Fractures

Definition: Break in the continuity of bone.

Etiology

***A- Predisposing causes* : -** pathological or physiological alterations in bone tissue as: osteosarcoma, osteoporosis, osteodystrophyfibrosa, rickets, osteomalacia, osteomyelitis, vitamin & mineral deficiency, lactation etc.

***B- Exciting causes* : -**

1- Direct: accident, trauma, falling on hard surface, slips, forcible releasing of stucking limbs etc.

2- Indirect: incoordinated muscle contraction (remote), force applied some distance from the actual site of fracture (e.g. fracture of femoral neck occurs due to fall on the extended rear leg), repeated stress etc.

Classification

Degree of bone damage:-

A- Incomplete fractures: common in young animals & characterized by partial breach in bone integrity & minimal displacement. This type is subdivided into : -

1- Green-stick fracture
2- Splintered fracture
3- Fissures
4- Star fractures
5- Subperiosteal fractures:

B- Complete fractures: *according to the direction of the fracture line:-*

1- Transverse 2- Oblique 3- Spiral or screw-like

According to displacement:-

1- Dentate fractures 2- Overlapping fractures 3- Distracted fractures
4- Depressed fractures: in flat bones (skull).

- According to the severity of fracture & nature of skin:-

1- Simple or Closed (skin is intact). It may be- * Single, when the bone is fractured at one place.

*** Comminuted, presence of 1 – 3 bone fragments at the site of fracture, & all of them meet at a common point.**

- *** Multiple, or fragmented fractures are those in which bone is broken into 3 or more segments. Skin may be still closed.**
- **2- Compound or Open: skin opened & breakdown of bone.**
- **3- Complicated fracture: bone fractured with destruction of other vital organ.**
- ***- According to location of fracture:-***
- **1- Diaphyseal; occurs in the midshaft near the axial centre of diaphysis.**
- **2- Metaphyseal; fracture within the anatomical metaphysis of long bone .**
- **3- Epiphyseal; occurs in mature animal after closure of epiphyseal plate .**
- **4- Condylar fracture; in either medial or lateral condyle or in both.**
- **5- Articular fracture; which may involving subchondral bone & articular cartilage.**

Clinical symptoms

- **1- Pain:** This may be only clinical indication in incomplete fracture.
- **2- Inability to bearing its weight.**
- **3- Deformity.**
- **4- Crepitating sound (Crepitus).**
- **5- Loss of function:** complete bone fractures results in marked dysfunction of the affected part than in cases of incomplete fractures.

Diagnosis

- 1- Case history.
- 2- Clinical symptoms.
- 3- X – ray: at least two views including joints above & below the fracture are obtained to help in diagnosis.
- *Prognosis*: depend upon age of the animal, species, nature & location of the fracture, nutritional status of the animal, therapeutic method & timing of surgical interfere.

** Factors enhance healing process:

1- *Species & Age*: healing is easier obtained in small animal than in large ones & sooner in young animals than in old.

2- *Type of fracture*: simple closed is more satisfactory healed than complicated types.

3- *Light & Docile animal*, showing good healing results.

4- *Condition of animal*: a good healthy animals, giving adequate nutrition showing rapid healing process than those suffering from longstanding or deficiency disease.

N. B.

Complete fractures in equine & large bovine especially those located above the carpal & tarsal joints are difficult to be treated & slaughtering is to be advised in such cases.

Treatment

A- First aid:-

1- Avoid unnecessary handling of the patient.

2- Treatment of shock & prevent hemorrhage if present.

3- Removal of contaminated & necrotic tissues.

4- Reduction & immobilization of the fractured ends.

B- Surgical interference

1- *Reduction*: i.e. reposition of displaced fragments to their normal position as nearly as possible. It can be carried out either by :-

- **a) Close manipulation (manual), traction, counteraction, rotation & other movements are applied, placing splinters in a normal position.**
- **b) Open approach, operation to expose the fracture site & manipulation of the fractured ends to bring them in apposition. Complete muscle relaxation is required & this can be achieved by the use of muscle relaxant, general or local anaesthesia.**

2- *Immobilization or Fixation*: i.e. holding the fractured ends together until clinical union is obtained.

