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The Skin

Atlas of Small Animal Wound Management and Reconstructive Surgery, Fourth Edition. Michael M. Pavletic.

Companion website: www.wiley.com/go/pavletic/atlas

SKIN FUNCTION

The integument is the largest organ of the body and serves as the body's first line of defense against microorganisms. It comprises 24% of body weight of the puppy but only 12% of that of an adult dog. The outer horny layer, the stratum corneum, provides protection against desiccation and hydration.

The skin is a sensory receptor for touch, pressure, vibration, pain, heat, and cold. Its multiple functions include vitamin D production; thermoregulation; and storage of water, fat, electrolytes, carbohydrates, and proteins; a barrier against chemicals and radiation; and, along with the subcutaneous fat, insulation. The skin protects the body from external trauma and infection.

SKIN STRUCTURE

The skin is composed of an outer stratified epithelium (epidermis) and an underlying fibrous dermis (corium). The epidermis is derived from ectoderm, whereas the dermis is of mesenchymal origin. Each of these two layers will be discussed separately.

Epidermis

The epidermis originates as a single layer of cuboidal ectodermal cells that becomes stratified as the fetus matures. In hair-bearing areas, the epidermis of hairy skin consists of three major layers: the stratum cylindricum (stratum basale), the stratum spinosum (stratum malpighii or prickle cell layer), and the stratum corneum. The combined stratum cylindricum and stratum spinosum layers form the *stratum germinativum*. Mitotic activity in both layers is responsible for proliferation of epidermal cells.

> **Surgical Relevance**
> In full-thickness skin wounds, the stratum germinativum along the viable skin margin is the source of epithelial cells to cover the exposed vascularized wound bed.

Melanocytes, which originate from the neural crest of the embryo, are located in the stratum cylindricum and the lower layer of the stratum spinosum. In a few hairy areas, the stratum granulosum and stratum lucidum are found where keratinization is retarded, such as around the hair follicle orifices. These two layers are well developed in the footpads, but are absent in the planum nasale. Epidermal pegging, evident in the footpads, planum nasale, and lip of the dog, is not present in the hairy skin. In contrast, the dermal–epidermal junction of hairy skin is thrown into folds that parallel the skin surface. Small tactile elevations termed *epidermal papillae* are found over hairy skin surfaces of the dog and cat. The epidermis is generally thicker in areas that lack a thick hair coat and thinner in regions with a dense hair growth (Figs 1-1 and 1-2). The nose and digital pads have the thickest epidermis.

The Basement Membrane Zone

The basement membrane zone (BMZ) is the dermal–epidermal junction. It is comprised of two zones, the *lamina lucida* and the *lamina densa*. The basement membrane is primarily comprised of fibronectin (an adhesive glycoprotein), laminin, type IV collagen, and heparin sulfate proteoglycan. The BMZ forms a base for connecting the epidermis and dermis.

The Dermis

The dermis (corium) is composed of collagenous, reticular (precollagen), and elastic fibers within a mucopolysaccharide ground substance. This ground substance is composed of hyaluronic acid and chondroitin sulfuric acid; it is the major component of the dermis. Ninety percent of the dermal fibers are composed of collagen. Fibroblasts, macrophages, plasma cells, and mast cells present throughout the dermis are more numerous in the superficial dermal layer. Occasionally chromatophores and fat cells are noted. The dermis contains the cutaneous capillary network, lymphatics, nerve components, arrector pili muscles, hair follicles, and glandular structures.

The dermis of the dog and cat is divided into the superficial stratum papillare and the deep stratum reticulare. The stratum papillare has fine elastic and reticular fibers in densely interwoven collagenous bundles. The basement membrane is formed from reticular fibers and a viscous ground substance, and the stratum cylindricum is attached to the basement membrane via cytoplasmic processes. The stratum reticulare is composed of coarse, densely interwoven collagen bundles.

The most pliable skin (axilla, flank, dorsum of the neck) has small and more loosely woven dermal collagen bundles and greater numbers of elastic fibers in the papillary layer (Fig. 1-3). Less pliable skin (tail, ear, digital pads) have wider, more closely packed collagen bundles with fewer elastic fibers. Collagen fibers in areas of thick skin (head, dorsal body surfaces) are roughly parallel to the cutaneous surface.

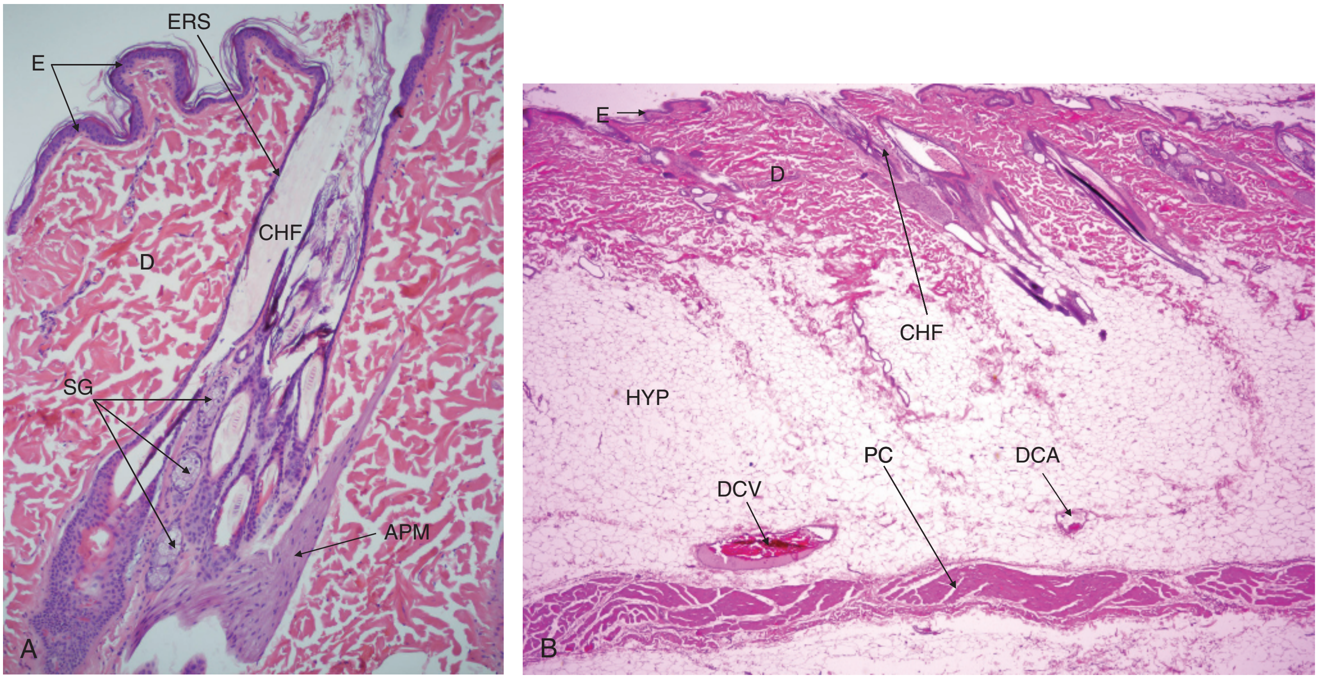

FIG. 1-1 (A, B) Histologic slides of canine skin identifying the following structures: E, epidermis; D, dermis; HYP, hypodermis; CHF, compound hair follicle; ERS, external root sheath; SG, sebaceous glands; DCA, direct cutaneous artery; DCV, direct cutaneous vein; PC, panniculus carnosus muscle; APM, arrector pili muscle. (Slides courtesy of Melanie A. Buote, DVM, DACVP.)

