20 Decubitus Ulcers in Animals

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Decubitus ulcers are a major health care problem in the United States. They are also a problem for veterinarians in both small pet animals (dogs) [1–6] and large animals (horses). As with humans, prevention is a major part of dealing with decubitus ulcers; however, once they develop, treatment becomes necessary just as with humans.

Naturally Occurring Decubitus Ulcers in Small Animals

Certain breeds of dogs are predisposed to decubitus ulcers because of a neurologic condition associated with the breed. The dachshund and Pekingese, for example, have chondrodystrophic degeneration of the intervertebral discs [7]. Intervertebral disc herniation in these breeds can result in paraplegia and occasionally tetraplegia. During neurologic recovery, these dogs are subject to decubitus ulcer formation. Another breed-associated neurologic condition that can result in decubitus ulcers secondary to temporary tetraplegia that may follow surgical intervention is the cervical vertebral instability/malformation syndrome seen in Doberman pinschers, Great Danes, and other large or giant breed dogs. These are two common examples of breed-associated neurologic conditions that can result in decubitus ulcers. As with humans, any neurologic condition that results in paraplegia or tetraplegia can predispose to decubitus ulcers.

Decubitus ulcers may also result from damage to peripheral nerves. Trauma to a forelimb with damage to the ulnar nerve that causes motor nerve deficit in the forelimb flexor muscles is an example. The abnormal weight distribution on the paw resulting from this deficit may lead to an ulcer at the proximolateral aspect of the metacarpal paw pad [8, 9].

Decubitus ulcers are also associated with orthopedic abnormalities in dogs [4–6]. Of course, the orthopedic–neurologic pathology caused by spinal trauma may have decubitus ulceration as a secondary factor to the paraplegia or tetraplegia associated with the condition. Animals immobilized from multiple long bone and/or pelvic fractures are also subject to decubitus ulcers. Related to orthopedic conditions causing dermal decubitus ulcers are the decubitus ulcers that develop over bony prominences as the result of an improperly applied or padded coaptation cast or splint [1, 5, 10, 11]. These lesions usually result from light pressure over a prolonged period [1]. Again, comparatively,

orthopedic conditions common to humans and small pet animals can predispose to dermal pressure lesions.

As in humans, debilitated animals and those convalescing from severe injuries or illnesses that are unable or unwilling to change body positions are subject to decubitus ulcer development. Predisposing factors to decubitus ulcers include: (a) lessening of padding between skin and bone that results from disease, atrophy, or loss of adipose tissue; (b) loss of tissue elasticity; (c) malnutrition (hypoproteinemia, anemia, vitamin deficiencies); (d) skin maceration; (e) soft tissue contusion; (f) skin chafing; (g) skin friction and stretching; (h) skin irritation from urine and feces; (i) skin burns and scalds; and (j) improper nursing care [3–6].

Greyhound dogs have a very angular conformation, short hair, and thin skin. Thus, they are quite subject to development of decubitus ulcers especially when they become debilitated [4, 12, 13].

Another condition that can result in a dermal decubitus ulcer is elbow hygroma. The hygroma is a fluid-filled cavity surrounded by a dense wall of fibrous tissue (Fig. 1). Hygromas are seen in young large or giant breeds of dogs (e.g., German shepherds, Great Danes, bull mastiffs, and Irish wolfhounds) secondary to repeated pressure or trauma over the olecranon [14, 15]. The condition is often seen in large or giant breeds of dog that tend to lie in sternal recumbency on unpadded surfaces, thus placing pressure on skin over

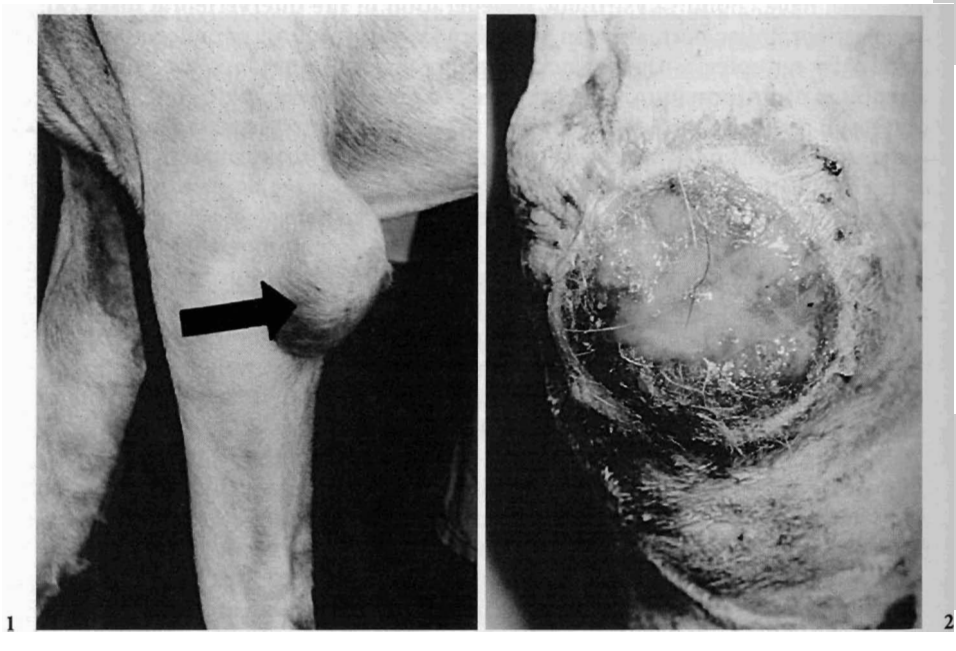

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Fig. 1. Elbow hygroma *(arrow)* over the olecranon of a bull mastiff dog

Fig. 2. Chronic elbow ulcer following wound dehiscence after surgical excision of an elbow hygroma on a Irish wolfhound (From [14] with permission)

the olecranons. Large dogs in hot weather may be more prone to elbow pressure lesions as they seek to lie in the shade on hard cool surfaces, i.e., concrete patios. After surgical excision of an elbow hygroma, wound dehiscence may result in a chronic nonhealing ulcer as the animal continues to lie in sternal recumbency and place pressure over the surgical site [14] (Fig. 2). Hygromas may become infected and form abscesses that rupture, with the result being a chronic open wound or ulcer over the olecranon.

