which is influenced by adequate blood supply and perfusion.[2] Early detection of flap compromise is essential to prevent flap failure, which can lead to significant morbidity and the need for additional surgeries.[3]

Traditional methods of monitoring flap viability, such as clinical observation of color, temperature, turgor, and capillary refill, are subjective and can be inconsistent. Objective methods, including Doppler ultrasound, near-infrared spectroscopy, and laser Doppler flowmetry, have been used but can be cumbersome and expensive4. Hence, there is a need for a simple, reliable, and cost-effective method to monitor flap perfusion.

Recent studies suggest that glucose monitoring within flap tissues may serve as a promising indicator of tissue viability. Glucose is a critical substrate for cellular metabolism, and its levels within tissues can reflect the adequacy of blood supply. Intra-flap glucose monitoring could potentially offer a real-time, quantitative measure of flap perfusion and viability.[5,6]

This study aims to evaluate the utility of intra-flap glucose levels as an indicator of flap viability and early detection of flap failure. By analyzing the correlation between glucose levels and flap outcomes, this research seeks to establish a practical approach for improving the management and success rates of flap surgeries. The findings of this study could have significant implications for clinical practice, offering a new tool for enhancing patient outcomes in reconstructive surgery.

MATERIAL AND METHODS

Study Design and Place of Study

This prospective analytical study was conducted at King George Hospital, Visakhapatnam, which is affiliated with Andhra Medical College. The study took place over a period from February 2020 to April 2022.

Study Population

The study population consists of patients from the Department of Plastic and Reconstructive Surgery at King George Hospital, which is affiliated with Andhra Medical College, who underwent flap surgery.

Sample Size

The study included 25 patients who underwent flap coverage surgery and met the inclusion criteria.

Inclusion Criteria

Patients willing to give consent to participate in the study.

Patients of all age groups undergoing flap surgery.

Exclusion Criteria

Diabetic patients.

Patients with buried flaps.

Materials & Methods

A total of 25 patients who underwent flap surgery in the Department of Plastic Surgery at King George Hospital were assessed postoperatively and followed up until the 3rd postoperative day.

Procedure

Flap capillary glucose levels were measured by pricking the surface of the distal part of the flap, up to 1 cm from the distal inset margin, with a 25G needle, penetrating through the dermis. The glucose level was then measured using a glucometer (Accu-Chek).

Glucose monitoring commenced once the flap inset was given. The initial reading was taken at 0 hour, followed by subsequent measurements every 6 hours for the next 3 days (72 hours).

A baseline capillary glucose level measurement was conducted for all patients.

A flap glucose level of >80 mg/dL was considered the cutoff, equivalent to normal blood capillary glucose levels.

Statistical Considerations

Data were entered in Microsoft Excel and analyzed using both MS Excel and SPSS software. Categorical data were expressed as proportions, while quantitative data were presented as means and standard deviations.

RESULTS

Age Distribution

The study included 25 patients ranging from 5 to 62 years, with a mean age of 42.84 years and a standard deviation of 13.22 years. The highest frequency of patients fell within the 40-49 year age group, constituting 32% of the population (Table 1). This predominance can be attributed to the majority of cases arising from trauma, primarily affecting males in this age bracket.

Sex Distribution

Out of the 25 patients, 80% were males, which correlates with the fact that 68% of the cases involved trauma victims, a demographic that predominantly includes men (Table 2).

Indications for Flap Reconstruction:

Of the 25 cases, 68% (17 cases) were due to trauma reconstruction, 20% (5 cases) were following burns, and 12% (3 cases) were related to oncologic reconstruction (Table 3 & Figure No:1).

Region of Body for Flap Reconstruction

The distribution of flaps based on body regions is summarized in Table 3. The lower limb had the highest number of axial flaps (9 cases) and random flaps (3 cases), followed by the trunk with 5 axial flaps and the head and neck region with 3 axial and 3 random flaps (Table 4 & Figure No:2,6,7,8,9).

