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Research Article

Role of Free Flap Blood Glucose Measurement as an Adjunct in Effective Post Operative Monitoring and to Detect Early Flap Congestion and Salvage.

Dr. Thyagaraj J[1], Dr. M. Ehtaih Sham[*2], Dr. (Col) Suresh Menon[3], Dr R Ritvik Vinayak[4]

1. Dr. Thyagaraj J, Professor, MS, MCh, Department of Plastic Surgery, Vydehi institute of medical sciences, Bangalore.

2. Prof. Dr. M. Ehtaih Sham, Professor, MD, MDS, MS, MRM, PhD Department of Oral and Maxillofacial surgery, Vydehi institute of Medical and Dental sciences and research centre, Bangalore.

3. Dr. (Col) Suresh Menon, MDS, FIBOMS, Professor and HOD, Department of Oral and Maxillofacial surgery, Vydehi institute of Medical and Dental sciences and research centre, Bangalore

4. Dr R Ritvik Vinayak, MDS post graduate resident, Department of oral and maxillofacial surgery, Vydehi institute of Medical and Dental sciences and research centre, Bangalore.

[*]**Correspondence to:** Prof. Dr. M. Ehtaih Sham, Professor, MD, MDS, MS, MRM, PhD, Department of Oral and Maxillofacial surgery, Vydehi institute of Medical and Dental sciences and research centre, Bangalore.

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Abstract:

Introduction

Free flap monitoring is of major importance in micro vascular surgery and clinical monitoring will always remain a gold standard. The salvage rates of free flaps are directly related to the time interval between the onset of vascular impairment and their clinical recognition. The authors suggested an efficient, simple and cost-effective technique to detect early thrombotic events in monitoring free flaps.

Aim

The aim of the study was to evaluate blood glucose measurement (BGM) for free flap monitoring and to establish a simple method that can be used widely to decrease the flap loss rate after tissue transplantation.

Materials and Method

Post-operative blood glucose measurement were regularly performed on 60 head and neck free flap transfers (38 males and 22 females). The flaps were 18 free fibula osteo-cutaneous flaps, 20 radial forearm free flaps, 14 anterolateral thigh flaps and 8 lateral arm flaps. Skin punctures and blood glucose measurements were made using freestyle Optium Neo H glucometer which are commonly used by diabetic patients.

Results

Partial necrosis of the vascular territory was found at 2 patients and obstruction due to a venous thrombus was found in two patients. The mean blood glucose level in the congestive flaps was significantly lower than that in healthy flaps. A cutoff value for BGM of 62 mg/dL, at which the sensitivity and specificity were 88% and 82%.

Conclusion

Blood glucose measurement is an easy and accessible adjunct to flap monitoring, and the combination of BGM and previously established methods is likely to reduce postoperative complications caused by the development of a venous/arterial thrombus after free tissue transplantation.

Introduction

Free flap reconstructions have become a reliable method for repair of any defect in almost any part of body[1]. Improvements and technical advances in microsurgical technique and instruments, availability of reliable flaps, and the development of various flap monitoring methods have helped improve the success rate of free tissue transfer. Though the success rate is reported to be 95% or higher, Complications associated with free flap surgeries include venous and arterial thrombosis, hematoma, wound infection, flap dehiscence, fistula formation, and so on, which may lead to partial or total flap failure. Vascular compromise (venous vs arterial) is the most common cause for flap loss[2]. Conscientious postoperative flap monitoring allows early detection of flap failure which is the only evidence-based strategy for optimizing free flap salvage[2]. The effective effort of flap salvage declines as the duration of time period from the occurrence of complication to its detection increases[3]. Flap survival can be augmented with timely restoration of blood flow. There have been numerous modalities and methods described for postoperative monitoring; however, no single gold standard exists and research is ongoing evaluating new and old methods[3].

Postoperative monitoring of free flaps relies on skin colour, temperature, capillary refill, turgor, pinprick/dermal scratch test and palpation of the arterial pulse wave to provide visual and manual evidence of flap perfusion. Recognizing the visual signs of flap failure requires considerable clinical experience[4].

