Massachusetts Task Force 1
Urban Search & Rescue

Wound Management of the Canine

Lori E. Gordon, DVM

WOUND MANAGEMENT

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SECTION 1A: WOUNDING and WOUND MANAGEMENT

Contents

I. Assessment of the Patient

A. Don't forget the rest of your patient!

It is important to first assess the overall condition of the patient. Initial wound management may necessarily be delayed to initiate treatment of life threatening injuries. Once stabilization of the patient is achieved, assessment of wounds can be made in order to establish wound management and a treatment plan.

B. In some instances the wounding *is* the life threatening injury.

Careful evaluation is paramount to discovering the extent of the injury so it may be properly addressed.

Examples include head trauma; tracheal puncture/laceration; thoracic injury to lung, vessels, heart; abdominal trauma to live, spleen, kidney; arterial and some venous hemorrhages; fracture of a femur, rib, skull, or spine.

Causes include blunt impacts (falls, hit by car, explosion), sharp impact (bite wounds, punctures, deep laceration), burns (chemical, electrical, fire), gunshot, venomous bites, and crush injury.

C. Analgesia is paramount as well as the most basic standard of care

Analgesia, local and/or systemic, provides the best environment for the patient as well as the care providers with respect to treatments and safety. Local lidocaine blocks and systemic narcotics are most common. Multiple drugs exist that cause minimal respiratory or cardiac compromise for those patients in emergent situations.

II. Drug Treatment Options and Regimens using FEMA-Approved Cache

Analgesia is a basic standard of care. Allowing an animal to suffer pain needlessly increases stress, delays recovery and healing, and increases safety risks to personnel.

A. Systemic Analgesia

1. **Narcotics -** FEMA-approved cache injectable narcotics include the opiates fentanyl, morphine, and partial opiate agonist butorphanol (Tobugesic, Stadol). Medetomidine (Domitor) and dexmedetomidine (Dexdomitor), veterinary-specific drugs, are α-2 adrenoreceptor agonists, providing sedation and analgesia. Oral narcotic medications approved include butorphanol (Stadol) and tramadol (Ultram).

2. **NSAIDs -** There are multiple non-steroidal drugs approved for use in dogs. They were developed in a way to block certain negative inflammatory substances while sparing others (cyclo-oxygenases, or COX). This decreses many of the side effects from using human-designed NSAIDs (gastric ulceration, renal and hepatic failure.

B. Sedation with analgesia

Certain drugs and combinations produce a nice sedation and analgesia for minor procedures, like clipping, cleansing, exploring, and suturing/stapling wounds.

It is recommended to monitor vital signs before, during, and after administration of these drugs. Cardiovascular systems will be affected. Bradycardia in particular, along with respiration and blood pressure, require attention. Allergic reactions to medications are not common, but certainly do occur.

1. **Ketamine & Diazepam mix 50:50** @ 1 ml/20 kg IV
    a. Diazepam = 5 mg/ml; ketamine = 100 mg/ml
    b. Minimal analgesia
    c. Pre-med with opiate will add analgesia, effectiveness, and avoid dysphoria upon recovery: **fentanyl** @ 0.004-0.01 mg/kg IV; **morphine** 0.5-2.0 mg/kg IM or SC

2. **Diazepam & Fentanyl**
    a. Diazepam dose @ 0.2-0.4 mg/kg IV
    b. Fentanyl dose @ 0.01 mg/kg IV
    c. Bradycardia is most common side effect; atropine 0.02-0.04 mg/kg IV; ♫*Note: in my experience, even the low dose often causes tachycardia (HR >300) so consider 1/2 of low dose; give more as needed*
    d. If giving **atropine** BEFORE the sedation, give the 0.02-0.04 mg/kg IM or SC; IV is for emergent situations
    e. Monitor BP for perfusion

3. **(Dex) Medetomidine**
    a. Dosing charts based on body mass are used for administration
    b. Provides sedation and analgesia
    c. Allow recovery or may reverse with same mls of atipamezole (Antisedan) but this is given IM only

4. **Butorphanol & Benzodiazepine (midazolam or diazepam)**
    a. Dose @ 0.4 mg/kg of each IV; may go IM with midazolam

5. **Butorphanol & Acepromazine**
    a. Dose @ 0.1 mg/kg each IM
    b. Alternative dose: butorphanol @ 0.2-0.4 mg/kg IM
       acepromazine @ 0.02-0.04 mg/kg IM

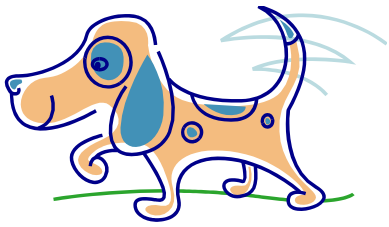
6. **Butorphanol & Dexdomitor**
    a. Dose butorphanol @ 0.1 mg/kg IM
       dexdomitor @ recommended IM chart dose

C. Local Analgesia

Two things: (1) always *draw back on the syringe* to make sure you are not in a vessel before injecting the drug and (2) know signs of *overdose*: initial sedation, followed by (as dose increased) twitching, convulsions, come, and death.

1. **Lidocaine (Xylocaine)**
    a. 0.5%, 1%, 2% concentrations (5, 10, 20 mg/ml)
    b. Dose @ 2.0 - 5.0 mg/kg (Toxic dose 8 mg/kg)
    c. Immediate onset, lasts 1-2 hours
    d. Stings; can add sodium bicarbonate @ 1:9 ratio (bicarb:lido)
    e. Dilute with saline (not water) for more volume and dose limit reached
    f. *Avoid epinephrine* due to severe vasoconstriction, tissue necrosis, and cardiac arrhythmias

2. **Bupivacaine (Marcaine)**
    a. 0.25%, 0.5%, 0.75% (2.5, 5, 7.5 mg/ml)
    b. Intermediate onset – wait!!! (15-30 min)
    c. Lasts 4-6 hours
    d. Dose up to 2.0 mg/kg (Toxic dose = 4 mg/kg)
    e. Dilute with saline for more volume



3. **Lidocaine + Bupivacaine** @ 1 mg/kg each gives the best qualities of both

4. **Opioid Addition** (0.075 mg/kg morphine or 0.003 mg/kg buprenorphine) to the local anesthetic mix may substantially extend duration of analgesia

5. **Ice** gives brief temporary pain relief

6. **Topical Creams -** Amethocaine, EMLA cream

7. **Blocking Methods**
    a. Line Block - subdermal inject ~2-4 mm from edge of laceration/wound
    b. Ring Block - 360º subdermal inject around limb to numb area distally
    c. Nerve Block - targeted inject to numb area fed by specific nerve; requires knowledge base of canine nerve anatomy

D. Anesthesia

Without extensive training in the field of veterinary medicine, this is not advocated. Should the need for complete anesthesia be required, transportation to a veterinary hospital is recommended. Should circumstances make this unattainable, direct communication with a licensed veterinarian is recommended.