Immobilization or Fixation

a) Indirect method (External fixation)

using splint & bandage. Splints may be wooden strips, pliable metal, plastics, Plaster of Paris (Gibsona), Plaster of Paris & gutters without padding, adhesive tape, gum & starch bandages, char, x-ray films etc.

Points considered in this type of immobilization :

* *Sufficient padding should be used to prevent further damage to soft tissues .*
* *Over padding should be avoided as it might impair immobilization*
* *The cast or splint should be accurately moulded to the configuration of the limb.*
* *joints above & below the fracture site should be incorporated in the cast.*
* *After applying the cast, the reduction should be checked by radiography in two different planes.*

** Modified Thomas splint:

it is indicated for fixation of stable fracture after reduction & to support fixation in combination with other types of fixation in joint, tendon, or nerve surgery. It is made from metal rods in diameters of 3\16, ¼ & 3/8 of an inch.

b) Direct method (internal fixation), the following methods are generally used:-

*** Extramedullary : using screws, plates & wires . Stadar splint & Kirschner/ Ehmer splint (K/E) are also used .**

*** Intramedullary: using bone pinning & bone grafting. There are different kinds of pins:-**

- **Steinman pins**
- **Rush pins**
- **Kuntscher nail**
- **Kirschner wire.**

Healing of fracture

Repair of the bone after fracture is by: callus formation- primary bone healing (Osteosynthesis). The process of healing can be divided into 4 stages:-

1- Stage of hematoma:

2- Stage of primary callus:

3- Stage of consolidation:

4- Stage of resorption, replacement & remodeling:

Complication of fractures

A- Immediate complications: - ***Injury to major blood vessels, nerves or vital organs; involvement of joints.***

B- Following complications: -

1- Fracture disease, *atrophy of muscles and stiffness of joints after long immobilization by external fixation.*

2- Infection of the fracture site, ***in cases of open fracture resulting into delayed union or non-union of the fractured ends.***

Treatment ***is by antibiotic sensitivity of the pyogenic organism & administration of effective antibiotics – Removal of dead bone (sequestra) or any foreign material in the fractured area, & then use of rigid & uninterrupted immobilization of the fractures.***

3-False joint (pseudoarthrosis):

* *Causes of false joint*:

a) Imperfect reduction & immobilization; interposition of soft tissue, stripping of periosteum.

b) Infection of bone, prolonged suppuration in open fractures.

c) Impaired process of bone regeneration.

d) Heavy doses of steroid.

* *Symptoms*: *abnormal motility; bowing at the fracture site; absence or minimal production of soft tissue callus at the fracture site; deformity & absence of inflammatory* response.

* *Treatment*: a) Operative, *it consists of resection of the fragment ends & promote osteosynthesis.* b) Use of bone grafting.

4- Faulty callus formation (malunion):

due to faulty reduction & immobilization. It may be result in shortening as the two ends united with over-riding manner. The condition is corrected by refracturing the bone & proper reposition.

 # Complication of bone pinning:

1- Aseptic & septic osteomyelitis.

2- Animal lick nail due to irritation.

3- Rejection of nail.

4- Rotation of distal part.

5- Lameness.

Affections of joint

* **Anatomy of typical synovial joint:** the major anatomical constituents are:-

1- Epiphyseal & metaphyseal ends of bone.

2- Joint cartilage.

3- Joint capsule.

4- Ligamentous system.

5- Synovial fluid.

6- Receptors & blood-lymph vascular system.

7- Periarticular tissues.

Effects of trauma on joint area:

*- Wounds of various types.

*- Contusions associated with hematoma (hemarthrosis) & sprain.

Penetrating wound (open joint)

the joint may be opened at the time of wounding at its level or later on due to infection & rejection of slough (dead tissue) above the joint .

* Diagnosis: In recent cases, oozing of the synovial fluid which flows copiously on active & passive movements of the joint;

Penetrating wound (open joint)

-foaming of the discharge due to sucking of air in the joint takes place.

-Probing of recent open joints is not recommended because of fear of introducing infection.

-The interior of the joint may be visible when the wound is gaping.

-There is no or little evidence of local inflammation.

