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The Possible Risk Factors for Bone Fractures in Animals and Management of Pre and Post -Operative Pain

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Abstract

The occurrence of fractures is more when the forces acting on the bone exceed its ultimate strength. The type of fracture depends on the magnitude, rate, and direction of the force applied and also on the shape, size, and structure of the bone involved. The predisposing factors may be bone neoplasia, generalized bone disease, bone defects, and a history of previous fractures, the possible forces resulting in fractures may be torsion (leading to spinal fractures), compression on bending forces leading to oblique fracture with/without comminution, shearing forces leading to transverse fractures. These bone fractures may be oblique/transverse/comminuted / Spinal/segmental.

Fractures in small animal patients represent a challenging combination of orthopedic and soft-time injuries. When compared to closed fractures the proportion of risk factors for open fractures is more. Open fractures are typically the result of high-energy trauma. Sexually intact dogs & cats are at high risk for fractures than sterilized animals as they tend to roam which may increase the likelihood of a traumatic event. Younger age was a significant risk factor for the occurrence of open fractures because of the more active nature of the puppies and kittens. This is because the physical properties of a more mature skeleton influence fracture configuration and thus the likelihood of an open fracture. Body weight was found to be a risk factor for open fractures in dogs after adjusting for age, breed, and neuter status. The force or energy necessary to fracture a bone in large dogs is more likely to be sufficient enough in larger dogs relative to the force or energy necessary to fracture a bone in smaller dogs. Comminuted was the only fracture configuration found to be a significant risk factor for an open fracture as it results due to higher energy and higher velocity trauma that causes soft tissue damage and more fracture fragments. Pain is a multi-dimension experience and its response is unique to each individual and involves two components as sensory component i.e., nociceptors, which is the neural processing of new noxious stimuli, and the effective component i.e., pain perception, which is the unpleasant sensory and emotional experience associated with either actual or potential tissue damage. Pain management is central to veterinary practice, alleviating pain, improving patient outcomes, and enhancing both, the quality of life and the veterinarian–client–patient relationship. Nociceptive pain, pathological pain, and maladaptive pain are the various dimensions of pain perceived by the animal.

For managing pain, non-steroidal analgesics can be used alone, but they are also synergistic with other analgesic drugs (opioids) or modalities (local, regional, and epidural analgesia). The NSAI Analgesics are inhibitors of cyclo-oxygenase (prostaglandin synthases) which catalyzes the incorporation of molecular oxygen into arachidonic acid. Fentanyl patches, butorphanol, and buprenorphine are opioid analgesics used for perioperative pain management. For spinal, pelvic & high comminuted hind limb fractures, epidural administration of 0.5% bupivacaine at induction can provide profound hind limb analgesia post-operatively for up to 24 hours

CRI (Continuous Rate Infusion) analgesia plays a key role in pre-operative, intra-operative, and post-operative situations, preemptive analgesia achieved in various ways has reduced the post-operative analgesia demand.

Keywords: *orthopedic, drugs, Spinal/segmental, injuries.*

Introduction

Fracture of long bones is a common orthopedic condition noticed in dogs. Fractures occur when the forces acting on a bone exceed its ultimate strength. Identifying a fracture as the cause of non–weight bearing lameness is usually straightforward. The challenging problem is to assess the patient, classify the fracture, and develop plans for fixation that will allow predictable and consistent results. Fractures in small animal patients represent a challenging combination of orthopedic and soft-time injuries

The type of fracture depends on the magnitude, rate, and direction of the force applied and also on the shape, size, and structure of the bone involved. Fractures are classified to allow accurate communication with the owners and colleagues and to aid in planning the appropriate treatment. Both the animal's limb and the radiographs are evaluated to clarify the fracture accurately according to whether the fracture is open to the environment, the degree of damage and displacement of the fragments, the type of fracture, the location of the fracture, and whether the fragments can be reconstructed to provide load bearing.

Depending upon the communication with the external environment, fractures may be closed or open. When compared to closed fractures the proportion of risk factors for open fractures is more. Contamination, and disruption of soft time integrity and blood supply, increase the risk for infection, delayed union, and non-union of bone. Open fractures are typically the result of high-energy trauma. Open fractures can be further categorized based on the mechanism of puncture and the severity of soft tissue injury, as Grade –I, Grade– II, and Grade – III. Grade – I open fracture has a small puncture wound on the skin caused by the bone penetrating to the outside. Grade – II involves more soft tissue damage with a variable amount of skin wound, which may be due to external trauma. Grade–III open fracture has served bone fragmentation associated with extensive soft tissue injury with or without skin loss. These fractures are usually high-velocity communicated fractures such as gunshot injuries or sharing types of injuries of the distal extremities (Fossum,2013).

