Differential Measurement of Free Flap and Body Glucose: An Objective Tool for Free Flap Monitoring

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ABSTRACT

Introdcution: Monitoring of free flaps is of major importance in micro vascular surgery and clinical monitoring remains gold standard. The salvage rates of is inversely related to the time interval between the onset of vascular impairment and their clinical recognition. The authors suggested an efficient, simple and cheap technique to detect early thrombotic events in monitoring free flaps. Study aimed to detect early thrombotic events in monitoring free flaps.
Material and methods: In this single centered prospective study, measurement of patient's blood sugar and simultaneous measurement of flap sugar were done. These parameters were compared to standard clinical monitoring during first 48hours. Two sets of data (eventful versus uneventful) were analyzed to define difference in body and flap glucose level for diagnosis of vascular complication and to establish parameters for this screening test.
Results: Out of 63 patients on whom differential sugar measurement done 6 patients developed venous thrombosis in post-operative period. There is significant decrease in flap sugar in comparison to body sugar.
Conclusion: Venous thrombosis was observed in 6 patients during post-operative period. A decrease in flap sugar was also observed. Although clinical monitoring of free flap is gold standard differential sugar measurement provides cheap and objective means for free flap monitoring

Keywords: Monitoring Free Flaps, Flap Sugar, Venous Thrombosis

INTRODUCTION

Free tissue transfer has become the standard of care for reconstruction of complex defects. Individual techniques for the postoperative monitoring of free flaps vary considerably. Historically, it was in the intensive care unit (ICU) patient's postoperative care of free tissue transfer took place. However, recent evidence has suggested that uncomplicated free flap patients may be safely cared for outside the ICU, thereby lowering overall cost and decreasing hospital stays.[1] The surgical units successes are still dependent on nurses highly trained in microvascular patients and relatively low patients-to-nurse ratios. The rates for flap salvage and overall success with free tissue transfer are closely related to surgical experience (number of cases performed per month). Any flap loss can be devastating to the patient and the surgeon. Because a failing flap can be salvaged with urgent re-exploration, a low threshold for re-exploration is critical for flap salvage. Although clinical flap monitoring is considered as gold standard there is always search for an objective method of flap monitoring. In searched for a cheap and objective method for monitoring of free flaps, we found the difference in blood sugar and flap sugar as monitoring tool and compared with standard clinical monitoring.

MATERIALS AND METHODS

The present study was a single-centered prospective study conducted at Jaipur National University Medical College and Hospital, Jaipur from January 2017 to December 2019. Patients who undergone microvascular free flap reconstruction for various defects conducted by senior author were randomly enrolled for sugar monitoring. A total of 63 patients were enrolled during this period for the study on whom differential sugar monitoring was done along with regular clinical monitoring.

Clinical monitoring was conducted by Senior Resident who was kept blinded about the differential sugar status which was monitored by Junior Resident. For sugar monitoring One touch select simple glucometer was used. For body sugar finger prick blood was taken from the hand in which iv fluid was not given and flap glucose was monitored from a scratch over the flap. The values were documented on a predesigned Performa (Performa 1,2). The difference between body sugar and flap sugar was calculated. Flaps were categorized according to type of flap, flap location. 2hourly clinical monitoring and differential sugar monitoring was done for 48hrs. Flap re-exploration done on basis of clinical monitoring by Senior Resident. All results were tabulated and statistical analysis was conducted.

STATISTICAL ANALYSIS

Clinical monitoring of flaps was done using three parameters i.e., skin color, temperature and flap bleed on pin prick/ scratch. Body sugar and flap sugar monitored and difference of body sugar and flap sugar were noted. Flaps were observed

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for 48 hour at a 2 hour interval. If there was any clinical signs of vascular compromise then flap re-exploration was done on basis of clinical observation. Differential sugar monitoring was done until flap re-exploration.

Each flap monitoring result were written in a flap monitoring chart.

All results were plotted in a Microsoft excel office worksheet and statistical analysis done. Only one clinical parameter i.e., color of bleed from flap is charted against sugar difference. Color of bleed can be bright or congested.

