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Technical note

Porcine abdominal cutaneous flap model: A simple and reliable method

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ABSTRACT

The increase of reconstructive microsurgery procedures leads to the development of various technologies. Before being validated in human clinical studies, these technologies and devices need to be validated on animal models. We present a simple, reliable and reproducible model of a cutaneous flap in pigs. This flap is pedicled on the superficial inferior epigastric pedicle (SIEP). The surgical technique is described. This flap can be buried and, if necessary, harvested on both sides. It did not alter the abdominal wall, and so it has allowed painless long-term follow-up of the animals. To our knowledge, this technique has never been reported in pigs.

1. Introduction

During the last decades, the number of reconstructive surgery procedures using free flaps has constantly increased. Many technologies are being developed to improve the planning, the dissection, the anastomosis and the monitoring of the flaps. Before surgery, perforating vessels can be located by echo-Doppler or CT Scan [1] and more recently by augmented reality [2]. Venous anastomoses are now performed faster and more safely with microvascular couplers [3]. Many techniques for monitoring the viability of the flaps have been developed, especially near-infrared spectroscopy (NIRS), implantable doppler probe, and microdialysis [4]...

All of these technologies had to be validated on animal models before clinical use. The tightening of regulations regarding medical devices has increased this need. So it is necessary to dispose of different types of animal flaps which are easy to harvest, reliable, with a constant pedicle, safe and painless for the animal, respecting ethical considerations and as close as possible to human clinical application.

The pig is an excellent model because of the similarity of their cutaneous and vascular features with humans [5]. Some musculo-cutaneous flaps have already been described such as: buttock flap, TRAM flap, pectoralis flap [6–8]...

The aim of this paper is to present a new, simple and reliable abdominal cutaneous flap in pigs, based on the superficial inferior epigastric pedicle (SIEP flap). The surgical technique and potential applications are described.

2. Technical note

Premedication consisted in intramuscular injection of azaperone (2 mg/kg) and atropine (0,04 mg/kg). Induction consisted in intravenous injection of zoletil (10 mg/kg). Animals were intubated and ventilated with oxygen and isoflurane. Morphine (0,2 mg/kg) was injected every 4 hours.

The pig was placed in decubitus dorsal position with the hind limbs retracted caudally.

Cutaneous incisions and landmarks were drawn (Fig. 1A).

The first step was to locate the pedicle at its emergence. The incision was placed in the inguinal fold, 5 cm laterally from the midline. The pedicle set in the subcutaneous tissue (Fig. 1B), 3 cm laterally from midline and 3 cm above the inguinal ligament. The pedicle consisted of an artery (2 mm in diameter) and two veins (1 mm in diameter). Once located, artery and veins were separated by blunt dissection on 4 cm.

The inferior part of the skin paddle was traced 10 cm above the inguinal fold. In Fig. 1A the paddle measured 8 cm high by 6 cm

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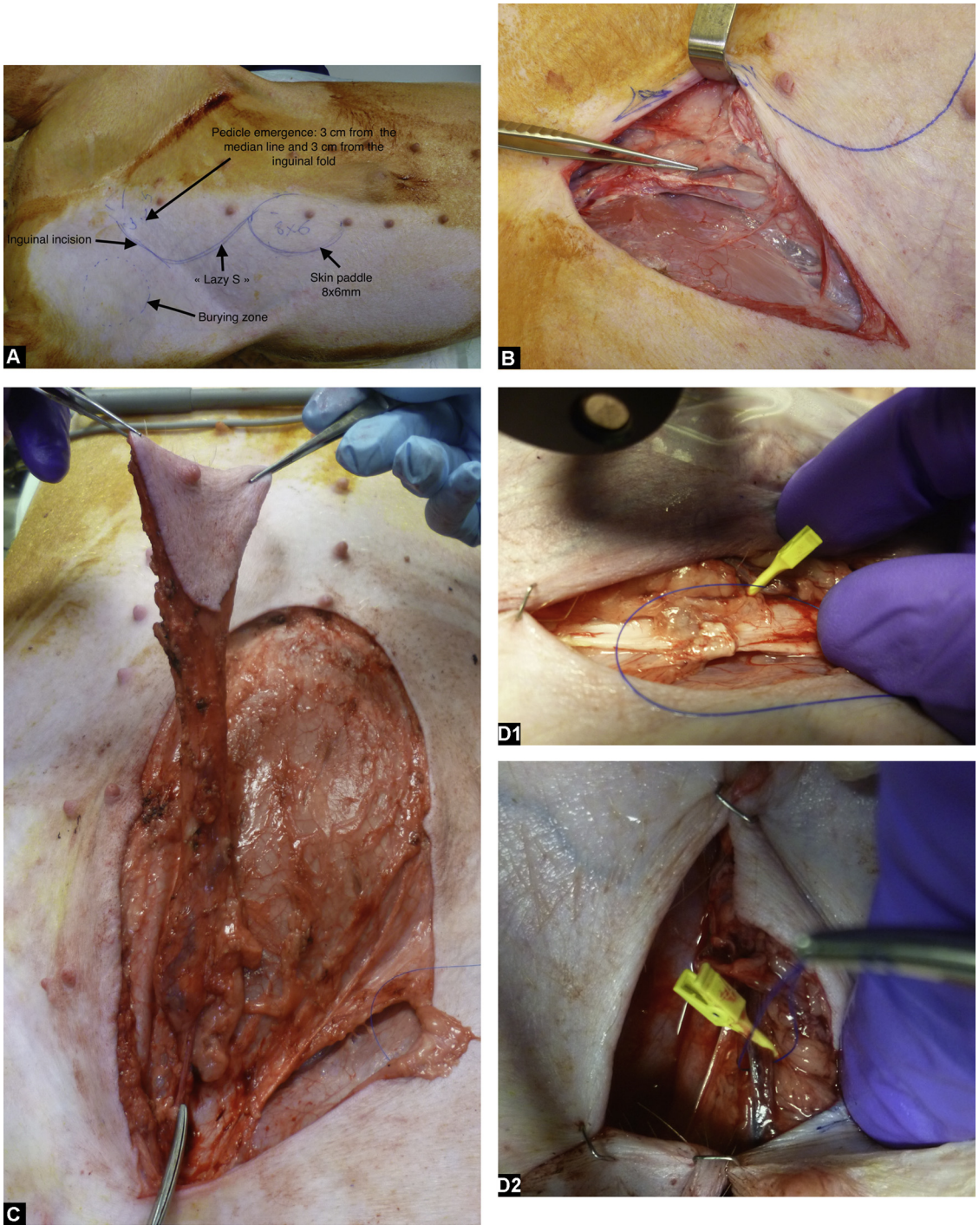