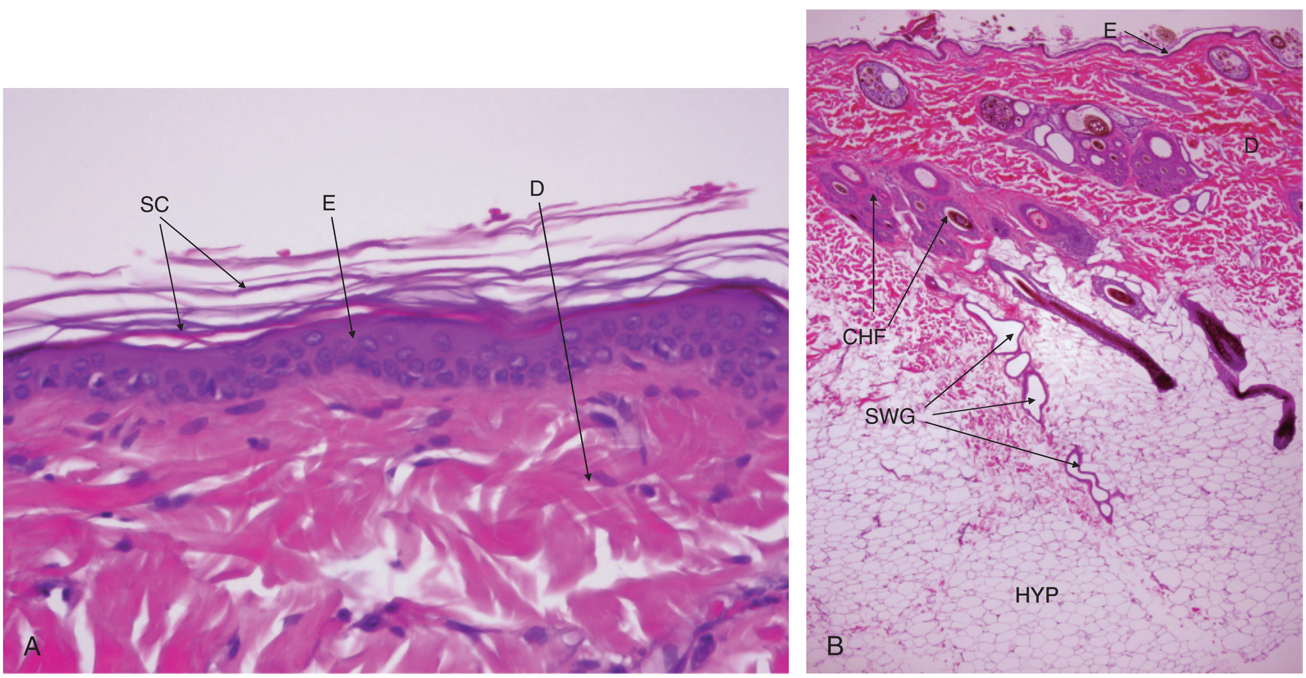

FIG. 1-2 (A, B) Histologic slides of feline skin identifying the following structures: SC, stratum corneum; E, epidermis; D, dermis; HYP, hypodermis; CHF, compound hair follicles; SWG, sweat glands. (Slides courtesy of Melanie A. Buote, DVM, DACVP.)

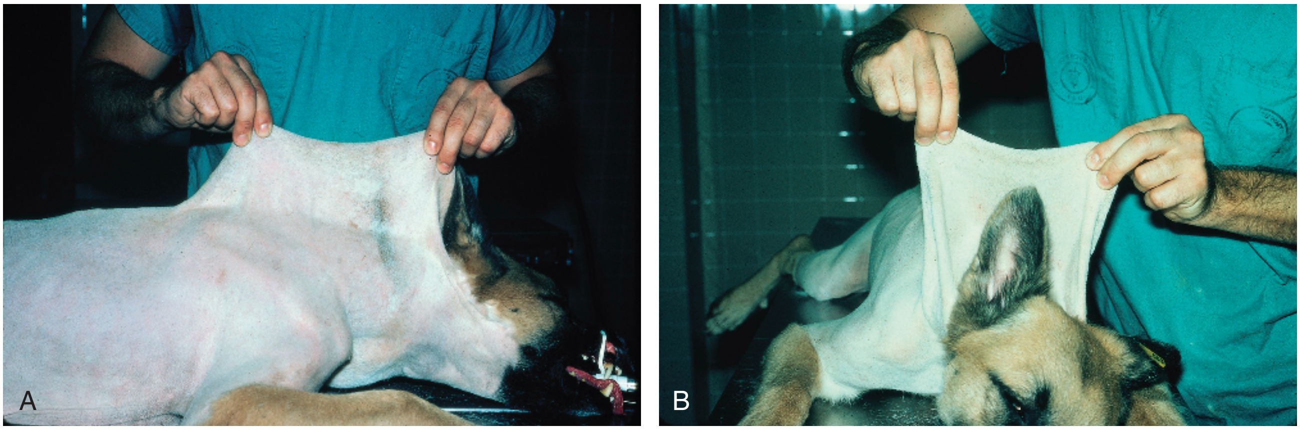

FIG. 1-3 (A) Lateral and (B) anterior view of a German shepherd demonstrating the inherent elasticity of the skin in the cervical region.

Skin of animals essentially is a nonhomogeneous viscoelastic tissue with the combined characteristics of a viscous fluid and elastic solid. The inherent elasticity of the skin describes the natural ability of skin to stretch or deform during normal activities.

Surgical Relevance

Surgeons normally assess the *inherent elasticity* of skin by grasping and lifting the skin or by pushing the skin with the index finger toward the direction of the proposed surgical site. Potential lines of tension are assessed, better allowing the surgeon to decide on how to close the surgical defect. (See Plates 14, 15, and 32.)

The skin's extensibility or ability to stretch is dependent upon three factors occurring consecutively as a load (stretching force), applied to the skin, is progressively increased: (1) convolutions in dermal collagen progressively straighten; (2) dermal collagen fibers align parallel to each other in the direction of the applied load; and (3) fully aligned collagen fibers extend only upon application of great increases in tension. As a result, it is possible to mechanically stretch skin sufficiently to facilitate wound closure by the processes of *mechanical creep* and *stress relaxation* (see Chapter 10).

Surgical Relevance

Skin can be manipulated to stretch beyond the limits of its inherent elasticity by the application of a force that stretches skin progressively over time. This newly recruited skin can be used to close problematic wounds. Examples include presuturing (Plate 34), skin stretchers (Plates 28, 35, 37), and tissue expanders (Plate 38). Details are discussed in Chapters 9 and 10.

Cat skin contains collagen bundles, which are generally coarser and denser than canine skin. The arrector pili muscles also are larger than those in the dog. The stratum papillare of feline skin contains fine, more uniform collagenous fibers, which usually parallel the epidermis. In the stratum reticulare, these fibers are dense, irregularly arranged, and three times larger than those of the papillary layer. In the most flexible cutaneous areas of the cat—the dorsal neck, scapular region, and lateral upper forelimb—the collagen bundles are smaller and more loosely arranged.

The thickness of the skin is directly related to the thickness of the dermal layer and varies according to body area, sex, breed, and species. In thick skin, the dermis usually is thicker than 1 mm, whereas in thin skin, the dermal thickness is less than 1 mm. The thickest skin of the dog and cat is located over the head and the dorsum of the neck, back, and sacrum. The thinnest skin is located along the ventral body surface, the medial surface of the limbs, and the inner pinna.

Surgical Relevance

The durability of fur-bearing skin is primarily the result of the dermal thickness. Skin thickness is taken into consideration when closing wounds in body areas more subject to direct trauma, including skin overlying bony prominences. Dense hair growth also affords some degree of protection.