All the observations at 2 hourly intervals (Total 1564 observations) were compared using Statistical Package for Social Sciences version 15.0. Mean blood sugar difference of observations with two outcomes was compared using Independent samples 't' test. Cut-off value for prediction of CON was generated by receiver operator curve analysis. Survival function was calculated and median survival time for 48 hr expiry was noted. A "p" value less than 0.05 indicated a statistically significant association.

RESULTS

A total of 63 flaps were monitored during the study period. Type of flaps used and flap location are summarized in Table 1. It was found that the following free flaps were used to reconstruct various defects and functions. Skin paddle was present in all flaps.

Out of 63 flaps 6 flaps (9.5%) developed vascular compromise. Flap which developed vascular compromise are summarized in Table 3.

The flaps which were in uneventful group were a total of 57. For the fasciocutaneous flaps like ALT, Radial forearm flap and parascapular flap the sugar level normalizes at 2.8hr. For myocutaneous flaps like LD myocutaneous & gracillis myocutaneous flaps sugar level normalizes at 3.7hr. For fibula osteocutaneous flap sugar level normalizes at 3.2hr. Cut off value: >25.50; 100% sensitive and 98.8% specific in prediction of Congestion of flap.

In eventful flaps where there was flap vascular compromise are only 6 in number and number of observations were 11 for congested flap. The mean sugar difference was 39.18 for congested flaps, whereas for bright bleed mean sugar difference is 3.8. as number of observations for congested flaps are only 11, so no statistical analysis could be done for

Flap Type	N = 63	Flap Location	
Lattismus dorsai myocutaneous	8	H&N	1
		Leg defect	5
		Foot defect	1
		Knee defect	1
Radial artery forearm free flap	14	H&N	11
		Penile Reconstruction	3
Anterolateral thigh flap	16	H&N	5
		Leg defect	4
		Foot defect	4
		Knee defect	2
		Forearm defect	1
Fibula osteocutaneous free flap	16	Mandibular reconstruction	11
		Leg defect	3
		Thigh defect	2
Gracillis myocutaneous free flap	6	H&N	2
		FFMT for BPI	4
Parascapular free flap	3	H&N	2
		Leg defect	1

Table-1: Flap Type and Flap Location

	Flap Type	Flap Location	Cause Of Failure	Time of Re-Exploration
1	Fibula osteocutaneous flap	H&N(Mandible)	Venous thrombosis	8hr
2	Anterolateral thigh flap	Leg defect	Venous thrombosis	12hr
3	Anterolateral thigh flap	Foot defect	Venous thrombosis	10hr
4	LD myocutaneous flap	Foot defect	Venous thrombosis	6hr
5	Radial forearm free flap	H&N(Cheek)	Venous thrombosis	6hr
6	Fibula osteocutaneous flap	Leg defect	Venous thrombosis	18hr

Table-2: Failed Flaps

	Bleed	No. of Observations	Mean ± SD	t Test	Significance
Sugar Difference	Br	1563	3.80 ± 5.620	20.742	p<0.001
	CON	11	39.18 ± 7.937		

Table-3: Association between outcome at different time intervals and Blood sugar difference

congested flaps. Sugar difference has atleast one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
For flaps that developed vascular compromise within 6hr sugar difference never been below 25.5. The flaps which developed vascular compromise after that has normalization of sugar difference below cut-off level. The sugar difference tend to rise above cutoff level at an average 1.6 hr before development of clinical congestion.
Sugar Difference has at least one tie between the positive actual state group and the negative actual state group.

