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ANALYSIS OF FLAP PERFUSION BY MEASURING CAPILLARY GLUCOSE LEVELS IN PEDICLED FLAP AND FREE TISSUE TRANSFER

Plastic Surgery

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ABSTRACT

Background- Flap harvest is frequently performed procedure in plastic and reconstructive surgery. Poor blood flow can lead to flap compromise and failure. Addressing this issue requires a reliable and valid instrument for flap monitoring to detect early signs of flap failure. We evaluate the efficacy of measurement of flap blood glucose level in predicting the flap congestion and salvage. **Method-** A prospective observational study was conducted in the department of Plastic & Reconstructive surgery, Institute of Post Graduate Medical Education & Research & SSKM Hospital, Kolkata, from September 2021 to March 2023.150 patients were included in the study for flap monitoring via capillary glucose level. For each flap, glucose level was plotted on ROC curve and sensitivity, specificity calculated. The value which is plotted nearer to 100 with highest sensitivity and specificity is the cut-off value. **Results-** In this study a cut-off value of 61.17 mg/dl is proposed for capillary glucose monitoring of flaps with sensitivity 96.77% and specificity of 88.24%. The mean sugar value for survival and non-survival group was 97.8 and 47.8mg/dl respectively. Mean glucose level in flaps that survived had almost a steady state whereas there was a significant fall in mean glucose level in flaps which did not survive over a period of time. **Conclusion-** The capillary glucose monitoring method as done in this study is simple, objective, without much technical issues, inexpensive and does not need any specialised set up. It can be done by residents, nurses and patients themselves and the result can be easily communicated to the medical staff. It may also be useful in monitoring intra oral flaps or in dark skinned individuals which are difficult to monitor based on flap color or other clinical features.

KEYWORDS

flap, flap monitoring, capillary glucose level

INTRODUCTION

Flap harvest is frequently performed procedure in plastic and reconstructive surgery. Ensuring adequate blood supply to the transferred tissue is a challenging task. Poor blood flow can lead to flap compromise and failure. Addressing this issue requires a reliable and valid instrument for flap monitoring to detect early signs of flap failure. Early detection of circulatory failure is critical for timely intervention and rescuing of failing flaps. The window period between the onset of circulatory compromise and salvage surgery is critical to the success of the surgery as delayed intervention can result in irreversible damage to the flap. Flap failure can have serious consequences for the patient including tissue loss, infection, the need for multiple surgeries and the resources required to address flap loss can be significant including hospital stay and rehabilitation. Vascular reasons are the most common cause of flap failure so improving our understanding of flap hemodynamics and how it responds to circulatory compromise is therefore crucial to minimize the risk of flap failure. The ideal monitoring method should be reliable, non-invasive, accurate, inexpensive and easy to use even for a normal person. Although many monitoring methods have been introduced, clinical evaluation is still the gold standard for flap evaluation, although it is subjective and may vary among individuals. This study is performed to evaluate the flap capillary glucose level estimation as a tool to monitor the viability of the flap.

METHOD

The patients who underwent pedicled and free flaps were assessed post operatively and followed up to 5th post operative day. The clinical examination was standardized with skin color, temperature, capillary refill time and bleeding test with a prick. Flap capillary glucose level was measured by pricking the distal part of flap with 26G needle till dermal layer and measured by strip based glucometer. Examination was done postoperatively hourly for first six hours, then 6 hourly till 5th post-operative day**.** Data was collected to analyse efficiency of capillary glucose measurement of flap for post operative monitoring. The data was compiled in excel sheet and statistical analysis was done using MedCalc software so as to determine whether capillary glucose measurement of flap could be used as a significant tool to monitor flaps.

The diagnosis of flap failure is according to the clinical features. Flap with pale colour, with delayed capillary refill or dusky flap with dark purplish ooze, cold on touch are features of a failing flap.