Hip dysplasia may also predispose to elbow hygroma and elbow lesions in large dogs. The pain associated with the condition may render the dog less able to protect the elbow from traumatization when attempting to lie down [5]. In other words, as the dog attempts to lie down in sternal recumbency, the pain in the coxo-femoral joint becomes so great that the dog drops on the olecranons rather than easing onto them. This traumatizes the skin and may be the beginning of elbow hygroma and possible ulceration problems.

Location and Pathogenesis of Dermal Pressure Lesions

As in humans, decubitus ulcers in dogs develop over bony prominences [5] (Fig. 3). Most of the decubitus ulcer sites are on the lateral aspect of the dog because recumbent dogs usually are in lateral recumbency. Owing to their greater weight, decubitus ulcers are more of a problem in large dogs, especially over the greater trochanter (Fig. 4), whereas smaller paraplegic dogs that tend to sit up on their perineal region for long periods tend to develop decubitus ulcers over the ischial tuberosities [3] (Fig. 5).

In dogs, as in humans, the primary pathologic change of decubitus ulcers is tissue ischemia with its resultant necrosis as soft tissues are compressed between a bony prominence and the surface on which the animal is resting. With improperly applied casts or bandages, the cast or splint material causes the compression.

Pressure on the soft tissues associated with a developing decubitus ulcer causes focal intravascular changes which result in vascular occlusion and tissue

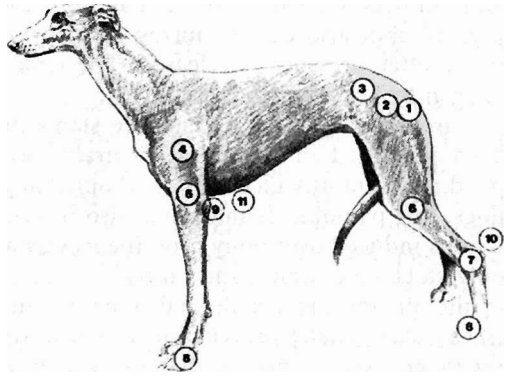

Fig. 3. Areas over bony prominences that are prone to decubitus ulcers. *1*, Ischiatic tuberosity; *2*, greater trochanter; *3*, tuber coxae; *4*, acromion of scapula; *5*, lateral epicondyle of humerus; *6*, lateral condyle of tibia; *7*, lateral malleolus; *8*, sides of fifth digit; *9*, olecranon; *10*, calcaneal tuber; *11*, sternum. (From [5] with permission)

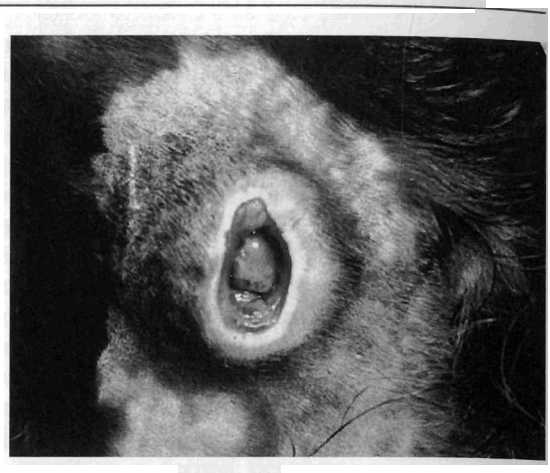

Fig. 4. Decubitus ulcer over the greater trochanter of an Irish setter. (From [45] with permission)

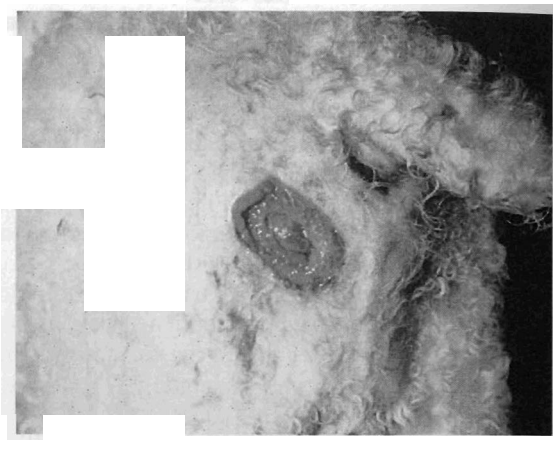

Fig. 5. Decubitus ulcer over the ischial tuberosity of a toy poodle. (From [45] with permission)

ischemia. The degree and severity of ulceration varies with the extent of vascular occlusion [16]. Biochemical changes take place within the ischemic skin and contribute to necrosis. It has been theorized that damage to the compressed skin also occurs during reperfusion with reoxygenation of ischemic tissue after pressure is released. The endothelium of vessels is damaged by oxygen free radicals that form [17].