In old septic cases, the joint becomes tense, swollen & painful with little or no weight can be born on the limb.

-The suppurative process extends deeply into the joint & articular cartilage becomes eroded & finally destroyed.

-Delayed therapy leads to exhaustion & proved fatal.

-Death from septicaemia or toxaemia is common.

Treatment

- *1- Keep the articulation at rest to permit rapid closure of the fistula.*
- *2- Application of antiseptic on the principles already laid down in the treatment of open wounds.*
- *3- If the wound is clean cut, it is sutured.*
- *4- Prophylactic use of antibiotics.*
- *5- Application of plaster bandage to absorb exudates; create rest for the affected joint & to provide better granulations conditions.*
- *6- Exercise immediately after the inflammatory symptoms subside to prevent adhesions between the surfaces of the synovial membrane.*

Bone Healing:

- By callus formation(Periosteal, Intercortical & Medullary bridging callus).
- By primary bone healing(Osteosynthesis), by direct cortical remodelling of the Haversian system.

Osteosynthesis: surgical fastening of the ends of a fractured bone by mechanical means. This is available by internal fixation of fracture fragments.

Aim: rapid return to full function of the fractured bone by:

1- Anatomical reduction of the fracture fragments.

2- Preserving the blood supply to bone fragments & soft tissues.

3- Stable internal fixation.

4- Early active pain-free movement.

Basic Principles(Golden rules)

1- High standerds of asepsis should be taken to prevent the devastating effects of PO bone infections.

2- Double gloving of the operator to reduce further possibility of contamination due to puncture of surgical glove by bone specules or sharp instruments.

2- Sketch the fracture on paper delineating all the fracture lines so that one can depict the method of reduction and fixation with accuracy and dimension. It is also essential to have an alternative plane in case the primary course of action should prove unworkable.

3- Adequate instruments and implants for either method should be available.

5- The sooner the fracture is stabilized the less trauma will be to the soft tissues and the vascular supply to the bone.
6- Not to rush into internal fixation before proper preparation has been completed.

7- In general, a fracture is best repaired within 6-12 hours of injury.

8- If the patient's condition renders this inadvisable, it is better to wait 48- 72 hours or until the animal's condition is stabilized.

9- Open fractures should be regarded as emergencies and treated soon after presentation.

10- The use of i.v. bactericidal antibiotics in relatively high concentration in the flush solution during the procedure is recommended.

Factors affecting wound healing

1- Patient age and Physical status:

Young animals heal more rapidly than old ones. Patients suffering from systemic infection, diseases of the liver, kidneys, or cardiovascular system, and animals with endocrine imbalances exhibit delays in wound healing.

2- Anaemia and Blood loss:

Anaemia resulting from blood loss can impair wound healing if it is corrected quickly. The malnutrition or chronic infection that may result in normovolemic anaemia and the decreased perfusion of the wound that occurs with hyopvolamic anaemia inhibits many of the responses initiating wound healing. Clinically, if chronic infection, malnutrition, and hypovolemia are corrected, wound healing should progress normally.

3- uremia: wound healing impaired if uremia develops within the first 5 days after surgery or wounding. No effect if uremia develops after 9 days. Patients with prerenal uremia caused by dehydration do not risk reduction in wound healing capabilities if treated properly with intravenous fluids.

4- malnutrition and protein deficiency:

Adequate nutrition enhance wound healing. It is essential to provide the animal a balanced nutrition prior to elective surgery and after wounding and emergency surgery. Hypoproteinemia alone adversely affects wound healing primarily by altering fibroplasia, neoaniogenesis, wound remodling, and wound tensile strength, thus prolonging the repair phase of healing. When plasma protein levels fall to 6gm/dl, healing is retarded. Below 5.5gm/dl,a 70% incidence of wound disruption is expected, and below 2gm/dl, wound healing is disrupted, edema occurs, and death ensues. Because fats can be synthesized from carbohydrates and carbohydrates can be synthesized from protein but protein can be fabricated only from protein or its digestive byproducts(amino acids and peptides), a protein –rich diet is required to counteract the adverse effects on wound healing.