Should this also be unavailable, consider treating the canine patient in like manner to a pediatric patient. Intubation and intravenous access is required. Intensive monitoring of vital signs until complete recovery is important. This includes HR, RR, PO, BP, EKG; if available CO^2. Drugs with a reversal agent are ideal.

III. Deep Penetrating Wounds: Assessment and Emergency Treatment

The purpose of assessment is to guide the management of the wound. By determining the type, extent, tissue viability and approximate age of an injury, one can determine a plan of treatment based on those observations. Is the injury superficial or deep? Is there soft tissue and/or hard tissue involvement? Is there an infection? Could there be a foreign body present?

What is visualized on the outside may represent the extent of the injury, or it may be the tip of the iceberg. Knowing what to look for is based on the anatomical location of the injury.

Prioritize: Life-threatening treatment, analgesia, wound care

A. Joints

Most commonly affected are joints of the extremities, evidenced by swelling and lameness of the affected limb. We must not overlook:

- Trauma of the face near the temporomandibular joint
- Trauma to the vertebral joints of the neck, body, and tail

1. Joint penetration from puncture, stab

a. Features

1. Typically a puncture from nail, knife, stick, metal shard, bite, or projectile. For the jaw it may be injury from inside the oral cavity.
2. The skin wound may be on or just near a joint (degloving injury covered elsewhere). Unless the inciting cause is present and still sticking out of skin, the depth and angle are unknown so even wounds near a joint are suspect
3. Joint capsule and muscle close back over and the wound, lacking drainage, forms closed pockets which provide an ideal environment for bacterial proliferation
4. Joint pain, swelling, and/or fever may not be evident right away

b. Signs

1. Early - None
2. Later - heat, pain, lameness, swelling, redness, fever, +/- joint fluid

c. Treatment:

1. External cleansing and systemic antibiotics (Cephalosporin)
2. Efficacy of these may or may not be sufficient to stave off complications
3. If joint sepsis occurs, recommend transport for advanced care: culture, ingress-egress flushing, radiographs and possible arthroscopy or surgical exploratory if foreign body suspected.
4. Sterile conditions preferred, but if under field conditions and no transport available, ingress/egress flushing can be very effective, delaying or eliminating the need for further, more aggressive treatment (joint exploration, and drain placement). Knowledge of joint anatomy for procedure important. Call a veterinarian for guidance if no option and conservative care with antibiotics not effective.

Ingress/Egress Joint Flush

The patient should be sedated. The joint should be clipped and prepped (alcohol and antimicrobial solutions). Two needles or IV catheters, 22 or 20 gauge, are placed at different locations within the so that flushing saline into one (ingress) will flush out the joint and the contaminated fluid will come out (egress) of the other needle. The needles or catheters should be held in place at their base so if too much pressure is used during flushing they won't be forced out. The process should be continued until the fluid runs clear.

2. Joint Fracture, Subluxation, Luxation

a. Features

1. External wounding may be quite minor, like bruising or superficial scrape.
2. Non-weight bearing lameness, swelling, abnormal limb angle
3. Pain at the site, crepitus (grinding) with range of motion, lack of range of motion, hyperextension/hyper flexion, and varus/valgus deformity are physical examination findings

b. Treatment

1. Even without a radiograph to confirm or support a fracture and/or luxation, apply external coaptation (splint, soft padded bandage) or a movement limiting sling (Figure-of-8, Velpeau) to limit motion and decrease pain
2. Transport.

3. Joint Ligament Damage

a. Features

1. Clip hair, cleanse wound
2. External wounds may also be minor, but pain, swelling, and lameness are present.
3. Hyperextension, hyperflexion, and assessment of the varus and valgus integrity of the joint are assessed.

b. Treatment

1. Clip hair, cleanse wound
2. External coaptation for temporary pain relief are provided until further treatment becomes available.
3. Transport

B. Long Bones

Non-weight bearing lameness, wounding over the area, swelling, crepitus, and abnormal limb angles all contribute to the diagnosis of a fracture.

1. Fracture Classification

a. **Closed** - no bone has penetrated outward; wound does not penetrate to bone

b. **Open Type I – First Degree -** bone fracture has penetrated skin but often not at examination. Low energy forces, wound < 1 cm long, minimal muscle damage, fracture often simple (2-piece)

c. **Open Type II – Second Degree** are more extensive communication of bone with skin before or at examination. High energy forces, wound > 1 cm, moderate soft tissue and muscle damage

d. **Open Type III – Third Degree** are from high energy trauma resulting in severe wounding, massive soft tissue damage often with loss of bone and soft tissue
   i. ***Type IIIa*** requires no major reconstructive procedures to cover bone or close wound
   ii. ***Type IIIb*** need plastic reconstruction as remaining soft tissues are insufficient for primary closure
   iii. ***Type IIIc*** have a major arterial injury that requires repair

e. **Type IV – Fourth Degree** involves amputation or near-amputation of the limb. Severe soft tissue damage and neurovascular injury are present

2. Wound Treatment Protocol

All open fractures are contaminated, assumed infected if untreated for > 8 hours

a. **Initial wound care** divided into 3 parts:
   i. *Preparation*: sterile jelly and cover wound while clipping hair and clean area with antiseptic
   ii. *Irrigation*: Sterile lavage solution to cleanse away jelly, hair, debris
   iii. *Decontamination*: sterile bandage applied, aseptic technique, at each debridement and lavage

b. **Lavage** is best with pulsating jet-type device, and additives are limited.
   i. Avoid hydrogen peroxide unless area highly contaminated and necrotic, anaerobes suspected
   ii. Chlorhexidine at 0.05% solution highly effective to reduce bacteria
   iii. Isotonic solutions - saline, LRs, normosol

e. **Bandaging** includes sterile, wet-to-dry or non-adherent antibacterial cover, secondary conforming absorptive layer for capillary action of fluids, splint if indicated, and outer tertiary layer

f. **Antibiotics** are recommended
   i. *Staph* and *strep* most common isolates
   ii. Cephalosporins are a good initial choice

g. Transport

C. Soft Tissue Neck Trauma

1. Cervical trachea

Injury may also show as upper respiratory distress signs and/or subcutaneous emphysema. This is when air, leaking out form the cervical trachea, collects under the skin. There is an odd crackling feel when palpated as the air moves throughout the subcutaneous tissues. Crushing injuries may be more devastating to the area than puncture wounds if the trachea is compromised and a temporary tracheotomy below the compromised area is required.