Outcome of Flap Surgeries

Of the 25 flaps performed, 17 were axial flaps, and 8 were random pattern flaps. Among the axial flaps, 3 (12%) developed complications, whereas only 1 out of 8 random pattern flaps had complications (Table 5). Overall, 21 flaps (84%) had no complications and survived, 1 flap experienced total necrosis, 1 flap had major partial necrosis, and 2 flaps had minor partial necrosis (Figure No:3).

Mean Flap Glucose Levels

The mean flap glucose levels were significantly different between the survival and non-survival groups. The survival group had a mean glucose level of 134.46 mg/dL, while the non-survival group had a mean of 55.3 mg/dL (Table 6 & 7). Over time, healthy flaps maintained elevated glucose levels above the cutoff value, whereas non-surviving flaps showed a gradual decrease in glucose levels (Figure No:4 & 5) .

Variation in Colour, Turgor, and Pin Prick Bleed:

All 4 flaps with complications exhibited changes in color (to purple), turgor (to firm/tense), and pin prick bleeding (to congested venous bleed). [Table 8]

Statistical Analysis

A statistically significant difference was observed in the mean flap glucose levels between the survival and non-survival groups, with a t-value of 11.985 and a p-value of 0.000. The survival group demonstrated significantly higher mean flap glucose levels. [Table 4]