The Extracellular Matrix

The tissue component outside the cellular walls of organs is referred to as the *extracellular matrix* (ECM): the noncellular components of the dermis are the ECM of the skin. Tissue cells and the ECM are in a state of "dynamic reciprocity." In embryonic development, their interaction plays an essential role in cellular differentiation and function. Cells in turn secrete macromolecules into their immediate environment, forming a matrix between the developing cells. The regional embryonic mesenchymal tissue induces epithelial cell differentiation: epithelial cells, in turn, influence the development and structure of the mesodermal tissues. The ECM includes the fibrillar proteins and glycosaminoglycans (GAGS) that attach to core proteins, forming proteoglycans. The dermal ECM can be described as a network of fibrillar proteins organized within a hydrated gel of proteoglycans. The two principal types of the skin's ECM are the *basement membrane* (or *basal lamina*) in contact with the basal epithelial cells and the underlying *stromal* or *connective tissue*. The stromal tissue provides structural integrity and support to the cellular components of the skin. Collagens are the major proteins of the ECM. However, the ECM comprises a variety of extracellular proteins that may be classified on a functional basis: structural (basal lamina and connective tissue) or adhesive (fibrin and fibronectin); remodeling or counteradhesive (thrombospondin, tenascin, SPARC—*secreted protein acidic and rich in cysteine*); proteolytic (serine proteases, matrix metalloproteases [MMPS]) and antiproteolytic (serpins, plasminogen activator inhibitor-1, tissue inhibitors of metalloproteases [TIMPs]). These proteins have a complex interrelationship during wound healing that will be discussed in Chapter 2.

> The ECM is a complex protein framework on which tissue cells attach to, migrate, and build upon during the processes of wound healing. See Chapter 2.

CUTANEOUS ADNEXA

The cutaneous appendages (adnexa) of hairy skin include the hair follicles, sweat glands, and sebaceous glands. Other cutaneous glandular structures include the mammary glands, supracaudal (tail) glands, anal sacs, superficial circumanal glands, and perianal (deep circumanal) glands. All these structures are ectodermal in origin.

Hair

The hair follicles are the units of hair production. They are located in the lower portions of the dermis but also extend into the subcutaneous tissue (subcutis, hypodermis). The wall of the hair follicle is continuous with the epidermis and is divided into inner and outer root sheaths. During fetal development, hair follicles originate from clusters of germinative cells in the epidermis. These ectodermal cells sink into the dermis and form a cylindrical epidermal peg, the base of which develops into the hair bulb. The hair bulb molds around a mesenchymal papilla. These germinative cells give rise to the inner epithelial root sheath and the hair shaft. The outer epithelial root sheath, which encircles the hair shaft, is a continuation of the stratum cylindricum.

> **Surgical Relevance**
> In partial-thickness skin losses, both the epidermis and variable portions of the dermis have been destroyed. The epithelial cells comprising the external root sheath of the compound hair follicles are the primary source of epithelial cells required for reepithelialization of partial-thickness skin defects (see Fig. 1-4).

Sebaceous glands develop as extensions of the outer root sheath at the upper part of the follicle. In dogs and cats, an apocrine sweat gland develops with each hair follicle and extends into the hypodermis. The duct empties into the common portion of the follicle complex between the skin surface and sebaceous gland orifice.

The arrector pili muscles originate in the dermal papillary layer and insert in the connective tissue of the hair follicle. They are anchored by elastic fibers at their attachments and are innervated by the autonomic nervous system. The arrector muscles are especially well developed along the back of the dog and cat, causing the hair to bristle upon their contraction.

In the newborn animal, hair follicles develop from a simple follicle containing a single hair to a compound follicle containing seven to ten hairs emerging from a common follicle orifice. This occurs at 28 weeks of age as a result of accessory buds arising from the original follicle. Sebaceous glands also become compound, emptying where the hairs are contained as a single tubular follicle. The compound follicle contains a main or guard hair surrounded by a number of finer, woolly lanugo, or underhairs. Although the hair shafts share the same external follicular orifice, they branch into their own respective hair follicles below the level of the sebaceous glands. The guard hair follicle is larger and penetrates into the subcutaneous tissue.

Feline hairs are arranged in clusters of two, three, four, and five, grouped around a central guard hair. Clusters of two and three are more common on the dorsal aspect of the feline body; clusters of four and five usually occur on the ventral body and lower extremities. Each lateral group contains three primary hairs surrounded by 6–12 lanugo hairs. In adult dogs, 3–15 hairs are noted in each compound follicle, whereas in cats, the compound follicles contain 12–20 hairs.

> **Surgical Relevance**
> Siamese cats have a temperature-dependent coat color, owing to an enzyme that converts melanin precursors to melanin at lower temperatures. As a result hair coats can grow back darker after clipping, a fact best explained to the owner prior to the surgical procedure.

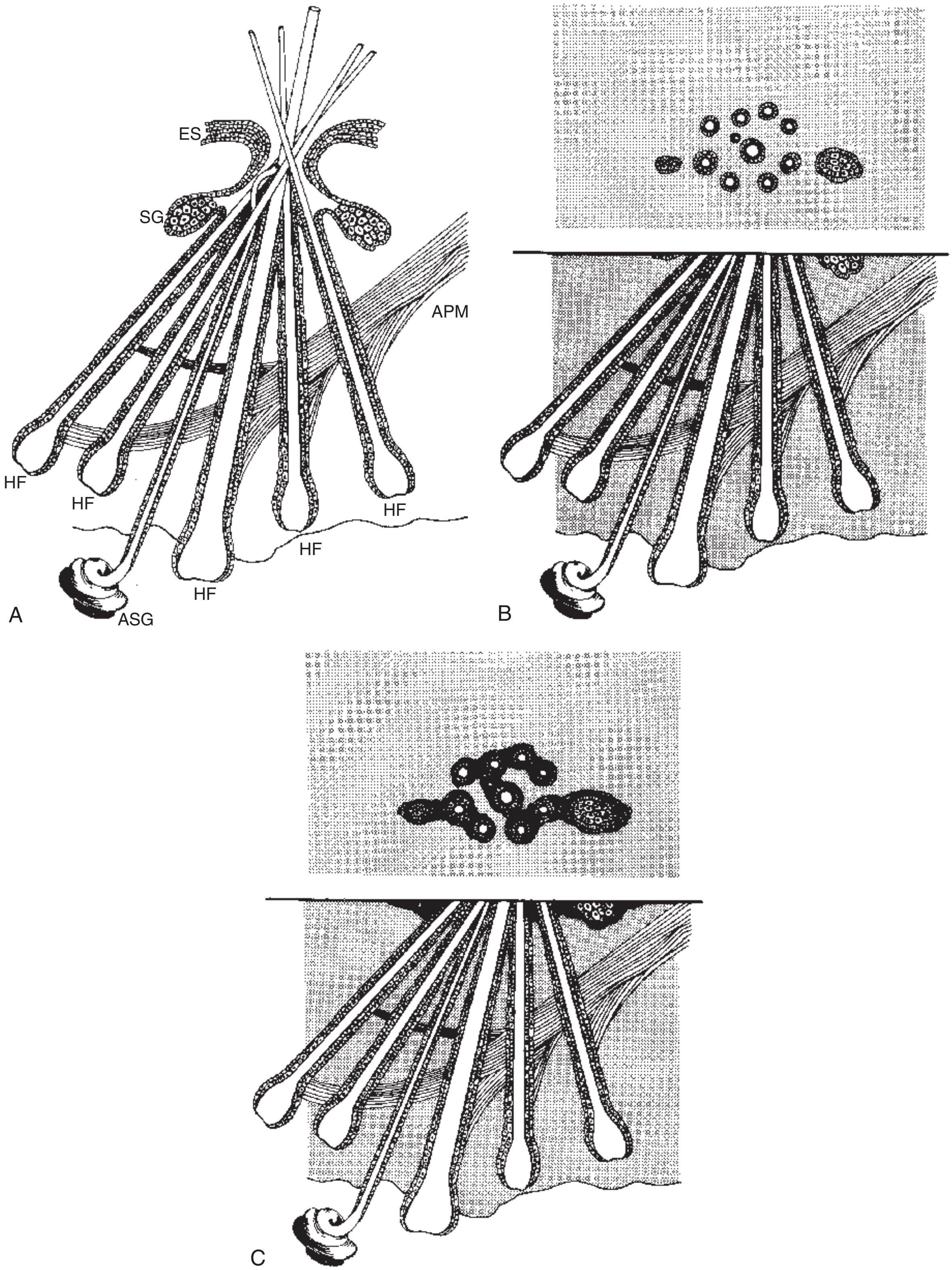

FIG. 1-4 (A) A compound hair follicle (HF) with its associated sebaceous gland (SG), apocrine sweat gland (ASG), and arrector pili muscle (APM). Note the epidermal cellular components of these cutaneous adnexa, which are continuous with the epidermal surface (ES). (Source: Pavletic MM. 1993. The integument. In: Slatter DH, ed. *Textbook of Small Animal Surgery*, 2nd ed. Philadelphia: WB Saunders. Reproduced with the permission of WB Saunders.) (B) Loss of the epidermis and superficial dermal surface. (C) Note epithelial cell migration primarily originating from the external root sheath of each hair follicle.

