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## Thermographic Mapping of Perforators and Skin Blood Flow in the Free Transverse Rectus Abdominis Musculocutaneous Flap

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There is no ideal method for preoperative or intraoperative mapping of cutaneous perforators or for postoperative monitoring of blood flow in cutaneous flaps. To study the suitability of thermography for the mapping and monitoring of free transverse rectus abdominis musculocutaneous (TRAM) flaps for breast reconstruction, we performed thermography pre-, intra-, and postoperatively (eight patients). The temperature of the TRAM flap increased during the induction of anesthesia and was still higher than normal on the first and second postoperative days ( $p < 0.05$ ). During the operation, the flap cooled, reaching its minimum temperature ( $3.62 \pm 0.6^\circ\text{C}$  below phase 2,  $p < 0.05$ ) after ligation of both pedicles of the flap. When blood flow had been re-established, all parts of the flap warmed rapidly. The locations of perforators ("hot spots") could be seen before, during, and after the operation. However, induction and cutting of both pedicles made the flap isothermic, and the perforators disappeared temporarily. Thermography is a potential method of mapping cutaneous perforators pre-, intra-, and postoperatively and of monitoring the flaps at bedside. The method is easy to use and the outcome can be seen immediately. Our results also showed that the temperature (blood flow) in free TRAM flaps is higher than in the tissue in its original position.

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The anatomy of the transverse rectus abdominis musculocutaneous (TRAM) flap has been clearly illustrated in precise cadaver studies [1-4]. Clinically, the free microvascular TRAM flap presents fewer edge problems [5, 6] than the pedicled TRAM because the blood flow of the skin paddle on the lower abdomen is mainly supplied by the deep inferior epigastric system [7]. To achieve optimal blood flow through the perforators of the skin and to minimize the muscular part harvested

with the flap, preoperative mapping of the perforators may be helpful. Chang [8], Rand [9], and Hallock [10] and their colleagues used color Doppler ultrasonography (US) to map and determine the size of these vessels, and Ahn and coworkers [11] used magnetic resonance imaging (MRI) to locate the perforators.

Thermography has been widely used in clinical medicine to measure skin temperature [12]. Skin surface temperature and infrared emission are proportional to local blood flow, the local metabolic process, and heat radiation from deeper tissues [13]. The surface temperature predominantly reflects heat exchange from the deep dermal plexus [14]. The correlation between thermographic and laser Doppler velocimetric results is good [15].

Although the anatomy of the TRAM flap for breast reconstruction is well known, only a few hemodynamic studies have been conducted on the TRAM flap. Using a preoperative laser Doppler flowmeter and transcutaneous oxygen tension measurements, we showed that skin blood flow on the random side of the pedicled TRAM flap dropped significantly when the inferior epigastric artery was ligated and that it remained low until the third postoperative day [16]. Very low laser Doppler flow (LDF) and oxygen tension values predicted edge necrosis in the pedicled TRAM. In contrast, when a free TRAM flap operation was performed, there was no drop in skin blood flow when the superior epigastric system was ligated at the level of the umbilicus [7]. Postoperatively, skin blood flow on both sides of the free TRAM was even better than in the tissue in its original position.

In this study of the free TRAM flap, we set out not only to map the skin perforators pre- and intraoperatively by thermography but also to study the hemodynamics of the free TRAM flap.