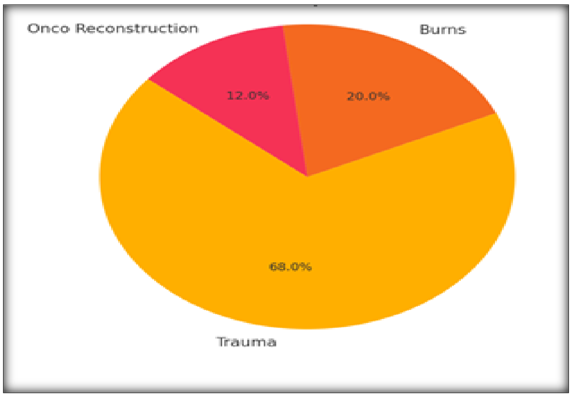

Figure 1: Indications for Flap Reconstruction

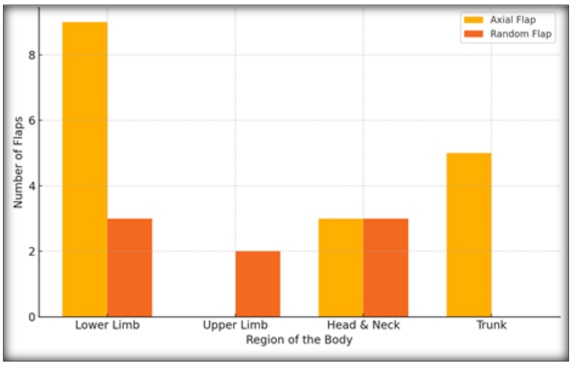

Figure 2: Distribution of Flaps Done by Body Region

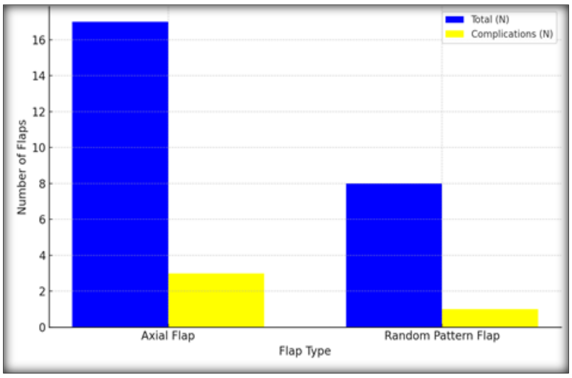

Figure 3: Outcomes of Flap Surgeries

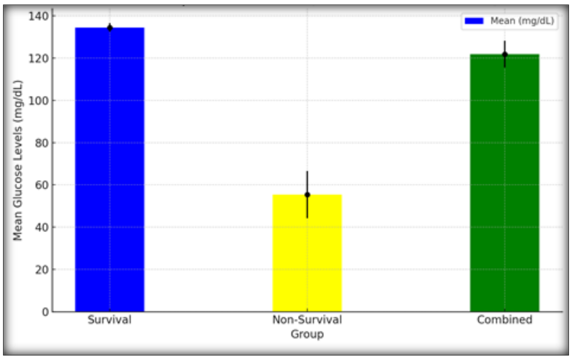

Figure 4: Mean Flap Glucose Levels (Survival vs Non-Survival)

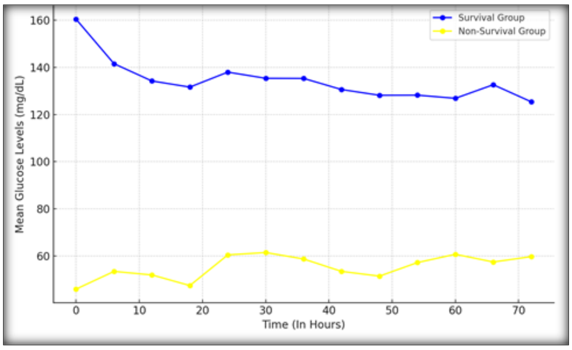

Figure 5: Mean Flap Glucose Levels Over Time

Figure 6: Reverse Sural Artery flap for soft tissue defect over distal third of leg

Figure 7: Medical Gastrocnemous flap cover for soft tissue defect of proximal third of leg

Figure 8: Forehead flap for nasal reconstruction

Figure 9: Abdominal Flap cover for Hiradenitis Supperativa

Table 1: Age Distribution of Study Population

Age Group (Years)	Frequency (N)	Percentage (%)
<20	2	8
21-29	2	8
30-39	5	20
40-49	8	32
50-59	7	28
60-69	1	4
Total	25	100

Table 2: Sex Distribution of Study Population

Sex	Frequency (N)	Percentage (%)
Male	20	80
Female	5	20
Total	25	100

Table 3: Indications for Flap Reconstruction

Indication	Frequency (N)	Percentage (%)
Trauma	17	68
Burns	5	20
Onco Reconstruction	3	12
Total	25	100

Table 4: Distribution of Flaps Done by Body Region

Region of the Body	Axial Flap	Random Flap
Lower Limb	9	3
Upper Limb	0	2
Head & Neck	3	3
Trunk	5	0
Total	17	8

Table 5: Outcomes of Flap Surgeries

Flap Type	Total (N)	Complications (N)	Percentage (%)
Axial Flap	17	3	17.65
Random Pattern Flap	8	1	12.5
Total	25	4	16

Table 6: Mean Flap Glucose Levels (Survival vs Non-Survival)

Group	Mean (mg/dL)	Std. Err.	Std. Dev.	95% Confidence Interval
Survival	134.46	2.11	9.67	130.06 - 138.86
Non-Survival	55.38	11.15	22.29	19.91 - 90.84
Combined	121.81	6.37	31.87	108.65 - 134.96
Difference	79.08	6.59		

Table 7: Mean Flap Glucose Levels Over Time

Time (In Hours)	Survival Group (mg/dL)	Non-Survival Group (mg/dL)
0	160.38	46
6	141.52	53.5
12	134.19	52
18	131.61	47.5
24	137.95	60.5
30	135.33	61.5
36	135.28	58.75
42	130.57	53.5
48	128.14	51.5
54	128.19	57.25
60	126.85	60.75
66	132.61	57.5
72	125.38	59.75

Table 8: Variation in Colour, Turgor & Pin Prick Bleed in Complicated Flaps

Observation	Change Noted
Colour	Purple
Turgor	Firm/Tense
Pin Prick Bleed	Congested Venous Bleed

DISCUSSION

The viability of flap tissue is crucial for the success of reconstructive surgeries, and timely detection of flap compromise is essential to prevent failure. Traditional methods of flap monitoring, although widely used, often rely on subjective clinical assessments that may delay the detection of complications (Salgado et al,[7] 2010). This study aimed to evaluate the utility of intra-flap glucose monitoring as a more objective and reliable indicator of flap viability.

