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Effects of perforator number and location on the total pedicle flow and perfusion of zone IV skin and fat of DIEP flaps☆

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Summary *Background:* DIEP flaps are a popular choice for autologous breast reconstruction, though many surgeons routinely discard zone IV, limiting transferrable tissue. We investigated the effect of altering number and location of perforators supplying the flap on total pedicle flow and perfusion of skin and fat of zone IV.
Methods: 20 cranially-based abdominal epigastric perforator flaps were raised in rats on two perforators. The perforators were sequentially clamped and released in a randomised order and total pedicle flow measured using microvascular flow-probes, on the following perforator combinations:

- P1(Superior perforator)
- P2(Inferior perforator)
- P1 + 2(Both perforators)

13 DIEP flaps were raised in post-mastectomy patients requiring breast reconstruction on two perforators. These were clamped and released as before to assess perfusion of fat and skin in zone IV using SPY indocyanine-green-fluorescence-angiography scans on the same perforator combinations as in our animal study, listed above.
Results: All data were analysed using 2-way-ANOVA and revealed that vascular flow was significantly ($p < 0.0001$) greater on one perforator as opposed to two. These results were supported by our human study, revealing both zone IV fat and skin perfusion were significantly ($p < 0.0001$) greater when a single perforator was used.
Conclusions: Our data suggests total pedicle flow and perfusion of zone IV fat and skin is significantly higher on a single perforating blood vessel as opposed to two. Reasons for these

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observed differences could be due to changing pressure gradients across a piece of tissue prone to venous congestion, with maintenance of flow better in a single lumen.

Background

The DIEP flap is a popular choice for autologous breast reconstruction, combining a large volume of tissue with an acceptable donor site. However, transferrable tissue volume can be limited, as many surgeons routinely discard zone IV of the flap, believing it prone to fat or skin necrosis.[1]

The selection of which perforator(s) to base a DIEP flap upon is largely made intra-operatively, based upon vessel caliber, intra-muscular course and location within the flap. Pre-operative perforator imaging with CT and MRI angiography can map perforators and decrease operating time, flap complications and donor site morbidity.[2–7]

In terms of choice of perforator row (medial or lateral) to base the flap upon, some research suggests medial row perforators are dominant, supply greater flap territory and perfuse reliably across the mid-line[1,8,9] whilst others report lateral row perforators are larger, dominant and have a simpler intra-muscular course.[10–13] However, the majority of these studies used cadaveric or non-vital tissue and the few clinical studies discarded zone IV.[8]

The surgeon must also decide how many perforators to base the flap upon and where within the row to take the perforator (superior vs. inferior). Perforator size can influence this choice; many surgeons take a single large perforator if available to minimize muscle and nerve damage during dissection, whereas if several smaller ones exist then two or three may be taken, in the belief that this will increase perfusion territory.[14] Literature upon this is scarce, however some studies report that in their experience 25% of flaps are taken on one, 50% on two and 25% on three or more perforators.[14,15] Lee et al. (2010) compared numbers of perforators within DIEP flaps, and reported no significant clinical outcome was observed between the one and two perforator flaps from a single row.[16] A recent cadaveric contrast injection study by Bailey et al. (2010) suggested that largest medial perforators are found within 3 cm of the umbilicus, and these should be seen as preferential to take to supply the flap as a single perforator.[1] They followed this cadaveric study with 16 clinical cases of DIEP flaps raised on a single large medial perforator, reported no flap failures but a fat necrosis rate of 25%, despite discarding zone IV in all but one case. In patients the superior perforator is usually peri-umbilical, usually larger and close to the edge of the flap whereas the inferior perforator tends to be more central but smaller.

In summary, evidence surrounding the choice of perforator row seems divided amongst researchers, and the evaluation of perforator number, zone IV and flaps *in-vivo* is limited.

Methods

This research comprised two studies, which will be described separately:

- An animal model (rat epigastric perforator flap study)
- A human DIEP study

Regional, local and Home Office ethical approval was obtained for both projects and strictly adhered to.

Animal study

20 cranially-based abdominal epigastric-perforator flaps were raised in male Wistar rats (295-350g) on two perforators, which were sequentially clamped/released in a randomised order and total pedicle flow measured on the following perforator combinations.

- P1 (Superior perforator)
- P2 (Inferior perforator)
- P1 + 2 (Both perforators)

All flaps were raised by the same surgeon, and all animals underwent gaseous anaesthetic induction with isoflurane in an induction box. The first 4 animals underwent oro-endotracheal intubation with a modified 16G/45 mm venous cannula using a trans-tracheal illumination technique and the following 16 animals received an intraperitoneal injection of sodium thiobutabarbital (Inactin). Anaesthesia was maintained by means of isoflurane in a N_2O/O_2 gaseous mixture (60:40 ratio). The operating environment temperature was maintained at 22—25 °C and core animal body temperature maintained between 37 and 38 °C using radiant heat.

Animals were positioned supine below the operating microscope, and the abdominal skin shaved using fine electric hair clippers. The flap was drawn and raised from lateral to medial, the perforator row identified and the second and third cranial perforators dissected through the rectus sheath to the main vessel, the superior epigastric being dominant. The distal ends of the epigastric vessels were ligated using a 9/0 nylon suture and the entire flap raised cranially on the epigastric vessel, cauterising contralateral perforators to isolate the flap on the pedicle (See Figure 1).

Flow measurements were performed on the different combination of perforating vessels described above, which were sequentially clamped and released, with 5 min allowed before taking any measurements to allow reactive hyperaemia to settle.[17] A transit-time ultrasound flow probe (Model 0.5V, Transonic Systems Inc.) was placed proximally around the main pedicle of the cranially dissected epigastric vessels with normal saline at 37 °C used as the acoustic couplant. Flow rate was measured for at least one minute by the transit-time ultrasound flow meter (T204, Transonic Systems Inc.) and converted to a digital signal by PowerLab 400 (AD Instruments Pty Ltd.).