To date, objective flap monitoring for head and neck reconstructions is limited. Recent systemic analysis has showed that techniques such as implantable Doppler, indocyanine green (ICG) angiography, tissue oximetry/ transcutaneous oxygen tension, dynamic infrared thermography (DIRT), hydrogen clearance, pH measurement, photoplethysmography and so on., have the potential to provide objective data for intraoperative flap perfusion assessment[5]. Micro dialysis is a method that measures certain metabolites like glucose, lactate, etc., levels in the flap blood. It is a more objective, reliable, and reproducible method documented in the literature for postoperative monitoring of free flaps but requires much more technical expertise[6].

The ideal monitoring method should be non-invasive, reliable, continuous, accurate, and inexpensive, and provide real-time information. Although a multitude of monitoring methods have been introduced, clinical observation is still the gold standard of flap assessment, despite its inherent problems[6].

Based on the principles of micro dialysis, monitoring of capillary blood glucose levels in free flaps using glucometer is being proposed as a cheap, rapid, and simple method for the early prediction of microvascular complications and thereby reducing flap failure[6]. To obtain more accurate monitoring method for flap congestion, we focused on the ratio of blood glucose change (RBGC). The purpose of this study was to evaluate and establish a simple and accurate method using RBGC measurement for detecting venous thrombosis and to consider an algorithm for flap salvage from congestion[7].

Materials & Methods

This study was conducted at vydehi Institute of medical sciences from 2019 to 2022, 60 patients (38 males and 22 females) who underwent head and neck free flap transfers at the institute were assessed post operatively and followed up till 5th post operative day. The flaps were 18 vascularised fibula osteo myo-cutaneous flaps, 20 radial forearm free flap, 14 anterolateral thigh flap and 8 lateral arm flaps (Table I). Skin punctures and blood glucose measurements were made using a Freestyle Optium Neo H blood glucose test strip, which are commonly used by diabetic patients.

Table 1. Patient, Lesion, Flap Demographics.

Number of patents	Male	Female	Lesion	Flap type
18	11	07	SCC	Fibula osteo-myo-cutaneous flap
20	10	10	SCC	Radial forearm free flap
14	10	04	SCC	Antero lateral thigh flap
08	05	03	SCC	Lateral arm flap

The clinical method of flap monitoring was standardized with skin paddle colour, temperature, turgor, skin reperfusion time, and Scratch test with a gauze on the de-epithelised portion of flap. Flap capillary glucose levels were measured by pricking the distal part of flap and measuring glucose levels of flap by glucometer. Examination was done postoperatively hourly for first six hours followed by every 6th hour thereafter for next five days.

A routine baseline capillary glucose level measurement was also done in all patients. Data was collected to analyse efficacy of capillary glucose measurement of flap for post operative monitoring. The diagnosis of flap failure is according to the clinical features. (Described by Mathes and Nahai) Flap with pale colour, delayed capillary refill or dusky flap with exceptionally brisk refill, dark purplish ooze, cold on touch are features of failing flap. Normal value of blood sugar in adult: 80-120 mg/ml. Values in flap should be as that of normal blood sugar levels. Flap capillary glucose levels decreases in compromised/failed flaps.

As flap capillary glucose is considered as the possible marker of flap failure, we expect it to decrease in ischemic flaps and should be normal if there is no ischemia. To minimize bias person doing glucose monitoring test will not make the diagnosis of flap failure. 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 levels 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 was divided in to two groups, i.e. Values noted in patient with flap survival and in patients with flap failure. Correlation of the flap glucose value was done to assess the diagnostic validity of the test.

Inclusion criteria: All patients undergoing free flap surgery.

Exclusion criteria: Patients undergoing pedicled flaps and buried free flap.

Figure 1: Normal level of Flap Capillary sugar levels indicating healthy flap

Results

Of the 60 free tissue transfers, partial necrosis in the vascular territory was found in 2 flaps and obstruction due to a venous thrombus was found in 2 flaps. Two flaps in the series were re-explored for presumed vascular thrombosis and were timely salvaged. The mean blood glucose level in the congestive flaps was significantly lower than that in the healthy flaps. 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, but not significantly. ROC curve analysis was used to determine a cutoff value for the Blood Glucose measurement of 62 mg/dL, at which the sensitivity and specificity were 88% and 82%, respectively ($p < 0.0001$).

Discussion

Early detection and immediate re-exploration are the key success factor in salvage of a congestive flap. Flap monitoring via clinical observation of skin colour, turgor, capillary refill, and dermal bleeding remains the benchmark, but there are multiple issues related to availability of adequately trained hospital staff for microvascular free flap monitoring and also difficulty of making a timely clinical judgement of a flap's perfusion. These multiple issues have generated lot of interest for more objective cost-effective monitoring methods[8,9,10].