Temporary Tracheotomy

With the patient on their back, front legs pulled towards the back legs, a small rolled up towel placed under the neck, clip (if there is time) the ventral neck and prep for incision. A midline incision is made below the trauma area and if maintaining a midline approach, separation of neck muscles will reveal the trachea. An incision in between the tracheal rings may be performed NO MORE THAN 1/3 THE WAY AROUND. Alternatively a vertical incision through 2-3 rings, just long enough to accommodate a tracheal tube or tracheotomy tube, may be performed. Transport to a veterinary hospital is recommended ASAP. Tracheotomy tube maintenance requires humidification, suctioning, and 24 hour intensive care.

2. Cervical Esophageal

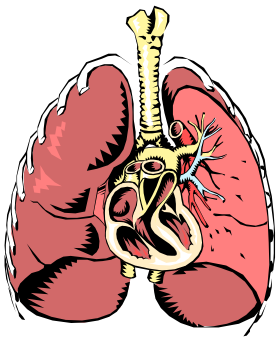
Trauma may not be readily apparent so close inspection of this track is needed. However if the mediastinum has been compromised, respiratory distress may be evident.

3. Recurrent Laryngeal Nerve

These nerves originate within the chest cavity, coursing along the trachea as they ascend to reach the larynx. Each recurrent nerve terminates in the laryngeal muscles. Cervical trauma anywhere along the neck may injure these nerves, which may cause laryngeal paralysis. The inability to abduct one or both arytenoid cartilages, necessary for proper air passage into the trachea, leads to signs of upper respiratory obstruction: noisy breathing, exercise intolerance, laryngeal stridor. Severe signs include inspiratory distress, severe dyspnea, cyanosis and collapse. Signs increase in severity during times of stress, heat, and activity when increased inspiratory ability is needed. Treatment depends on the severity of signs which are related to the degree of paralysis, unilateral versus bilateral. Keeping the animal cool, calm, and quiet may be sufficient. Life threatening signs ideally require surgical intervention. Options for temporary relief in an emergency situation: intubation and temporary tracheostomy.

4. Jugular Veins and Carotid Arteries

Large vessel hemorrhage must be controlled and supportive care initiated. Pressure may be applied to the side of the trachea, angling back towards the top of the neck and slightly inward. Both the jugular and carotid may be tied off without causing death in and of themselves due to the collateral circulation present in dogs. If pressure is not enough, a cut-down of the skin over the vessel (jugular) or midline incision through skin and muscle, then to side of trachea (carotid) will reveal the vessel for ligation if the specific area of hemorrhage cannot be easily seen via the wound.



D. Thoracic Cavity Penetration

Anything that can penetrate the thoracic cavity has the potential to cause life-threatening injury to the animal.

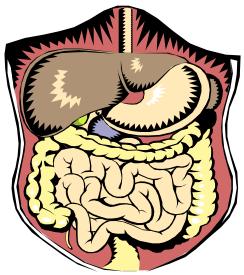
1. **Pneumothorax -** Puncture wounds of any type (bites, foreign bodies, knife, gunshot, rib fracture) that compromise the negative pressure of the thorax can cause pneumothorax. It arises when the lung, trachea, or thoracic wall is penetrated so that gas has access to the pleural space. Tap the chest.

2. **Tension Pneumothorax** – The puncture acts as a one-way valve. Positive pressure builds up with each inspiration and the air has no escape, leading to total lung collapse and respiratory arrest. Tap the chest.

3. **Hemothorax** – Vessel compromise may clot on its own. If a major artery is involved, immediate surgical exploration is the treatment of choice but poor prognosis to make it that far. This is rarely available in the field and medical management may be the only option. Tap is for diagnosis. May collect blood if have capability and re-infuse IV.

4. **Cardiac/Pericardial Effusion -** hemorrhage into the pericardial sac surrounding the heart when it has been punctured eventually builds up enough pressure to compromise cardiac function. Termed cardiac tamponade, heart sounds are muffled, jugular vein distended, and pulses are weak at inspiration while strong on expiration (pulsus paradoxus). FAST exam reveals fluid. Sac tap is contraindicated as hemorrhage will quickly fill emptied space.

E. Abdominal (Peritoneal) Cavity Penetration



1. **Hemoperitoneum** may be the result of any abdominal wound and is associated with many organs, especially the spleen, liver, and kidney. Many stop hemorrhaging before the diagnosis. More severe bleeds require fluids, blood transfusions, and if no response possible surgical exploration.

2. **Uroperitoneum** is associated with renal, ureter, bladder and proximal urethral damage. The abdomen may be painful. Peritoneal tap may be diagnostic. Lack of urination is suspect. Hyperkalemia is a major finding, requiring dextrose and insulin drug intervention. Passing a urinary catheter will divert some urine from leaking in a bladder tear: by maintaining small bladder, the tear may be minimized by the wall contraction. A catheter can bypass a proximal urethral tear.

3. **Bile Peritonitis** – Trauma to the bile duct, gallbladder, and liver are sources for this. Sterile bile may not be recognized for weeks. Infected bile will cause bile peritonitis.

4. **Septic Peritonitis** – Intestinal tract compromise is the primary cause. Signs vary in the time manifested and in severity depending on the size and location of the compromise. Pain, fever, depression, tachycardia, vomiting, vague illness all are possible. Blood work, ultrasound, supportive care, surgery are needed.

F. Central Nervous System

Wounds of the skull or along the back may alert one to the possibility of head or spinal trauma. Blunt trauma, penetration injuries, or disc extrusion secondary to extreme force may occur. Signs are manifested as varying degrees of paralysis. The prognosis varies depending on the severity of damage. Appropriate medical and/or surgical intervention may markedly influence recovery.

1. Head Wounds

- **a.** Examination may include wet fur (CSF, blood, or both), crepitus (skull/facial fractures), or neurologic signs (altered mental state, seizures, visual deficits, pupillary abnormalities (dilated, miotic, or unequal), bradycardia (increased CSF pressure).
- **b.** Treatments include elevating head by 15^{o}, oxygen, pain management, benzodiazepine for seizures, fluids as appropriate.
- **c.** Systemic blood pressure should be maintained in a normal range, and if the patient is still deteriorating give one gram per pound of 20% mannitol IV over about 45 minutes. Nothing else is of benefit.
- **d.** Corticosteroids of any kind of any dose should not ever be given.
- **e.** Transport ASAP.