Our findings demonstrate a significant difference in mean flap glucose levels between the survival and non-survival groups, with the survival group showing consistently higher glucose levels. This suggests that higher glucose levels within the flap tissue are indicative of adequate perfusion and metabolic activity. In contrast, lower glucose levels in the non-survival group reflect compromised blood supply and impending flap failure (Taeger et al,[8] 2020).

The mean flap glucose levels in the survival group remained above the cutoff value of 80 mg/dL, while those in the non-survival group consistently fell below this threshold. This trend supports the use of glucose monitoring as a real-time, quantitative measure for assessing flap perfusion. Notably, all flaps with complications exhibited changes in color, turgor, and pin prick bleeding, further validating the correlation between glucose levels and clinical signs of flap compromise (Singh et al,[9] 2023).

The predominance of trauma-related cases and the higher incidence of flap surgeries in males align with the demographic patterns observed in reconstructive surgery. The exclusion of diabetic patients, who inherently have altered glucose metabolism, ensured that the observed changes in flap glucose levels were not confounded by underlying metabolic disorders (Abdelwahab et al,[10] 2019).

Our study supports the findings of previous research highlighting the importance of objective monitoring techniques in flap viability. For instance, wireless infrared thermometry and Laser-Doppler Flowmetry have been explored for flap monitoring, indicating the evolving landscape of objective methods in postoperative care (Xie et al,[11] 2023; Salvatori et al,[13] 2022). Similarly, extracorporeal perfusion techniques and the use of modified solutions have shown potential in maintaining tissue viability (Molnar et al,[12] 2020).

While our sample size was limited to 25 patients, the statistically significant results underscore the potential of intra-flap glucose monitoring as a valuable tool in clinical practice. Future research with larger sample sizes and diverse patient populations will be beneficial to validate these findings and establish standardized protocols for glucose monitoring in flap surgeries (Mücke et al,[14] 2014).

CONCLUSION

Flap blood glucose monitoring (BGM) is a valuable, objective, easy, and inexpensive tool for early detection of flap ischemia. It can be performed by any medical professional without specialized equipment. Our study found no major complications from using a glucometer for monitoring. BGM is a reliable adjunct to traditional clinical monitoring, allowing early detection of flap compromise and delineation of partial necrosis. Combining BGM with established methods enhances postoperative flap management, reducing the risk of flap failure and improving patient outcomes.

REFERENCES

1. Hara H, Mihara M, Iida T, Narushima M, Todokoro T, Yamamoto T, et al. Blood glucose measurement for flap monitoring to salvage flaps from venous thrombosis. J Plast Reconstr Aesthet Surg. 2012 May;65(5):616-9. doi:

10.1016/j.bjps.2011.11.026. Epub 2011 Dec 8. PMID: 22153849.