Normal value of random blood sugar in adult is around 80-120 mg/dl. Values in flap were supposed to be as that of normal blood sugar levels. Flap glucose measurement was done on the patients who underwent reconstruction with flap. As flap capillary glucose was considered as the possible marker of flap failure, it was expected to be decreased in compromised flaps and would be normal if there was adequate perfusion. Quantitative data was expressed in frequency and percentage. Data was expressed as mean value and standard deviation (SD) for capillary glucose levels in flap. Diagnostic accuracy measuring sensitivity and specificity was calculated with 95% confidence interval. In order to decide the best cut- off value ROC curve was plotted with clinically assessed tissue as survived or failure. These findings were tabulated against glucose monitored value. Flap capillary glucose level at every 6th hour was arranged for survived and failure cases and ROC curve was plotted. The best of all this ROC was identified and best cut-off value of blood sugar for this ROC was selected.

Collected data were divided into two groups, i.e. values noted in patients with flap survival and in those with flap failure. Correlation of the flap glucose value was done to assess the diagnostic validity of the test.

RESULTS

There were 150 cases in this study. Glucose levels of flap with necrosis and without necrosis were compared and were statistically analysed with ROC curve. Mean age of patients was 32.3 years. There were 114 (76%) males and 36 (24%) females in this study.115(76.67%) flaps were done for trauma related defects, 21(14%) flaps were done for oncological defects, 13(8.67%) flaps were done for burn reconstruction and one (0.67%) flap was done post keloid excision. There were 137(91.33%) pedicled flaps and 13(8.67%) free flaps. Out of 150 flaps, 119(79.33%) flaps had survived and 31(20.67%) flaps underwent major necrosis and flap loss. The mean sugar value for survival and non-survival group was 97.8 and 47.8mg/dl respectively. Mean glucose level in flaps that survived had almost a steady state whereas there was a significant fall in mean glucose level in flaps which did not survive over a period of time. A cut off value of 61.17 mg/dl was determined to detect flap ischemia with sensitivity of

96.77% and specificity of 88.24% allowing early detection of vascular insufficiency.

Table 1: Distribution Of Cases As Per Etiology For Which Flap Harvest Was Done

Etiology	No. of patients	Percentage
Traumatic	115	76.67
Oncological	21	14.00
Burns	13	8.67
Post keloid excision	1	0.67
Total	150	100.00

115(76.67%) flaps were done for trauma related defects, 21(14%) flaps were done for ncological defects, 13(8.67%) flaps were done for burn reconstruction and one (0.67%) flap was done post keloid excision.

Table 2: Distribution Of Cases According To The Type Of Flap

Type of flap	No. of patients	Percentage
Pedicled	137	91.33
Free	13	8.67
Total	150	100.00

There were 137(91.33%) pedicled flaps and 13(8.67%) free flaps.

Table 3: Distribution Of Outcome And Complication Of The Flaps

Outcome and complication	No. of patients	Percentage
Flap survived	119	79.33
Major necrosis	31	20.67
Total	150	100.00

Out of 150 flaps, 119(79.33%) flaps had survived and 31(20.67%) flaps underwent major necrosis and flap loss.

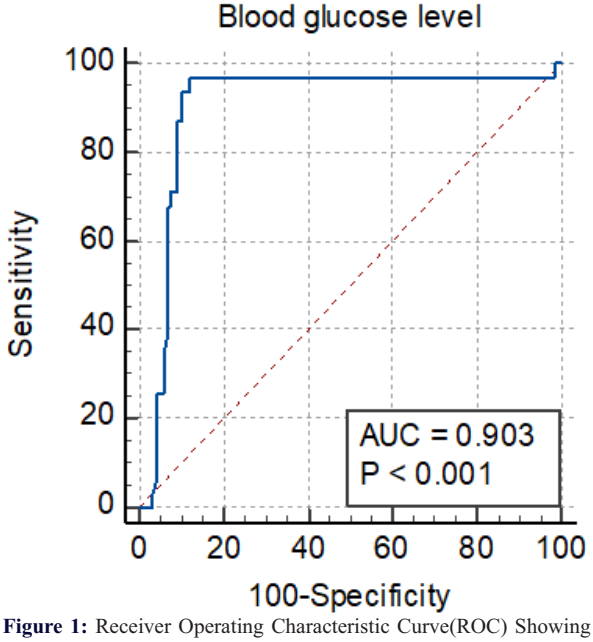


Figure 1: Receiver Operating Characteristic Curve(ROC) Showing Diagnostic Performance Of Flap Glucose Level For Monitoring

