Comparative viability of peninsular and island axial pattern flaps incorporating the cranial superficial epigastric artery in dogs

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Summary: *Experimental island and peninsular axial pattern flaps that incorporated the cranial superficial epigastric artery and vein were developed in 6 Beagles. Mean percentage of flap area that survived, for both flaps, was 87%, and percentage of surviving flap area was not significantly different for island versus peninsular flaps. In 1 dog, ligation of an aberrant, perforating branch of the cranial epigastric artery resulted in necrosis of 53% of the flap area. The cranial superficial epigastric axial pattern flaps have potential application for closure of skin defects within their arc of rotation and may be particularly useful for closure of large defects on the ventral aspect of the thorax. A peninsular flap was used to close a defect of the ventral portion of the thoracic wall in a clinical case.*

Pedicle skin grafts are classified, on the basis of their blood supply, as subdermal plexus flaps and axial pattern flaps. A pedicle skin graft that receives blood supply only from the subdermal plexus entering the base of the flap is called a subdermal plexus flap. A pedicle skin graft that incorporates a direct cutaneous artery and vein is called an axial pattern flap. Axial pattern flaps have a better blood supply than do subdermal plexus flaps, allowing development of longer and wider flaps in a single stage. Axial pattern flaps are valuable in coverage of areas with poor vascularity or where padding and skin durability are needed and in closure of large skin defects within their arc of rotation. Because of the elastic nature of canine skin, large flaps can be developed without creating defects that are not amenable to primary closure.[1]

Axial pattern flaps can be subclassified as peninsular and island axial pattern flaps. Peninsular axial pattern flaps remain attached to surrounding skin along 1 border; whereas, island axial pattern flaps do not have a direct attachment to surrounding skin and are tethered only by their direct cutaneous artery and vein. Because they are not restricted by a cutaneous pedicle, island axial pattern flaps have greater rotational mobility than do peninsular axial pattern flaps. For instance, island axial pattern flaps can be rotated 180° to cover defects and are especially useful for closure of skin defects that encroach on 1 border of a proposed axial pattern flap.[1-3] However, use of island axial pattern flaps is not yet routine, possibly because of concerns that the blood supply from the subdermal plexus is an important supplemental source of circulation.

The purposes of the study reported here was to establish anatomic guidelines in dogs for development of peninsular and island axial pattern flaps that incorporate the cranial superficial epigastric artery and to compare viability of these 2 flap designs. Because of the anatomic location of the cranial superficial epigastric artery and vein, a flap incorporating these vessels could potentially be used to close large wounds on the lateral aspect of the abdomen or ventral aspect of the thorax.

Materials and Methods

Surgical procedure—Six purpose-bred adult Beagles (2 males and 4 females), weighing between 8 and 21 kg, were used. The study protocol was approved by the institutional Animal Research Committee.

Dogs were premedicated with butorphanol tartrate[a] (0.2 mg/kg of body weight, IM), acepromazine maleate (0.05 mg/kg, IM), and glycopyrolate (0.01 mg/kg, IM) 30 minutes prior to anesthetic induction. General anesthesia was induced with sodium pentothal (10 mg/kg, IV) and maintained with isoflurane administered by means of a semiclosed circle system. Each dog was placed in dorsal recumbency, and the ventral aspects of the thorax and abdomen were clipped of hair. An alcohol-resistant marking pen was used to draw the outline of the proposed flaps, and routine surgical skin preparation was then performed.

For each dog, an island axial pattern flap was created on one side of the ventral aspect of the abdomen, and a peninsular axial pattern flap was created on the contralateral side. The side on which each flap was created was alternated between dogs. Each flap incorporated skin, mammary glands 3 and 4 (cranial and caudal abdominal mammary glands), and a variable portion of mammary gland 5 (inguinal mammary gland). The cranial border of each flap was a horizontal line at the level of the xiphoid process, and the caudal border was a horizontal line at the level of the fourth mammary gland. The ventral midline served as a common, medial border for the flaps. At each level, flap width was twice the perpendicular distance from the ventral midline to the nipple (Fig 1).