4- zinc, copper and other minerals:

Zinc . deficient animals heal poorly, with characteristic defects in the rate of epithelialiazation. Oral administration of zinc to zinc-deficient animals is more effective than zinc applied topically.

Copper.Ceruloplasmin, the principal copper metal protein in blood, increases rapidly following injury and inflammation. This complex is essential for collagen formation, collagen crosslinking, and collagen maturation. Copper protects the healing tissues from the effects of superoxide radicals produced by phagocytes during the debridement phase of wound healing.

Other minerals. Ca, iron and manganese are essential cofactors in several of the enzymatic steps in the formation of collagen.

5-Vitamins: Although vitamin deficiencies are not common in horses, they play an important role in wound healing.

Vitamin A. experimentally induced vitamin A deficiency caused retardation of epithelialization, wound contraction, collagen synthesis and collagen crosslinking.

Vitamin K. essential for blood clot formation. A deficiency of vitamin k may result in excessive bleeding, hematoma formation, impairment of healing, and increased susceptibility to infection.

Vitamin E. vitamin E, like steroids, will stabilize cellular membranes and in doing so, alter the normal inflammatory process. A high dose of vitamin E may inhibit wound healing and collagen synthesis. Vitamin A can counteract the anti-inflammatory effects of vitamin E.

Vitamin C. is necessary for epithelialization, blood vessel formation, and synthesis of collagen. It is an essential cofactor in the hydroxylation of protein and lysine in the formation of collagen. When deficiencies occur an improper sequence of amino acid is produced, the procollagen chain development is retarded, and polymerization does not occur.

In reality, vitamin deficiencies are probably not a problem in horses. However, when animals are chronically debilitated and undernourished, vitamin supplementation may be considered.

6- Nonsteroidal Anti-inflammatory Drugs (NSAIDS)

since inflammation is a part of the wound healing process, it is logical that anti-inflammatory drugs such as phenylbutazone, aspirin, indomethacin, and flunixin meglumin would have an effect on wound healing.

However, excessive amounts of these drugs may alter wound healing; when administered at recommended dosages no alteration in the quality of wound healing is observed.

7- Corticosteroids:

When given in a moderate or large amounts within the 5 days after injury, significantly retard wound healing. They also suppress fibroplasia, ground substance formation, collagen formation, capillary proliferation, and granulation tissue formation.

8- Trauma:

Excessive trauma, within the wound or from other sites of involvement(multiple lacerations or fractures), will prolong the early phase of healing, decrease the gain in tensile strength, make the wound more susceptible to infection, and may result in excessive scar production.

9- infection: **wound infection results when the number of organisms reaches a concentration of 10^6 organisms/gm of tissue or 10^6 organisms/ml of fluid. Contaminated wounds with lesser concentrations of organisms may become infected when: (1) excessive necrotic tissue is left in the wound, (2) excessive bleeding(the ferric ion can increase bacterial virulence and replication),**

(4) Local tissue defenses are impaired such as in the case of the burn patients or patients on immunosuppressive drugs, or (5) the vascular supply is altered.

- High doses of local irradiation, particularly within the first 4 to 48 hours after wounding, make the contaminated wound more susceptible to infection.

- Foreign bodies such as organic material common in the grossly contaminated wound, bone sequestra, suture material, glove powder, bone plate and screws promote infection by providing protective surface areas for bacteria to grow.

- Infection delays healing by mechanically separating the wound edges with exudate, by reducing the vascular supply(as a result of mechanical pressure and the formation of micro thrombi in small vessel adjacent to the wound). Bacteria also produce proteolytic enzymes that digest collagen.

In the surgical wound, the best way to prevent infection is to follow proper wound preparation, use good surgical principles, reduce surgery time as much as possible, and use aseptic technique.

In the traumatized patient , this means proper wound preparation, ample lavage, thorough debridement, wide excision, meticulous hemostasis, elimination of dead space with the use of suction drains if needed and the use of proper suturing techniques.

10- Antiseptics for skin preparation: e.g. povidone iodine and chlorhexidine(4% chlorhexidine gluconate was superior to povidone iodine in humans but this has not been proven true when these preparations were used in dogs). In a rare occasion a skin reaction may be noticed when povidone iodine used in horses.