Methods that have been currently used include internal and external thermometry, laser Doppler flowmetry, internal and external Doppler monitoring, quantitative fluorescein fluorescence, pulse oximetry, transcutaneous oxygen monitoring. The most popular of these methods are external Doppler monitoring, implantable Doppler monitoring, and assessment of cutaneous blood flow using laser Doppler flowmetry[12].

These tests are extremely expensive and needs specialized setup and specialised personnel. Interstitial glucose monitoring is highly sensitive and specific for vessel occlusion[13].

This technology offers a rapid, inexpensive, and accurate method of monitoring free tissue transfer. In 2010, Sakakibara et al. reported the first use of a blood glucose meter for flap monitoring in diabetic patients and a lower blood glucose level in congestive flaps in clinical case[14]. Leena Setala et al. found that the blood glucose levels in ischemic or congestive flaps is reduced, which was effectively identified using microdialysis[15].

Hara et al.1 described blood glucose measurement for flap monitoring and reported that the blood glucose level of 62mg/dl is the best cutoff value for detecting venous thrombosis[16].

Hypothesis behind low Flap glucose levels in ischemic flap is still not clear. It is believed that there is a raised capillary and venous pressure in ischemic flaps causing reduced blood flow entering the flap. Due to the reduced blood flow the supply of glucose to flap will be reduced and it will attain a state of hypoglycaemia. Hypoxic state of flap due to reduced blood flow will lead to anaerobic metabolism. Cells under anaerobic metabolism do not consume oxygen, indicating low consumption of glucose and reduced flap blood glucose measurements (BGM). Thus, a flap with vascular complications shows numerous metabolic changes that can effectively be monitored by micro-dialysis[15]. The concentration of pyruvic acid and lactic acid increases after occlusion of pedicle vessels, and the anaerobic metabolism overcomes the aerobic metabolism. Although micro-dialysis shows excellent sensitivity and specificity, the instrument is very complicated and expensive and may not possible to introduce it into every hospital setup.

In our study, flap monitoring was done by measuring blood glucose levels using a glucometer, which is routinely used for regular capillary blood glucose measurements. The procedure is rapid and simple and requires only minimal amounts of blood (06-10 μL). Furthermore, this method is more quantitative than the traditional ways of flap monitoring. In the current study, a cutoff value of 62 mg/dl is proposed for the effective blood glucose measurement (BGM). For this cut off value the sensitivity is 93% and specificity is 80%. A higher sensitivity would be better for most certain detection of venous thrombosis for flap salvage. However, the use of a higher Cut off value may lead to unnecessary re-exploration of flaps. In our present study, the blood glucose level showed a gradual elevation with time. In tissue transplantation, and especially in free flaps, blood supply to the tissue depends on 1 or 2 small arteries. With time, vascularization is slowly established between the graft bed and the flap. This gradual increase in the postoperative blood glucose level in flaps seems to reflect this hemodynamic change: The blood supply to the flap may be insufficient or delayed soon after the anastomosis, but it improves with time. Except for the initial glucose fall in flaps similar glucose profiles and glucose concentrations were recorded in flaps and fingertip. The initial fall was not statistically significant. By taking differential sugar measurements we could avoid bias arising due to intra venous fluid administration in post-operative period and also in patients with diabetes. In immediate post operative period the sugar difference was more which gradually normalized if there was no vascular compromise. The different time requirement for different type of flaps may be due to content of flap i.e., the time is more for myo-cutaneous flaps in comparison to fascio-cutaneous flaps. It was also noted that flaps which developed early compromise their sugar level never came back to normal level. Also, Flaps which developed delayed vascular compromise have a gradual fall of flap sugar levels before developing clinical congestion. As none of the flaps developed arterial compromise glucose variation in arterial compromise could not be calculated.

Blood glucose measurements (BGM) also cannot be used in patient undergone buried tissue transfer. To perform blood glucose measurement, the flap needs to be traumatized using a needle. Although the flap can be damaged by this method, especially in cases where multiple blood glucose measurements are necessary in a small flap, no flaps were lost due to skin puncture in our experience. In addition, this method is safe because the depth of the puncture was set to 1.8 mm, which corresponds to the depth of the dermal layer in the back or abdomen.