Skin was incised with a scalpel, and the flap was elevated, starting at the caudal flap border and advancing cranially toward the origin of the cranial superficial epigastric artery, by dissecting with Metzenbaum scissors between the subcutaneous tissue and the external abdominal fascia. Hemorrhage was controlled by means of electrocautery. After the flaps were completely elevated, they were replaced and fixed in their original anatomic position with skin staples[b] that were supplemented with 3-0 monofilament nylon[c] sutures placed in a simple interrupted pattern.

Postoperatively, a soft, padded bandage was placed around the trunk of each dog to obliterate dead space and prevent self-mutilation. The analgesic butorphanol tartrate (0.2 mg/kg, IM, q 6 h) was given for a minimum of 24 hours after surgery, but was given for a longer period if needed. The band-

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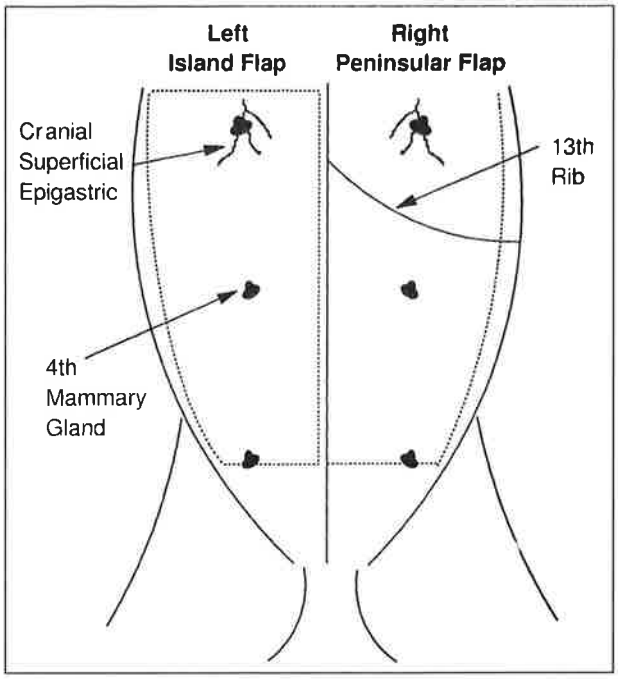

Figure 1—Schematic diagram of the ventral portion of the abdomen of a female dog depicting the cranial superficial epigastric artery, abdominal mammary glands, and outline (dotted lines) of proposed island and peninsular axial pattern flaps.

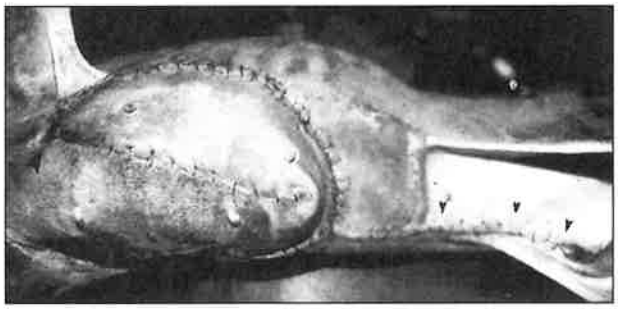

Figure 2—Immediate postoperative appearance of a peninsular axial pattern flap, incorporating the right cranial superficial epigastric artery and vein, used to close a skin defect on the left ventral aspect of the thorax in a dog. A 2 × 3-cm portion of the wound that was not covered by the flap was left open to heal by second intention (large arrowhead). The donor site was completely closed (small arrowheads). The dog's head is to the left.

age was changed daily, or more often if it became soiled or moist. At each bandage change, we checked for signs of hyperemia, drainage, swelling, heat, pain, and discoloration.

Statistical analysis—A paired *t*-test for dependent variables was used to compare percentage of flap area that survived for peninsular versus island flaps.

