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Analysis of flap sugar as an objective monitoring of intra-operative flap vascularity following a single vein vs. a double vein anastomosis

A. Sindhuja, S. A. Sahu, J. K. Mishra, A. Saha, J. J. Rahmi, A. Valsalan

Department of Burns & Plastic Surgery, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India

Summary

Introduction: Venous thrombosis is a common cause of flap failure. Performing a second vein anastomosis provides a backup channel for draining. However, this may not be useful in circumstances of vessel kinking and compression. When a flap is compromised, there is a decrease in glucose levels and an increase in anabolic metabolites like lactate. In our study, we measured the ratio of flap/peripheral sugar levels (glucose index – GI) as a metabolic indicator and assessed flap perfusion after the second vein anastomosis. **Materials and methods:** This was a single-centre prospective cohort study. Based on the inclusion criteria, eligible patients reconstructed with a free flap (anterolateral thigh flap / radial forearm flap / fibula flap) were included in the study. **Results:** In our series, the mean flap sugar levels after the first and the second vein anastomoses were 116.60 mg/dL and 131.5 mg/dL, respectively. There was an increase in the flap sugar level after the second vein anastomosis. This increase was found statistically significant (P = 0.009), suggestive of better perfusion. In this study, the flap/peripheral glucose level (GI) ratios after the first and the second vein anastomoses were 0.90 and 0.99, respectively. The increase in this ratio after the second vein anastomosis indicated better flap perfusion after a double vein anastomosis. **Conclusion:** The study concluded that there is a better perfusion after a double vein anastomosis.

Key words

single vein vs. double vein anastomosis – flap sugar – peripheral sugar – free flap – flap metabolism

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Introduction

The 1960s marked the arrival of a free flap technique when Julius Jacobson and Ernesto Suarez perfected vascular anastomosis. Since then, several microvascular advancements have been made to improve the success rate [1]. However, flap failure due to venous thrombosis remains a major complication [2]. To decrease failure due to venous thrombosis, a double vein anastomosis is done; however, its role in the free flap still remains debatable [3]. Theoretically, performing anastomosis of two veins provides a "backup" drainage if one gets occluded. However, even having a backup vein does not decrease the risk of a flap loss in situations like infection, external compression, kinking or thrombosis of the distal vasculature because of an iatrogenic injury or a prolonged ischemia.

A literature search revealed that a single vein vs. a double vein anastomosis in a free flap has been compared regarding flap failure or partial flap necrosis. No study has evaluated flap/peripheral sugar (glucose index – GI) ratio as an indicator in comparing the roles of single and double vein anastomoses. Jain et al. found that the blood glucose level in flaps is reduced in ischemic or congestive conditions using microdialysis [4]. Hence, blood glucose levels are a good monitor of flap vascularity, metabolic activity, congestion and drainage.

In this study, the ratio of flap/peripheral sugar levels (GI) is taken as a metabolic indicator in assessing flap perfusion intra-operatively. Also, the adequacy of drainage is evaluated by the blood glucose level of the flap by comparing single vein and double vein anastomoses [5].

Materials and methods

This prospective cohort study was conducted in our institute. Eligible patients between 18 and 65 years who

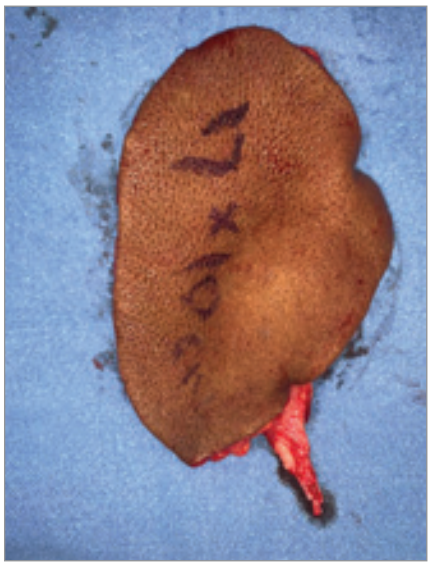

Fig. 1. Anterolateral thigh flap after pedicle division.