2. Spinal Wounds

- **a.** Examination may include wet fur (blood), crepitus (vertebral fracture), or neurologic signs.
- **b.** Neurologic signs range, depending on the lesion location, to paralysis (loss of voluntary motor) or paresis (partial paralysis), hyperreflexia, hyporeflexia, painful to loss of pain perception.
- **c.** Involvement may be all four limbs or just the hind legs
- **d.** Shiff-Sherrington posture, indicative of severe trauma between T2 and L5, is severe forelimb extensor rigidity with rear limb flaccid paralysis
- **e.** Treatments include emergent needs (cardiovascular and pulmonary), pain management, secure for transport with minimal spinal manipulation
- **f.** Corticoseroids and NSAIDs are used, but remain controversial. There is a 6-8 hour window of opportunity so these are best left for the emergency hospital

IV. Superficial Wound Management

A. Tissue Viability

Wound debridement is the most important factor in management of contaminated wounds. Debridement reduces bacteria and foreign bodies in the wound as well as removes devitalized tissues. Foreign bodies and dead tissue impair the host immune system, increasing the risk of infection. Tissue viability is not always clear cut. As little as 10% of the total cutaneous circulation is needed for nutritional support of the skin. Trauma resulting in major circulatory impairment to the skin may not lead to skin necrosis unless this minimal nutrient flow is compromised. Even insult to a direct cutaneous artery and vein will not result in skin necrosis unless collateral vascular channels have also been damaged.

1. **Skin**
   Acute ischemic necrosis may be noted within 24 hours, or compromise is slower and a clear delineation between viable and nonviable tissue may not be apparent for up to 7 days after the insult. Some ischemic areas may survive if vascular channels are established from the underlying wound bed before irreversible damage occurs. Signs include cyanosis, lack of warmth, lack of bleeding, infection, purple or black hue.

2. **Note on Bleeding**
   Assessment of skin viability can be difficult. Lack of bleeding from skin edges may be due to transient vasospasm. Aggressive debridement based on this alone may lead to the excision of viable tissue. In areas where there is little extra available skin for closure, like the extremities, a wait and see attitude may be beneficial. Daily assessment is needed.

3. **Underlying Tissues**
   Damage beneath the skin to muscle and adipose tissues should also be assessed for viability. Left untreated damaged tissues are a bed for infection and delayed healing.

B. Contamination versus Infection

1. **Eight-Hour Rule**
   If a complicated wound can be treated within the first eight hours of injury, closing the wound primarily may be attempted if at all possible.

2. **Foreign Body Presence**
   If a wound is more than 8 hours old and grossly infected, necrotic, or contains ground-in foreign material, wet-to-dry bandaging and second intention healing is recommended.

C. Prevention of Further Wound Contamination

When initially seen, wounds should be temporarily protected from drying and further contamination by application of a topical antimicrobial agent and a sterile dressing until definitive care can be provided.

1. **Hair clipping**
   In an emergency situation this may not be attempted right away, although clipping or trimming hair around the wound would be beneficial. Without sedation or anesthesia it may be impossible. Topical lidocaine with bicarbonate can be used to decrease pain. Meticulous clipping is usually performed in preparation for definitive wound cleansing and surgical management. While the wound is being clipped it should be protected by gauze sponges impregnated with sterile K-Y Jelly, sterile saline, or an antimicrobial solution.

2. **Antibiotic ointments**
   Water-miscible better absorbed but petroleum-based agents fine, too.

3. **Wet saline dressings**
   Sterile gauze soaked with 0.9% saline with or without a nonirritating antimicrobial agent can be used. Solutions of 1% povidone iodine (1 part iodine to 9 parts sterile saline) or 0.05% chlorhexidine diacetate (1 part chlorhexidine to 40 parts sterile water) can be used to flush the wound and can be incorporated into sterile dressings.

4. **Systemic broad-spectrum antibiotics**
   These are used in more seriously contaminated wounds.

D. Debris Removal

Dirt, clay, tar, and organic debris promote infection and delay healing. Removal of gross contaminants after the initial debridement is done by manual removal gross debris followed by pressure lavage. Gross contaminants adhered to adipose tissue overlying muscle or adhered to the subcutis of the skin may be more easily removed by excising the tissue tangentially. This will also better preserve blood supply. Lavage with saline or Lactated Ringer's is performed under pressure by using an 18-gauge needle on a 35 ml syringe, full force on the plunger, perpendicular to the wound surface. This will deliver 8 lb/in^2. Elevate skin edges gently to explore hidden areas that may harbor debris.

E. Debridement of Dead and Dying Tissue

Obvious necrotic tissue is excised. Debridement of areas of questionable viability may be staged rather than a single aggressive excision which may damage viable tissue. If daily opportunity to assess and treat an area is unlikely to occur, a judgment call must be made based on the importance of the area to be treated. Unfortunately, bleeding from the skin edges is no guarantee of viability nor is it immune to the potential for further trauma, edema, infection, venous compromise or thrombosis.

F. Open Wound Management

1. Circumstances

Debris, necrosis, and/or infection remain. Delayed primary closure allows for drainage and inspection of the wound, but requires at least daily bandage changes until wound is clean and/or granulation develops..

2. Wet-to-Dry Bandaging

The wound is packed with a sterile wet dressing (saline, 1% iodine solution, 0.05% chlorhexidine solution) using several layers of soaked gauze pads, followed by layers of dry absorbent cotton roll, gauze roll, and an outer elastic covering which incorporates a paper drape to prevent strike-through contamination. There is now maximum drainage, tissue hydration, absorption of drainage from wound, protection from the environment, and when changed will mechanically debride the wound surface. Depending on the drainage, closure is attempted in 3-5 days.

3. Promotion of a Viable Vascular Bed (Granulation)

The reward for treating a wound for necrosis, contamination, infection, and drainage, and protecting it from additional trauma, is that the remaining tissues can improve and support the development of a granulation bed - a plump, glistening, granular, capillary-rich, bacterial-resistant red tissue that means a viable vascular bed is present. It is made up of capillary loops that form from capillaries damaged in the wounding. Once formed, either contraction or delayed closure of the wound can proceed.

a. Significance

Granulation tissue is important in the healing of open wounds for several reasons. It is extremely resistant to infection, serving as a barrier to systemic infection, provides a surface over which epithelium is able to migrate, plays a role in wound contraction, and contain the fibroblasts that produce collagen for wound healing.

b. Treatment

Granulation tissue bleeds readily when cut due to the numerous capillary loops. Protective covering should be non-adherent so as not to pull this important layer away from the healing wound.

