

Effects of venous supercharging in deep inferior epigastric artery perforator flap¹

Efeitos da vascularização venosa ampliada na viabilidade do retalho perfurante da artéria epigástrica profunda

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ABSTRACT

Purpose: To evaluate the effects of venous supercharging in deep inferior epigastric artery perforator flap in rats. **Methods:** 20 Wistar rats were randomized in 2 groups: control group (C), all had flaps raised based on the deep inferior epigastric perforator vessels (DIEP), and experimental group (E), which was identical to group C, except that the contralateral superficial inferior epigastric vein was also kept with the flap. Flow studies using laser Doppler flowmetry were performed daily in the four zones of the flap. On the 7th postoperative day rats were killed and flap survival was determined using digital planimetry. **Results:** Flow values were presented as a percentage of the baseline flow after incision of the flap edges. The surviving flap area was demonstrated as a percentage of the total flap area. Evaluation by digital planimetry showed that flap survival in group E was higher than in group C (97,38%±1,32% vs. 44,13%±4,83%, p=0,0006). **Conclusion:** This study shows that venous supercharging of the rat DIEP flap results in greater flap survival.

Key words: Surgical Flaps. Tissue Survival. Models, Animal. Laser-Doppler Flowmetry. Rats.

RESUMO

Objetivo: Avaliar o efeito da vascularização venosa ampliada na viabilidade do retalho perfurante da artéria epigástrica profunda em ratos. **Métodos:** Vinte ratos foram divididos em 2 grupos: controle(C), no qual se realizou o retalho perfurante da artéria epigástrica profunda e experimento(E), no qual se realizou o mesmo retalho e se manteve a veia epigástrica superficial inferior contralateral ao pedículo. Foi realizada determinação diária do fluxo sanguíneo por fluxometria por *laser-doppler* em quatro quadrantes do retalho previamente estabelecidos e a viabilidade foi determinada, no 7º pós-operatório, através de planimetria. **Resultados:** A análise do fluxo sanguíneo demonstrou não haver diferença entre o grupo C e E nas médias de fluxo entre as zonas do retalho (Zona I: 103,44±8,09 vs. 84,70±7,98, p=0,114)(Zona II: 109,18±6,99 vs. 113,67±26,89, p=0,401)(Zona III: 89,15±11,11 vs. 106,79±15,93, p=0,599)(Zona IV: 104,43±11,50 vs. 124,90±23,17, p=1,00). A viabilidade do grupo E foi superior do que no grupo C quando determinada por planimetria digital (97,38%±1,32% vs. 44,13%±4,83%, p=0,0006). **Conclusão:** Há aumento da viabilidade do retalho DIEP submetidos à *supercharging*. **Descritores:** Retalhos Cirúrgicos. Sobrevivência de Tecidos. Modelos Animais. Fluxometria por Laser-Doppler. Ratos.

Introduction

Random flaps were used in the past as the sole resource for defects coverage; however those flaps had limited applications regarding location and size of the defect. These limitations were solved by incorporating a vessel within the flap, the axial flap. Mathes and Nahai in early 80's described the muscles irrigation pattern, and muscles started to be used as flaps. The great advantage of muscle flaps is the rich arterial supply, which makes it a great choice for bigger defects. Later Koshima and Soeda¹ introduced a new concept: a flap presenting the same advantages of muscles flaps, however without the morbidity related to the donor area. This concept originated the perforator flaps. The first perforator flap was described by Koshima and Soeda¹, composed of periumbilical fat and skin, with total preservation of rectus abdominis muscle. After the first description, these flaps were described for various purposes: lower and upper limb reconstruction, head and neck reconstruction and even augmentation mammoplasty. Allen and Treece² described their experience with these flaps in breast reconstruction. Promising results in this field had turned perforator flaps in a very important option in breast reconstruction³, especially because several series showed lower donor site morbidity. Some partial flap loss were described, and it was hypothesized the those flaps were more susceptible to venous congestion⁴. There are advantages of the perforator flaps over muscle flaps, mainly related to donor site morbidity, but the necrosis risk must be assessed to justify its election for first choice flaps in many fields, including breast reconstruction. However one aspect of these flap remains controversial: is lower venous outflow responsible for literature described partial flap loss? The purpose of the present study is to determine if venous supercharging has any influence on perforator flap viability.

Methods

Twenty male Wistar rats, between 250-300 g, were used in this experiment. Animals were anesthetized with ketamine and xylazine. The DIEP flap was marked over the abdominal wall; superiorly at the xiphoid level, inferiorly at the level of the anterosuperior iliac spines and laterally at the posterior axillary line (Figure 1).

Groups

The animals were randomly assigned for one of two groups: control and experiment.

Control Group

The DIEP flap harvested based on a single perforator of the right rectus abdominis muscle (Figure 2). Superficial epigastric vessels as well as others perforators vessels were

cauterized. All dissection was performed with an surgical microscope (model G-Ni 8024, KAPS, Germany).