Thromboxane B_2, a measurable stable metabolite of thromboxane A_2, has been identified in tissues of naturally occurring decubitus ulcers and impending decubitus ulcers in greyhound dogs [12]. In addition, in greyhound dogs, this pathobiochemical has also been identified in early dermal pressure lesions induced over bony prominences by application of coaptation casts with only stockinette lining and no padding [13, 18]. Thromboxane A_2 contributes to the already present dermal ischemia and causes vasoconstriction and intravascular platelet aggregation which leads to vascular thrombosis and thus restricted vascular flow to the tissues as progressive dermal ischemia develops

[18]. Research indicates this as a factor in pathogenesis since the systemic administration of a thromboxane antagonist (a thromboxane synthetase inhibitor) in a greyhound dog model for dermal pressure lesions resulted in lower thromboxane tissue levels, fewer physical dermal abnormalities, and fewer severe histopathologic changes in the pressure-exposed skin of treated dogs than of untreated dogs [18, 19].

Preventive Measures

As with humans, the goal in animals is prevention of decubitus ulcers, and numerous measures are available for this. Some methods are the same as in humans, but others are modifications of techniques used with people. Still other techniques are unique to veterinary medicine due to the nature of the patient.

Padding. Padded bedding is a primary means of preventing decubitus ulcers. Blankets, coated or closed-cell foam pads, air mattresses, water mattresses, sheepskin pads, or artificial fleece pads have been described for providing a padded surface [1–7]. Sheepskin pads and foam rubber mattresses help provide some air circulation under the animal and help wick moisture (i.e., urine) away from the skin. Placing these on grates or racks also helps separate the animal from urine and feces [1, 3, 7]. Foam rubber with a convoluted, "egg-crate" design has been found to provide a good bedding surface. In evaluation of dogs with severe paraparesis or paraplegia resulting from thoracolumbar spinal trauma, it was found that the Schiff-Sherrington posture was followed by pelvic limb spasticity. This neurologic status resulted in some dogs maintaining a posture distributing weight on the ischial tuberosities, thus predisposing the area to decubitus ulcer development. Vinyl-covered convoluted foam rubber pads (Comfy Dog Bed; J. & M. Stuart Co., Inc., St. Louis, Missouri) were quite effective in helping prevent decubitus ulcers in this area [20]. An artificial fleece (Unreal Lamb Skin, Alpha Protech, North Salt Lake, Utah) over these vinyl-covered foam rubber pads has also been found effective in helping prevent decubitus ulcers in dogs. The fleece provides an additional dry soft surface to the bedding. A factor that veterinarians have to deal with that their counterparts in human medicine do not encounter is the tendency of some dogs to bite, chew, or scratch mattresses and foam pads.

Proper padding of coaptation casts is important in preventing pressure lesions over bony prominences. Evaluation of the dermal effects of different configurations of cast padding in coaptation casts on dogs indicated that absence of cast padding can result in dermal pressure injury over sharp prominences. In some areas, localized cast padding may settle around larger prominences and increase pressure to potentiate dermal pressure injury. Although pressure over bony prominences may be elevated immediately after applying full-length cast padding and a coaptation cast, some compacting of the padding occurs and this provides the best form of cast padding to prevent dermal pressure injury [11].

Inspection. The veterinarian and veterinary technician have a challenge that their counterparts in human medicine do not have in that their patients are hirsute. Thus, the hair coat will conceal skin that is undergoing the early changes associated with an impending decubitus ulcer. It is important for animal care personnel to part the hair over bony prominences and observe the underlying skin, looking for hyperemia, moisture, and easily epilated hair [1, 3–6].

If an animal tends to lick or chew at a bandage or cast, it may just be the nature of that animal to do so. However, the animal may be indicating an underlying dermal pressure lesion because of an ill-fitting cast or bandage. It is wise to remove the cast or bandage and check for pressure lesions. Likewise, if a cast or bandage has an offensive odor or an internally derived stain over a bony prominence, it should be removed and the tissues checked for pressure wounds.

Positioning. As with humans, changing the body position of an animal unable to or unwilling to change its own position should be done frequently to help prevent decubitus ulcers [1–6]. Ideally, position should be changed every 2 h [1, 3]; however, a range of 1–5 h has been described [6]. Positions should alternate between left lateral, sternal (prone), and right lateral [1, 3]. When a dog is placed in sternal recumbency, positioning the pelvic limbs caudally in extension helps prevent joint contraction problems [1]. Some dogs that are able to change their position will prefer and will get into their preferred position (sometimes with difficulty). This is when decubitus ulcers begin to develop. In dogs that do not cooperate with periodic attempts to change their position, barriers (cardboard boxes, pads, etc.) are used to restrict their movement [3].

Occasionally slings are used to support tetraplegic and tetraparetic dogs in a standing position for 2–4 h daily [7]. The dog's limbs are placed through holes in the sling material which is suspended from a frame (Fig. 6). This is probably the most effective way of keeping pressure off the skin overlying the tuber coxae, trochanter major, and acromion of the scapula on large dogs. For paraplegic or paraparetic dogs, wheeled carts that support the pelvic area are often used as part of the rehabilitation of the dog. These carts provide mobility for the dog and help keep pressure off bony prominences on the hindquarters.

Skin Hygiene. Keeping the skin clean and dry and free of urine and feces is an important factor in preventing decubitus ulcers in dogs [1–6]. Clipping the hair of the perineal area, especially on dogs with long hair, facilitates cleaning in the presence of fecal incontinence [3]. A closed collection system can help prevent urine scalding and skin maceration in patients with urinary incontinence. However, this requires proper maintenance [3]. Whirlpool or warm-water baths two to three times daily help keep the skin clean and promote circulation [6].

Nutrition. Animals, like humans, require proper nutrition as part of the preventive routine for decubitus ulcers [3–6]. A high-protein, high-carbohydrate diet with vitamin supplements has been advocated [4, 6].