Vibrissae are larger, more prominent tactile or sinus hairs involving the muzzle and facial area. They allow dogs and cats to locate and assess the proximity of adjacent objects.

Hair growth rates vary seasonally among breeds. Hair growth in male beagles has been noted to be 0.4 mm/day in the winter and 0.34 mm/day in the summer, whereas greyhound hair has a growth rate of 0.18 mm/day in the fall and 0.04 mm/day in the summer. Hair growth is more rapid in the winter. As a rule, short canine hair coats take approximately 130 days to regrow. However, as long as 18 months is required for regrowth of the hair coat in long-haired breeds such as the Afghan. These facts must be taken into account prior to clipping a patient, particularly when dealing with show dogs and cats.

The characteristics of the hair coat in dogs and cats vary with the location on the body. The hair coat is usually thicker over the back and sides of the body, whereas the hair inside the ears and on the flanks, ventral abdomen, and underside of the tail is thinner. Cosmetic wound closure should account for variations in growth patterns and direction of growth of the coat.

> **Surgical Relevance**
> When attempting to close major wounds, hair growth pattern usually plays a secondary role in selecting the method of closure. The surgeon and owner must consider the safest, simplest, and most economical method to effectively restore function to the affected area. It is the author's experience that changes in regional hair growth color and pattern are not a serious concern of pet owners.

Cutaneous Glands

The glandular structures of the skin include the sebaceous glands, sweat glands, supracaudal (tail) glands, anal sacs, circumanal glands, and mammary glands. These ectodermally derived structures form by the downgrowth of epidermal cells into the dermis during embryonic development.

Sebaceous Glands

Sebaceous glands commonly originate from the external root sheath. They produce an oily secretion that exits through the pilosebaceous canal to keep the skin and hair soft and pliable and to protect them from excessive moisture and drying. Sebaceous glands are well developed over the neck, back, and tail of the dog, particularly in the tail gland area.

The sebaceous gland complex in the cat is smaller and simpler in structure than that of the dog. Larger sebaceous glands are found in association with the hair follicles of the upper jaw, prepuce, and dorsal tail surface. Sebaceous glands not associated with hair follicles include the meibomian, or tarsal, glands of the eyelids and glands of the labia, vulva, anus, prepuce, glans penis, and external ear canal. These holocrine glands empty directly onto the epithelial surface.

Circumanal glands (superficial sebaceous glands) and perianal glands (deep sebaceous glands) are modified sebaceous glands located at the mucocutaneous junction of the anus. Perianal glandular tissue also can be found in the skin of the prepuce and groin. Circumanal glands have well-defined ducts and contain fat. Perianal glands have solid ducts and show no secretory activity. Circumanal glands contain fat, unlike the deeper perianal glands. Perianal gland cells are filled with proteinaceous cytoplasmic granules.

Sweat Glands

Sweat (sudoriferous) glands are apocrine and merocrine (eccrine) in nature. Cutaneous apocrine sweat glands are large, simple, saccular or tubular structures with a coiled secretory portion and a straight duct. The glands may be tortuous or serpentine. The apocrine sweat gland duct opens at the external root sheath between the skin surface and pilosebaceous canal. Merocrine glands are coiled, simple, tubular glands found mainly in the footpads of the dog and empty directly onto the epidermal surface. Sweat glands are better developed in dog breeds with long, fine hair.

Sweat glands in the hairy skin of dogs and cats do not participate actively in the central thermoregulatory mechanism but protect the skin from an excessive rise in temperature. This is in contrast to human beings, in whom the cutaneous sweat glands are vital for vaporizational heat loss to cool the body at high temperatures.

Other Glandular Structures

A number of apocrine glands have specialized structures and functions. These include Moll's glands of the eyelids, the ceruminous glands of the external ear canal, the anal sac, and the glands of the prepuce, vulva, and circumanal region.

The mammary glands of the skin are compound tubuloalveolar apocrine glands resembling sweat glands in their mode of development. They undergo conspicuous changes during pregnancy and during and after lactation in the female. They remain rudimentary in the male dog and cat.

Anal sacs have a thin, stratified squamous epithelial lining that includes sebaceous and apocrine sweat glands.

Sebaceous glands tend to line the neck of the sac, whereas the apocrine glands are concentrated in the fundus.

Surgical Relevance

Increased secretory function of the sebaceous and apocrine sweat glands is noted with inflammatory processes involving the skin, especially where a large number of these glandular structures are assembled. During these inflammatory processes, more frequent bandage changes may be expected. Wound care is important to the prevention of tissue maceration and infection secondary to moisture accumulation.

THE HYPODERMIS

The hypodermis (subcutis) or superficial fascia is associated with the overlying dermis. This subcutaneous tissue is composed primarily of fat with loose collagenous trabeculae and elastic fibers. It varies in thickness regionally but is poorly developed beneath the eyelids, ears, and scrotum, and other areas where the skin is closely attached to underlying structures.

The inherent elasticity of the skin; its lack of firm attachments to bone, muscle, and fascia; and the length and extensibility of the direct cutaneous vessels account for the high degree of mobility of skin over the head, neck, and trunk of the dog and cat. In one histological study, two distinct layers of the hypodermis were reported: the stratum adiposum subcutis (containing fat) and a deeper stratum fibrosum subcutis, which includes the panniculus muscle layer. This fatty layer provides insulation to the body, serves as cushion to external impact, and a storage source of energy.

The hypodermis is closely associated with normal skin function. The subdermal plexus is associated with the hypodermis. Direct cutaneous vessels must traverse this layer to supply the overlying skin. In this respect, the panniculus muscles play an important role during the surgical elevation of the skin (see Figs 1-1 and l-2).

Panniculus Muscles

The *panniculus muscle* (panniculus carnosus) is a collection of thin muscles beneath some cutaneous areas in the dog and cat (see Figs 1-1 and 1-2). The panniculus muscles in the head and neck regions are the platysma, sphincter colli superficialis, and sphincter colli profundus. The cutaneous trunci is the major cutaneous muscle of the body, extending from the gluteal region cranial and ventral to the pectoral region. It is not present beneath the skin over the middle and lower portions of the limbs. Fibers from this muscle make up the preputialis muscle in the male dog and the supramammarius muscle in the female dog.

The cat has a similar cutaneous muscle distribution. The cutaneous trunci (cutaneous maximus) of the cat extends over the thoracic and abdominal regions of the body. The platysma in the cat covers the head and neck. In the cervical region, the platysma can be subdivided into the supercervicocutaneous muscle and cervicofacial muscle along a line of attachment to the skin. The associated sphincter colli superficialis muscle is smaller and of irregular occurrence. The feline panniculus muscle is a component of the stratum fibrosum subcutis, the deep connective tissue layer of the hypodermis.

