13

Axial Pattern Skin Flaps

PLATES

INTRODUCTION: AXIAL PATTERN FLAPS

An axial pattern flap is a pedicle graft that incorporates a direct cutaneous artery and vein into its base. The vessels extend up the length of the flap to a variable degree, the terminal branches of which supply blood to the subdermal plexus. As a result, axial pattern flaps have better perfusion as compared to pedicle grafts, whose circulation is derived from the subdermal plexus alone (subdermal plexus flaps). Experimental studies and clinical trials have demonstrated that large axial pattern flaps can be safely elevated and transferred in a single stage for closure of major cutaneous defects within their general radius.

There are several axial pattern flaps that have been formally researched and designed for clinical use in the dog. They are based on the following direct cutaneous arteries: the omocervical artery, thoracodorsal artery, lateral thoracic artery, superficial brachial artery, caudal superficial epigastric artery, cranial superficial epigastric artery, deep circumflex iliac artery, genicular artery, caudal auricular artery, lateral caudal (tail) artery, and superficial temporal artery. The caudal superficial epigastric artery (Figs. 13-1–13-3) and thoracodorsal artery (Figs. 13-4–13-6) have the greatest clinical promise for axial pattern development, both in the cat and dog (see Table 13-1). Other axial pattern flap techniques, such as the genicular (Fig. 13-7), cranial superficial epigastric (Fig. 13-8), and deep circumflex iliac (Fig. 13-9) (dorsal and ventral branches) are effective for a more selective group of defects based on their size and location. A variation of the ventral deep circumflex iliac, the flank fold flap (Fig. 13-10), can be useful for defects involving the caudal abdomen and inguinal area.

Axial pattern flaps are generally rectangular in shape (standard peninsula configuration), although they can be modified with a right-angle extension (L, or hockey-stick configuration). The right-angle design enables the surgeon to cover irregular or wider defects that may not be completely covered by the standard peninsular design. Furthermore, this latter design can avoid encroachment upon the other side of the patient whereby the opposite direct cutaneous vessels may be necessarily sacrificed during flap elevation.

Axial pattern flap development and transfer requires careful planning. Measuring and drawing the flap on the patient's skin prior to surgery minimizes errors. Alcohol-resistant marking pens (VWR markers, VWR Scientific, San Francisco, CA) are preferable when isopropyl alcohol is used for surgical preparation of the skin. Alternatively, skin staples may also be used to silhouette the outlined flap to avoid losing the markings of the predrawn flap. Because axial pattern flaps rotate into adjacent defects, guidelines for local transposition flap measurement and transfer are equally applicable to their planning.

ISLAND ARTERIAL FLAPS

Island arterial flaps can be developed from axial pattern flaps by dividing the cutaneous pedicle but preserving the direct cutaneous artery and vein entering the newly created "skin island." Although island arterial flaps have considerable mobility tethered to the direct cutaneous vessels, their routine clinical use is unnecessary. One exception involves large defects that encroach upon the origin of a direct cutaneous artery and vein. Under these circumstances, it is possible to rotate an island arterial flap (the base of which shares a common border with the wound) 180 degrees over the defect (Fig. 13-8 and 13-9).

Island arterial flaps have potential for use in free flap development and transfer, using present-day microvascular surgical techniques; however, the surgical training, skill, equipment, and cost involved in microvascular surgery restrict such techniques to the largest academic institutions. Fortunately, most wounds can be handled more easily with the reconstructive techniques covered in this textbook.

REVERSE SAPHENOUS CONDUIT FLAPS

A variation of the axial pattern flap, the reverse saphenous conduit flap, has clinical application for wounds involving the tarsal and metatarsal areas of the dog. This flap is based over the saphenous artery and medial saphenous vein, which supply small direct cutaneous vessels to the overlying skin. Upon division from the femoral artery and vein, circulation flows in reverse fashion through the saphenous vessels via anastomoses with collateral vascular tributaries (Fig.13-11).

