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Evaluation of post-operative blood glucose monitoring as a objective tool for flap monitoring

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Abstract
Traditionally, clinical monitoring of free flaps in the postoperative period requires a clinician to monitor the flap's physical characteristics, capillary refill time, temperature, bleeding characteristics after a pin prick, external or handheld Doppler ultrasound device or a combination of these approaches. The objective of this study was to evaluate post operative blood glucose monitoting within flap as a tool that can help in early detection of flap compromise. We performed 25 free flaps on patients aged between 18yrs to 65yrs. GRBS was checked at the finger tip of the patient and simultaneously flap is scratched and GRBS is noted. Blood glucose monitoring done at 6, 12, 18, 24 and 48 hours post operative using blood glucometer. Regular examination for clinical signs of vascular compromise was done to determine flap viability for up to 7th day after operation. Total of the 25 flaps, 20 (80%) were performed on men and the mean age of the patients was 47.68years. Considering cut-off value for the mean blood glucose level was set at 62 mg/dL based on receiver operative characteristics (ROC) curve, true positive and false positive cases were 20 and 0 respectively, whereas true negative and false negative cases were 4 and 0 respectively. The sensitivity and specificity are 100% each. Hence we conclude that blood glucose monitoring within flap is easy diagnostic tool and should be used to detect early vascular compromise so that salvage surgery is possible.

Keywords: Free flaps, glucose monitoring

Introduction
Free flaps are micro vascular tissue transfer used for reconstruction of varied types of defects. Most common cause of flap loss is venous compromise. Traditionally, clinical monitoring of free flaps in the postoperative period requires a clinician to monitor the flap's physical characteristics, capillary refill time, temperature, bleeding characteristics after a pin prick, external or handheld Doppler ultrasound device, color duplex sonography, near-infrared spectroscopy, microdialysis, and laser Doppler flowmetry or a combination of these approaches. There should be a reliable and simple post operative method of monitoring for salvage of flaps so that early detection and re-exploration can be done for flap salvage. The microdialysis system, which analyzes the chemical changes within flap, have shown that the blood glucose concentration within flap is decreased in the ischemic or congestive condition [6]. Blood glucose measurement (BGM) from flap establishes a simple method that can be used widely to decrease the flap loss rate after free tissue transplantation. Skin punctures and blood glucose measurements were made use which are commonly used by diabetic patients. This study can help to reduce postoperative complications caused by the development of a venous thrombus after free tissue transplantation.

Methods
The study was conducted in the department of Plastic surgery in Yenepoya Medical College Hospital during the period from August 2017 to August 2018 to all the patients undergoing free flap after approval from Yenepoya University Ethics Committee. 25 free flaps on patients aged between 18yrs to 65yrs were taken into study. All patients undergoing free flap cover irrespective of flap size, diabetic or non-diabetic status, infective or non-infective status were taken into study excluding Muscle flaps, Flaps in inaccessible areas like gracalis flap in rectovaginal and rectovesical fistulas, deep buried flaps in head and neck reconstruction. Sample size was calculated using G power software with level of significance $\alpha = 5\%$, Power $1-\beta = 80\%$, Effect size $d = 0.6$, Sample size $=24 \approx 25$. A written informed consent was taken from the

study participants before enrolling them into the study explaining the objectives of the study, procedure involved, and likely implications in a language understandable to patients.

After taking all the sterile precautions, skin over the flap is scratched using a Medisafe-fine touch needle which is commonly used by diabetic patients. The puncture needle thickness is 25 G. Two tests done i.e. GRBS is checked at the finger tip of the patient and simultaneously flap is scratched and GRBS is noted. Blood glucose monitoring done at 6, 12, 18, 24 and 48 hours post-operative using blood glucometer. The cut-off value for the mean blood glucose level was set at 62 mg/dL based on receiver operative characteristics (ROC) curve and previously published data [8].

The data was entered and tabulated in Microsoft excel sheet. Appropriate descriptive statistical tests was used to describe the data. Data was analyzed using SPSS version. Differences between blood glucose levels in healthy and congestive flaps at each time point were evaluated using Student's t-test, with the significance level set at 0.01.

Results

In 25 patients who underwent flaps 20 were men and 5 were women (Table 1). Among 25 patients, 6 (24%) were below 40 years, 14 (56%) were between 40-60 years and 5 (20%) were above 60 years of age (figure 1). The mean (SD) age who underwent these flaps was 47.68.