Panniculus muscle fibers are very irregular and tend to run transversely. Fibers penetrate the dermis and allow voluntary movement of the skin. The cutaneous trunci is used to shake the skin in response to irritating or noxious stimuli. Repeated contraction (shivering) of this muscle can increase heat production in cold animals. The platysma muscle moves the vibrissae and gives expression to the face. The preputial muscle in dogs helps to draw the prepuce over the glans penis after erection. The supramammary muscle aids in the support of the mammary glands and perhaps in milk ejection in the bitch.

Surgical Relevance

The direct cutaneous vascular supply and associated subdermal plexus of the skin are closely associated with the panniculus muscle layer, where present. Preservation of this thin muscle layer with the overlying skin helps preserve cutaneous circulation during the surgical manipulation of the skin (e.g., skin flaps, tissue undermining). See Figs 1-5 and 1-6.

CUTANEOUS CIRCULATION

The cardiovascular system is the first major system to function during embryonic development. The hemangioblast is believed to be the precursor to blood vessels and blood cells during embryonic development. Blood vessels are constructed by two processes: *vasculogenesis* and *angiogenesis*. In vasculogenesis, blood vessels are created *de novo* from the lateral plate mesoderm. Hemangioblasts formed from these splanchnic mesodermal cells condense into "blood islands." The inner cells of these blood islands become hematopoietic stem cells, the precursors of blood cells. The outer cells become angioblasts, the precursors of blood vessels. Angioblasts differentiate into endothelial cells. Endothelial tubes form and interconnect to form the *primary capillary plexus*. Angiogenesis is the process in which this primary capillary network is remodeled and pruned into distinct arteries, veins, and capillary beds. The developing vascular network is essential to supplying the tissues with the necessary oxygen and nutrients essential to fetal development. *Cytokines*, or growth factors, play a central role in the initiation of vasculogenesis.

The cutaneous vascular system is divided into three interconnected levels:

1. The deep, subdermal, or subcutaneous plexus
2. The middle or cutaneous plexus
3. The superficial or subpapillary plexus

This general vascular arrangement is present in the hairy skin. Variations in the arrangement are noted in the canine external ear, footpad, nipple, and the mucocutaneous junctions of the nostril, lip, eyelid, prepuce, vulva, and anus.

The Subdermal Plexus

The subdermal plexus is the major vascular network to the overlying skin. The vessels of this plexus generally run in the subcutaneous fatty and areolar tissue on the deep face of the dermis of the middle to distal portions of the limbs where no panniculus muscle is present. Where there is a layer of cutaneous muscle, the subdermal plexus lies both superficial and deep to it (Fig. 1-5). An experimental study (Pavletic) on the misapplication of subcutaneous pedicle flaps in the dog demonstrated the vital relationship between the panniculus muscle and the overlying skin. Complete severance of the panniculus muscle results in necrosis of the island flap, whereas preservation of the muscular layer assures its survival by preserving the subdermal plexus. The skin should always be undermined in the fascial plane beneath the cutaneous musculature to preserve the integrity of the subdermal plexus. In areas devoid of this muscle layer, one should undermine in the fascial plane well below the dermal surface to preserve it (Fig. 1-6).

Cutaneous (Middle) and Superficial Plexuses

The subdermal plexus supplies the hair bulb and follicle, tubular glands, and deeper portions of the ducts as well as the arrector pili muscle. Branches of the subdermal plexus ascend into the dermis to form the middle, or cutaneous, plexus located at the sebaceous glands. Branches from the

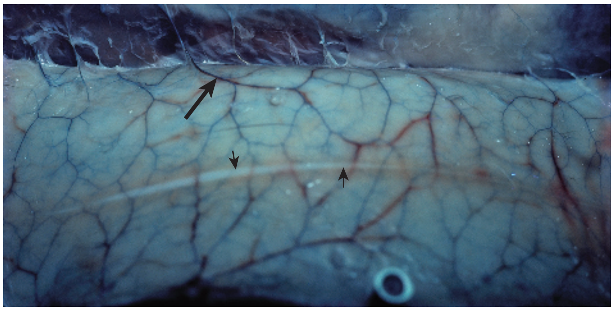

FIG. 1-5 Skin reflected from the back of a cat cadaver. Blue latex has been injected into the arterial system to highlight the direct cutaneous arteries. The thin cutaneous trunci (panniculus) muscles on each side of the cat join over the dorsal midline (small arrows). A direct cutaneous artery can be seen approaching the panniculus muscle and overlying skin in parallel fashion (large arrow). As it arborizes, terminal branches "form" and supply the subdermal plexus. Note the "mirror" image formed by the direct cutaneous vasculature on each side of the midline. (Source: Pavletic MM. 2003. The integument. In: Slatter DH, ed. *Textbook of Small Animal Surgery*, 3rd ed., 250–9. Philadelphia: WB Saunders. Reproduced with the permission of WB Saunders.)

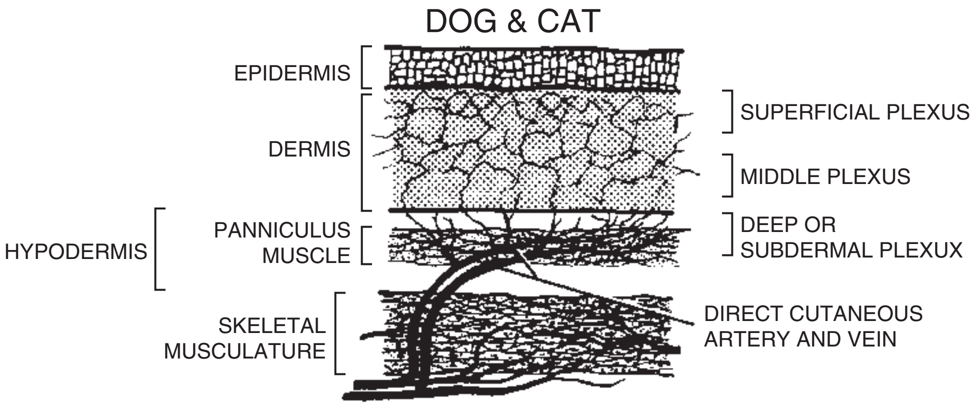

FIG. 1-6 Cutaneous circulation in the dog and cat. The subdermal plexus is supplied by terminal branches of direct cutaneous vessels at the level of the panniculus muscle in the dog and cat. Note the parallel relationship between the direct cutaneous vessels and the overlying skin. This is unlike the perpendicular orientation of musculocutaneous vessels in the human. (Source: Pavletic MM. 2003. The integument. In Slatter DH, ed. *Textbook of Small Animal Surgery*, 3rd ed., 250–9. Philadelphia: WB Saunders. Reproduced with the permission of WB Saunders.)

cutaneous plexus ascend and descend into the dermis to supply the sebaceous glands and reinforce the capillary networks around the hair follicles, tubular gland ducts, and arrector pili muscle. The middle plexus shows developmental and positional variations according to the distribution of the hair follicles in the skin. Radicals from the middle plexus ascend to supply the superficial plexus. The superficial plexus lies in the outer layer of the dermis. Capillary loops from this plexus project into the dermal papillary bodies to supply the epidermal papillae and adjacent epidermis. However, the capillary loop system and papillary bodies are poorly developed in the dog and cat, unlike the human, anthropoid ape, and pig, all of which have well-developed capillary loops. This anatomical difference explains why canine skin generally does not normally blister with superficial burns.

Surgical Relevance

Split-thickness skin grafts are normally harvested with the use of a dermatome. The depth of the dermal incision will expose different levels of the dermal vascular network. For example, thinner grafts expose the finer, numerous vascular channels of the superficial plexus. Exposure of the graft's vascular channels increases the probability of successful revascularization. For this reason, thin split-thickness skin grafts reportedly have a higher probability of revascularization when compared to thicker skin grafts. The bleeding pattern on the cut dermal surface will reflect the depth of the graft harvested.