SECONDARY AXIAL PATTERN FLAPS

A secondary axial pattern flap is a modification of the axial pattern flap design. Skin segments positioned over vessels or tissue containing a major artery and

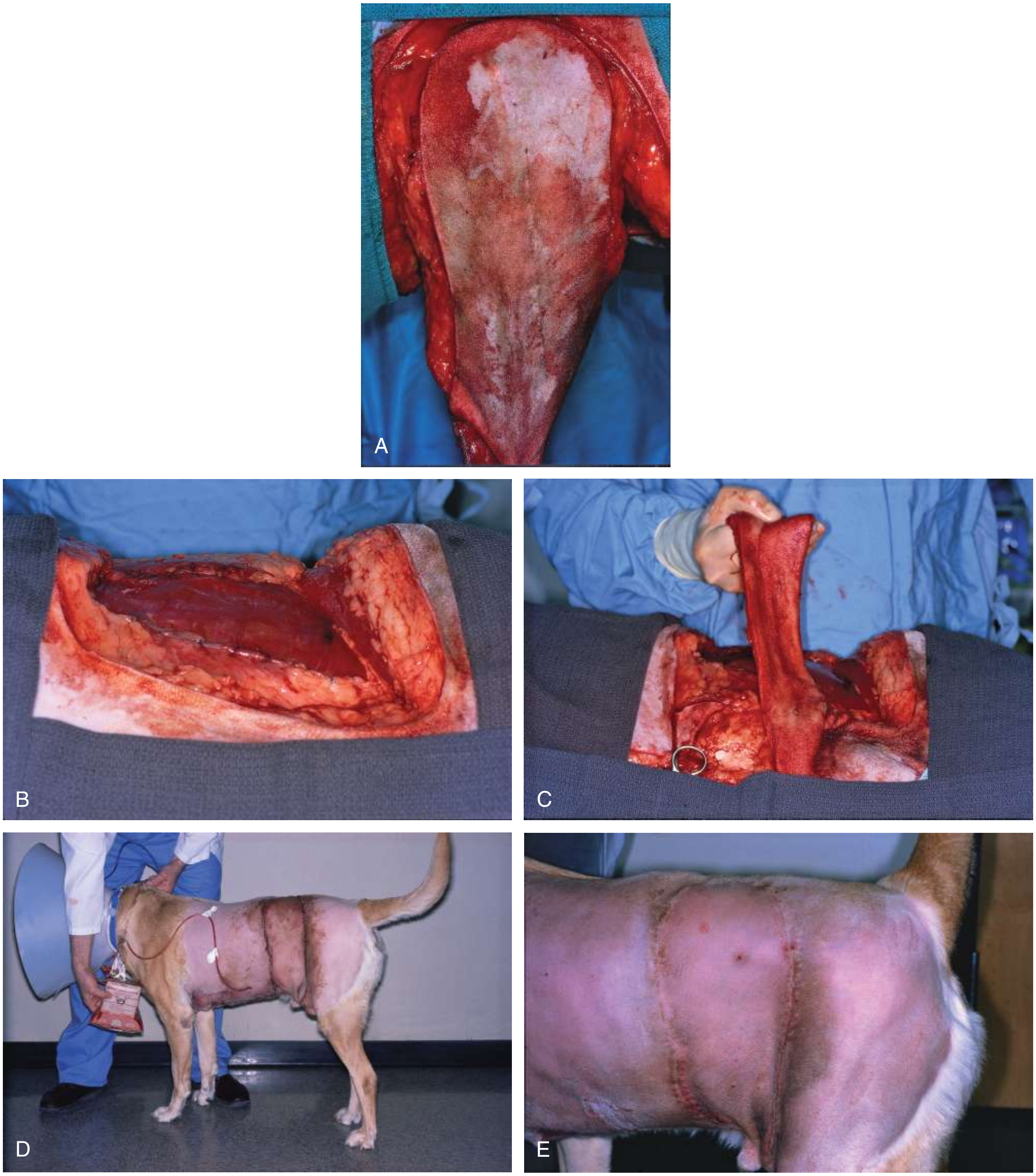

FIG. 13-1 (A) Wide resection of fibrosarcoma involving the left flank and lateral abdomen. (B) The external abdominal oblique muscle also was resected. (C) Elevation of the left caudal superficial epigastric axial pattern flap. (D) Closure of the wound. 35W skin staples were used to secure the flap. The drain was secured to the dog's collar. Tape strips applied to the vacuum tubing were secured to the thoracic skin with staples. (E) Complete survival of the flap.