Table 1: Gender distribution of patients underwent flap reconstruction

Gender	Male	Female	Total
No. of patients	20	5	25
Percentage	80	20	100

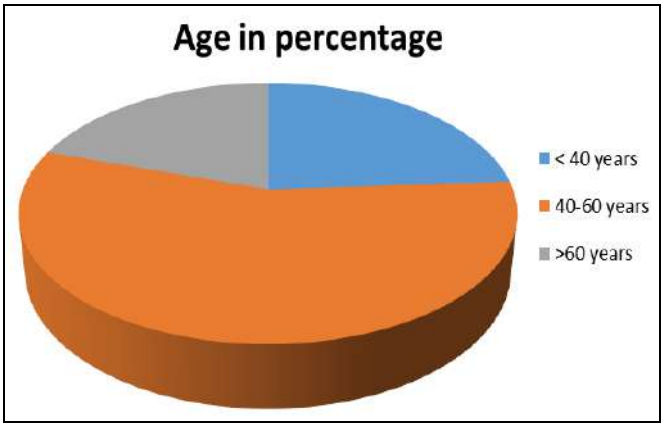

Fig 1: Age distribution of patients underwent flap reconstruction

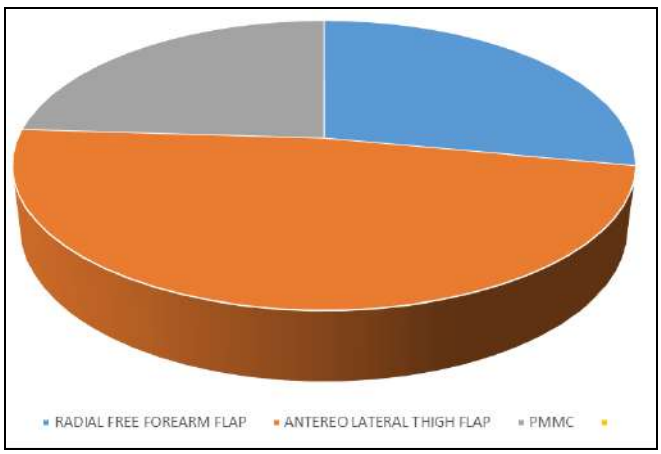

Fig 2: Distribution of various flap reconstruction

Considering cut-off value for the mean blood glucose level was set at 62 mg/dL based on receiver operative characteristics (ROC) curve, true positive and false positive cases were 20 and 0 respectively, whereas true negative and false negative cases were 4 and 0 respectively (figure 2). The sensitivity and specificity are 100% each.

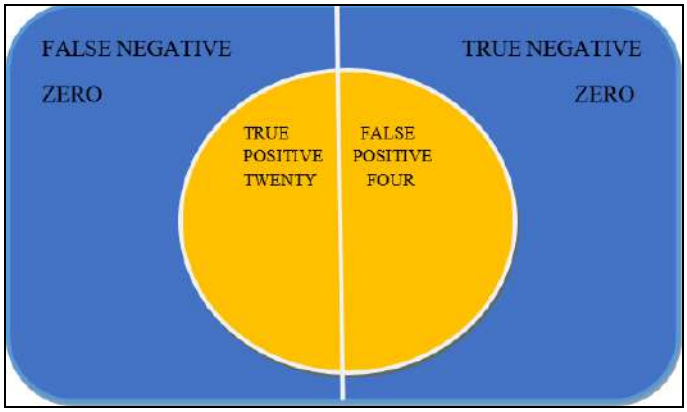

Fig 3: The figure shows true and false with positive & negative scores

Group Statistics				
Group		Mean	Std. Deviation	Significance
0hrs	FLAP	145.20	31.336	t = -2.807
	UL	199.90	53.071	p = 0.012
6hrs	FLAP	147.10	48.186	t = -2.666
	UL	200.90	41.824	p = 0.016
12hrs	FLAP	129.11	58.023	t = -2.930
	UL	209.00	57.676	p = 0.10
24hrs	FLAP	119.63	67.968	t = -3.411
	UL	209.38	30.298	p = 0.004
48hrs	FLAP	145.00	88.786	t = -1.532
	UL	209.60	31.675	p = 0.164

Fig 4: Mean and standard deviation of various flaps

Discussion

The success of free-tissue transfer is dependent on the continuous arterial inflow and venous outflow through the patent microvascular anastomoses, until neovascularization is established by peripheral in-growth of vessels [1, 4]. Flap-threatening complications that may develop include vascular thrombosis, pedicle kinking / compression, venous congestion and arterial spasm [2-5].