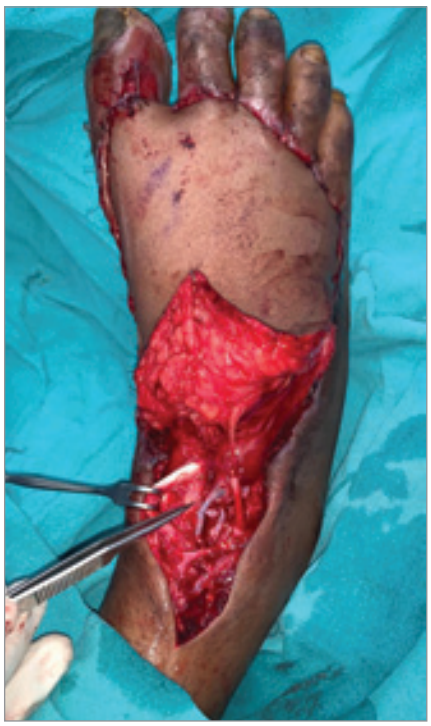

Fig. 2. Anterolateral thigh flap after the second vein anastomosis.

underwent reconstruction with a free flap between October 2022 to January 2024 were included in the study: those with a radial forearm free flap / fibular free flap / anterolateral free flap / medial sural artery free flap (Fig. 1). All patients were given standard preoperative workup.

Fig. 3. Anterolateral thigh flap after inset.

Patients with uncontrolled diabetes, hypertension, any chronic illness, cases where only one vein was available for anastomosis (due to anatomical variation or calibre mismatch) and patients not giving consent were excluded from the study.

Patients in the study were informed and explained about repeated flap sugar measurement by scratching the flap with a needle of the size 24/26 and peripheral blood sugar measurement from the fingertip simultaneously. Blood sugar measurement is done by using the standard glucometer Ozocheck. The depth of scratching was dermis deep.

Intraoperatively, pedicle artery and 1st vein anastomosis were done. Clamps were removed from both the artery and the vein. Thirty minutes were allowed to drain the blood completely for adequate washout of the ischemic metabolites from the flap. Simultaneous flap/peripheral sugar levels were measured, as described above. Again, after the second vein anastomosis (Fig. 2), the clamps were removed, and 30 min later, capillary flap and peripheral sugar levels were measured (Fig. 3) again after the flap inset (Fig. 4).

Recorded values were entered in a form and statistical analysis was done by the Mann Whitney test.

Fig. 4. Anterolateral thigh flap sugar monitored with a glucometer.

Tab. 1. Details of aetiology for free flap and procedure.

Subject No.	Etiology	Frequency (%) (total N =30)
1	head and neck malignancy	17 (56.7)
2	diabetic foot	1 (3.3)
3	post burns defect	3 (10)
4	giant cell tumour (right radius)	1 (3.3)
5	post traumatic soft tissue defect of the lower limb	6 (20)
6	post snake bite contracture over dorsum of left foot	1 (3.3)
7	fasciotomy wound for compartment syndrome (left dorsum of hand)	1 (3.3)

Subject No.	Flap done	Frequency (%) (total N =30)
1	free fibular flap	10 (33.3)
2	free anterolateral flap	11 (36.7)
3	free radial forearm flap	7 (23.3)
4	medial sural artery perforator flap	2 (6.7)

Tab. 2. Values of the glucose level measured.

Subject No.	Variable	Flap sugar (mean) mg/dL	Peripheral sugar (mean) mg/dL	Glucose index (flap/peripheral sugar ratio)
1	before division	119.07	127.23	0.96
2	after first vein anastomosis	116.60	131.73	0.90
3	after second vein anastomosis	131.50	134.07	0.99
4	post-surgery	117.69	129.17	0.91

Results

The mean age of patients enrolled in our study was 42 years, with the majority in the age group 41–50 years (26.7%). Most of them were males (76.7%). Details of the aetiology for which the free flap was done are listed in Tab. 1.

The measured blood glucose levels of the flap and periphery at various stages of surgery are given in Tab. 2. From the measured blood glucose levels, GI (flap/peripheral glucose levels) at various stages of the procedure was also calculated (Tab. 2).