11- Antiseptics for wound lavage: lavage solutions are most effective when delivered by a fluid jet of at least 7psi. Higher pressure(10to 15psi) has shown to be approximately 80% effective in removing soil potentiating factors from a wound. the water pick delivers 40 to 50 ml/min at 10 to 15 psi at the low intermediate setting and appear to be the most effective for heavily contaminated wounds.

Antiseptics for wound lavage:

Povidone-iodine solution(Betadine): solutions between 0.1 and 0.2% (1 to 2ml/1000 ml) concentrations are best for wound lavage in the horse.

Chlorhexidine diacetate solution: have a wide antimicrobial spectrum and are commonly used as lavage solutions, particularly in small animals. Currently, 0.05% chlorhexidine diacetate (1:40 dilution of the 2% concentrate) are recommended for use in wound lavage.

Hydrogen Peroxide: used as wound irrigant with impressive foaming action. It has little value as an antiseptic but is an effective sporocide. Three percent hydrogen peroxide is damaging to tissues and in fact its cytotoxic effect on fibroblasts exceeds its bactericidal activity. Additionally, there is evidence that it causes thrombosis in the microvascular adjacent to the wound margins. Because of this, hydrogen peroxide is not recommended for wound lavage.

Acetic Acid Solution: 0.5 or 0.25% solutions are reported to be most effective against *pseudomonas* organisms. Acetic acid solutions effectively change the PH of a wound. Because it retards epithelialization and fibroblasts, it is regarded as unsuitable for wound care.

12-Wound Debridement: reduces the number of bacteria and removes the contaminants (dead tissues, foreign bodies). Sharp debridement converts the contaminated wound to a clean one.

13-Local Anaesthetics: local anaesthetics with or without epinephrine have been shown to adversely affect wound healing.

14-Suturing Techniques and Suturing: the simple interrupted sutured skin wounds had less edema, an increased microcirculation, and a 30% to 50% greater tensile strength after 10 days. Since each passage of a suture through tissue creates a small wound, those patterns with a single passage, such as the simple interrupted pattern, create less inflammation than those patterns requiring a greater number of penetrations (e.g., vertical mattress and far-near-near-far suture).

Generally, the synthetic absorbable and nonabsorbable sutures cause less reaction than natural products (surgical gut, cotton, cotton and silk). A monofilament design suture has less reactivity compared to twisted and braided sutures.

15-Hematoma and Seroma: collection of blood or serum within the tissues can delay healing by mechanically separating the wound. These fluids provide an excellent nutrient environment for bacterial growth. Although hemoglobin inhibits local tissue defenses, iron is necessary for bacterial replication and the ferric ion may play a role in increasing virulence.

16-Movement vs. Continuous Passive Motion: movement of one portion of the wound with respect to another can disrupt neovascularisation, cell migration, and the formation of early stromal elements within the wound. This prolongs wound healing and promotes excessive scar tissue formation.

17-Topical Insulin: insulin applied to wounds increases protein synthesis, cellular multiplication, wound contraction and fat deposition. It also enhances phagocytosis and reduces tissue oedema.

18- Bandaging and Dressing: **bandaging is beneficial for the following reasons:(1) protection from further contamination, (2) reduce edema, (3) absorb exudate, (4) increase temperature and reduce CO_2 loss from the wound surface, thus reducing pH, and (5) immobilize a region, reducing trauma(e.g., a wound on a dorsal surface of the hock).**

Clinically, the adherent dressing should be used only on the early phases of wound healing when debridement is needed. If the wound requires little debridement but exudate and bacteria are present, the petrolatum semiocclusive dressing appears to be most beneficial. These dressing not only absorb the exudate and bacteria into the secondary bandage but may improve the rate of granulation tissue formation and wound contraction. After a healthy granulation tissue bed is formed, the use of non adherent semiocclusive dressing is recommended.

19- Magnetic Fields: the use of magnetic dressings in the treatment of soft tissue injuries has become popular in Europe. Although magnetic dressings are supposed to increase circulation, reduce tissue inflammation, increase collagen synthesis, suppress collagen lysis and suppress keloid formation, the evidence of their effectiveness is largely speculative.