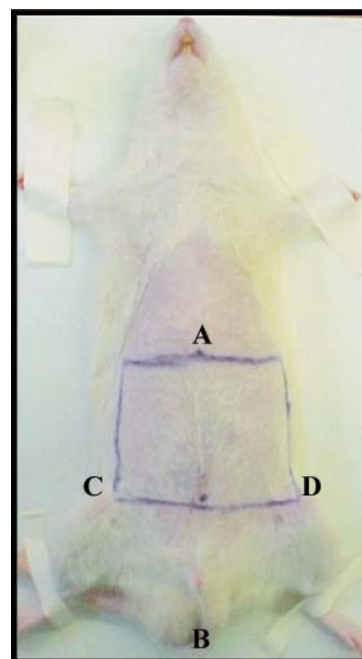


FIGURE 1 - Flap markings: (a) horizontal line over xyphoid; (b) horizontal line over anterosuperior iliac spines; (c,d) vertical lines over posterior axillary line

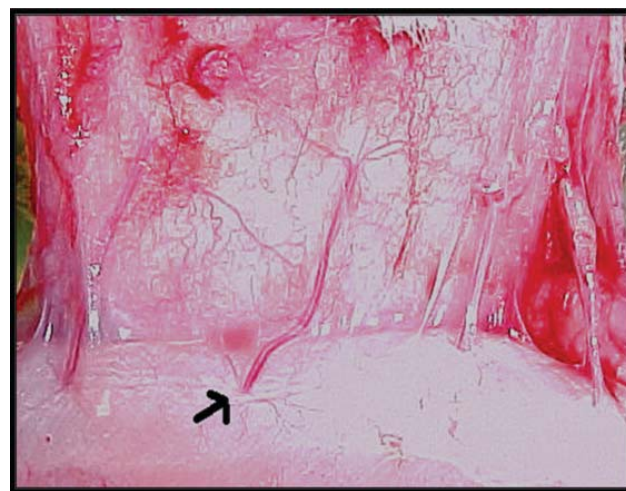


FIGURE 2 - Flap harvested. Perforator vessels in na upward direction. Arrow on 2nd perforator vessel, which was preserved in every animal

Experiment Group

Flap was harvested the same way as control group, except that the right inferior superficial epigastric vein was left intact (Figure 3). The flap was sutured to its bed. The flap was divided in 4 zones: I the area over the perforator vessels; II the area lateral to midline; III area lateral to zone I and IV the area lateral to zone II (Figure 4).

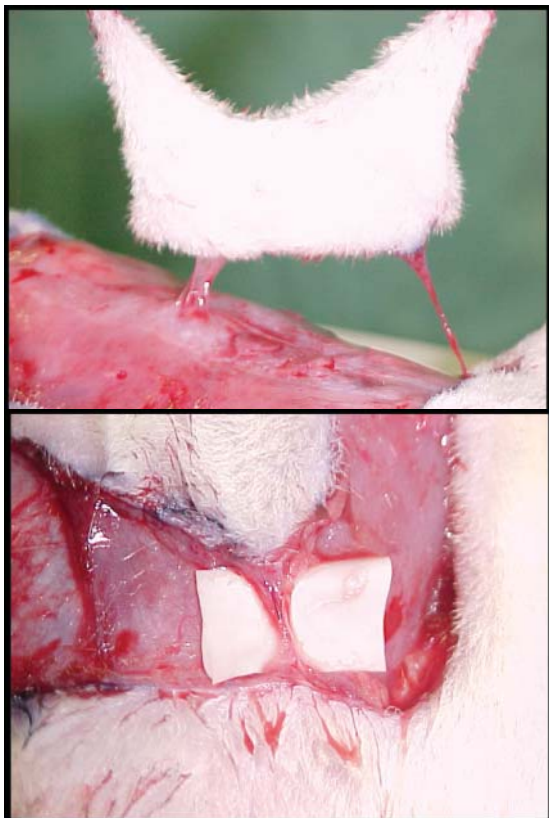


FIGURE 3 - Left: diep flap harvested and nourished by deep inferior epigastric perforator vessels. Right: superficial inferior right vein dissected and preserved in experimental group

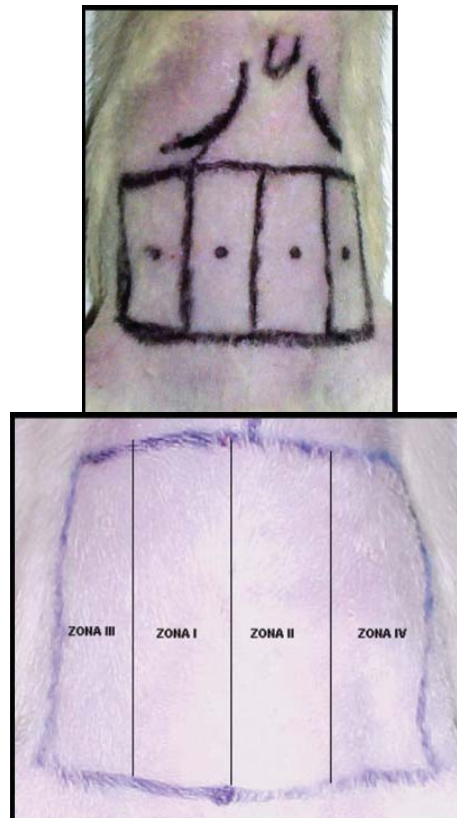


FIGURE 4 - Zone demarcation over the flap. Zone I, over the vascular pedicle; Zone II, lateral to midline; Zone III, lateral to Zone I; Zone IV, lateral to Zone II