The ratio of flap/peripheral capillary glucose levels was relatively stable across different stages of surgery (Tab. 2). This indicates that while glucose levels fluctuated, the relative glucose levels in the flap compared to peripheral tissues remained consistent throughout the surgical process.

To see the effect of a double vein anastomosis, the mean change of flap sugar levels and GI levels after doing the second vein anastomosis from the first vein anastomosis were also calculated (Tab. 3). There was a mean increase in the flap glucose level by 14.9 mg/dL after the second vein anastomosis which was found significant (P = 0.009). The mean GI also increased by 0.09 but this increase was not found significant (P = 0.05).

In our series, three flaps got congested. GI of this congested flap is tabulated separately for analysis (Tab. 4). However, timely intervention salvaged the flaps.

Discussion

Successful free tissue transfer is based on establishing continuous arterial inflow and venous outflow through the patent microvascular anastomosis, until neovascularization [6]. A common cause of flap failure is venous thrombosis but the reasons are multifactorial [3]. Performing a double vein anastomosis is a debatable concept. The perspective of performing a double vein anastomosis is

Tab. 3. Mean change after doing the second vein anastomosis from the first vein anastomosis.

Mean difference	Mean	SD	P-value
flap capillary glucose	+14.9	29.07	0.009
glucose index	+0.092	0.282	0.084

Tab. 4. Glucose index (flap/peripheral sugar levels) of congested flaps.

	Glucose index after first vein anastomosis	Glucose index after second vein anastomosis
Case 1	1.01	0.75
Case 2	0.83	0.82
Case 3	0.89	0.86

solely based on the fact that it will provide a "backup outflow in the event of a thrombosis of one vein.

The gold standard method to monitor the flap includes a conventional method of assessing the flap margin and inset, colour, turgor, refill, and pinprick showing bright red blood. Microdialysis monitoring is very effective but not cost-effective. Adjuncts to this include handheld Doppler, implantable Doppler, near-infrared spectroscopy, laser Doppler flowmetry, flow coupler, hyperspectral imaging, thermal imaging, and oxygen partial pressure measurement used for early detection of flap failure and hence increased flap salvage [7]. All this monitoring is done in the postoperative period.

Monitoring by measuring the flap sugar and comparing it to peripheral sugar is also used. Measuring flap sugar is a common method to monitor the flap. Many authors have tried to find out the cut-off value of flap sugar post-operatively at a point where the flap fails. A thorough search could not find any study to subjectivise the benefits of performing a double vein anastomosis. So, in this study, we measured and compared the flap and periphery sugar levels intraoperatively and after doing single- and double-vein anastomosis.

The mean increase in the flap sugar level after the second vein anastomosis from the first vein anastomosis is 14.9 mg/dL, which is statistically significant. This increase in the value is statistically significant. Stephan et al. studied the metabolism of a free flap by blood gas analysis of flap blood. In their study, they explained that 52 min of tissue ischemia leads to a decrease in pH ($p = -0.03$) with an increase in lactate, potassium, sodium and chloride levels due to anaerobic glycolysis [8]. When perfusion resumes, aerobic metabolism sets in, with a decrease in lactate level and an increase in glucose level. This proportionate increase in the glucose level is an indicator of flap perfusion. Thus, capillary glucose is a direct indicator of flap metabolism.

Similarly, Kishi et al. also stated that an increase in flap glucose level and a decrease in lactate level suggests that the flap's perfusion is increased [9]. Applying this concept to our series, there is an increase in flap sugar levels after the second vein anastomosis.

Hara et al. [10] have proposed that GI (flap/peripheral sugar levels) is a more reliable indicator than the flap glucose level alone for flap monitoring. The GI decreases progressively in time in failing flaps. Likewise, an increase in GI means that the perfusion of the flap is increasing. In our study, GI of the flap after the first and second vein anastomoses were 0.90 and 0.99, respectively. The GI increased after the second vein anastomosis indicating better perfusion of the flap although this increase in GI was not found statistically significant. Statistical significance could have been established with a higher sample size.