Fig. 6. A sling being used to help prevent decubitus ulcers in a large dog. (courtesy Dr. D.C. Sorjonen)

Innovative Bandaging. Because of the nature of the patient being dealt with and the fact that they cannot be reasoned with, it is often necessary to apply innovative bandages and splints. These keep pressure off skin over a bony prominence or prevent the animal from assuming a posture that would place pressure on skin over a bony prominence.

A "donut" bandage can be placed over a bony prominence on the lateral aspect of a limb (i.e., lateral malleolus) to keep pressure off of the skin. Such a bandage is made from a rolled and tightly taped hand towel that is cut to the appropriate length and the ends are taped together to form a "donut." This is taped to the limb with the "donut hole" over the lesion [5] (Fig. 7) . Although this type of bandage is not advocated in treating decubitus ulcers in people,

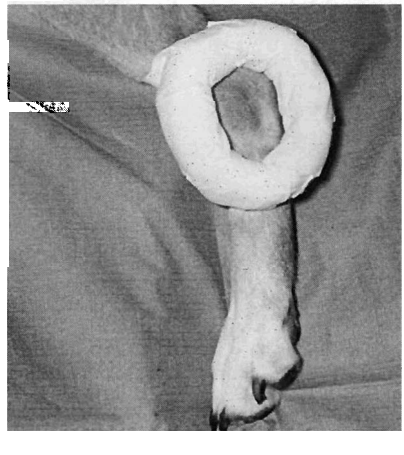

Fig. 7. A "donut" bandage made from a taped and rolled hand towel. The bandage is taped over the lateral malleolus area. (From [5] with permission)

they have been used in keeping pressure off decubitus ulcers and decubitus ulcer repair sites on the lower limbs of dogs. Donut bandages are difficult to hold in place around decubitus ulcers over bony prominences higher on the limbs, e.g., over the acromion of the scapula or greater trochanter. As they slip out of position, they can place pressure over the wound. If they do stay in place on these heavier and higher areas, there is the potential for them to impair healing by the pressure they place on vasculature in the tissue near the periphery of the ulcer.

Another pressure relief bandage that has been used to keep pressure off the olecranon area is a pipe insulation bandage. Two or three pieces of foam rubber pipe insulation of the proper length and diameter are split lengthwise and a hole large enough to accommodate the olecranon is cut in the center of each piece of split rubber (Fig. 8a). The pieces are stacked and taped together.

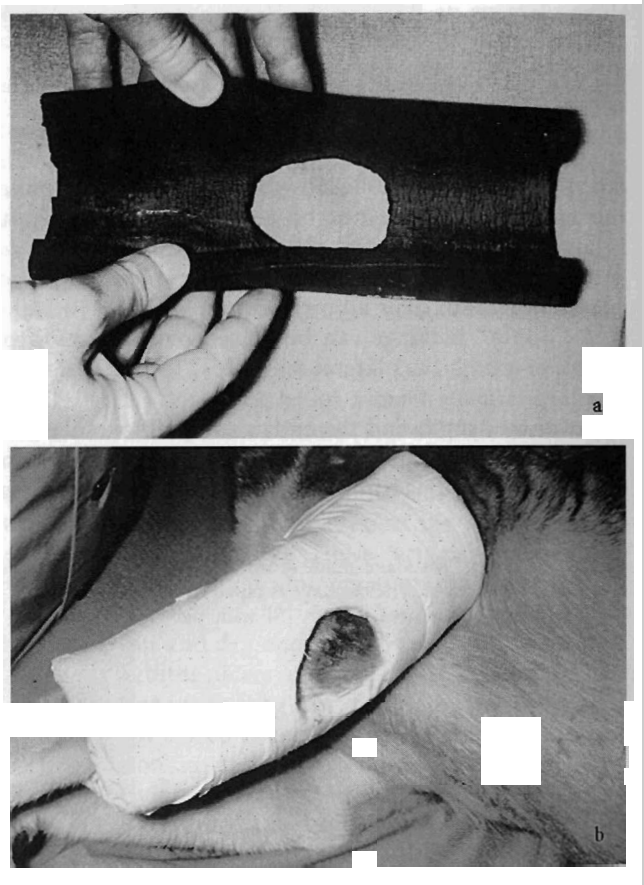

Fig. 8a,b. Pipe insulation split lengthwise with a hole cut in its center to fit over an impending decubitus ulcer, ulcer, or repair site (**a**). Two pieces of pipe insulation stacked and taped together and affixed with the hole over the olecranon area after the cranial surface of the elbow has been well padded (**b**). (From [5] with permission)

With the radial-humeral joint in extension, the cranial surface of the joint is padded well with cast padding material. The foam rubber pad is placed on the caudal aspect of the limb with the hole over the olecranon. The padding and foam rubber pad are taped in place (Fig. 8b). The bulky padding on the flexion surface of the joint helps prevent joint flexion and thus keeps the dog out of sternal recumbency. This, with the foam rubber padding on the olecranon area, keeps the dog from putting pressure on the olecranon area. On obese dogs with a short humeral area a spica-type bandage is sometimes needed to keep the bandage from slipping distally [5].

Another method of keeping pressure off the olecranon area by keeping the dog from bending its elbow to get in sternal recumbency is to place an aluminum rod splint in the front of the elbow bandage. The splint bridges the radial-humeral joint (Fig. 9).

On small paraplegic dogs that tend to sit on their perineal area, decubitus ulcers over the ischial tuberosity can be prevented by placing side splints along each side of the dog so they extend beyond the perineal area. One piece of aluminum splint material can be bent in a "U" shape and placed on the dog such that the base of the U extends beyond the perineal area (Fig. 10). Such a splint must be removed daily to accommodate defecation. One straight splint on either side extending beyond the perineal area is a bit more awkward, but precludes their removal for defecation since the perineal area is left unobstructed. The extensions of the splints beyond the perineal area prevent the dog from getting the ischial area in contact with the surface on which it is resting [5, 21].