Cutaneous Arteries

Segmental vessels arising from the aorta, well beneath the body muscle mass, give off perforator branches that traverse the skeletal muscle to supply the subdermal plexus. Two types of arteries supply the cutaneous circulation in the human: musculocutaneous arteries and direct cutaneous arteries. Musculocutaneous arteries are the primary vascular supply to the skin of humans, apes, and swine. Perforator arteries send several branches to the overlying muscle mass before terminating as musculocutaneous arteries perpendicular to the skin. Direct cutaneous arteries arise from perforator arteries that send few branches to the overlying muscle mass before ascending to the subdermal plexus. Direct cutaneous arteries run parallel to the skin and supply a greater area of the skin compared with a single musculocutaneous artery, but play a secondary role in the total cutaneous circulatory pattern in the human (Figs 1-5 and 1-6).

Hughes and Dransfield divided arteries supplying the canine skin into two groups: mixed cutaneous arteries and simple cutaneous arteries. Mixed cutaneous arteries run through a muscle mass and supply a significant number of branches to it before emerging and supplying the skin. Simple cutaneous arteries give few branches to muscles, between which they run, before supplying the skin. Despite the descriptive similarities to the perforator-musculocutaneous and perforator-direct cutaneous systems of humans, all vessels in the skin of dogs and cats approach and travel parallel to the skin and are direct cutaneous arteries (Fig. 1-7). Two of the most visible direct cutaneous artieries include the caudal and cranial superficial epigastric arteries covered by the thin ventral abdominal skin (Figs 1-8 and 1-9). Standard anatomy texts illustrate the superficial arteries of the canine trunk (Fig. 1-10).

Clinical Relevance

By far, the single most important consideration in reconstructive surgery is preservation of the circulation. Because of differences in skin circulation, care must be taken when attempting to adapt human reconstructive surgical techniques to the dog and cat.

PINNA: CUTANEOUS CONSIDERATIONS

Chapter 23 discusses the anatomy of the pinna as well as reconstructive surgery of this unique anatomic structure. The terminal third of the pinna is comprised of skin affixed firmly to the underlying perichondrium. The inner or medial surface of the pinna is covered with skin that is sparsely covered with hair, whereas the lateral surface of the pinna is primarily covered by looser fur-bearing skin that is not attached to the perichondrium. This is a potential donor source for pinnal reconstructive surgery, along with the skin surrounding the base of the ear.

CONGENITAL SKIN DISORDERS

Cutaneous Asthenia

Cutaneous asthenia is a congenital hereditary collagen defect in humans and animals that is highlighted by fragile, hyperextensible skin. The condition is analogous to *Ehlers-Danlos Syndrome* (EDS), an eponym for eight variations (EDS I–VIII) of this disorder in humans. Other names include *dermatosparaxis* and *collagenous tissue dysplasia* in sheep, cats, sheep, and cattle, a condition similar to EDS I in humans. The disease is generally considered autosomal dominant with incomplete penetrance in dogs, cats, and mink. Dermatosparaxis in some cats, cattle, and sheep may be a recessive trait. (In humans, EDS I, II, III, and VIII are considered autosomal dominant; EDS V, X-linked recessive; EDS VI and VII, autosomal recessive.)

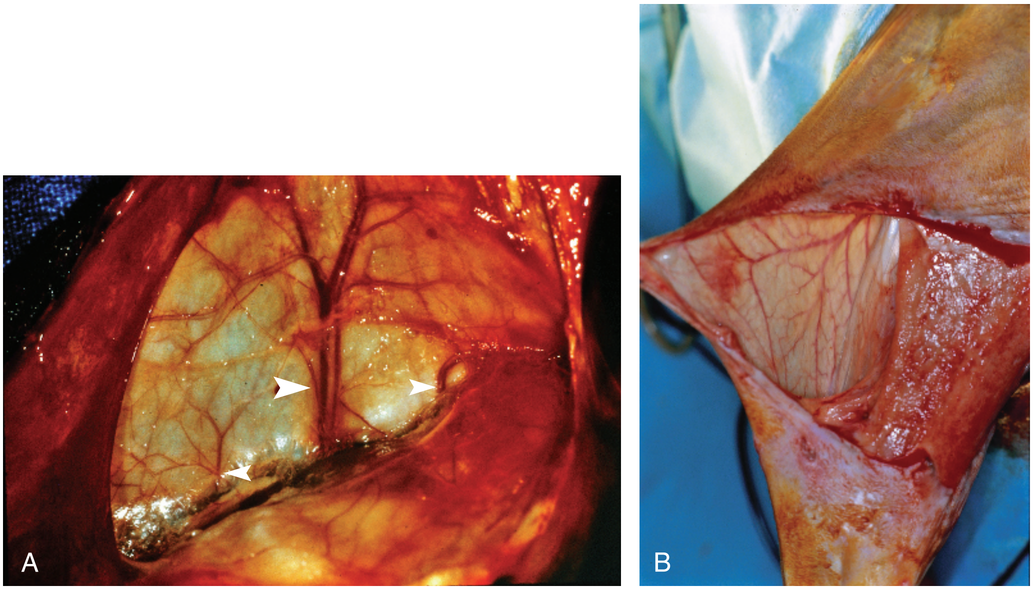

FIG. 1-7 (A) Elevation of a skin flap illustrating a large direct cutaneous artery and vein (large arrow). Small direct cutaneous vessels (small arrows) also are noted. (B) Intraoperative view of the ventral branch of the deep circumflex iliac artery and vein in a cat. The skin is being elevated to close a skin defect involving the left mid-thigh region.

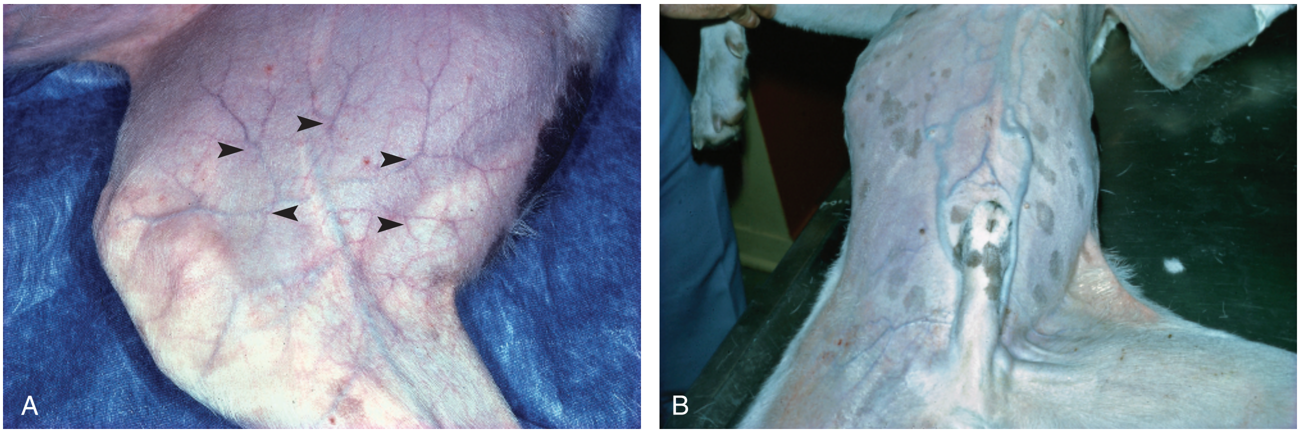

FIG. 1-8 (A) Inner thigh of a greyhound illustrating several direct cutaneous vessels traveling parallel to the overlying skin surface. (B) Ventral abdomen in a thin-skinned retriever, demonstrating prominent caudal and cranial superficial epigastric vessels.

Canine breeds affected with cutaneous asthenia include springer spaniels, beagles, Manchester terriers, Welsh corgis, German shepherds, dachshunds, boxers, St. Bernards, and mixed breeds. It has been reported in Persian, Himalayan, and domestic short-haired cats (Figs 1-11 and 1-12).