Fig. 1. A. Skin landmarks and incisions. B. Identification of the pedicle at the level of the inguinal fold. C. Flap and pedicle at the end of dissection. D1 and D2. Clamping test.

wide and was drawn laterally relative to the udders, but it could be larger. The cutaneous incision was prolonged in a « lazy S » route to join the external part of the inguinal incision.

Through this incision the pedicle was controlled along its entire length between the inguinal incision and the skin paddle. A subcutaneous cuff was preserved all around the pedicle to avoid injury and drying. The urethra, which had a rich vascularization, was the medial limit of the dissection. Then the paddle was undermined above the right rectus abdominis muscle's aponeurosis. The pedicle was ligated at its cranial part (Fig. 1C). In the medial part of the paddle, some collateral branches should be included.

The donor site was easily closed, even in bilateral harvesting. Inguinal incision was left open to get an access to the pedicle.

Once the pedicle entirely dissected, the flap had a 360 degree rotation arch. It could be buried subcutaneously in the thigh or in the lateral part of the abdominal wall. In these cases the flap was spread and fixed by transfixing stitches. The flap could also be easily buried in the abdominal cavity.

As long as the dissection was purely cutaneous, the procedure was painless for the animal which has recovered rapidly its autonomy and could be fed without restriction.

Experiments were performed at Biovivio and approved by the Ethical review board in animal research no. 1612-V3 (A691270505).

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3. Discussion

We have presented a very simple, reliable and reproducible cutaneous flap. Dissection planes and the pedicle are easy to find. The vascular anatomy is constant.

The SIEP flap is very similar to certain human flaps like the forearm flap or anterolateral thigh flap. It has the same dimension, the same plasticity and the same type of vascularization.

The SIEP flap is very useful to evaluate new monitoring devices. The easy access of the pedicle facilitates the clamping tests, whether it is for the artery or the veins (Fig. 1D1 and D2).

Another advantage of this flap is the poor morbidity of the donor site. Indeed, the size of skin paddle and the abdominal cutaneous laxity allows direct closure. The SIEP is not a major vascular axis, so its suppression did not compromise the survival of the animal, which is useful in long-term studies. Furthermore, a skin flap is less painful than a musculo-cutaneous flap which is important for ethical and financial reasons (cost of painkillers for example).

This flap can be buried all around its arc of rotation which can exceed 10 cm.

It can be harvested bilaterally if needed, but it can compromise the skin vascularization of the midline residual skin strip.

To our knowledge, the SIEP flap has never been reported in pigs.

This flap has been described in rats [9] and in rabbits [10]. In rats, the SIEP flap is commonly used in flap monitoring study [11,12]. The major limitation of the SIEP flap in rats is the lack of volume tissue and the small size of the pedicle (sometimes difficult to isolate). It can be responsible for the measurements' failures, the monitoring devices being calibrated for thicker flaps [11,12].

Other flaps have been reported. The musculo-cutaneous flaps [5–8] are widely used but they are more disabling. Several flaps are described particularly in the abdomen area. The TRAM flap [7] and the transmidline flap, [8] based on the deep superior epigastric pedicle, involve a wound in the abdominal wall.

Some cutaneous flaps have already been described such as the flap based on the cranial gluteal artery perforator [13] and flap based on the superficial circumflex iliac pedicle [14]. Those flaps have a bigger skin island than the SIEP flap. But they have some disadvantages: their short pedicles limit the rotation of the flap and particularly the possibility of burying. It is also impossible to harvest bilaterally the same two flaps without changing the position of the pig.

Disclosure of interest

The authors declare that they have no competing interest.

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