G. Closed Wound Management

1. Materials - Suture, staples, and glue are used to close wounds.

2. Closure Method Selection

a. **Primary Closure (1st intention)**

Defined as closure of a skin incision 'wound' which was made purposely. All other wounds are considered contaminated and dealt with accordingly. An early laceration may be debrided, flushed, and closed. Drains are placed based on the underlying soft tissue damage.

b. **Delayed Primary Closure**

Wound closure after 3-5 days of treatment to promote a vascular (granulation) bed. This is used in wounds that are mildly contaminated or infected on initial presentation.

c. **Secondary Closure (3rd intention)**
Wounds requiring longer treatment may have mechanical and surgical work, allowing time to control infection. Closure is after 5 days or when granulation tissue appears. This is common with marked contamination, when bone or joint exposure is present, or infection is invasive.

d. **Second Intention Healing**
This is healing without surgical intervention, by contraction and epithelialization. It is used in dirty and infected wounds in which the first three methods cannot be used. This method can be a valuable ally and should not be underestimated, even in large wounds.

e. **Reconstruction Procedures**
Local and distant skin grafts, myocutaneous flaps, axial pattern flaps, free grafts, and other specialized surgical procedures may be employed to attain closure of a wound.

V. Bandaging

A. Indications

The following comprise the functions of various bandages and dressings. Some wounds need only minimal covering while others require intense daily management and assessment.

1. **Absorption** of wound drainage (serum, blood, purulent exudate, necrotic debris) by wicking it away from the wound bed and storing without strike-thru to the outside

2. **Protection** of the wound from further trauma, the environment, and contamination**.**

3. **Antisepsis** via aqueous antibiotics or diluted antiseptic solutions within a wet saline dressing.

4. **Pressure** (without interfering with blood flow, lymph flow, or nerve health) to decrease dead space, control hemorrhage, reduce seroma and hematoma formation which delay healing

5. **Immobilization** to place the wound at rest, decrease pain, mechanical trauma, and scarring.

6. **Debridement** by the use of wet saline dressings, which take debris and secretions away when they are changed.

7. **Packing** of deep infected wounds with antiseptic-soaked gauze to allow an exit for necrotic, purulent debris.

8. **Information** on wound healing by assessing the nature, amount, and odor dressing secretions.

9. **Comfort** of a bandage goes a long way towards helping it stay on, as an animal is less likely to gnaw off something that is not objectionable.

10. **Esthetics** may help those less used to seeing grave wounding concentrate on the animal rather than the horror of the wound.

B. Closed Wounds

These may not need bandaging unless immobilization, environment protection, prevention of self-mutilation, or a drain covering is required. Immobilization uses the most padding, simple protection may be just enough to create a fancy Band-aid. Bandages absorbing drain exudate should be changed one or more times per day, depending on the amount of exudate.

C. Open Wounds

1. **Primary Contact Layer -** The primary layer lies in direct contact with the wound.

   a. **Nonadherent Dressings**
   These are applied to facilitate bandage removal without disturbing the underlying tissue**.** They are advantageous when a healthy wound bed, granulation, has formed. Two types are Telfa pads and Adaptic dressings. Spreading gauze with K-Y jelly or a water-miscible antibiotic is another option. When removing the gauze, warm saline will facilitate painless removal.

   b. **Adherent Dressings**
   These are useful in the mechanical debridement of wounds. In a dry-to-dry method, dry coarse or wide mesh gauze is applied to moist wounds with loose necrotic tissue. The dry gauze absorbs the necrotic debris and fluids. When lifted off 'dry' the bandage strips the necrotic tissue from underlying viable tissue. In a wet-to-dry method, the contact layer is saline-soaked to soften and loosen tenacious necrotic debris. The wicking action pulls fluid away from the wound.

2. **Inner Intermediate Absorptive Layer**
   The secondary layer of a bandage is an absorptive layer composed of cotton fiber enveloped by gauze for compression.. It acts to wick fluid and exudate from the wound surface. Bandage changes depend on the amount of exudate from the wound (often higher at first) and the storage capacity of the absorptive layer. Early stage wounds may require bandage changes 1-3 times a day. As healthy granulation tissue forms, changes can be reduced to every 2-4 days.

3. **Outer Intermediate Compressive Layer**
   This is the next layer that serves as a binding or security layer for the contact and absorptive layers. Stretch gauze, 3 inches or more (to avoid a tourniquet effect) is wound around in 3-4 layers.

4. **Protective (Final) Outer Layer**
   Elastic bandage material is used to cover and protect the bandage. Porous tape will allow aeration and the passage of moisture from the secondary layer, but also allows environmental moisture into the bandage. Non-porous tape is protective, but will not allow evaporation and more frequent changes may be needed. The elastic or self-adhering wraps are durable, strong, supportive, slightly porous and somewhat water resistant (not water proof).

5. **Additional Support**

   If the wound is over a fracture or luxation that requires more rigid support, a splint can be added between the secondary and tertiary layers. For example there are various sized aluminum rods which are malleable enough to be shaped to the limb while strong enough to provide needed support. A metal coat hanger for smaller animals is another option. There are pre-made plastic devices. Sometimes you just need to use whatever is available! Roll gauze is used to secure it to the area.

D. Just Remember: Not Too Tight, Not Too Loose, Check often!

VI. Specific Wound Treatment Protocols

A. Abrasion

An abrasion implies loss of the superficial layer of dermis. The wound may encompass a small area or be quite extensive. It may be left open to dry and scab or a light non-adherent dressing applied to protect it from the environment, constant licking, and further damage as well as provide pain relief.

B. Bite Wounds

These can result in punctures, crushing, lacerations and avulsions of flaps of skin and other tissue. Often present is the 'iceberg' effect with a small surface wound and great underlying damage. During the slashing action of a bite, a tooth catches the skin and moves through the underlying subcutaneous and muscular tissue. The skin moves with the tooth, causing torn muscles, separated fascial planes, severed vessels and crushed nerves and tendons. The wound is contaminated with oral and dermal bacteria. Wounds over the thorax, neck, or abdomen of a small dog may be the least of the injuries. Evaluation of these patients for underlying damage is important. Bite wounds should be cleansed, debrided, dead space closed or drainage provided, followed by appropriate bandaging. Antibiotics that cover aerobic and anaerobic organisms are given. Analgesics should also be a part of any treatment regimen.