Depending on the extent of the cortex involved, fractures may be complete or incomplete. A portion of the cortex is intact in green stick fracture, thus stabilizing the bone to some extent. When the insertion portion of a ligament or a tendon is fractured and distracted from the rest of the bone, avulsion fractures may occur.

Fractures may be displaced or non-displaced. The orientation and the number of fracture lines determine the type of fracture. Transfer fracture results when the fracture line is perpendicular to the long axis of the bone. Oblique fracture lines run at an angle to the perpendicular line to the long axis of the bone. It may be short oblique or long oblique. Spinal fractures wrap around the long axis of the bone. Single fractures have one fracture line whereas communicated fractures have multiple fracture lines, communicated fracture range from three–piece fractures with a butterfly fragment to highly communicated fractures with five or more pieces. Based on the number of fragments, fractures may be classified as reducible or non-reducible, and fractures may be further classified as diaphyseal, metaphyseal, or physeal based on location.

The degree of instability depends on the severity of the fracture. The degree of load sharing between implants and the bony column also influences complication rates. Ideal load sharing occurs when a transverse fracture is repaired because much of the force is transmitted axially through the limb loading of the implant is minimized, so loosening and fatigue failure are less likely, conveniently, when loads are transmitted from bone segment to bone segment through implants rather than through the bony column, (segmental bone reactions and limb – lengthening procedures) implant loosening and fatigue failure are more common. The complication occurs more frequently when stresses are applied and implants are heavily loaded immediately after surgery.

The possible etiological features for the fracture may be direct trauma which may be due to a road traffic accident, gunshot, or compression which may be due to a fall from height or shearing forces such as a trapped limb, or it may be due to severe dog bite wounds leading to fractures in young puppies or kitten or abuse. These bone fractures may be

oblique/transverse/comminuted/Spinal/segmental.

The forces acting on the bone also play a major role. Torsion forces result in spiral fractures, and shearing tension or bending forces results in transverse fractures. Compression or bending forces result in oblique fractures with or without comminution. High energy stress such as RTA or ballistic often causes severe communication and damage to surrounding tissue, sometimes variable fracture patterns result due to a combination of the above forces usually acting in any one instance. Compression forces acting on the vertebra may cause compression fractures. Depression fracture occurs in the bone resulting in concave deformity of the bone. Impaction fracture occurs when the fractured bone ends are driven into one another.

An open fracture is one in which fractured bone is exposed to environmental contamination that results from disruption of soft tissue integrity. Traumatic fractures of the appendicular skeleton are a common cause of muscular skeleton disorders in small animals, comprising almost 30 % of all appendicular diagnosis (Johnson *et al. (*1994). The establishment of the proportion of open fractures and risk factors associated with open fractures is the first step in identifying characteristics that may help guide treatment and increase the likelihood of a successful outcome.

Risk Factors

Risk factors are evaluated such as characteristics of the animal like age, sex, neuter status, body weight, and breed and characteristics of fracture as affected bone segment, location of the fracture on bone, configuration of fracture, and type of trauma.

Age

Younger dogs are more likely to have a traumatic fracture, however of those with a traumatic fracture, older dogs were more likely to have an open fracture. It may be possible that the physical properties of a more mature skeleton influence fracture configuration and thus the likelihood of an open fracture (Millard *et al*. (2014). Young animals of age less than 6 months are more prone to long bone fractures. Mohiuddin *et al*.(2018), also reported a higher frequency of fractures in newborn calves and cats as these animals tend to be energetic and playful, which may contribute to their decreased bone density and stiffness, or it may be a result of their immature skeleton.

In dogs with osteopenia bones, most of the fractures are recorded during the first 6 months of life, in particular between 2 to 4 months of age (Kumar *et al*. 2007). As most of the bone growth occurs duly this period (Braden, 1993), the dogs may be most vulnerable to a variety of developmental/ metabolic bone diseases. Very young dogs, less than 2 months are relatively less prone to get injured, as they are normally protected in the early age of life and their bones are less brittle and more flexible.