2. Dakpé S, Colin E, Bettoni J, Davrou J, Diouf M, Devauchelle B, et al. Intraosseous microdialysis for bone free flap monitoring in head and neck reconstructive surgery: A prospective pilot study. Microsurgery. 2020 Mar;40(3):315-323. doi: 10.1002/micr.30529. Epub 2019 Oct 22. PMID: 31638286; PMCID: PMC7155115.
3. Ooms M, Winnand P, Heitzer M, Peters F, Bock A, Katz M, et al. Flap perfusion monitoring with an attached surface probe in microvascular reconstruction of the oral cavity. Clin Oral Investig. 2023 Sep;27(9):5577-5585. doi: 10.1007/s00784-023-05177-x. Epub 2023 Jul 31. PMID: 37522990; PMCID: PMC10492739.
4. Pérez Colman MC, Schauvinhold CF, Chavanne JM, Errea GF, Bou M, Ernst G. DIY Flap Monitoring: The Glucose Index. Plast Reconstr Surg Glob Open. 2023 Sep 22;11(9):e5289. doi: 10.1097/GOX.0000000000005289. PMID: 38152706; PMCID: PMC10752491.
5. Stephan D, Blatt S, Riedel J, Mohnke K, Ruemmler R, Ziebart A, et al. The Impact of Transfer-Related Ischemia on Free Flap Metabolism and Electrolyte Homeostasis-A New In Vivo Experimental Approach in Pigs. J Clin Med. 2023 Oct 19;12(20):6625. doi: 10.3390/jcm12206625. PMID: 37892763; PMCID: PMC10607031.
6. Chakraborty SS, Sahu RK, Midya M, Malhotra A, Goel AD, Pundhir A,et al. Difference between Capillary Blood Glucose of Free Flap and the Patient: A Novel Objective Marker of Free Flap Vascular Compromise during Postoperative Monitoring. Indian J Plast Surg. 2022 Dec 22;56(3):260-266. doi: 10.1055/s-0042-1759726. PMID: 37435338; PMCID: PMC10332902.
7. Salgado CJ, Chim H, Schoenoff S, Mardini S. Postoperative care and monitoring of the reconstructed head and neck patient. Semin Plast Surg. 2010 Aug;24(3):281-7. doi: 10.1055/s-0030-1263069. PMID: 22550449; PMCID: PMC3324228.
8. Taeger CD, Friedrich O, Horch RE, Distler C, Kengelbach-Weigand A, Wenzel C, et al. Tissue Viability of Free Flaps after Extracorporeal Perfusion Using a Modified Hydroxyethyl Starch Solution. J Clin Med. 2020 Dec 3;9(12):3929. doi: 10.3390/jcm9123929. PMID: 33287393; PMCID: PMC7761798.
9. Singh K, Shah S, Mittal RK, Garg R. Role of Lactate Measurement in Flap Monitoring: An Useful Adjunct. Indian J Plast Surg. 2023 Jun 1;56(4):344-349. doi: 10.1055/s-0043-1769111. PMID: 37705814; PMCID: PMC10497328.
10. Abdelwahab M, Kandathil CK, Most SP, Spataro EA. Utility of Indocyanine Green Angiography to Identify Clinical Factors Associated with Perfusion of Paramedian Forehead Flaps During Nasal Reconstruction Surgery. JAMA Facial Plast Surg. 2019 May 1;21(3):206-212. doi: 10.1001/jamafacial.2018.1829. PMID: 30703191; PMCID: PMC6537837.
11. Xie R, Liu Q, Zhang Y, Guo C, Huang X, Liu M. A wireless infrared thermometry device for postoperative flap monitoring: Proof of concept in a porcine flap model. Int Wound J. 2023 Aug;20(6):1839-1848. doi: 10.1111/iwj.14034. Epub 2022 Dec 19. PMID: 36535065; PMCID: PMC10332992.
12. Molnar A, Magyar Z, Nachmias DB, Mann D, Szabo B, Toth L, et al. Effect of short-term ischemia on microcirculation and wound healing of adipocutaneous flaps in the rat. Acta Cir Bras. 2020 Feb 10;34(12):e201901203. doi: 10.1590/s0102-865020190120000003. PMID: 32049184; PMCID: PMC7011208.
13. Salvatori P, Paradisi S, Zani A. Free flaps monitoring by Laser-Doppler Flowmetry in head and neck surgery. Acta Otorhinolaryngol Ital. 2022 Oct;42(5):427-433. doi: 10.14639/0392-100X-N1956. PMID: 36541380; PMCID: PMC9793142.
14. Mücke T, Rau A, Merezas A, Loeffelbein DJ, Wagenpfeil S, Mitchell DA, et al. Identification of perioperative risk factor by laser-doppler spectroscopy after free flap perfusion in the head and neck: a prospective clinical study. Microsurgery. 2014;34(5):345–351.