C. Burns

1. Classification

Burn wounds are assessed by the depth of damage to the skin as well as the area affected. Burn wounds are very painful. They require evaluation of extent and injury to other systems as well.

a. Superficial =First Degree

The epidermal layer is affected in these wounds. There is transient erythema and desquamation of cells and the area is hyperesthetic (painful). Hair may be singed but firmly attached. Healing is rapid once epithelial desquamation has occurred.

b. Partial Thickness = Second Degree

There is complete loss of the epidermis and extension to mid-dermis in these wounds. The area is painful but there is also decreased sensitivity. Plasma exudation occurs from dermal capillaries and venules and subcutaneous edema develops. Hair may still be attached or easily epilate, depending on the depth into the dermis. Healing is slow after the damaged skin sloughs.

c. Full Thickness = Third Degree

Both the epidermis and dermis are coagulated and non-viable. There is severe edema of the subcutis. Hair is missing or easily epilates. The skin may be black or pearly white. There is little pain or total insensitivity. Dark brown leathery eschar develops. Healing is slow unless grafting or other surgical wound closure is performed.

2. **Treatment**

Depending on the extent and severity of the burn, there are two areas of approach for patient care. First is the evaluation and treatment of systemic abnormalities (shock, electrolytes, hydration, and respiratory system). Second is the wound management.

a. **First Degree –** A treatment regimen consists of the following:
   i. Analgesics - most efficacious are oxymorphone and morphine
   ii. Antibiotics – systemic and local
   iii. Avoid proximity of wound to heating lamps and pads
   iv. Chilled saline or water – applied to the wound for 20 minutes if within 2 hours of injury. Use caution in hypothermic patients.
   v. Clip the area of hair around the wound carefully and gently cleanse.
   vi. Debride necrotic skin
   vii. Copious lavage with isotonic solutions
   viii. Apply topical agent – silver sulfadiene (Silvadene^{R})
   ix. Apply dressing

b. **Second Degree**
   i. Shock Treatment – isotonic fluids, maintain urine output of 1 ml/kg/hr, body temperature, electrolyte imbalances.
   ii. Respiratory evaluation – especially with burns from fire because of the smoke inhalation or an electrical etiology which can spread throughout the body and affect the lungs.
   iii. NPO for 48 hours
   iv. Delay whole blood transfusions for 24 hours
   v. Analgesics and sedatives if needed
   vi. Wound treatment as above

c. **Third Degree**
   i. Evaluate extent – small wounds may be excised and sutured or treated as above. Extensive wounding carries a grave prognosis and euthanasia should be considered.
   ii. Treat for systemic abnormalities as above.
   iii. Watch for development of septicemia, renal failure, hypoalbuminemia.
   iv. Hydrotherapy in antiseptic solution for wound

3. **Prognosis**

The prognosis for recovery is fair if < 15% of the body is involved. A fair to poor prognosis is given if 15% - 50% of the body is wounded. Any patient with > 50% of the skin burned carries a grave prognosis. Estimation of body percent burned follows the **Rule of Nines**: 9% each forelimb, 9% head & neck, 18% each hind limb, 18% each trunk half (dorsal, ventral)

D. **Chronic Wounds**

Chronic wounds are slow healing or nonhealing wounds. Various stages of granulation, fistulae, or sinus tracts may be present. Non-adherent dressings to protect the vascular bed may be applied while contraction and epithelialization occur. Old granulation tissue will appear faded and dull. Surgical intervention may be needed to complete healing. There may be a foreign body still present which needs to be removed. A bacterial or fungal infection may be present, including osteomyelitis. A culture and sensitivity as well as lavage and drainage may be required to effectively treat the infection.

E. Contusion

Bruising in animals may be difficult to diagnose. The epidermis appears red rather than the purple seen in humans. It is often hidden under the hair. It may be the only evidence of an injury, and examination for underlying damage (fracture, luxation, internal bleeding) should be performed.

F. Crushing

These injuries often have underlying damage that needs evaluation through physical examination, diagnostics (radiographs), and appropriate treatment. The external wounding is usually the 'tip of the iceberg'.

G. Degloving

Evaluate underlying damage through examination and radiographs, then treat the wound. Open wound management with mechanical and surgical debridement, absorptive dressings, and once to three daily treatments as needed. Place a splint or soft padded bandage to support orthopedic trauma.

H. Electrical

The level of damage caused by contact with live wires depends on the current intensity, duration of exposure, and pathway through the body. Contact sites include oral and nasal cavities and skin, especially the paw pads. Lesions appear as pale yellow to tan or gray burn marks. Muscle spasms, abdominal pain, and vomiting may occur. More severe signs include respiratory distress form pulmonary edema, seizures, and cardiac arrest. If patient still in contact with current, it must be shut off/unplugged and then the patient removed from the source. Emergency treatments follow the ABCs: secure airway, 100% oxygen, intubate and IPPV as needed ; treat shock: IV/IO access, fluids with caution if pulmonary edema, diuretics and bronchodilators. Wound treatment includes clip, cool fluid cleanse, debride, systemic and topical antibiotics, open versus closed management, bandaging as possible, and daily reassessment.

I. Frostbite

Peripheral tissues where the hair is sparse and circulation is poor (ear, tail tip, scrotum, mammary glands) are susceptible to freezing temperatures. The skin is pale, hypoesthetic, and cool to the touch. Treatment begins with rewarming of the area using warm water or a warm surface (rather than air warming with a blow dryer). Twenty minutes often suffices. This is painful and analgesics should be administered. The area turns hyperemic and scaliness may appear. Apply aloe vera to the area to decrease vasoconstriction and tissue hypoxia. Avoid tight bandages, debride dead, mummified, or gangrenous tissue. Silver sulfadiazine dressing can also be applied. Some necrotic tissue may actually survive even after 3-6 weeks, so debridement may be delayed.

J. Gunshot/Shotgun

The external wound from a projectile is similar to a puncture wound. It is also usually the 'tip of the iceberg'. The underlying damage ranges from extensive to mild, depending on the velocity, type, and specific tissue damage caused by the bullet. The wounding is contaminated. Treatment of orthopedic damage and internal damage is foremost. Entrance and exit wounds are cleansed and left open to drain and close on their own.

K. Laceration

These wounds are usually obvious. They range in depth from superficial to deep. Hemorrhage control, cleansing, antibiotics, surgical exploration, debridement, and closure are performed.