Area Under The ROC Curve (AUC)

Area under the ROC curve (AUC)	0.903
Standard Error [a]	0.0360
95% Confidence interval [b]	0.844 to 0.945
z statistic	11.208
Significance level P (Area=0.5)	<0.0001

Youden index J	0.8501
Associated criterion	≤61.17
Sensitivity	96.77
Specificity	88.24

For each flap, glucose level was plotted on ROC curve and sensitivity, specificity calculated. The value which is plotted nearer to 100 with highest sensitivity and specificity is the cut-off value.

The area under the ROC curve (Figure 1) was 0.903 which denotes a strong relationship between flap capillary glucose levels and flap survival. Flap capillary glucose value at which the sensitivity was 96.77% and specificity 88.24% was determined-61.17mg/dl and proposed as cut-off value. A value less than 61.17 mg/dl is suggestive of flap compromise. Keeping cut off value as 61.17 mg/dl, cross tabulation was done to calculate PPV (Positive Predictive value) and NPV (Negative Predictive Value). Mean sugar values were significantly low in the non survival group on different times. Chi-Square test was done to check the null hypothesis. The p value was <0.001, which rejects the null hypothesis and indicates a strong relationship between low flap blood glucose level and flap failure.

Table 4: Sugar Level Outcome Cross Tabulation

Mean sugar level (mg/dl)	Outcome				Total	
	Not survived		Survived			
	N	%	N	%	N	%
≤61.17	30	96.77	14	11.76	44	29.33
>61.17	1	3.23	105	88.24	106	70.67
Total	31	100.00	119	100.00	150	100.00

Chi square 85.73, P value <0.0001 (S)

Among flaps which survived, 88.24% had mean sugar level above 61.17mg/dl and 11.76% had value below 61.17mg/dl. 96.77% flaps that did not survive had mean sugar level below 61.17mg/dl and 3.23% had value above 61.17mg/dl.

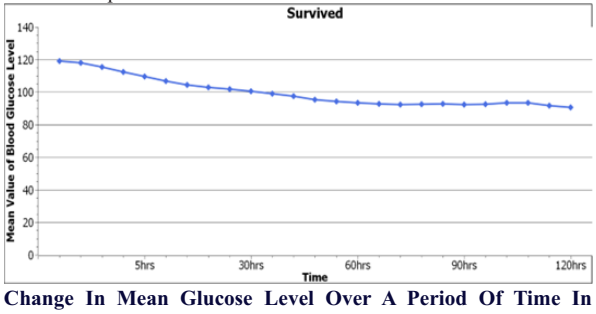
Table 5: Mean, Median And Standard Deviation

	Survived	Not survived
Mean(mg/dl)	97.8	47.8
Standard deviation	21.84	14.33
Median	105	44.93

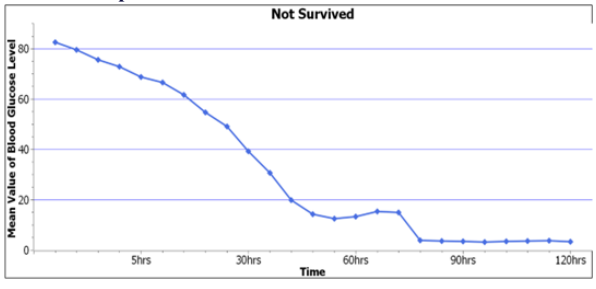
Unpaired t test value 15.33, P value <0.0001 (S)

The mean blood sugar level among flaps which survived was 97.8mg/dl with median value 105 and standard deviation of 21.84 whereas in flaps that did not survive had mean value 47.8mg/dl, median 44.93 and 14.33 as standard deviation.

Figure 2: Mean Capillary Glucose Levels In Survived And Non-survived Flaps



Change In Mean Glucose Level Over A Period Of Time In Survived Flaps.