Clinical case—In an 8-year-old female Doberman Pinscher, a peninsular axial pattern flap based on the right cranial superficial epigastric artery flap was used to close a 10 × 25-cm ventral thoracic wound that had resulted from dehiscence following removal of left mammary glands 1 through 3. A healthy granulation bed had formed after debridement and open wound management following the mastectomy. The flap was elevated as described, and sutured into the defect with 2-0 polydiaxonone suture material in an interrupted subcutaneous pattern, followed by simple, interrupted skin sutures of 2-0 monofilament nylon. A soft, padded bandage was placed over the flap for 3 days after surgery (Fig 2).

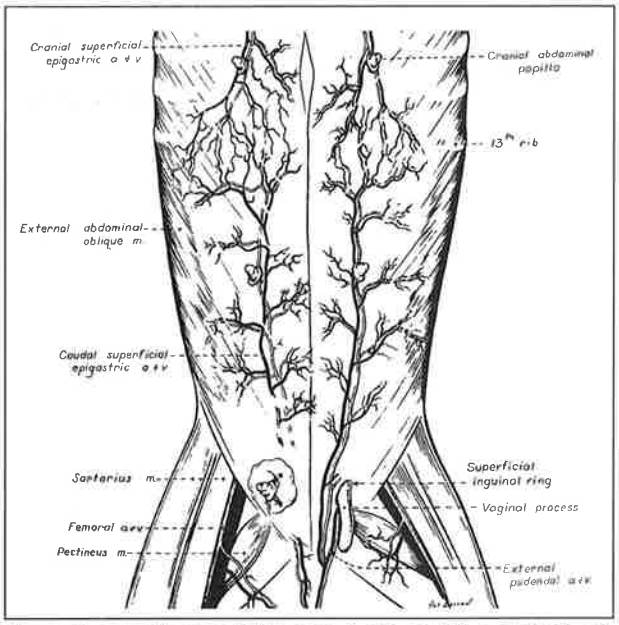

Figure 3—Distribution of the cranial and caudal superficial epigastric vessels (From Evans HE, Christensen GC. Miller's Anatomy of the dog. Philadelphia: WB Saunders Co, 1979;732. Reproduced with permission).

Results

Flap survival—Mean percentage of flap area that survived was not significantly ($P = 0.88$) different for island versus peninsular flaps. In 4 dogs, 90% of the area of each flap survived. In 1 dog, only 87% of the area of the island flap survived, but 100% of the area of the contralateral peninsular flap survived. In the remaining dog, only 47% of the area of each flap survived. In this dog, aberrant, perforating branches of the cranial epigastric artery and vein were encountered during elevation of each flap, approximately 3 cm caudal to the point where the cranial superficial epigastric vessels emerged from the rectus abdominus muscle. These aberrant vessels were ligated and divided during elevation of the flap, and the cranial superficial epigastric vessels were subjectively smaller than vessels in the other dogs in this study. A marked, purple discoloration of the caudal half of the flap was evident within the first 24 hours after surgery, and the tissue subsequently underwent necrosis. A clear delineation between viable and nonviable skin in each flap was evident by day 5.

Complications—In all 6 dogs, hyperemia and mild edema of the flap was detected. In 5 dogs, signs of superficial infection of a portion of the incision were detected 3 days after surgery, and administration of trimethoprim-sulfamethoxazole (25 mg/kg, PO, q 12 h) was instituted.[d] A seroma developed in 4 dogs. In each dog, the seroma was aspirated aseptically (range of volume aspirated, 20 to 400 ml), and a bandage was applied. In 1 dog, the seroma recurred 3 times, and placement of a closed suction drain was necessary.[e] The drain was removed after 3 days. In 3 dogs, a portion of the incision dehisced. In 1 of these dogs, the dehiscence was a 3-cm long defect along the medial border of the 2 flaps, at the level of the prepuce, and was determined to be a result

of self-mutilation. The defect was sutured and healed without further complications.

Clinical case—The peninsular axial pattern flap allowed closure of the defect. Approximately 93% of the flap area survived. A small, 3 × 6-cm area of the distal portion of the flap did not survive, and the resulting defect was allowed to heal by second intention. Healing was complete within 6 weeks.