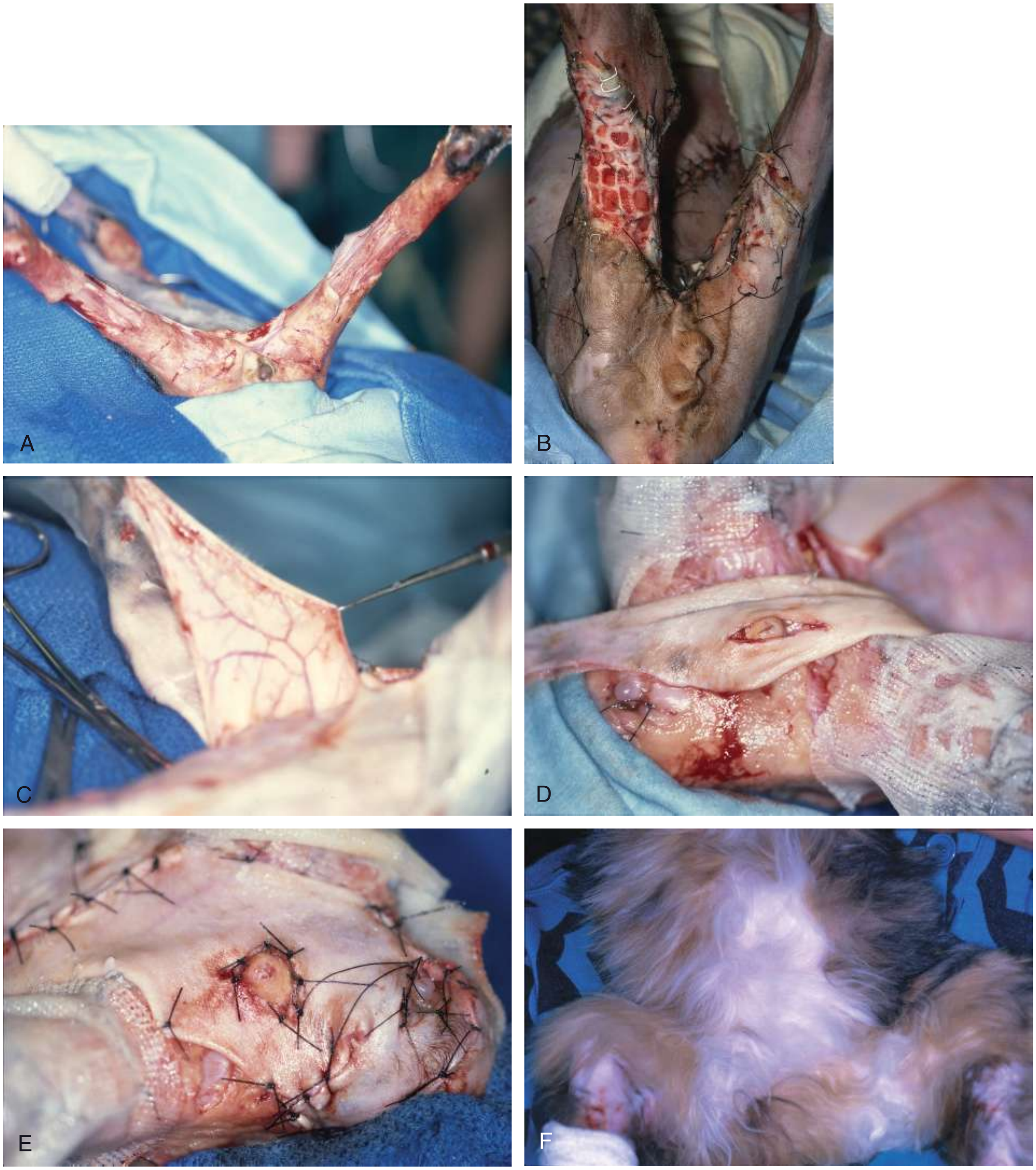

FIG. 13-2 (A, B) Extensive burn sustained by a cat. Necrotic tissue debridement was facilitated by warm saline baths in a sterilized stainless steel bucket (Fig. 7-15). Wound closure was attempted when a healthy granulation bed formed. Contractures in the popliteal areas were released; mesh grafts were applied to the rear extremities.

(C) Elevation of a caudal superficial epigastric axial pattern flap. Note branching of the epigastric vasculature.

(D) A slit was created in the flap, between branches of this direct cutaneous artery and vein, to accommodate the prepuce and penis.

(E) The flap was carefully fashioned around the anus and prepuce.

(F) The patient a few months later, completely rehabilitated. The medical and surgical management of the wounds (flaps/grafts) and an additional operation to release a scar stricture/contracture involving the anus and right forelimb, respectively, were costly. Several years after the surgery, the patient is in excellent health.