Documented biochemical disorders in humans have included type III collagen synthesis (EDS IV), lysyl oxidase deficiency (EDS V), lysyl hydroxylase deficiency (EDS VI), a type I collagen defect (EDS I, II, III), and a procollagen peptidase deficiency (EDSVII).

In humans, EDS can result in joint hypermobility, congenital vascular fragility, bowel ruptures, ocular lesions, and hernias. Hernia repairs in human patients normally require the use of reinforcement mesh. However, increased skin fragility with hyperelasticity and laxity is the primary clinical feature of EDS in humans. Extracutaneous collagen fragility has been noted in the mesentery, intestinal wall, aorta, and muscle attachments in dogs.

Hyperlaxity may increase with age in dogs: the skin may appear excessive, hanging in folds, especially around the limbs. Affected animals usually have a history of lacerations and abscesses. The skin tears easily with comparatively minor trauma. Scars appear tissue-paper thin (onion-skin scars). "Pseudotumor" formation secondary to vascular fragility may be noted.

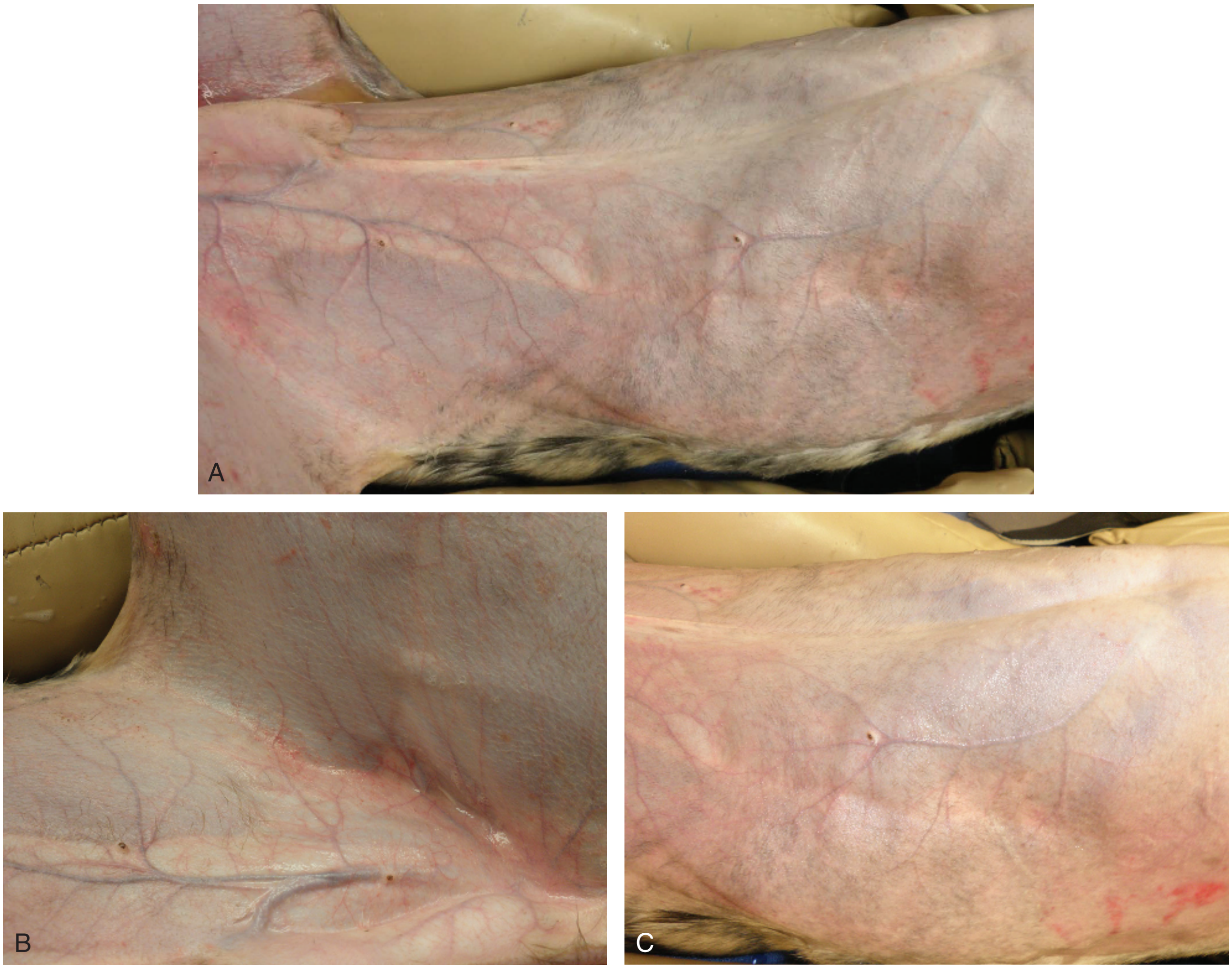

FIG. 1-9 (A) Note the caudal and cranial superficial epigastric vessels in this greyhound. (B) Close-up view of the caudal superficial epigastric artery and vein: note the small branches supplying the adjacent skin. (C) Close-up view of the left cranial superficial epigastric artery and vein.

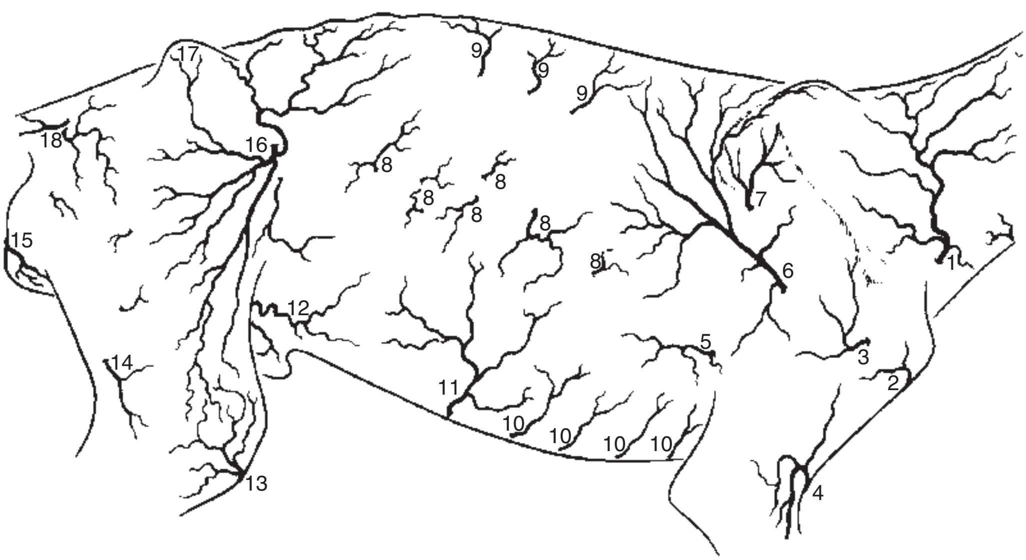

FIG. 1-10 Superficial arteries of the canine trunk. 1, Superficial cervical branch of omocervical; 2, cranial circumflex humeral; 3, caudal circumflex humeral; 4, proximal collateral radial; 5, lateral thoracic; 6, cutaneous branch of thoracodorsal; 7, cutaneous branch of subscapular; 8, distal lateral cutaneous branches of intercostals; 9, proximal lateral cutaneous branches of intercostals; 10, ventral cutaneous branches of internal thoracic; 11, cranial superficial epigastric; 12, caudal superficial epigastric; 13, medial genicular; 14, cutaneous branch of caudal femoral; 15, perineal; 16, deep circumflex iliac; 17, tubera coxae; 18, cutaneous branches of superficial lateral coccygeal. (Source: Evans HE. 1993. *Miller's Anatomy of the Dog*, 3rd ed. Philadelphia: WB Saunders. Reproduced with the permission of WB Saunders.).