Discussion

The cranial superficial epigastric artery originates from the cranial epigastric artery and is the chief blood supply of the cranial abdominal mammary glands (Fig 3).[4] Our results suggest that the cranial superficial epigastric artery and vein will provide adequate cutaneous circulation for an axial pattern flap created using the aforementioned general anatomic guidelines.

Admittedly, flaps in the experimental dogs were replaced in their original anatomic positions. A better test of flap viability would have been to rotate each flap into a defect created in the ventral aspect of the thorax or lateral aspect of the abdomen. However, in this study, paired flaps were created to allow comparison of the viability of these 2 flap designs. Had the 2 flaps been rotated, the resulting defect in the ventral aspect of the abdomen would have been too large to close. Further clinical studies are needed to definitively demonstrate that viability of cranial superficial epigastric axial pattern flaps is not adversely affected by rotation. On the basis of results of rotation of axial pattern flaps incorporating various other vessels,[3,5-10] we do not believe that flap survival would be adversely affected by rotation. Surgeons should pay close attention to avoiding excessive tension or kinking of the vascular pedicle during rotation of an axial pattern flap into a nearby skin defect.[3]

Guidelines for width of the flaps in this study were similar to guidelines for the width of caudal superficial epigastric axial pattern flaps. Clearly, flaps should not be made so wide that the defect created by elevation of the flap cannot be easily closed. Maximal flap width depends on individual body conformation and inherent cutaneous elasticity; however, these guidelines should be appropriate for most dogs.

In 1 of these 6 dogs, aberrant, bilateral, perforating branches from the cranial epigastric arteries were encountered 3 cm caudal to the cranial superficial epigastric arteries and were ligated during flap elevation. The poor flap survival in this dog suggests that these aberrant branches were an important source of supplemental circulation and that, when found in other dogs, should not be ligated. Unfortunately, this will limit the size and mobility of the flap. The prevalence of these aberrant vessels in dogs is not known.

Concern over the loss of circulation contributed by the cutaneous pedicle of a peninsular axial pattern flap has prompted many surgeons to avoid the routine use of island axial pattern flaps. However, in a study performed on pigs,[11] island flaps survived to at least the same extent as those having a cutaneous pedicle containing direct cutaneous vessels. In the present study, percentage of surviving flap area was not significantly different for island versus peninsular flaps. Therefore, the type of axial pattern flap to use can be decided on the basis of flap mobility required (ie, location of recipient bed). Flaps that do not contain a direct cutaneous artery and vein depend on the subdermal plexus for nutritive support, and in previous studies,[2,3] the area of a subdermal plexus flap that would survive was only about half that of an axial pattern flap.

Flap survival is primarily dependent on the perfusion pressure of the circulation incorporated into the flap.[3,12] Necrosis at the caudal border of some of the flaps in this study suggests that their length exceeded the perfusion pressure of the nutrient vessels. In general, flap length should be minimized to reduce the possibility of necrosis of the caudal portion of the flap. Additionally, because of difficulties associated with closure of the donor site near the prepuce, the caudal border of the flap should be cranial to the prepuce.

Seromas were evident in 4 of the 6 dogs by days 2 through 8, despite placement of bandages after surgery. Therefore, we now recommend routine placement of closed suction drains to control dead space and minimize the potential for seroma formation. The drain should remain in place until fluid accumulation has reached a minimum; this usually requires 2 to 3 days. A soft, padded bandage should be used to protect the drainage system and to maintain compression on the flap. We do not routinely administer antibiotics pre- or postoperatively.

[a]Torbugesic, Fort Dodge Laboratories Inc, Fort Dodge, Iowa.
[b]Richard-Allan Reflex One 35W Skin Staples, Richard Allen Medical Industry, Richland, Mich.
[c]Ethilon, Ethicon Inc, Somerville, NJ.
[d]Tribrissen, Coopers Animal Health Inc, Kansas City, Kan.
[e]Blake drain, Johnson & Johnson, New Brunswick, NJ.

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