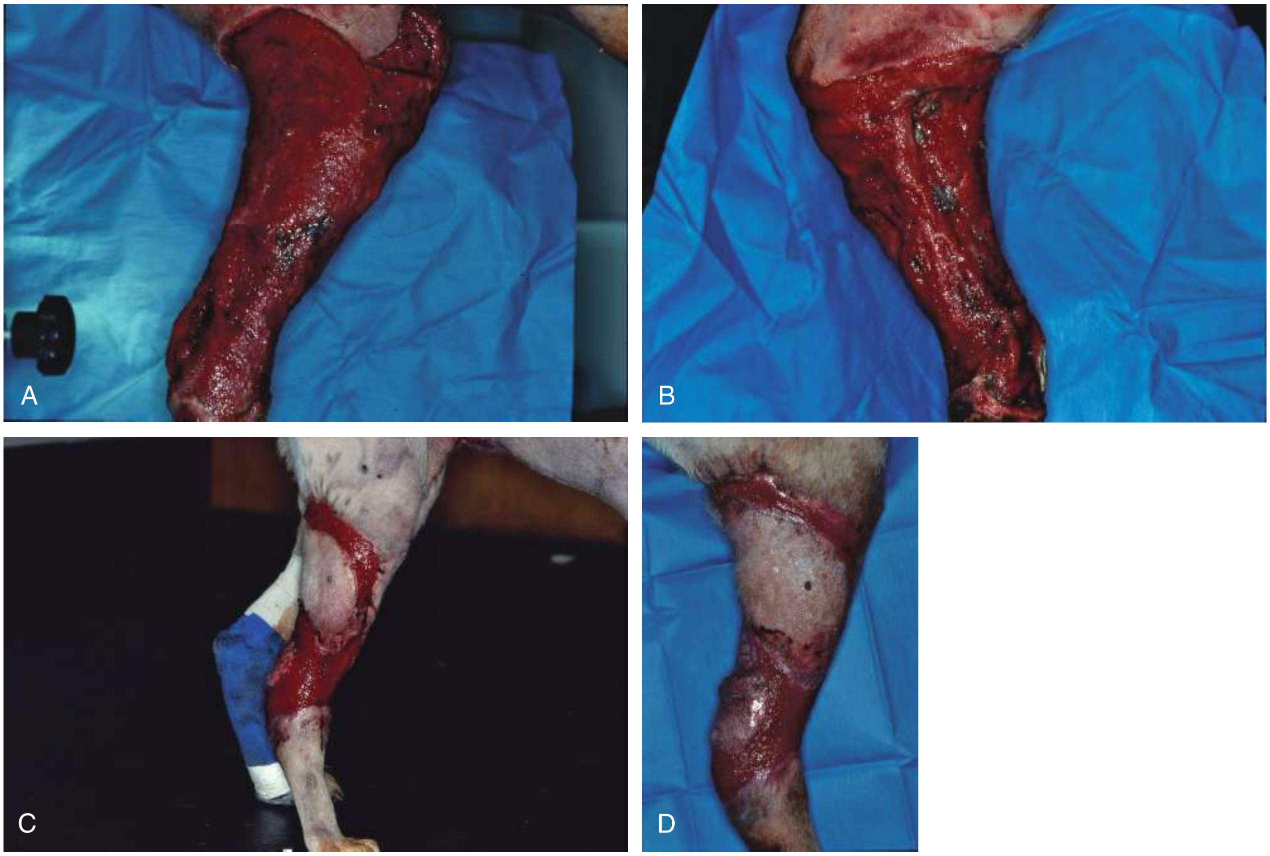

FIG. 13-3 (A, B) Massive circumferential loss of skin from the rear leg of a German shepherd, secondary to vehicular trauma. (C, D) Successful coverage with two caudal superficial epigastric axial pattern flaps, in a double-helix fashion. The second flap was delayed for approximately 5 days to allow mobilization of additional abdominal skin with skin stretchers. This maneuver was needed to assure the ventral abdominal donor site could be closed after recruitment of both flaps, which accounted for the skin of the entire ventral abdomen. Areas of exposed granulation tissue rapidly epithelialized from the borders of the flaps.

FIG. 13-4 (A) Nonhealing, traumatic antecubital defect in a German shepherd.

(B) Tubed thoracodorsal axial pattern flap coverage of the defect.