Fig. 9. A splint made from aluminum splint rod incorporated in the cranial surface of an elbow bandage. This prevents elbow flexion to keep pressure off of the olecranon area. (From [45] with permission)

Fig. 10a,b. A piece of aluminum splint bent in the shape of a "U" and affixed to a body bandage (**a**). The base of the U keeps pressure off an ischial tuberosity decubitus ulcer (**b**)

Classification and Treatment

As with humans, decubitus ulcers in animals are graded from I to IV as to their severity (Table 1).

A major part of treating decubitus ulcers is relieving the pressure over the ulcer. The adage that "anything can be placed on a decubitus ulcer but the patient" holds true for animals as well as people. Therefore, many of the factors presented as preventive measures also apply in the therapy of decubitus ulcers. Wound debridement, stimulation of healthy granulation tissue and wound contraction, and surgical wound closure are the wound management principles used in treating decubitus ulcers. The following is the general treatment regimen used by one author (SFS) in managing decubitus ulcers [5].

General Wound Management

Grade I ulcers may be treated by periodic wound cleansing and removal of sloughing surface tissue. The wound is allowed to heal by second intention.

Grade II ulcers are surgically and/or bandage debrided (wet-to-dry bandage) to cleanse the wound and free it of necrotic tissue. After a healthy bed of granulation tissue has formed, the wound is either allowed to heal by second intention or it is closed by secondary closure. When secondary closure is used, efforts are made to keep suture lines away from bony prominences.

Grade III ulcers with undermining of surrounding skin are debrided of nonviable tissue and treated as open wounds until a healthy bed of granulation tissue is present. Either wet-to-dry or dry-to-dry bandages are used. When pockets are present in the undermined skin a 5-mm diameter Penrose drain is placed at the most dependent area. Secondary closure is performed once a healthy bed of granulation tissue has formed.

With grade IV ulcers, infected tissue, to include any infected bone, is removed. Sinus tracts and pockets are excised or opened and debrided. From this point, management is like a grade III ulcer with regard to bandaging, drain placement, and secondary closure.

Table 1. Classification of decubital ulcers (after Swain and Henderson 1990)

Ulcer type	Characteristics
Grade I	1. Dark reddened area that does not blanch on pressure. 2. Epidermis and upper dermis may slough.
Grade II	1. Full-thickness skin loss down to the subcutaneous tissue.
Grade III	1. Ulcer extends through the subcutaneous tissue down to the deeper fascia. 2. Wound edges may be undermined.
Grade IV	1. Ulcer extends through the deep fascia down to the bone. 2. Osteomyelitis or septic arthritis may be present.

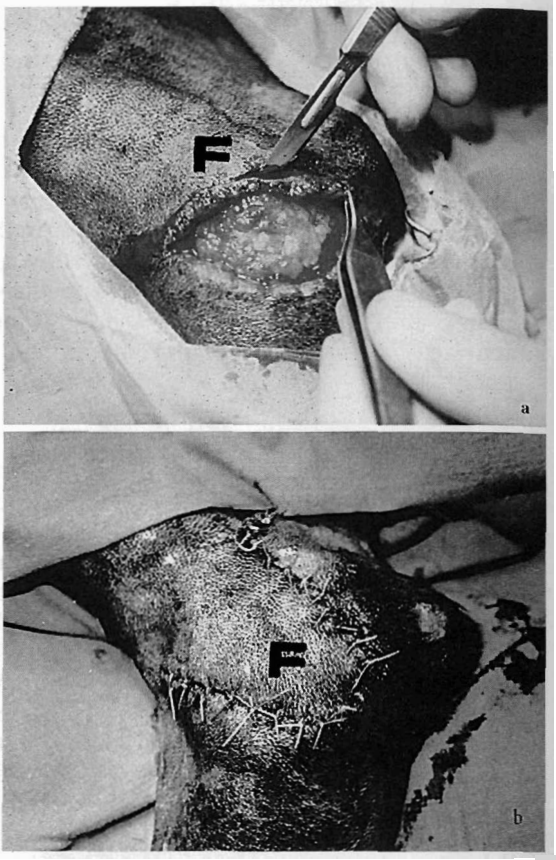

Fig. 11a,b. Debridement of wound edges of a decubitus ulcer over the lateral humeral epicondyle area. **a** Skin for creating transposition flap for surgical repair (*F*). **b** Transposition flap covering the ulcer (*F*). (From [45] with permission)

Owing to the size and/or location of some ulcers, a local skin flap may be necessary for closure (Fig. 11). An axial pattern skin flap based on the thoracodorsal vessels has been used to correct an elbow pressure ulcer in an Irish wolfhound [14] (Fig. 12). A similar potential flap that could add bulk over the olecranon area would be a myocutaneous flap containing the latissimus dorsi muscle transposed off the side of the dog [22]. Muscle flaps from the cranial sartorius and rectus femoris muscles have been used successfully to treat decubitus ulcers over the greater trochanter in dogs [23].