Young growing dogs are more prone to multiple fractures. The inherent weakness of bone in their growing stage with a premature skeleton was the predisposing cause of fracture as observed by Kumar *et al.* (2007). Furthermore, young animals are still precocious and inexperienced, especially around automobiles and heights, two of the leading causes of fracture. (Kolliampur. *et al.* 2018). In most of the skeletally immature dogs less than 6 months of age, the bones were osteopenia characterized by reduced cortical density. Mineral imbalance and Vitamin D_3 deficiency stimulate the release of parathyroid hormone, leading to the demineralization of long bones (Rosal and Capen, 1997) and thus predisposing them to fractures (Sato *et al.* 1999). This may be factored by the multiple traumas, automobile accidents, and immature skeletal., system, compounded by improper dietary, supplementation of minerals leading to multiple fractures (Kallianpur *et al.* 2018). In the study of Minar *et al* 2013, almost 50% of fracture occurred at less than one year of age and 65 % of the patient was less than 3 years old. The younger dogs were in the developmental stage, having soft bone in the osteogenesis stage, which was fragile to have fractures with some forces (Shapino 2008). Higher incidence of fractures in young animals is mainly due to the hyperactivity of these animals making them more vulnerable to trauma (Vani *et al.*2022)

Sex and Neuter status

The proportion of open fractures in dogs and cats was higher in sexually intact animals. This result is supportive of a commonly observed association between sexually intact animals and the prosperity to roam, which may increase the likelihood of a traumatic event. In the study of Akter *et al.* (2022), male calves are more prone to fractures because of their lively natural behavior and wandering behaviors. On another hand, the study by Jain *et al.* (2014) revealed that female cats had a higher incidence of fractures than male cats which may be due to the result of negligence or attacks by other animals. In the study of Kallianpur *et al.* (2018), and Vani *et al.* (2022) majority of fractures were recorded in male dogs. The higher male pet dog population owing to the straying nature of males and their aggressive temperament

may be the factors that led to increased incidence of fractures (Aithal *et al.* 1999). Dvorak *et al.* (2000) recorded many more fractures in male dogs probably because males are metabolically more active than their female counterparts. Minar *et al.* (2013) reported more no of fractures in male dogs than in female dogs.

Body Weight

Body weight is also found to be a risk factor for open fractures in dogs, after adjusting for age, breed, and neuter status. The heaviest groups of dogs were approximately 4 to 5 times as likely to have an open fracture, after adjusting for age, breed, and neuter status. The possibility that the force or energy necessary to fracture a bone in larger dogs is also more likely to be sufficient enough to disturb the soft tissue envelope in larger dogs relative to the force or energy necessary to fracture a bone in smaller dogs. In the study of Minar *et al.* (2013), fractures were found in dogs weighing less than 5 Kg.

Breed

Vani *et al.* (2022) recorded a higher incidence of bone fractures in the mongrel breed and this may be due to its higher population in that particular locality and the free-living nature of the animals making them more prone to road accidents. In the study of Millard and Weng (2015), an attempt was made to identify a breed or group of breeds that have an increased risk of occurrence of open fracture secondary to trauma. Indigenous or local breeds of bovine calves and cats had the highest frequency of long bone fractures. (Akter, 2022 Jenni, 2014) as these local breeds may experience the highest rate of fractures as a result of their excessive jumping and playing. Raghunath *et al.* (2007) and Bishnoi *et al.* (2013) discovered the highest incidence in cross-breed bovine calves. Also, it is thought that Indian spitz and non–descript dogs are allowed free roaming and hence are prone to injury (Aithal *et al.*1999). A study in a different locality by Ramesh (2011) also reported non–descript dogs as the highest breed presented followed by Indian spitz. (However, there was no significant relationship of the breed with other parameters hypothesized). In the study of Kumar *et al.* (2007), the highest occurrence of fractures is in spitz and in indigenous dogs, which may be attributed to the large population in their locality.

Season

The summer season had the highest frequency of fractures in calves (Mohiuddin *et al.* 2018) when compared to the winter and rainy seasons. Kolliampur *et al.* (2018) reported a lower frequency of fractures in winter which may be due to the reluctance of the client to present the case at the referral center owing to the harsh climatic conditions in their region. Sedentary behaviors of dogs during winter are an alternate hypothesis for the decreased occurrence of fractures (Minar *et al.* 2013). In the study of Minar *et al* 2013, many causes of the fracture had related to door activity, it was the summer and fall when the fracture most often happened as the pet owners feel reluctant to take their pets outside in winter & rainy seasons because of the chilly weather and rain.