(C) Close-up view of the tubed pedicle. At the time of surgery, a tubed transfer was considered easier to position the flap, compared to a bridge incision.

(D, E) Two months after transfer, the tubed pedicle was divided at both ends to complete the transfer. The dorsal end of the flap was divided first, and the thoracodorsal vessels were ligated. Note the "reverse" bleeding from the cut end of the tube.

(F) Completion of the tube resection.

FIG. 13-5 (A) Thoracodorsal axial pattern flap used to close a massive skin loss over the elbow region, secondary to infection. A small portion of the terminal flap underwent necrosis, necessitating debridement and resuturing. Note early epithelialization of the exposed granulation bed. (B) Healing of the area was complete within 4 weeks after surgery. The flap provided a durable coverage to the elbow region of this greyhound.

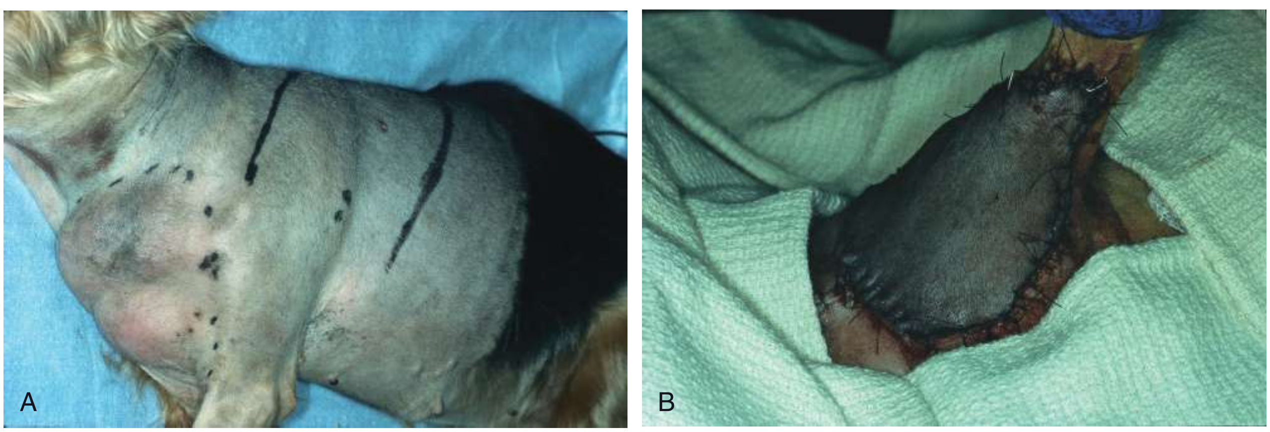

FIG. 13-6 (A) Mast cell tumor involving the left shoulder region. (B) Wide excision was followed by rotation of the adjacent thoracodorsal axial pattern flap. The patient later underwent radiation therapy and chemotherapy.

TABLE 13-1
Summary of guidelines for axial pattern flap development.