Change In Mean Glucose Level Over A Period Of Time In Non-survived Flaps.

Mean glucose level in flaps that survived had almost a steady state whereas there was a significant fall in mean glucose level in flaps which did not survive over a period of time.

DISCUSSION

Capillary glucose monitoring for flap is highly sensitive and specific for flap compromise.[1] It is rapid, inexpensive, easy to do and accurate method of monitoring flaps. In 2010, Sakakibara et al. reported a lower blood glucose level in compromised flaps in clinical cases.[2] Setalare et al. found that the blood glucose level in flaps is reduced in ischemic or

congestive conditions by using microdialysis[3,4]. In 2011, Hara et al described blood glucose measurement (BGM) in a flap over a period for flap monitoring in 33 free or pedicled flaps and reported that the blood glucose level of 62mg/dl is the best cut-off value for detecting flap compromise at which the sensitivity and specificity are 88% and 82% respectively[5]. In 2015, Bashir MM et al described diagnostic accuracy of blood glucose measurements in flap monitoring in 127 cases of pedicled and free flaps on patients between 12 and 60 years and reported a cut-off value of 62 mg/dl with sensitivity and specificity of 90% and 78% respectively.[6]The reason for low glucose levels in compromised flap is still not very clear but it is believed that raised capillary and venous pressure in ischemic flaps causes less blood flow to the flap which results in reduced supply of sugar to the flap causing hypoglycaemia.

Under anaerobic conditions there is accumulation of pyruvate and lactate which can be monitored by microdialysis but the instrument is too expensive and complicated. In this study a cut-off value of 61.17 mg/dl is proposed for capillary glucose monitoring of flaps with sensitivity 96.77% and specificity of 88.24%. The mean sugar value for survival and non-survival group was 97.8 and 47.8mg/dl respectively. Mean glucose level in flaps that survived had almost a steady state whereas there was a significant fall in mean glucose level in flaps which did not survive over a period of time. Flap monitoring via blood glucose measurement is quick, easy and requires minimal blood. It is also more quantitative than the traditional ways of clinical evaluation. It provides a surrogate representation of adequate flap perfusion and allows objective analysis between tests. Diabetic patients were not included in this study as their blood glucose level often fluctuates more than normal individuals so it may be necessary to modify blood glucose level for flaps done in diabetic patients and further more study will be needed in this aspect.

The capillary glucose monitoring method as done in this study is simple, objective, without much technical issues, inexpensive and does not need any specialised set up. It can be done by residents, nurses and patients themselves and the result can be easily communicated to the medical staff. It may also be useful in monitoring intra oral flaps or in dark skinned individuals which are difficult to monitor based on flap color or other clinical features. Flap glucose level has also got prognostic value as glucose levels over a period of time may indicate the survivability of flap. The rate at which the flap's glucose level falls is very sensitive in indicating flap failure. The clinical examination is considered the benchmark for flap monitoring but with capillary glucose monitoring as an adjunct can help with early diagnosis and reduce postoperative complications. Few studies have evaluated the effectiveness of flap glucose for flap monitoring. The flap blood glucose monitoring method is an objective, simple and inexpensive method for flap monitoring that can be performed by any healthcare professional and requires no special setup.

CONCLUSION

The capillary glucose monitoring method as done in this study is simple, objective, without much technical issues, inexpensive and does not need any specialised set up. It can be done by residents, nurses and patients themselves and the result can be easily communicated to the medical staff. It may also be useful in monitoring intra oral flaps or in dark skinned individuals which are difficult to monitor based on flap color or other clinical features . A cut off value of 61.17 mg/dl was determined to detect flap ischemia with sensitivity of 96.77% and specificity of 88.24% allowing early detection of vascular insufficiency.

Limitations of the study-Diabetic patients were not included in this study as their blood glucose level often fluctuates more than normal individuals so it may be necessary to modify blood glucose level for flaps done in diabetic patients and further more study will be needed in this aspect. This method cannot be used to monitor buried flaps. This method requires multiple puntures in the flap.

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