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Porcine experimental model for perforator flap raising in reconstructive microsurgery

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ABSTRACT

Background: Perforator free flap–based reconstruction of the head and neck is a challenging surgical procedure and needs a steep learning curve. A reproducible mammal large animal model with similarities to human anatomy is relevant for perforator flap raising and microanastomosis. The aim of this study was to assess the feasibility of a swine model for perforator-based free flaps in reconstructive microsurgery.

Methods: Eleven procedures were performed under general anesthesia in a porcine model, elevating a skin flap vascularized by perforating musculocutaneous branches of the superior epigastric artery to evaluate the relevance of this model for head and neck reconstructive microsurgery.

Results: The anterior abdominal skin perforator–based free flap in a swine model irrigated by the superior epigastric artery was elevated in eleven procedures. In six of these procedures, we could perform an arterial and venous microanastomosis to the great vessels located in the base of the neck.

Conclusions: The porcine experimental model of superior epigastric artery perforator–based free flap reconstruction offers relevant similarities to the human deep inferior epigastric artery perforator flap. We could demonstrate this model as acceptable for perforator free flap training due to the necessity of perforator and pedicle dissection and transfer to a distant area.

Introduction

Reconstructive surgery begun around 2600 B.C. with the description of nasal amputations and available flaps for its reconstruction in the Hindu culture. In the seventh century B.C., Sushruta described in detail the frontal flap, as well as the surgical instruments necessary for its realization and the way of training with fruits to acquire the necessary skills.

From its beginnings, reconstructive surgery has needed models to acquire the necessary technical skills for its accomplishment. These skills, the study of scientific evidence, human anatomy and a hint of imagination to adapt to each case, constitute the basis of modern reconstructive surgery.

In 1889, Manchot[1] described the cutaneous vascularization. The details of the skin vascularization were later confirmed by radiopaque material injection techniques.[2] Taylor and Palmer,[3] in 1987, described the "angiosomes theory", and

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defined the angiosome as a three-dimensional space that includes skin, subcutaneous tissue, and muscle irrigated by a single artery and drained by a single venous system. This is the first development of an arterial body map that serves as the basis for scientific planning of flaps and incisions that also defines viable tissues for free tissue transfer.

The first clinical application of this theory was provided by Koshima and Soeda[4] in 1989, demonstrating the possibility of abdominal skin and subcutaneous cellular tissue elevation, both being vascularized from the deep inferior epigastric artery, through a "perforator" vascular pedicle that crosses the rectus abdominis, preserving in this manner the muscle and its innervation. This technique is notable for the drastic reduction of morbidity in the donor site, a characteristic of perforator-based flaps.

Twenty years later, Sain-Cyr *et al.*[5] described, based on the previous study of Taylor,[3] the "perforasome" theory, going from the description of territorial donor arteries to the one of perforating arteries that irrigate a determined cutaneous territory.

The use of perforator free flaps in head and neck surgery can provide advantages in versatility, as the different fasciocutaneous, muscular or bony components can become independent. They also make it possible to reduce sequelae in the donor site by preserving functional structures that are not necessary for reconstruction. However, dissection of the perforating pedicle itself requires extensive training, and initiation into these procedures can be challenging. As described by other authors, a learning curve is needed to be able to safely develop these interventions.[6] With the intention of minimizing this learning curve and avoiding complications, the technical, physical, and psychological training for these interventions should be performed in experimental models. There are currently several programs for reconstructive microsurgery training, but repeating the technique in an environment without potential harm to patients is the best way to get used to these demanding procedures.

The aim of this article was to describe and analyze our experience with a porcine model as a training method for the dissection and elevation of a perforator free flap, with no aid for the identification of vascular pedicles except for optical magnification, and its transfer to the cervical region, basing the results on surgical time and immediate vascular permeability.

To achieve this goal, we performed the elevation of a ventral abdominal myoadipocutaneous flap based on perforators of the superior epigastric artery and microanastomosis to cervical vessels.

Methods

Limiting schedules

We have performed experimental surgical procedures with a maximum limit of 4 h of operating time due to the limitations imposed by the experimental operating room staff.

Experimental model

For the present study, 11 experimental porcine models (*Sus scrofa domestica*) were used under the approval of the Scientific Committee of the Biodonostia Research Institute with project number ANIM 12/04.

The animals were treated according to the rules set out in Directive 2010/63/EU of the European Parliament and of the Council of Europe adopted on the 22nd of September on the protection of animals used for scientific purposes, as well as Spanish Royal Decree 53/2013 adopted on the first of February 2013, which establishes the basic regulations applicable for the protection of the animals used in experimentation and other scientific purposes, including teaching.

Animals were fasted 24 h before the intervention with hydration on demand. Intramuscular anesthetic premedication was performed with Ketamine 10 mg/kg, azaperone 3 mg/kg, and atropine 0.05 mg/kg 10 min before anesthetic induction was performed via inhalation with 2% sevoflurane. As an intraoperative analgesic, a continuous infusion of 250 mL/h of a 0.09 mg/100 mL fentanyl dilution and atracurium besilate as muscle blocker in a continuous infusion of 250 mL/h at a concentration of 30 mg/100 mL were administered. Intraoperative maintenance of hypnosis is performed with 1% sevoflurane.

Anesthetic monitoring was conducted by personnel with appropriate permissions and qualifications for the handling of experimentation animals.

Following the principles of an ethical use of animals for experimentation and only with teaching purposes, a second surgical team performed several oncologic surgeries in the head and neck area, not related with this specific model, while main reconstructive surgeons prepare the free flap to be raised and transferred. The neck vessels are prepared during these secondary procedures to be ready for anastomosis after free-flap harvest.

After the procedure, the animals were sacrificed, under the influence of general anesthesia with an intravenous injection of a lethal dose of potassium chloride. Subsequently, they were included in post-mortem experimental procedures, with organ extraction for other experimental studies, for a lesser use of animal resources in secondary procedures.

Equipment

The perforator free-flap elevation procedure was performed under optical magnification with 2′5× loupes for the assistant and 4′5× for the lead surgeon.

Owing to the great consistency of the abdominal vascular anatomy in this experimental model, it has not been necessary to identify the perforators to the abdominal skin in advance with Doppler devices.

Basic instruments for abdominal and neck dissection and microsurgery and microanastomosis instruments, all of them for exclusive use in the experimental operating room, were used.

Surgical technique

The experimental animal, with orotracheal intubation and after verification, by trained personnel, of the appropriate level of anesthetic depth and analgesia, was placed in a supine position with adaptive attachment of the four limbs.