Artery	Anatomic Landmarks	Reference Incisions	Potential Uses*
Cervical cutaneous branch of the omocervical artery	Spine of the scapula Cranial edge of the scapula (cranial shoulder depression) Dogs in lateral recumbency, skin in natural position, thoracic limb placed in relaxed extension Vessel originates at location of the pre-scapular lymph node	*Caudal incision*: spine of the scapula in a dorsal direction *Cranial incision*: parallel to the caudal incision equal to the distance between the scapular spine and cranial scapular edge (cranial shoulder depression) *Flap length*: variable; contralateral scapulohumeral joint	Facial defects Ear reconstruction Cervical defect Shoulder defect Axillary defects
Thoracodorsal artery	Spine of the scapula Caudal edge of the scapula (caudal shoulder depression) Dog in lateral recumbency, skin in natural position, thoracic limb in relaxed extension Vessel originates at caudal shoulder depression at a level parallel to the dorsal point of the acromion	*Cranial incision*: spine of the scapula in a dorsal direction *Caudal incision*: parallel to the cranial incision equal to the distance between the scapular spine and caudal scapular edge(caudal shoulder depression) *Flap length*: variable; can survive ventral to contralateral scapulohumeral joint	Thoracic defects Shoulder defects Forelimb defects Axillary defects
Superficial brachial artery	Flexor surface of elbow Humeral shaft Greater tubercle	*Incision Lines:* Flap base includes flexor surface of elbow, anterior one-third Lateral and medial incisions parallel humeral shaft Flap is progressively tapered approaching greater tubercle *Flap Length*: Variable, flap ends at level of greater tubercle	Antebrachial defects Elbow defects
Caudal superficial epigastric artery	Midline of abdomen Mammary teats Base of prepuce	*Medial incision*: abdominal midline In the male dog, the base of the prepuce is included in the midline incision to preserve the adjacent epigastric vasculature *Lateral incision*: parallel to medial incision at an equal distance from the mammary teats *Flap length*: variable: may include the last four glands and adjacent skin	Flank defects Inner thigh defects Stifle area Perineal area Preputial area
Cranial epigastric artery	Hypogastric region Abdominal midline Mammary teats Base of prepuce	*Base of flap*: location in hypogastric region *Medial incision*: abdominal midline *Lateral incision*: parallel to midline incision at an equal distance from mammary teats *Flap length*: glands 2, 3, 4; anterior to prepuce	Closure of wounds overlying sternal region
Deep circumflex iliac artery (dorsal branch)	Cranial edge of wing of ilium Great trochanter Dog in lateral recumbency, skin in natural position, pelvic limb in relaxed extension Vessel originates at a point cranioventral to wing of the ilium	*Caudal incision*: midway between edge of wing of ilium and greater trochanter *Cranial incision*: parallel to caudal incision equal to the distance between the caudal incision and cranial edge of the iliac wing *Flap length*: dorsal to contralateral flank fold	Thoracic defects Lateral abdominal wall defects Flank defects Lateral/medial thigh defects Defects over the greater trochanter
Deep circumflex iliac artery (ventral branch)	Anatomic landmarks of flap base are the same as dorsal branch of deep circumflex iliac artery Shaft of femur	*Caudal incision*: Extends distally, anterior to cranial border of femoral shaft *Cranial incision*: Parallel to caudal incision *Flap length*: proximal to patella	Lateral abdominal wall defects Pelvic defects Sacral defects—as an island arterial flap

TABLE 13-1
Summary of guidelines for axial pattern flap development. *Continued*

Artery	Anatomic Landmarks	Reference Incisions	Potential Uses*
Genicular	Patella Tibial tuberosity Greater trochanter	*Base of the flap:* 1 cm proximal to the patella and 1.5 cm distal to tibial tuberosity (laterally) *Flap borders:* extend caudodorsally parallel to the femoral shaft. Flap terminates at the base of the greater trochanter	Lateral or medial aspect of the lower limb, from the stifle to the tibiotarsal joint
Lateral caudal arteries (left and right)	Proximal third of tail length Transverse processes of vertebrae	*Incision*: dorsal or ventral midline skin incision, depending on intended flap usage; careful dissection along deep caudal fascia of the tail; vessels located lateral and slightly ventral to transverse processes, in proximal tail region; amputation of tail at third to fourth intervertebral space, preserving skin *Flap length*: proximal third of tail length	Perineum, caudodorsal trunk
Caudal auricular	Wing of atlas Spine of the scapula	*Base of flap*: palpable depression between lateral aspect of wing of atlas and vertical ear canal: flap centered over wing of atlas *Width of flap*: central "third" of lateral cervical area over lateral aspect of wing of atlas: in cats, dorsal border close to dorsal midline *Flap length*: up to spine of scapula (survival length variability)	Facial area Dorsum of head Ear
Reverse saphenous conduit flap**	Inner thigh Tibial shaft	*Proximal incision*: central third of inner thigh at level of patella; ligate saphenous artery and vein at level of femoral artery and vein *Cranial and caudal incisions:* skin incisions extended distally in converging fashion, 0.5–1.0 cm cranial and caudal to cranial and caudal saphenous artery and medial saphenous vein; flap undermined beneath saphenous vasculature; ligate and divide peroneal artery and vein *Flap length*: variable, base of flap at level of anastomosis of cranial branches of medial and lateral saphenous veins	Defects of tarsometatarsal regions *Note:* use of flap requires intact collateral blood to lower extremity
Superficial temporal	Caudal edge of zygomatic arch Lateral border of caudal orbital rim	*Base of Flap*: level of zygomatic arch; flap *Width of Flap*: approximates width of zygomatic arch *Incisions*: parallel incisions from landmarks, extending over dorsum of head towards opposing landmark, to the mid-dorsal orbital rim of the opposite eye. Undermine below frontalis muscle layer	Defects over dorsal nasal area, lateral facial area
Lateral thoracic	Axillary skin fold Deep pectoral muscle	*Base of Flap*: axillary skin fold; Ventral border: parallel to dorsal border of deep pectoral muscle Dorsal border: below origin TDA *Flap length*: terminates at/before costal arch; second teat not included	Elbow; axilla, upper extremity