Affected bone segment

Puppies are most affected by femoral fractures due to low bone density in their development (osteogenesis) (Libardoni *et al.* 2018) phase as these bones are fragile even for minor trauma (Miner 2013) and due to lack of ability of the puppies to avoid trauma (Vidane *et al.* 2014). Akter *et al.* (2022) documented more than no metatarsal bone fractures in calves as these are most frequently brought on by severe traction during birth, car accidents, unintentional falling or jumping, and abuse beating (Ali 2013). Cats are more prone to femoral bone fractures (Rani 2007, Ragunath *et al.* 2007) because of eccentric loading of the femur during weight bearing and spastic muscle contractions. Puppies are more prone to proximal or distal physeal femoral fractures whereas metaphyseal and diaphyseal fractures or more common in mature patients (Libardoni *et al.* 2018). Fractures involving pelvic limbs were more frequently recorded than those involving pectoral limbs (Kumar *et al.* 2007). In contrast to the scapula, the pelvis is fixed rather rapidly and hence more likely to sustain an injury during a fall or an automobile accident. (Aithal and singh 1999). Singh *et al*. (1983) believed that more fractures occur in the hind limbs because animals are slower to react to their hind limbs. A higher incidence of fractures (67.5%) was recorded in femoral bone in the study of Vani *et al.* (2022), which may be because of counteracting pulls of flexors and extensors muscles which act antagonistically

Etiology of fractures

Accidents and falls may be the most frequent causes of femoral fractures in dogs and cats (Libardoni *et al* 2018). Traumatic events are the main cause of orthopedic disorders in dogs and cats (Streeter *et al.* 2009, Elzomer *et al.* 2014) and fractures result mainly from can accidents (Vidane *et al.* 2014) ballistic projectiles, fights, and falls (Kumar *et al.* 2007). The high incidence of car accidents was due to the high number of both, animals with access to public roads and owners who suppress the containment and protection measures in their homes and during

outings (Libardoni *et al.*2016). In the study of Kollianpur *et al.* 2018, the leading cause of fractures of long bones was automobile accidents. The high vehicular flow in the city and the housing conditions in the locality may be a major reason for this, with a tendency for active territorial male dogs to jump from heights while chasing monkeys. An alarming number of fractures, due to abuse or malicious injury also indicate mistreatment of animals (Surbhi *et al.* 2011).

Kumar *et al.* (2007) reported an increased occurrence of fractures probably due to an increased population of dogs, increased vehicular traffic, and greater awareness among the dog owners of the veterinary services available. In the study of Minar *et al.* (2013) fractures are caused mostly by being hit by a car, followed by falling, trauma, and being struck by a door. Pelvic fractures are accounted for approximately 25 % of all fractures in dogs. The study by Vani *et al.* (2022) revealed that 42.3% of the etiology of fractures was due to automobile accidents which may be due to the active nature and managerial negligence.

The force or energy necessary to fracture a bone in large dogs is more likely to be sufficient enough in larger dogs relative to the force or energy necessary to fracture a bone in smaller dogs. Comminuted was the only fracture configuration found to be a significant risk factor for an open fracture as it results due to higher energy and higher velocity trauma that causes soft tissue damage and more fracture fragments. Calves are more prevalent for transverse fractures. (Sinum *et al.* 2011 and Minar *et al.* 2013) reported a higher incidence of oblique and femoral fractures in calves which suggests that bending or compression forces are the main forces acting on the long bone. (Samad *et al.* 2019). The distal fracture was the most common in long bone fracture (67%) followed by middle and proximal fracture. The simple fracture of extremities (84%) was more overwhelming than the commnuited (16%) fracture. The most common commnuited fracture was the digital tibia or fibula followed by the femur.

In the case of osteopenic bones, fractures are recorded almost with equal frequency along the whole length of the long bones, suggesting that the stress is distributed equally along the length of the osteopenic bone, possibly due to material property differences (Aithal *et al.* 1999). Pelvic fractures were often multiple fractures. The strong impact can cause complicated pelvic fractures by destroying the multiple connections of the pelvic structure (Harasen *et al.* 2007).