Topical Medications

There are many topical medications that may be used in treatment of decubitus ulcers. Those mentioned in this chapter are primarily those used at the Auburn University College of Veterinary Medicine. Following surgical and/or bandage debridement of a wound, the goal is to control infection and stimulate the development of a healthy bed of granulation tissue in the ulcer. Topical anti-

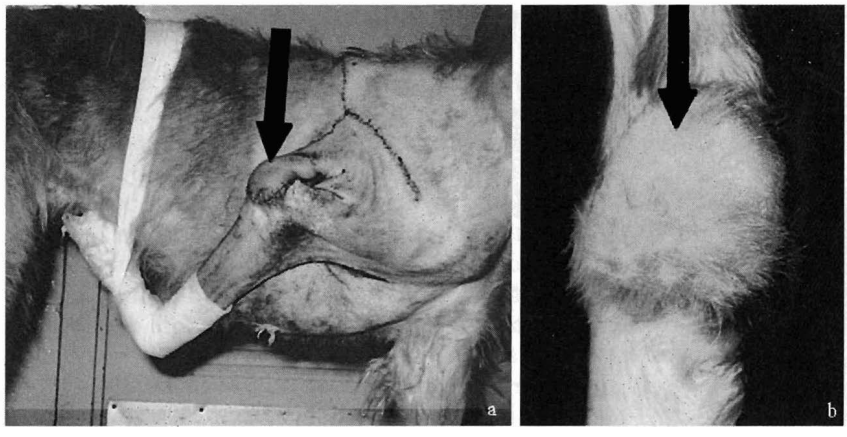

Fig. 12. a Axial pattern flap based on the thoracodorsal vessels (*arrow*) used to correct a chronic elbow ulcer. b Final appearance of elbow after completion of flap correction (*arrow*). (From [14] with permission)

biotics do not necessarily enhance granulation tissue development. They help control infection. However, once a healthy bed of granulation tissue is developed, topical antibiotics may help control surface bacteria, but the granulation tissue serves as a barrier to control against deeper infection. If deeper tissue infection is a factor, systemic antibiotics are indicated with the selection being based on culture and sensitivity tests.

There are topical medications that are used to help stimulate the formation of granulation tissue in wounds. One veterinary compound is Granulex (Pfizer Animal Health, West Chester, Pennsylvania), which contains trypsin as an enzymatic debriding agent and the angiogenic stimulant balsam of Peru. An acemannan-containing hydrogel topical dressing, Carravet (Carrington Laboratories, Inc., Irving, Texas), has also been used to stimulate granulation tissue formation. Acemannan is a macrophage stimulant, enhancing the production of the cytokines interleukin-1 and tumor necrosis factor [24]. These two cytokines in turn stimulate angiogenesis in wounds [25].

Hydrophilic agents are also used to enhance wound healing. These medications pull body fluids through the wound tissues to bathe them from the inside. A dry starch copolymer flake dressing, Avalon, Copolymer Flakes (Summit Hill Laboratories, Navesink, New Jersey), and a hydrophilic dextran polymer, Debrisan (Johnson and Johnson Products, Inc., New Brunswick, New Jersey) have been used for this purpose [26].

Contact (primary) bandage materials used in decubitus ulcer therapy are adherent gauze sponges when using wet-to-dry or dry-to-dry bandages. Once debrided, the wounds are covered with a nonadherent bandage such as a Telfa pad (The Kendall Co., Boston, Massachusetts), Release Nonadherent Dressing (Johnson and Johnson Products, Inc., Arlington, Texas), or Hydrasorb sponge (Kenvet, Animal Care Group, Ashland, Ohio). These are used in combination with the above medications.

Naturally Occurring Decubitus Ulcers in Large Animals

Horses that are recumbent for long periods of time, particularly those with postanesthetic myopathies, neurologic disease, limb fractures, or laminitis, are most prone to develop decubitus ulcers (Fig. 13). As in other species, in horses, decubitus lesions usually occur as a result of prolonged pressure in a relatively small area of the body that leads to tissue ischemia followed by necrosis [27, 28]. The condition is particularly serious when it occurs near a joint because infection of the synovial spaces can result [29]. Pre-existing conditions which accelerate the onset of decubitus ulcers in horses include some of the same factors associated with decubitus ulcers in dogs, such as loss of subcutaneous padding as a result of disease, malnutrition, skin friction, urinary and fecal incontinence, inadequate nursing care, or poor skin hygiene [28].

Although no detailed pathologic or pathobiochemical studies have been reported for pressure lesion pathogenesis in large animals, it is reasonable to assume that these changes would be similar to those occurring in tissues of other species. Lesions are initially characterized by an erythematous reddish-purple discoloration. There is progression to oozing, necrosis, and ulceration. The resultant ulcers tend to be deep, undermined at the edges, secondarily infected, and very slow to heal [30].

Casting of limbs in large animals, along with considerable movement by the animal, may cause friction sores underneath the casting material. Although the sores are not classified as decubitus ulcers, they nonetheless create full-thickness skin lesions that can have mortal results if not cared for properly (Fig. 14). To reduce the chances of friction sores, the fiberglass casting material must conform to the limb as perfectly as possible. Excessive padding compresses inside the cast, resulting in increased movement of the limb with resultant friction sores.

Reluctance to bear weight on a cast when a horse had originally borne weight on it is one of the initial signs of an ill-fitting cast. Swelling of a limb

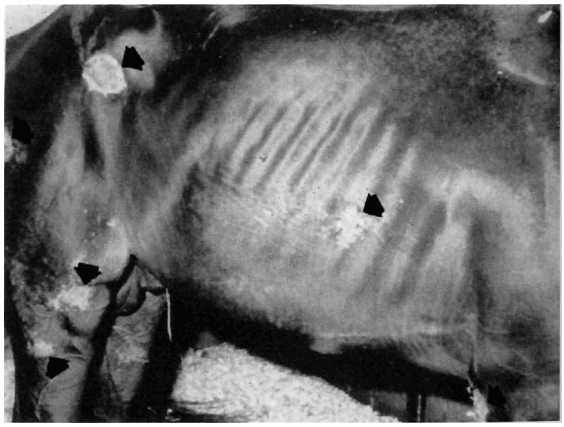

Fig. 13. Decubitus ulceration (*arrows*) present in a horse recumbent for an extensive period due to chronic laminitis. (From [45] with permission)

Fig. 14. Movement sore of medial aspect of the carpus that developed under a cast for repair of a limb fracture

above a cast, moisture of the cast, or any foul odor emanating from above or within the cast area warrants cast removal, limb evaluation, and new cast application. Skin necrosis or wound dehiscence can progress to the point where the damage from the cast is worse than the original lesion that led to cast application [31, 32].