If the compromised circulation of a free flap cannot be re-established within 8 – 12hours, salvage of such free-tissue transfer may be impossible because of the "no-reflow" phenomenon [2, 5, 11]. So establishing a reliable method for flap monitoring is crucial.

Various methods for flap monitoring that have been reported include physical assessment of flap colour or turgor [12], an implantable / transcutaneous Doppler system [13], colour duplex sonography [14], laser Doppler flowmetry [15], near-infrared spectroscopy [16], microdialysis [17], surface temperature scanning, blood-flow monitoring with intravenous catheter, transcutaneous pO2 and pCO2 monitoring [18].

In our present study among 25 patients who underwent flaps 20(80%) were men and 5(20%) were women, where as in other studies like Bashir *et al.* [1]. Of the 127 flaps included in the

study, 76 (60%) were performed on men and 51(40%) were women. In our present study mean (SD) age who underwent these flaps was 47.68 years, where as in other studies like Bashir *et al.* [1] mean (SD) age of the patients who had these flaps was 35.8 years.

In the study true positive and false positive cases were 20 and 0 respectively, whereas true negative and false negative cases were 4 and 0 respectively, where as in other studies like Bashir *et al.* [1] true positive and false positive cases were 81 and 8, respectively, whereas the true negative and false negative cases were 29 and 9, respectively. It found in the study sensitivity and specificity of 100% each, where as in other studies like Bashir *et al.* [16] the sensitivity is 90% and the specificity is 79%. Another study Hara *et al.* [17]. Twenty-four (73%) flaps were free tissue transfers for reconstruction of traumatic and oncologic soft tissue defects. Six (18%) flaps were pedicled flaps and 3 (9%) were amputated finger re-plantations. Sensitivity was 90% and the specificity was 79%.

Partial necrosis of the vascular territory was found in 6 cases, while blood flow disorder due to a venous thrombus was found in 1 case which was rexplored and flap was salvaged. There was a gradual elevation of the blood glucose level over time in the healthy flaps, whereas the blood glucose level gradually decreased in the congestive flaps. The mean blood glucose level in the congestive flaps was significantly lower than the patient's actual blood glucose level.

In these cases, low capillary blood glucose levels within the flaps were detected early, even before the flap discolouration occurred.

Differences between blood glucose levels in healthy and congestive flaps at each point of time were evaluated using Student's t-test, with the significance level set at 0.05. As shown in figure 4.

The findings were consistent with the studies done by Hara *et al.* and Sakakibara *et al.* [1].

A study done by Zoccali *et al.* reveals that the critical period for flap-threatening complications is the first 24 –48 post-operative hours; however, the window for the onset of these complications remains open for up to 7 days post-operatively [2].

The procedure is rapid and simple and requires only minimal amounts of blood (10 – 20µL). This method is found to be more quantitative than the traditional ways of flap monitoring, such as observing flap color, flap turgor, or the pinprick test.

Advantages

- Low capillary blood glucose level in congested flaps indicates an early sign of venous thrombosis.
- The capillary blood glucose level within the flap monitoring method described here is simple and can be performed by residents, nurses, or even patients themselves.
- Cost-effective.
- The capillary blood glucose level within the flap may also be useful for monitoring intraoral flaps, which are difficult to monitor on the basis of flap color, or in tissue transfers with a small skin paddle.

Disadvantages

- The use of this method is limited in cases of ischemic flaps because in such cases, sufficient blood may not be obtained to measure the glucose level in a pinprick test.
- It is also uncertain if capillary blood glucose levels for flap monitoring can be used in diabetic patients, since the blood glucose level often fluctuates at both higher and lower values more than that in non-diabetic persons and hence, it may be necessary to modify the blood glucose values obtained from diabetic patients, and further studies on this issue are needed.
- This method also cannot be used in buried tissue transplantation cases.
- The cut-off value, sensitivity, and specificity of this method in the diagnosis of early flap congestion have not been determined and is yet to be elucidated by further research.

Conclusion

Capillary blood glucose monitoring within the flap is an easy, accessible and cost-effective adjunct to flap monitoring, which helps in early detection of flap congestion, even before flap discoloration occurred.

The incorporation of blood glucose measurement in addition to clinical monitoring, aids in early detection and possible reduction of post-operative complications due to venous thrombosis.

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