L. Pressure

Pressure sores are also known as decubital ulcers. They develop over bony prominences from pressure in animals that are recumbent for long periods of time or from cast and bandage sores. Prevention is the best treatment! Proper nursing care and padding are essential. Wound management

1. **Grade I Ulcers**
   These appear dark red and may slough the dermis and upper dermis. They can be treated by cleansing and debridement, then allow it to heal as an open wound.

2. **Grade II Ulcers**
   These have full thickness skin loss down to the subcutaneous fat. They may also be treated as open wounds, with application of wet-to-dry dressings until a granulation bed forms followed by secondary closure.

3. **Grade III Ulcers**
   These extend through the subcutaneous fat down to the deeper fascia. Wound edges may appear undermined. These need debridement of nonviable tissue, open wound management, possibly drains, and secondary closure when ready.

4. **Grade IV Ulcers**
   These extend through the deep fascia down to the bone. Osteomyelitis or septic arthritis may be present. These require excision of infected tissues, open wound management dry-to-dry or wet-to-dry dressings, antibiotics, and secondary closure when appropriate. Skin grafts or flaps may be needed to close the wound.

M. Puncture

Like gunshot wounds, the depth of injury is important in treatment. Superficial wounding is cleansed, flushed, and left open to drain and close. If a puncture is part of a bite wound injury, underlying damage may be extensive. A foreign body may be present deep in the wound as well.

N. Snakebite

Venomous snakebites may result in tissue necrosis and wounds that require surgical reconstruction after treatment. Local signs include two fang puncture wounds (often bleeding), immediate and progressive swelling, tissue discoloration, ecchymoses and petechiae, and severe pain. The severity varies depending on the amount of venom injected and the location of the bite. Systemic effects are shock, lethargy, salivation, painful lymph nodes, weakness, muscle fasciculations, and respiratory depression. Treatment goals are neutralization of the venom, systemic care, and local wound care (debride, cleanse, flush, drain, dress).

VII. Complications

A. Seroma Formation

Underlying ' dead space', especially in areas of movement (under arm, inguinal) may develop fluid build-up, called a seroma.

1. Aspiration and drainage will reveal serosanguineous (red-tinged) fluid. Repeated drainage may be needed, but should be performed as cleanly as possible so as not to introduce bacteria.
2. Bandaging, to decrease space and movement at the site, may also promote scarring and discourage seroma formation
3. Transport to a hospital may be needed to place drains

B. Skin Death

Questionable dermal viability should be left until tissue death is assured. Some areas may survive but not be apparent for several days. Dark purple to black tissue, as well as hard eschar, may be debrided with a sharp blade without analgesia as the tissue has no functional nerve endings. Scissors tend to torque and may be uncomfortable to surrounding areas. Once viable bleeding edges are exposed, healing can begin.

C. Tetanus

Dogs are relatively resistant to the neurotoxin *Clostridium tetani*, an anaerobe found in soil and the GIT. Deep necrotic tissue wounds provide the environment for organism growth. Incubation averages 10-14 days, though may be several weeks in more resistant species. The neurotoxin released causes local stiffness, especially the masseter (jaw) muscles, and muscles of the neck, hind limbs, and infected wound area.

Signs include increased reflex intensity, easily excited by noises into violent muscle spasms, stiffness of affected muscles, difficulty eating ('lockjaw'), and sweating which can be detected on the paws.

Treatment includes tetanus antitoxin, toxoid vaccination (repeated in 30 days), penicillin, and wound treatment consisting of debridement, flushing, and excision of necrotic or suspicious tissues.

D. Patient Health Deteriorization

If a patient continues to deteriorate despite wound treatments, re-evaluate both the wound and the patient.

Signs of deterioration include fever, malaise, anorexia, vomiting, diarrhea, respiratory distress.

Possible complications include sepsis, pneumonia, ARDS, SIRS, and other undiagnosed wound damage.

Diagnostics may require transport to a veterinary hospital, and include blood work, urinalysis, radiographs, ultrasound, advanced wound treatments, and/or surgery.

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Written by Lori E. Gordon, DVM

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ADDENDUM

NERVOUS SYSTEM - VETERINARY NEUROLOGICAL ASSESSMENT

A. Central Nervous System

1. **Head trauma**
   It has been well shown that for head trauma humans and dogs that corticosteroids of any kind of any dose should not every be given. For head trauma the head and neck should be kept elevated by 15%. Systemic blood pressure should be maintained in a normal range, and if the patient is still deteriorating give one gram per pound of 20% mannitol IV over about 45 minutes. Nothing else is of benefit.

2. **Spinal Lesion Characterization** – This are the reflex responses.

   a. **Upper Motor Neuron (UMN)**
   Signs include paralysis (loss of voluntary motor) or paresis (partial paralysis), normal to increased reflexes, normal to increased muscle tone, mild muscle atrophy, decreased sensation, pain, and proprioception.

   b. **Lower Motor Neuron (LMN)**
   This unit consists of spinal cord and peripheral components, so differentiation is made between central cord and peripheral nerve disease. Signs include paresis or paralysis, hyporeflexia or areflexia, loss of muscle tone, early and marked muscle atrophy, decreased sensation, pain, and proprioception.

3. **Injury Severity**
   The more severe an injury, the more neurologic dysfunction occurs. From least to most severe are:

   a. Conscious Proprioception
   These information tracts are located superficially in the white matter and are therefore most vulnerable to injury. They relay information to the brain regarding orientation and movement of muscles and joints. The patient should be able to right the toes when they are placed on their dorsal surface.

   b. Voluntary Motor
   This is the conscious effort and successful ability to move a limb or joint. While supporting an animal they should be able to move a joint or limb on their own.

   c. Superficial Pain
   These tracts are deeper within the white matter, carrying information regarding cutaneous sensation to the brain. Reaction to skin pain is an indication of the integrity of these tracts.

   d. Deep Pain
   These nerve tracts are dispersed throughout the white matter and are the most resistant to injury. They conduct painful stimuli in structures below the skin. They are the last to go and the first to return when improvement of neurologic function occurs.

4. Lesion Localization

a. Brain
Signs include mentation abnormalities, cranial nerve deficits, seizures, and cerebral lesions that often lateralize as hemiparesis.

b. Upper Cervical C1-C6
Lesions can be seen as UMN to front and rear limbs, hyperpathia (exaggerated pain response), or as a root signature. This involves pain associated with neck motion due to trauma of the spinal nerve or nerve root without neurologic deficits.

c. Cervicothoracic C7-T2
Lesions involve the brachial intumescence. Gray matter damage affects the brachial plexus (front limbs); white matter damage affects the rear limbs. Tetraparesis/paralysis, LMN fore and hindlimbs, Horner's Syndrome (T1-T3).