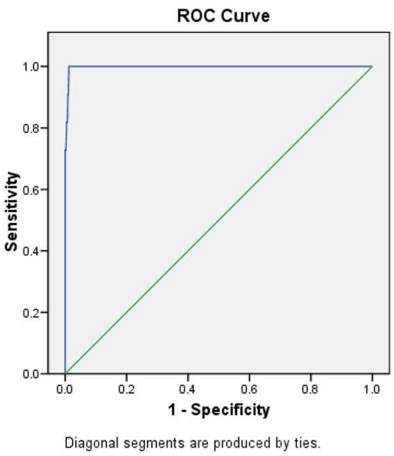

Figure-1: Area Under the Curve

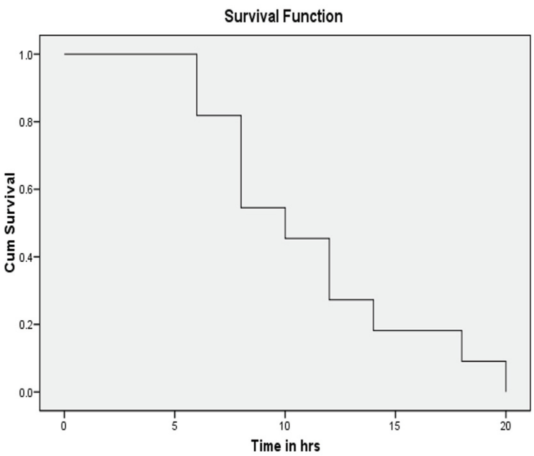

Figure-2: Survival Function for CON

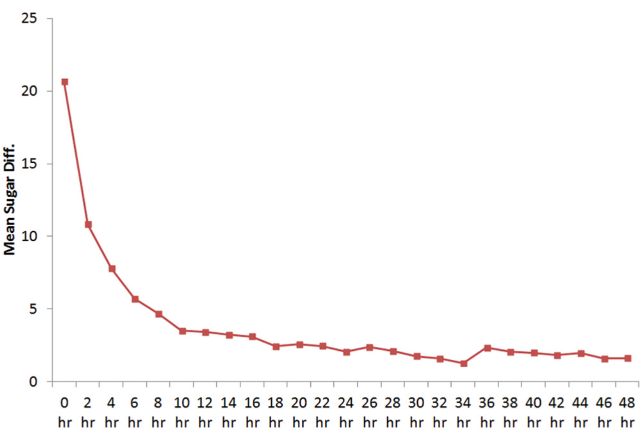

Figure-3: Mean Sugar Difference

Statistics may be biased.
a Under the nonparametric assumption
b Null hypothesis: true area = 0.5
Cut off value: >25.50; 100% sensitive and 98.8% specific in prediction of Congestion

DISCUSSION

Microvascular free tissue transfer is a reliable method for reconstruction of complex surgical defects, with success rates ranging from 91 to 99 percent.[2] The high rate of success is likely attributable to technological advancements in magnification, suture material, and surgical instruments and increasing surgical experience with microsurgery. Despite these advancements, there is still a small risk of flap compromise necessitating urgent re-exploration. Many recent large series of free tissue transfers report a re-exploration rate of 6 to 14 percent, resulting in a mall number of complete flap losses.[3,4] Various studies and techniques are evolved for monitoring of microvascular free tissue transfer.[5,6,7] Despite these improving success rates, microvascular failure remains a costly disaster. As salvage rates have been reported to be inversely related to the time interval between the onset of ischemia and its clinical recognition,[8] the monitoring of free flaps remains of major importance.
The present study was aimed to detect early thrombotic events in monitoring free flaps. It was observed that the differential sugar as patients' blood sugar may vary with time to time during post-operative period and also different patients also have different sugar level. Here a sugar difference of more than 25.5 is 100% sensitive and 98.8% specific in detection of flap congestion. By taking differential sugar we could avoid bias arising due to iv 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 myocutaneous flaps in comparison to fascocutaneous 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 gradual fall of flap sugar before development of clinical congestion. As none of the flaps developed arterial compromise sugar variation in arterial compromise could not be calculated.
Due to time constraint, a large sample size of patients with compromised flaps couldn't be included for achieving a significant statistical result.
Creech and Miller[9] (1975) described what the ideal monitoring device should be like. It should be harmless to patient and flap, rapidly responsive, accurate, reliable, and applicable to all types of flap. Furthermore, it should be equipped with a simple display so that even relatively inexperienced personnel can alert the development of circulatory impairments. Despite the introduction of various new and improved techniques, none of these techniques has succeeded to meet all these so-called ideal criteria. Conventional monitoring