Pain Management

Most orthopedic surgeries are considered moderately to severely painful. Pain is a multi-dimension experience and its response is unique to each individual and involves two components as sensory component i.e., nociceptors, which is the neural processing of new noxious stimuli, and the effective component i.e., pain perception, which is the unpleasant sensory and emotional experience associated with either actual or potential tissue damage. Pain management is central to veterinary practice, alleviating pain, improving patient outcomes, and enhancing both, the quality of life and the veterinarian–client–patient relationship (Epstein *etal.,.,* 2015). The management of pain requires a continuum of care that includes anticipation, early intervention, and evaluation of response on an individual–patient basis. Depending on the expected time, the pain may be classified as acute or chronic pain. Nociceptive pain, pathological pain, and maladaptive pain are the various dimensions of pain perceived by the animal. These patients benefit from perioperative analgesics. The perioperative analgesic should be selected in such a way that the projected level of post-operative discomfort and the duration of discomfort should be met. Anesthetic protocols should be chosen based on signalment, physical examination findings, and laboratory analysis. Balanced anesthetic protocols that include analgesic agents supplemented with epidural analgesia are recommended to decrease intra-operative pain response and reduce the amount of anesthetic needed. For spinal, pelvic & high comminuted hind limb fractures, profound hind limb analgesia post-operatively for up to 24 hours, Epidural anesthesia with lidocaine or bupivacaine or ropivacaine in combination with general anesthesia provides profound relaxation by temporarily paralyzing rear limb muscles, easing fracture reduction of the pelvis, femur, and tibia fibula, Morphine or buprenorphine can be added to the epidural injection, providing post-operative pain relief for up to 24 hours. In patients undergoing surgery of the forelimb, brachial plexus block with local anesthetics will provide additional analgesia and muscle relaxation.

For managing pain, Non-steroidal analgesics can be used alone, but they are also synergistic with other analgesic drugs (opioids) or modalities (local, regional, and epidural analgesia) depending on the severity of the animal's pain. Fentanyl provides immediate relief. Fentanyl patches, butorphanol, and buprenorphine are the opioid analgesics used for perioperative pain management (Monteiro, and Steagall 2017) Opioid analgesics should be

administered for at least 12 to 24 hours after surgery, depending on the procedure and results of serial patient evaluations. Buprenorphine or butorphanol is often sufficient for patients undergoing procedures requiring minimal tissue manipulation. Hydromorphone or morphine is recommended in more painful full procedures like triple pelvic osteotomy (Fossum,2013).

The NSAID analgesics are inhibitors of cyclo-oxygenase (prostaglandin synthases) which catalyze the incorporation of molecular oxygen into arachidonic acid. NSAIDS such as flunixin, meglumine, carprofen, ketoprofen, meclofenamic acid, and phenylbutazone can be used for post-operative pain management. Post-operative management should be directed toward allowing early pain-free controlled mobilization of the limb to prevent 'fracture diseases" like joint stiffness, osteoporosis, and muscle atrophy. Pre-emptive pain relief provides superior post-operative analgesia. The onset of NSAIDs is 30 minutes to an hour. An advantage of these drugs is that they provide sustained relief and their duration of action is 12-24 hours. Carprofen and Derocoxib are effective for post-operative pain relief in dogs, given before surgery. If blood loss is anticipated, it is prudent to reserve NSAIDs for post-operative administration. Depending upon the NSAID chosen, there may be some inhibition of platelet function. Although Carprofen and meloxicam inhibit Cox-1, and thus platelet function, it is reasonable to wait until the post-operative period to add one of these to the pain protocol. Ketoprofen, Phenyl butazone- nonselective Cox inhibitors are contraindicated for surgical procedures, in which hemorrhage is anticipated (Mathews 1996). NSAIDs should not be used in patients with marked hypotension, renal or hepatic disease, or severe pulmonary disease (especially asthmatic patients). NSAIDs can be continued orally for several days after surgery to provide pain relief after the animal has been discharged.

CRI (Continuous Rate Infusion) analgesia plays a key role in pre-operative, intra-operative, and post-operative situations, pre-emptive analgesia achieved in various ways has reduced the post-operative analgesia demand.

Physiotherapy in the form of "cold" therapy can begin the day after surgery to help reduce swelling and pain. Heat therapy can be started 48 hours after surgery or on the day of the Robert Jones bandage. PROM (Passive Range of motion) exercises can be started from day one post-operatively, till the day the bandage is removed. Dogs undergone orthopedic surgery of limbs can be well padded with Robert Jones Bandage as it is useful in reducing post-operative edema and pain. Weight shift exercises are a good safe way to encourage controlled loading of the operated limb from 0-6 weeks post-operative period. Once the radiographic signs of fracture healing are evident at the 6-8 weeks post-operative controlled exercise may be started and the exercise can be increased slowly by 10-15 minutes a week during 8-12 weeks post-operatively. Deep water swimming for 10-15 minutes several times a week is an excellent therapy at this stage.

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