Postanesthetic myopathies occur in horses in which there is hypoperfusion during anesthetic recumbency because of inappropriate positioning and inadequate padding. It is particularly a problem in heavy-muscled breeds. When the myopathy and neuropathy are local, it resolves many times with symptomatic treatment. However, the generalized myositis associated with hypotension may be so severe that the horse is unable to stand and ultimately requires euthanasia. Such horses are in extreme pain and require aggressive supportive therapy [33].

Preventive Measures

During anesthesia, careful attention to patient positioning, padding, and limb support is critical for the prevention of postoperative neuropathy and myositis [34]. Facial, radial, and peroneal nerve paresis may be produced by even short periods of lateral recumbency on hard surfaces. If the horse is in lateral recumbency, the undersurface, especially the shoulder and hip, should be padded. Inner tubes, air mattresses, dunnage bags, or foam padding (15-20 cm thick) have all been used. The limbs that are dependent should be pulled forward to protect major nerves. Halters should be removed to prevent facial

nerve paralysis. The nondependent limbs should be supported to prevent undue compression of and impaired blood flow to the large chest and thigh muscle masses. No unpadded ropes or tape should be used for positioning. In dorsal recumbency, the horse's back and neck should be padded and the legs should be loosely extended to prevent compression and impairment of blood flow caused by limb flexion. Postoperative myositis has been linked to hypotension; therefore, the anesthetist should monitor blood pressure closely to prevent hypotension [34].

In the recumbent horse, preventive measures should be taken in any horse which remains recumbent for more than 3 h. These measures include bandaging the lower extremities to prevent self-inflicted trauma and having clean dry bedding free from excreta [35, 36]. The horse's lateral recumbency should be changed every 6 h. It is preferable to maintain the horse in a sternal position to minimize pulmonary congestion and prolonged weight-bearing on skin surfaces over bony prominences. A body sling is useful to assist the horse to stand. This decreases muscle damage and the likelihood of decubitus ulcer development. Slings may also improve a horse's attitude in addition to increasing limb use and circulation [35] (Fig. 15). Slings should be used on an individual basis since some horses do not tolerate them well. One author (RRH) has found that stall bedding made with a 40-cm thickness of peat moss above a clay-based floor works well in minimizing the incidence of decubitus ulcers. The peat moss reduces shearing forces and skin friction, and acts as a drying agent by allowing excessive moisture to wick away from the skin. It is imperative that the top level of the peat moss be changed frequently to prevent the build up of urine and feces. Plastic-covered pillows can also be used to minimize decubitus ulcers (Fig. 16). If approximately 40 pillows are placed on one side of a 3.6 × 3.6-m stall above a straw base, the horses will learn to lie on the side of the stall with the pillows. Although more expensive than peat moss, it is a cleaner method and equally as effective.

Fig. 15. A body sling assisting a horse to stand. (From [45] with permission)

Fig. 16. Plastic-lined pillows above a straw base used under a recumbent horse to minimize decubitus ulcer development. (From [45] with permission)

Treatment

Severe myositis develops rapidly in horses totally recumbent for more than 24 h that have not received proper care. To minimize the problems associated with recumbency and self-induced trauma, the previously mentioned precautions should be employed as soon as possible. This minimizes further pressure to major muscles and other susceptible areas. Slinging the horse should be attempted if feasible [35]. Any skin sores or abrasions should be cleaned and lavaged twice daily with saline and antiseptic solutions to avoid secondary infections [31, 35, 36]. Topical antibiotic ointments, aluminum and magnesium hydroxide solutions (Maalox, William H. Roarer, Inc., Ft. Washington, Pennsylvania), emollient creams (Silvadene cream, Marion Laboratories, Inc., Kansas City, Missouri) otic cleaning solutions (Oti-Clens, Pfizer Animal Health, West Chester, Pennsylvania), and granulated sugar have all been advocated to aid in healing of decubitus ulcers [29, 36].

If spontaneous urination is not observed, the bladder should be manually expressed per rectum or it should be catheterized aseptically. If prolonged recumbency is anticipated, and indwelling urinary catheter may be advisable. Urine scald should be prevented by application of petrolatum or other water-repellent ointments to areas likely to become wet with urine [35]. However, prolonged use of oil-based ointments may lead to maceration of tissues.

Adequate nutrition is necessary to promote healing of decubitus ulcers. A protein deficiency can result in general debilitation and increased susceptibility to tissue breakdown. Severe anemia can cause a low oxygenation of tissue and lead to the death of tissues subjected to pressure. Anorexia and decreased food intake result in nutritional and caloric deficiencies that delay the healing process [35, 36]. Affected horses should be fed a high-roughage, high-protein, and vitamin-supplemented diet [29, 35, 36].