methods include clinical assessment of skin color, turgor (especially in replants) and temperature of the flap, and capillary refill. Handheld Doppler may also be regarded as a conventional technique.[10,11]. Current technologic advances in media and the Internet inspired some authors to use regular digital images to monitor color. It can help detect changes in time more quickly. Another advantage is that images can be transmitted via the Internet to the consulted surgeon at home. In dynamic processes, a video recording can be made as well.[12, 13] to monitor color, buried flaps can be given an external component (either skin[14] or a vessel stump [15]). These can be removed later during a secondary procedure. Nevertheless, monitoring the color of muscle flaps covered by a skin graft remains cumbersome and not infrequently vascular problems are not signaled in time to allow for successful re-intervention. The temperature can be monitored using touch, temperature probes[16], temperature-sensitive tape [17], and a handheld noncontact thermometer.[18]

Surface temperature monitoring is regarded by some authors to be of value only in monitoring re-plantations and small free flap reconstruction because of its inability to detect changes before flap failure or reoperation in deep inferior epigastric perforator flaps[19.] The raising of a micro-vascular free flap is a lengthy and costly procedure in financial and physical terms for staff and patients. For patients, the successful outcome of tissue transfer is of huge importance to their recovery, rehabilitation and ongoing quality of life. Early detection of vascular compromise to the flap can lead to and instigate successful surgical salvage of the existing flap, thereby preventing further surgery and associated delay to adjunctive surgery or therapy.

Clinical evaluation by an experience microsurgeon is considered the gold standard for perfusion assessment. Clinical evaluation requires no specialized equipment, but does rely heavily on the experience of the evaluator. Clinical monitoring is effective, but can be difficult, and imperfect, even with the most experienced observer. Often it can be tricky to tell if a flap has a circulatory problem. The examiner looks at flap color and sometimes capillary refill or temperature depending on the setting. In addition, there are confounding factors that interfere with assessment by even the most experienced clinician. Patients with low hemoglobin levels are pale. Flaps and replants are often bled or medicinally leeched to alleviate or attempt to pre-empt venous obstruction, leaving the skin stained with blood and difficult to assess. These and other factors make clinical evaluation often unsatisfying despite being the accepted gold standard in detecting replant and flap compromise.

In large volume medical centers where microvascular free flaps are performed frequently, the monitoring of free flaps usually done by residents or paramedical staffs. A minor mistake in judgment leads to disastrous results leading to loss of free flaps. Microsurgeons, therefore, use their clinical judgment as well to identify arterial or venous insufficiency in the free flap. In so doing, the surgeon relies on capillary refill, palpable temperature, tissue turgor, and flap color to clinically assess the health status of the flap. A change in the status of the flap mandates a return to the operating room to try to salvage the flap by correcting the problems with the vein or artery. Unfortunately, the surgeon cannot be present at the bedside 24 hours a day over the next few days until the certainty of flap survival has been determined. We all rely on nurses, residents, and nursing aides to inform us when there is concern over flap viability. Although they are very well trained, there is variability in the personnel maintaining surveillance of the flap. Nursing and nursing aide shortages mean more rotations of these wonderful caregivers to wards where they have less experience.

Though clinical monitoring of flap is considered as gold standard, there is always search for a better objective method for free flap monitoring. Differential sugar monitoring offers a cheap, objective and reliable method for free flap monitoring. The monitoring can be done by nursing staff, para-medical personale or junior residents. Sitzman et al [20] described detection of flap venous and arterial occlusion using interstitial glucose monitoring in a rat model. They monitored interstitial glucose using transcutaneous sensor in vertical rectus abdominis myocutaneous flap in a rat model. Interstitial glucose monitored after arterial and venous occlusion. Both arterial and venous occlusion produced rapid decline in interstitial sugar level.

It is 100% sensitive and 99.8% specific for fall in sugar level.

CONCLUSION

Although clinical monitoring of free flap is gold standard for detecting vascular compromise, it is not always possible to monitor the flaps by experienced personals. There are various objective and subjective methods of monitoring but almost all methods are cumbersome and expensive. So, from the results of our current study, we suggest that differential sugar measurement can be used as a cheap and objective method of free flap monitoring. It can also be used to detect vascular compromise prior to its clinical appearance.

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