FIG. 1-11 (A) King Charles Cavalier with Ehlers-Danlos syndrome. (B) Note the hyperextensible facial skin. (C) Hyperextensible skin of the trunk. (Slides courtesy of Dr. Klaus Loft.)

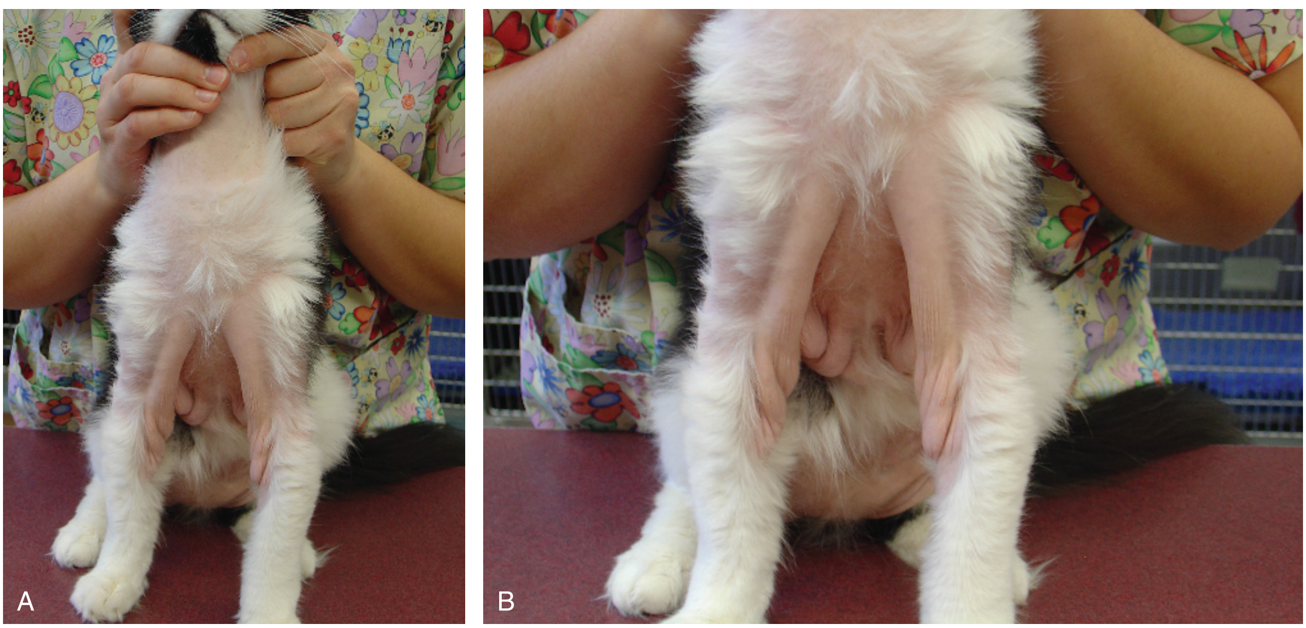

FIG. 1-12 (A) Elhlers-Danlos syndrome in a feline patient. (B) Close-up view demonstrating the thin elastic skin of the forelimbs and trunk. (Slides courtesy of Dr. Klaus Loft.)

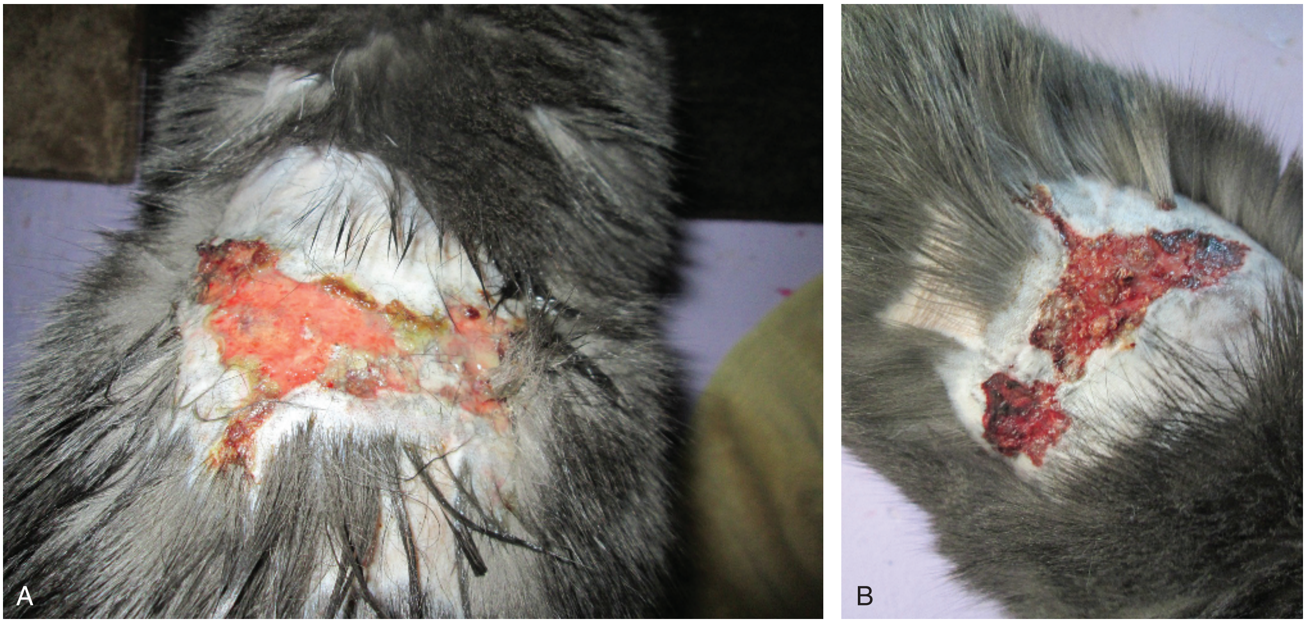

FIG. 1-13 (A) Skin tear of the dorsal trunk area in a cat. (B) Note the dorsal skin overlying the thoracic area of this feline patient. Second-intention healing is one option for promoting closure in both patients. However, debridement followed by careful undermining and closure is another option, as noted in the text.

Histologically, the dermis and epidermis may have variable thickness. The most notable alteration is the size, shape, and orientation of the collagen bundles. Many collagen fibers appear smaller in diameter than normal, and larger collagen fibers may be fragmented. Collagen bundles may be dissociated and haphazardly arranged and lack the characteristic interwoven appearance seen in normal skin. Abnormalities in dermal collagen packing into fibrils and fibers have been noted in mixed-breed dogs. A decrease in acid glycosaminoglyan also has been reported without histological evidence of collagen fiber disorders. The collagen may also lack normal staining uniformity. A skin extensibility index greater than 17% correlates consistently with collagen packing defects.

The prevention and management of skin injuries is of primary concern in dogs and cats. Care is required to prevent trauma to the skin from clippers. Use of atraumatic or reverse-cutting needles are used to help prevent suture pull-out. Combining an intradermal pattern with a vertical mattress suture pattern may be advisable to reduce the risk of dehiscence. In cats, declawing the patient can reduce self-inflicted trauma from scratching. An Elizabethan collar also should be considered to prevent licking and chewing at any surgical area. Interestingly, wounds can heal readily by second intention, and the stages of healing appear similar to those in unaffected skin. Tensile strength of healed wounds appears comparable to that of the surrounding skin (Fig. 1-13).

Epitheliogenesis Imperfecta

Epitheliogenesis imperfecta is a heritable condition highlighted by areas of skin and mucosa lacking an epidermis. It has been reported in cats, lambs, and horses. Skin ulcerations are susceptible to infection. If the condition is limited to a few areas, wound-closure techniques may be considered. Breeding of affected animals is inadvisable.

Suggested Reading

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