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Porcine model for free-flap breast reconstruction training

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Summary *Background:* Free-flap breast reconstruction is a challenging surgical procedure with a steep learning curve. A reproducible large animal model could be relevant for free-flap harvesting and microsurgical anastomosis training. The aim of this study was to assess the feasibility of a porcine model for free-flap breast reconstruction.
Methods: Three female pigs were placed under general anesthesia in order to study feasibility and estimate relevance for training. The deep inferior epigastric perforator (DIEP) flap, the transverse musculocutaneous gracilis (TMG) flap, and the superior gluteal artery perforator (SGAP) flap were harvested and anastomosed to the internal thoracic vessels. Differences were noted between pig and human anatomy, and the surgical procedure was adapted to build training models.
Results: Under a more prominent anterior thoracic wall, the internal thoracic vessels were slightly deeper and larger than in human anatomy. The DIEP flap was never feasible in the porcine model. However, the superior epigastric artery perforator (SEAP) flap showed anatomical similarity with the human DIEP flap, and it proved to be suitable for an inverted training model. The porcine TMG flap harvesting was close to the human one, reproducing specific dissection and anastomotic difficulties. The SGAP flap was not a muscular perforator flap in pigs but a septocutaneous flap. Because of the thinness of the hypodermal fat, porcine flaps were not considered adequate training models for breast-mound shaping.

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Conclusions: Despite any anatomical variations, the pig has proven to be a suitable training model for free-flap harvesting and transfer in the field of breast reconstruction.

Introduction

Free-flap breast reconstruction procedures offer the advantages of providing a definitive natural appearance and texture to the reconstructed breast as opposed to silicone implants. Several donor sites have been described arising from the infra-abdominal skin, the medial thigh, and the buttock. However, microsurgical harvesting and anastomoses require high training skills, and starting such procedures may be problematic. A surgical learning curve has already been demonstrated for the abdominal perforator flap, and it may logically be effective for other free tissue transfer.[1,2] In order to minimize the learning curve in beginners and complications, training to those interventions should be provided in experimental models before performing the actual procedures in the operating room. Educational programs for reconstructive microsurgery are currently available, but the relevance of pig models for breast reconstruction has not been widely studied and published yet.

The aim of this original work was to study anatomical similarities between porcine and human free-flap harvesting, and to investigate the usefulness of the model for microsurgical breast reconstruction programs. Internal thoracic vessel preparation, flap harvesting, and microsurgical anastomosis were successively performed in pigs. The authors tested the deep inferior epigastric perforator (DIEP) flap, the transverse musculocutaneous gracilis (TMG) flap, and the superior gluteal artery perforator (SGAP) flap. They described similar dissection parts and differences between pig and human anatomy. The surgical procedure was adapted if necessary in order to build a useful training model.

Materials and methods

Animals

A total of three female swine (*Sus scrofa domesticus*, ssp. large white; 35—40 kg) were used in the present experimental non-survival study. Animals were included in an experimental protocol (Protocol No. 38.2010.01.001), which received complete approval from both the local Ethical Committee on Animal Experimentation and the French Ministry of Superior Education and Research (MESR). In accordance with the 3Rs (reduction, refinement, and replacement) principles for a more ethical use of animal testing, at the end of the scheduled protocol, animals could be included in an additional non-survival, experimental procedure. All animals used in the experimental laboratory were managed according to French laws for animal use and care and according to the directives of the European Community Council (2010/63/EU). Pigs were fasted for 24 h before surgery with free access to water. Premedication by the intramuscular injection of ketamine (20 mg/kg) and azaperone (2 mg/kg) (Stresnil, Janssen-Cilag, Belgium) was administered 10 min before surgery. Induction was achieved by intravenous propofol (3 mg/kg) combined with pancuronium (0.2 mg/kg). Anesthesia was maintained with 2% isoflurane. At the end of the procedure, the pig was sacrificed according to our protocol with an intravenous injection of a lethal dose of potassium chloride.

Equipment

Flap-harvesting procedures were performed under 4× binocular loupe magnification (working distance of 450 mm). Internal thoracic dissection and microanastomosis were carried out using 5× binocular loupes (working distance of 300 mm). The VITOM® 25 EXOscope (Karl Storz Endoscope, Tuttlingen, Germany), a visualization system for microsurgery, was used to view the operative field on a high-definition screen to help the assistant and to provide a shared vision for the whole surgical team. Perforators were detected on the skin using an 8-MHz pencil Doppler probe (Dopplex® MD2 bidirectional Doppler, Huntleigh Diagnostics Ltd., Cardiff, UK).

Procedures

Dissections were performed by a senior plastic surgeon specialized in microsurgical breast reconstruction. Two surgical fellows supported him. The first dissection tested the DIEP flap and the inverted DIEP flap. During the second session, the inverted DIEP flap and the TMG flap were harvested. Finally, the SGAP flap was performed during a third dissection.

The internal thoracic artery (ITA) and vein (ITV) were prepared as recipient vessels in all cases. In total, four types of free flaps were created in three animals. The DIEP, TMG, and SGAP flaps were harvested based on our experience with human breast reconstruction and previous data published on pig dissections. The superficial epigastric artery perforator (SEAP) flap was an inverted DIEP flap.[3]

The DIEP flap was harvested in a supine position. An elliptic transverse skin paddle was drawn with a surgical marker on the inferior hemi-abdomen, according to human landmarks (Figure 1a and b). The skin incision was performed using a No. 23 scalpel deep into the anterior sheath of the abdominal wall. The skin flap was then peeled from the rectus sheath searching for dominant perforators. The vascular pedicle was then dissected in the muscle. An