*Major defects only
**Axial pattern flap variation

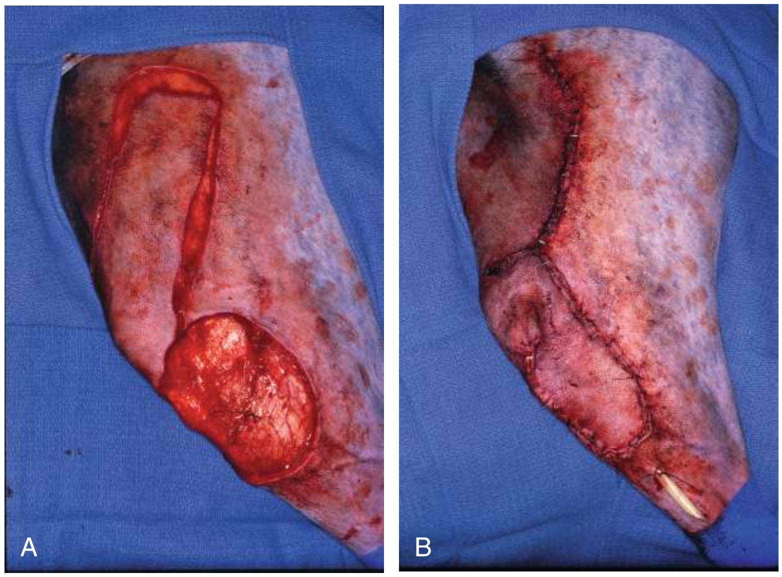

FIG. 13-7 (A) Elevation of a genicular axial pattern flap to close a skin defect secondary to sarcoma removal. (B) The flap was successfully transposed into the defect.

FIG. 13-8 (A, B) Wide mast cell tumor resection over the sternal area and closure with the cranial superficial epigastric axial pattern flap, island arterial flap variation. Today, the author would have used skin stretchers to prestretch the skin of the thorax 72 hours prior to excision to facilitate wound closure. Nonetheless, the cranial epigastric axial pattern flap can be useful for closing the more challenging skin defects in this area.