Viability assessment

Laser-doppler flowmetry

The first reading of the flow in the flap was taken immediately after the flap incised (vasamedics, laserflo bpm2, minessota, us) and this value was adopted as basal value. The measurements were performed daily in every quadrant of every animal

Digital planimetry

In the seventh post operative day the animals were killed and its flaps were photographed at a 20 cm distance from the object (Canon Powershot S400, Canon, Japan). The images were captured and sent to a computer. Adobe Photoshop® was used to convert the images to bitmap and calculate the viability through pixels numbers. Flap viability= viable area (number of pixels)/total area (number of pixels) x100.

Statistical analysis

Mann-Whitney test was used to compare blood flow and Kruskal-Wallis to compare viability.

Results

Flap viability

All animals were evaluated in 7th po regarding viability. Four animals were excluded, two in each group due to death during anesthesia performed daily to assess blood flow. Viability rate among control group was 44,13% and 97,38% , a significant statistical difference (p=0,0006).

Laser-doppler flowmetry

Basal values were obtained just after incising the flap, and daily in all four zones previously marked. The mean values of flow shows a similarity between groups in zone II and discrepant in zones I, III and IV, however there is no significant statistical difference between groups. Analysis of flow daily shows a marked decrease of mean values on 3rd and 4th po in both groups, statistically significant lower in control group (p=0,0011 and p=0,0379) (Table 1).

TABLE 1 – Mean flow values in experimental and control group. Daily measurement (ml/min/100g of tissue)

day	Control (n=8)		Experiment (n=8)		P
	Mean	EP	Mean	EP	
0	52,93	3,34	60,17	3,65	0,1049
1	50,80	3,07	49,01	2,55	0,5054
2	64,68	2,63	59,04	3,11	0,7984
3	34,42	2,33	53,32	3,20	0,0011
4	48,30	2,98	62,94	2,60	0,0379
5	51,88	2,93	59,45	3,40	0,2786
6	52,21	3,63	54,52	4,31	0,6126
7	42,75	3,22	49,93	2,82	0,2345

Note: n–number of animals, ep–standard error, p–statistical significance level.

Discussion

Perforator flap model

The model used in the present study was first described by Oksar et al.⁵ and it was based on a single perforator of the right deep inferior epigastric artery. Although Hallock and Rice⁶ have described another flap and called it true perforator flap, the model used in the present study allows a complete analysis of hemodynamics and physiology. The size of the flap was variable, following anatomical landmarks as described by Oksar et al.^{5, 6}. Vascular predominance of DIEP flap in humans is the same as the TRAM flap, inferiorly based⁷. In rats the DIEP and TRAM flaps are superiorly based (deep inferior epigastric artery)⁶. Hallock⁶ debated this fact and concluded that although the TRAM flap is not perfectly related to the rat, the results obtained in experimental surgery can make important contributions to clinical research.

Venous and arterial supercharging

Supercharging is a procedure to increase flap vascularization. It can be a venous supercharging, an additional vein to increase drainage or an arterial supercharging, when an artery is added. Some authors⁸ hypothesized that perforator flaps have more venous congestion due to the size of its veins. Left inferior superficial vein was chosen for being the vein more contralateral to the pedicle. Sano⁶ have already described increase in viability in supercharged TRAM flaps in rats.

Laser-doppler flowmetry

Laser-doppler flowmetry is a non-invasive method to monitor blood flow in free flaps, and blood flow variation is a useful tool to determine flap evolution, since viability

is directly related to adequate blood flow. Blood flow has a great variability in every animal. Ratio of flow is more important to evaluate, so the first measurement was determined to be the basal flow, as described by Hallock⁶. In the present study, blood flow was higher in experiment group, statistically significant on 3rd and 4th po.

Flap viability

Digital planimetry as described by Sano⁶ was performed. In the present study it was encountered 44,13% of viability on control group and 97,38% on experimental group, and the difference was statistically significant (p=0,0006). It was observed a pattern of necrosis contralateral to the pedicle, already described by others authors^{5, 6}.

Conclusion

The viability of the deep inferior epigastric artery flap is superior in the venous supercharging group.

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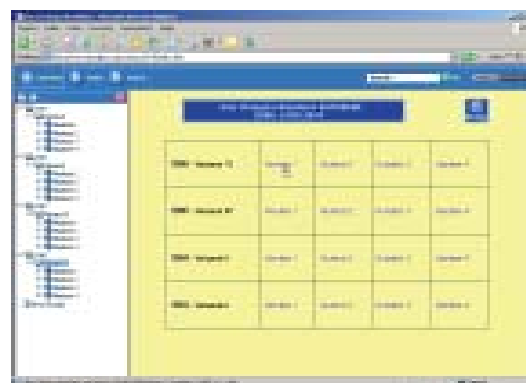
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