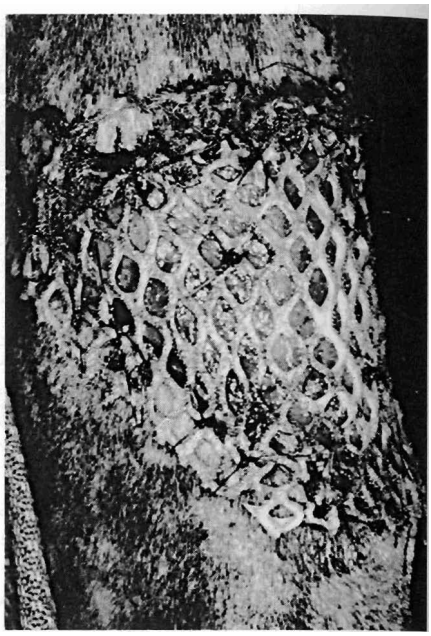

Fig. 17. A split-thickness mesh graft has been applied to the palmar aspect of the third metacarpus following cast removal and repair of a limb fracture

The most important aspect of therapy, however, is to identify and correct the cause of the prolonged recumbency so the patient can stand. Surgical treatment of decubitus ulcers is not as frequently performed in horses as it is in humans and small animals [29]. Surgical debridement of infected granulation tissue, undermined and traumatized skin, and infected muscle and bone, along with primary closure of the remaining skin defect has been used successfully. The use of skin flaps and grafts, and myocutaneous flaps has not been specifically described for correcting equine decubitus ulcers. If such procedures were used, it would only be after correction of the condition causing the recumbency that resulted in the ulcer [29]. Skin grafts have been used to correct limb lesions resulting from improper casting (Fig. 17).

Induced Dermal Pressure Lesions in Animals

Since decubitus ulcers are a major health care problem in the United States, research on the prevention and treatment of these wounds is certainly in order. Thus, animal models have been used for such research.

Over the years, various animal models have been described for the study of decubitus ulcers. Pressure applied to the ischial area of rabbits with and without spinal cord transection was used in early studies of decubitus ulcers. Using this model, it was concluded that there was an inverse relationship between pressure and its duration required to produce a pressure lesion. The most severe pathologic changes occur in deep muscle with only minimal

changes in the skin, and pressure necrosis was similar in paralyzed and normal rabbits [37].

Decubitus ulcer studies have been performed using dogs. In one study, pressure was applied over the greater trochanter and lateral aspect of the tuber ischii by a pneumatic piston apparatus. Both high pressure for a short time and low pressure for a prolonged time resulted in muscle necrosis [38].

Using the pneumatic piston pressure device, pressure has been applied to hamstring muscles of normal and paraplegic rats. Low constant pressure for a short period caused the most damage. Application of equal amounts of alternating pressure was less damaging to tissue. No microscopic differences were noted between normal and denervated tissue after applying either constant or alternating pressure [39].

Pigs have also been used in decubitus ulcer studies. Eight days following spinal cord transection, mechanical pressure was applied to the posterior iliac spine in pigs. In addition, friction was applied to areas of pressure. It was found that friction increases the susceptibility to skin ulceration at a constant pressure of less than 500 mmHg, and friction with repetitive pressure of only 45 mmHg resulted in skin ulcers. As with the earlier work in dogs, it was found that there was an inverse relationship between the magnitude and duration of pressure in producing decubitus ulcers [40].

In a 1981 report, a computer-controlled electromechanical pressure applicator was used on normal and paraplegic pigs to produce decubitus ulcers over the greater trochanter. It was found that muscle was more susceptible to pressure damage than skin. High pressure in a short time (500 mmHg–4 h) caused muscle damage, whereas skin destruction required high pressure over long duration (800 mmHg–8 h). It was hypothesized that the pressure duration threshold for production of decubitus ulcers is lowered markedly following changes in soft tissue coverage due to paraplegia, infection, and repeated trauma [41].

In a more recent study using spinal-transected pigs, an automatic computer-controlled system was used to apply pressure over the greater trochanter for periods of 4–16 h. Since 6 weeks were allowed between spinal cord transection and pressure application, considerable muscle atrophy was present. Results indicated that spinal-transected animals developed pressure lesions at lower pressures than in normal animals. It was stated that the difference was due to the marked soft tissue atrophy [42].

The pig has also been used as an animal model to study the physiologic characteristics of cutaneous wounds induced by a device that applied both pressure and temperature over a 5-h period. Twelve 5.6-cm diameter sites along the backs of pigs were subjected to pressure and temperature, and were evaluated using various parameters to include histopathologic evaluation [43]. This model was used to further evaluate the quantitative relationship between the severity of induced decubitus ulcers and the causal factors of variable pressures, temperatures, and time. These studies were performed to define critical thresholds for changes in cutaneous function related to these causal factors, with clinical implication for establishing safety standards for such things as warming devices [44].

With its natural proprensity to develop decubitus ulcers, the greyhound dog could be considered as a model for decubitus ulcers, utilizing the naturally occurring wounds that occur in this breed. In addition to this, a model has been established for experimentally inducing early dermal pressure wounds on greyhounds. A short-limb walking cast on one pelvic limb of greyhound dogs has been found to produce lesions over bony prominences that have physical characteristics, pathobiochemical (thromboxane B_2) changes, and histopathologic characteristics that are consistent with early decubitus ulcers [13]. This model has been used to evaluate the efficacy of a systemically administered thromboxane synthetase inhibitor in helping prevent or reduce the severity of dermal pressure lesions. All three of the above-mentioned dermal pressure parameters were less severe in treated dogs than in the placebo-treated control greyhounds [19]. The greyhound induced dermal pressure technique could also be used for dermal reperfusion injury studies, whereby no medications are administered during the presence of dermal pressure. Dermal pathologic changes could be assessed following pressure relief (cast removal). Factors that are not present in the greyhound induced dermal pressure model that are often present in the naturally occurring decubitus ulcer patient are hypoproteinemia and malnutrition [13].

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