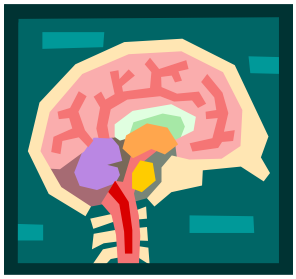
d. Thoracolumbar T3-L3
Lesions have normal forelimbs, paresis/paralysis of hindlimbs with normal to UMN reflexes, depressed postural reactions, and depressed pain perception. Spastic bladder consisting of frequent, inadequate, squirting discharge of urine and manual expression is difficult. Schiff-Sherrington Syndrome is a severe cranial thoracic cord lesion. Extensor rigidity of the forelimbs with hypotonia and normal to hyperreflexia of the hindlimbs occurs.

e. Lumbosacral L4-S2
Lesions of the gray matter of the lumbar intumescence cause LMN signs of the hindlimbs. There can also be hyporeflexia of the perianal reflex, hypopathia, and flaccid anus. The bladder retains urine and overflow leads to dribbling. The bladder is easily expressed.

f. Sacral S1-S3
Lesion will have normal forelimbs and may have normal hindlimbs. Potential abnormalities include sciatic release, where the patella reflex will be exaggerated, and cranial tibial hyporeflexia. LMN bowel and bladder can also occur.

g. Caudal Cd1 to end of tail
Lesions may occur with a tethering injury, where the tail is caught or pulled and the cauda equina is damaged. There is loss of tail sensation and movement. Flaccid anus or decreased anal tone as well as LMN bladder may be seen if the lesion includes sacral segments.

h. Myelomalacia
The complete destruction of a central cord(s) segment. This is the result of severe trauma or an explosive disc extrusion from severe trauma. Disintegration of the cord continues in ascending and descending directions. Signs occur as cord areas are affected. Eventually respiratory paralysis occurs. There is no treatment.



B. Peripheral Nerves - Head and Neck

Injury to these areas can cause damage to the peripheral nerves lying underneath. These are known as focal traumatic neuropathies.

1. Vestibulocochlear Nerve Injury

This is associated with blows to the side of the head and fractures of the petrous temporal bone. Most consistent signs are blood in the external ear canal and head tilt toward the affected side. Other signs include circling, rolling, or falling toward the side of the lesion, horizontal or rotary nystagmus with fast phase away from the affected side. Facial nerve paralysis may occur as well. Wound care and anti-inflammatory medications are primary treatments. With tincture of time various levels of neurologic improvement may occur.

2. Facial Nerve Injury

This is associated with trauma in two areas: the middle or inner ear region and the side of the face or base of the ear. Deficits include inability to move the eyelid, lip, or ear on the affected side. Damage at the middle ear level produces additional signs of Horner's Syndrome (ptosis, miosis, and enophthalmos) in the eye on the damaged side. Wound care and anti-inflammatory medication are primary treatments. Tincture of time is the treatment of choice for middle ear facial nerve injury recovery.

**Note: inner ear infection, which can have similar signs to inner and middle ear trauma, will not have Horner's Syndrome, facial paralysis, or evidence of trauma.

3. Trigeminal Nerve Injury

Bilateral injury can occur with traumatic temporomandibular joint subluxation. This is diagnosed when, after joint reduction, the animal loses ability to close the jaw or chew. Most improve over 3-4 weeks and can lap liquid gruel in the meantime.

4. Recurrent Laryngeal Nerve Injury

This is associated with trauma to the neck region. These nerves originate within the chest cavity, coursing along the trachea as they ascend to reach the larynx. Each recurrent nerve terminates in the laryngeal muscles. Cervical trauma anywhere along the neck may injure these nerves, which may cause laryngeal paralysis. The inability to abduct one or both arytenoid cartilages, necessary for proper air passage into the trachea, leads to signs of upper respiratory obstruction: noisy breathing, exercise intolerance, laryngeal stridor. Severe signs include inspiratory distress, severe dyspnea, cyanosis and collapse. Signs increase in severity during times of stress, heat, and activity when increased inspiratory ability is needed. Treatment depends on the severity of signs which are related to the degree of paralysis, unilateral versus bilateral. Keeping the animal cool, calm, and quiet may be sufficient. Life threatening signs ideally require surgical intervention. Options for temporary relief in an emergency situation include intubation and temporary tracheostomy.

C. Peripheral Nerves - Spine

Injury to any extremity may include peripheral nerve damage. These are known as focal traumatic neuropathies of the spinal nerves.

1. **Suprascapular Nerve Injury**
   This can occur as it crosses the cranial border of the distal scapula (neck area). There is minimal gait deficit. Over time atrophy of the supraspinatus and infraspinatus muscles result, resulting in cosmetic defects than functional ones.

2. **Axillary Nerve Injury**
   This can occur as it crosses the neck of the scapula. There are no gait or spinal reflex abnormalities, only a sensation loss on the dorsolateral aspect of the brachium.

3. **Musculocutneous Nerve Injury**
   This is associated with trauma to the medial aspect of the brachium. Loss of elbow flexion is the deficit.

4. **Radial Nerve Injury**
   Distolateral humeral and lateral elbow trauma can cause injury to this nerve, which is responsible for all extensor motor function of the elbow, carpus, and digits. Also, sensation deficits to the cranial aspect of the limb from elbow to digits are indicative of injury.

5. **Median and Ulnar Nerve Injury**
   These both course along the medial aspect of the forearm. Flexion of the carpus and digits would be lost with injury, as well as sensation along the caudal aspect of the forearm from elbow to digits.

6. **Brachial Plexus Injury**
   Causes of this include automobile accidents, gunshot, axillary foreign bodies, fall or jump from moving vehicle. The most common signs are loss of elbow and digit extension, forepaw knuckling, inability to bear weight on the limb. Extensive injury may cause ipsilateral Horner's Syndrome and loss of panniculus reflex.

7. **Sciatic Nerve in Hindlimb Injury**
   This is the most common nerve injury of the pelvic limb. It is associated with fractures of the ilium and proximal femur. Stifle flexion is lost, the tarsus is dropped, and there is knuckling of the digits. Sensory loss occurs below the stifle except medial digit area.

8. **Peroneal and Tibial Nerve Injury**
   These can be individually injured and produce the signs listed in the tables at the end. The peroneal (fibular) nerve runs along the cranial and dorsal limb below the stifle. The tibial nerve runs along the caudal and plantar surfaces.

9. **Lumbosacral Plexus Injury**
   This is rarely seen. Signs of femoral and sciatic nerve injury are observed.