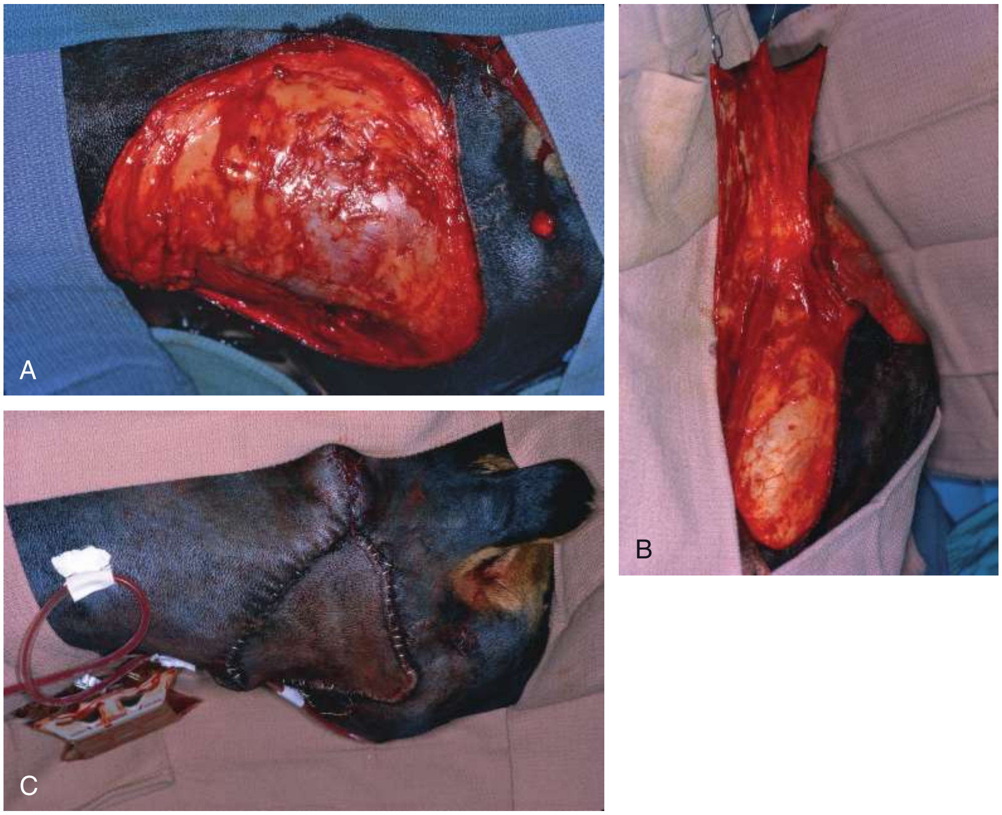

FIG. 13-9 (A) Excision of a chronic granulomatous lesion overlying the left dorsolateral pelvic region.
(B) Elevation of a deep circumflex iliac axial pattern flap, island arterial flap variation, based on the ventral branch of this vessel. Note the base of the flap shares a common border with the defect, thereby creating an island arterial flap.
(C) A small dorsal portion of this skin defect was closed by direct apposition of the adjacent skin margins. The bulk of the defect was successfully closed with this flap.

FIG. 13-10 (A, B) Cat with lower abdominal wall defect: dehiscence secondary to sarcoma resection. The wound contracted and epithelialized minimally after a period of open wound management. (C, D) Closure of the defect with the left flank fold flap. The primary source of circulation to this flap is derived from the ventral branch of the deep circumflex iliac artery and vein. This technique is a variation of the axial pattern flap.

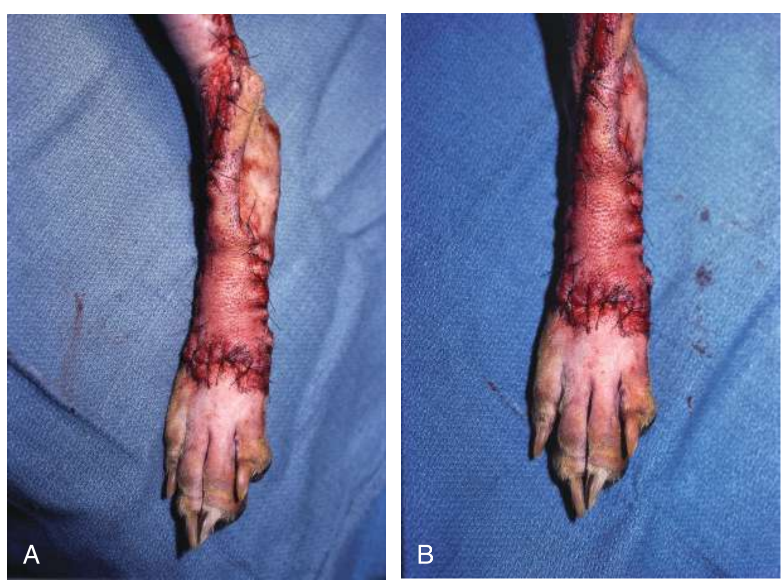

FIG. 13-11 (A, B) Example of the reverse saphenous conduit flap for closure of a metatarsal defect. The other common method of closing large defects in this area is a full-thickness mesh graft using a no. 15 scalpel blade to create the holes.

vein can be transferred as a unit at a later time. Once circulation is established between the dermal circulation and underlying vasculature, the elevated skin island tethered by the long vessels can be rotated into a regional defect or transferred using microvascular surgical techniques. One example of a secondary axial pattern flap includes skin segments developed over an omental pedicle that includes the epiploic vessels. Unfortunately, two-staged development and transfer is slow and comparatively expensive. It cannot be used for immediate closure of wounds, unlike the other flap and free graft techniques discussed in this book.

> Flap guidelines are simply that: guidelines. Use of the longest variations of *any flap* includes the risk of partial necrosis of its terminal end, secondary to ischemia. Traumatic surgical technique, improper flap elevation and transfer, infection, and insufficient postoperative care can contribute to circulatory compromise to the terminal end of the flap. In most axial pattern flaps, this usually amounts to the last few centimeters. Debridement and resuturing may be required for full-thickness skin loss. In some cases, skin loss is partial thickness, with resultant survival of a portion of the dermis: resection is not necessary in these cases. If the terminal end of a longer flap is considered vital to the closure of a problematic area, a delay procedure (see Chapter 12) may should be considered.

Suggested Readings

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