The blood glucose measurement method (BGM) described here is simple and can be performed by residents and nurses who do-not have adequate training in flap monitoring. Blood flow in the flap can be determined quantitatively in cases in which blood flow is decreased as determined by the physical appearance or a scratch test. Application of blood glucose measurement (BGM) in flap monitoring is also particularly useful for comparing the blood flow through the flap, immediate after anastomosis and after the flap settles down. It may also be useful for monitoring intraoral flaps, which are difficult to monitor on the basis of flap colour or in tissue transfer with a small skin paddle.

Flap blood glucose has a prognostic value, with glucose levels improving over a period of time is indicative of better flap perfusion while vice versa is true for ischemic flaps. Rate of flap glucose fall is highly sensitive for vessel occlusion. Faster the rate of fall of blood glucose, is suggestive of rapid development of vascular thrombosis or occlusion. (Fig 2)

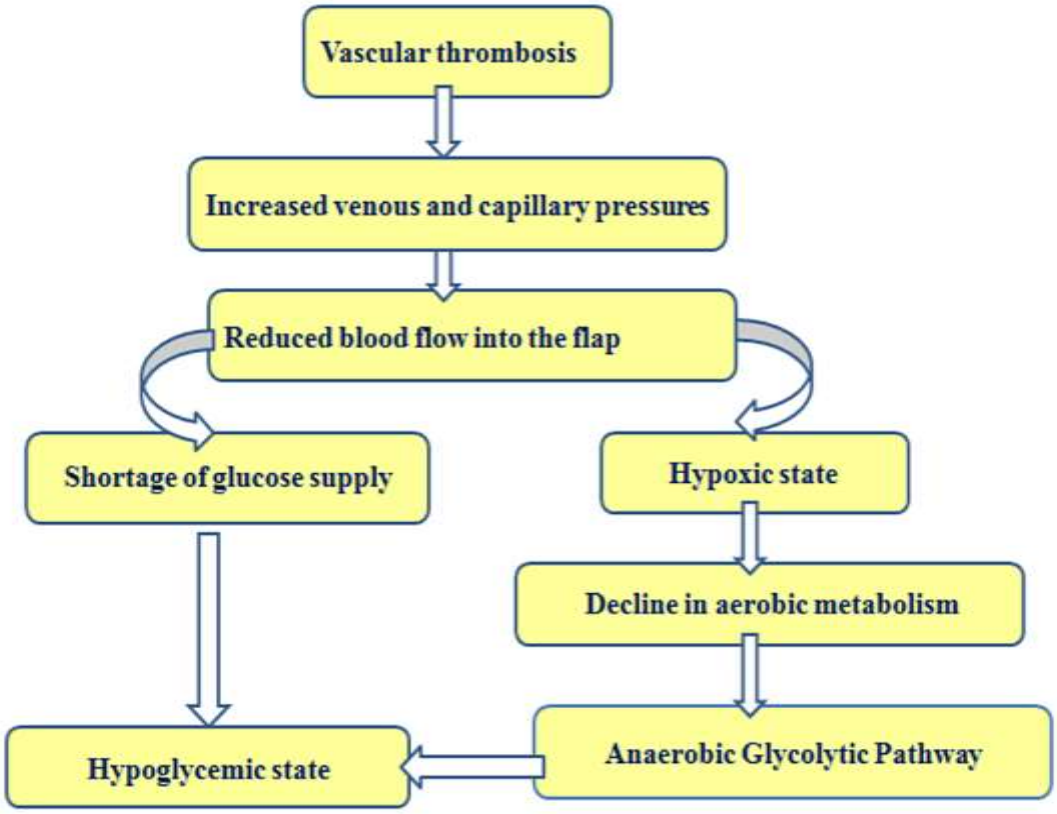

Figure 2: Mechanism involved in low sugar levels in ischemic flap

Conclusions

Clinical monitoring of free flaps is gold standard for detecting vascular compromise, it is not always possible to monitor the flaps by experienced personals. Although there are various objective and subjective methods of monitoring but almost all or most of the methods are sophisticated and expensive. So, from the results of our current study, we suggest that flap blood glucose monitoring can be used as a cheap, alternative objective method for effective post operative flap monitoring. A limitation of the blood glucose monitoring is that this method cannot be used in buried flaps and multiple pinpricks required may end up damaging a small flap paddle.

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