This theory is in contrast to a study by Hansano et al. They emphasised that the second vein anastomosis reduces the blood velocity of the draining veins. The explanation was that the mean blood venous velocity after the second vein anastomosis is significantly lower: 7.5 ± 4.3 cm/s, leading to venous stasis leading to venous thrombosis. Even at this velocity, the authors did not have any venous thrombosis or flap failures in their case series [11]. This can be understood in light of Virchow's hypothesis, which asserts that a low blood flow velocity alone is not the sole factor in thrombosis formation without the presence of hypercoagulability and endothelial damage. Therefore, reduced velocity following the second venous anastomosis may contribute to thrombus formation, but it is not the direct cause of thrombosis.

Malignancy is a hypercoagulability state. However, head and neck malignancy patients have always had better outcomes than those with a lower extremity free flap reconstruction [2]. This is due to the high vascular resistance of the venous system of the lower limb leading to a low velocity and the endothelial damage. The vessel concurred during the trauma increases the possibility of a thrombus [2]. So, a double vein anastomosis can be beneficial in free flaps of extremity cases.

Each vena commitantes drains a different area of the flap, thus performing a double venous anastomosis may also prevent a partial loss of the flap due to insufficient drainage because of the presence of a single vein. This is

supported by the study by Stranix et al. where they compared the outcomes of single vs double vein anastomosis by major and minor complications. A double vein anastomosis had lower partial flap failure with a statistical significance of P = 0.008 [12].

In our study, three flaps were congested on the first postoperative day. Tab. 4 shows GI after the first vein and then after the second vein anastomosis. Reexplanation was done for all. In case 1 with a free anterolateral thigh flap, there was a vessel compression and the flap survived after the release of superficial sutures. In case 2, intraoperatively venous thrombosis was detected and anastomosis was done. In case 3, both veins were thrombosed intraoperatively, and a redo anastomosis was done. In our series, GI increased after the second vein anastomosis. But in these three cases, the value of GI after the second vein anastomosis decreased, indicating compromised perfusion. This is an important finding from our study; however, more studies are needed to prove it. This will be helpful to anticipate flap congestion intraoperatively by monitoring GI.

The advantage of performing a single vein anastomosis is that it reduces the operative time during the primary surgery.

The advantage of performing a double vein anastomosis is that it becomes a backup if venous thrombosis is set in a vein. Studies have proven that partial flap necrosis and failure occur less commonly in a double vein anastomosis. Our study concludes that flap perfusion and metabolism are better with a double vein anastomosis. Considering the advantages it has to offer, it is desirable to perform a double vein anastomosis when feasible. Longer duration of the procedure may be reduced by using a venous coupler.

Conclusion

This study concludes that a double vein anastomosis improves flap metabolism. Further, a decrease in GI after the second vein anastomosis indicates a compromise in flap circulation.

Limitations

The limitation of our study is the lower sample size. Statistical significance could have been established in GI between a single vein and a double vein anastomosis if a higher number of patients were included. The patients included were heterogeneous.

Roles of authors

Dr. Abi Sindhuja – writing manuscript, flap sugar measurement, part of the operating team in all cases; Dr. Shamendra A. Sahu – operating surgeon, statistical analysis, editing of the manuscript; Dr. Jiten K. Mishra – operating surgeon, editing of the manuscript, Dr. Aparajita Saha – data compilation, writing the manuscript, assessment of the results; Dr. Abhijith Valsalan – flap monitoring, data collection; Dr. Jalaz J. Rahmi – flap monitoring, data collection.

Disclosure

The authors have no conflict of interest to disclose. The authors declare that this study has received no financial support. All procedures performed in this study involving human participants were in accordance with ethical standards of institutional and national research committee and with ethical standards of the institutional and national research committee and with Helsinki declaration and its later amendments or comparable ethical standards.

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Assoc. Prof. Shamendra Anand Sahu, MBBS, MS, MCh
Department of Burns & Plastic Surgery
All India Institute of Medical Sciences
Raipur, Chhattisgarh, India (Pin 492099)
shamendrasahu@gmail.com

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