# *MUSCLE DISEASES*

# Postmortem Changes

- **Rigor mortis:**
- Rigor mortis is contracture of the skeletal muscle that develops after death.
- Rigor mortis is characterized by stiffening of the muscles and immobilization of the joints.
- It proceeds in orderly fashion from the muscles of the jaw to those of the trunk and then to those of the extremities, and it passes offin the same order.
- The time of onset, in average circumstances, is 2-4 h after death; maximum rigor is achieved in 24-48 h, after which it disappears.
- The intensity of rigor varies considerably as does the time of onset.

# *Rigor mortis*

- The factors influencing the time of onset and degree of rigor are
- the glycogen reserves,
- the pH of the muscles at the time of death, and
- the environmental temperature.

- Rigor is slight or absent in cachectic or chronically debilitated animals.
- Rigor occurs with extraordinary rapidity in animals that die during or shortly after intense muscular activity, when muscle pH and glycogen stores are low.

# *Rigor mortis*

- Onset of rigor can be delayed in wellrested, well-fed animals.
- It is hastened in onset and disappearance in a warm environment, and retarded in a cold environment.

# Mechanism

- Immediately after death, glycogen is converted to lactic acid by anaerobic glycolysis and creatine phosphate is broken down to produce creatine.
- These are both mechanisms for the resynthesis of adenosine triphosphate from adenosine diphosphate.
- Rigor will occur when the rate of adenosine triphosphate degradation exceeds its rate of synthesis.
- Muscle does not require energy to contract, but contraction is dependent on the presence of free calcium ions.
- Sequestration of calcium requires energy and is necessary for muscle relaxation.
- Rigor develops because muscles deprived of energy are unable to maintain calcium in sequestered stores.
- The eventual disappearance of rigor, and its failure to develop in cachectic animals, may be due to complete exhaustion of the chemical systems that produce energy and/or myofibrillar protein loss or breakdown.

# *DISTURBANCES OF GROWTH*

**1-Muscle Atrophy**

- **Denervation atrophy**
- **Disuse atrophy**
- **Atrophy of cachexia**
- **Atrophy of endocrine disease**
- **Myopathic atrophy**

**2- Muscle Hypertrophy**

- ***Compensatory hypertrophy***
- ***Physiologic hypertrophy***

## Denervation atrophy:

- *Myofibers that have lost connection with peripheral nerves due to neuropathy or neuronopathy undergo rapid and severe atrophy due to denervation.*
- This form of atrophy has also been referred to in the somewhat contradictory terms "neurogenic atrophy.«
- It is asymmetrical (the hallmark of equine protozoal myeloencephalitis) gluteal atrophy in the horse, and radial or brachial paralysis in dogs and horses due to trauma.
- Lesions involving the ventral gray matter of the spinal cord or the ventral roots emerging from the spinal canal, and inherited or acquired peripheral neuropathies, are also common causes of denervation atrophy.

# *Muscle atrophy*

- Muscle atrophy can refer to reduction in overall muscle mass.
- Reduction in mass most often reflects decreased myofiber diameter that can involve all fibers uniformly or that can selectively involve muscle fiber types.

- **Disuse atrophy**
- Disuse atrophy occurs due to decreased contractile activity of innervated muscle.
- Decreased muscular activity due to painful lameness, bone fracture or disease, or limb immobilization are most common.

- **Atrophy of cachexia:**
- Atrophy of cachexia and malnutrition occurs when an animal is unable to supply enough dietary nutrients to maintain muscle; muscle proteins become the source of nutrients for the rest of the body.

# *Muscle Hypertrophy*

- Hypertrophy can refer to the muscle as a whole or to increased diameter of myofibers.
- Overall muscular hypertrophy occurs due to physiologic increase in myofiber diameter due to exercise conditioning.
- This process of physiologic hypertrophy of fibers is accomplished by adding sarcomeres, by adding myofilamerits to the periphery of myofibrils, and by adding new myofibrils to the existing ones by a process of longitudinal splitting.

# *CONGENITAL AND INHERITED DEFECTS*

## Arthrogryposis and Dysraphism

- ***Arthrogryposis*** literally means crooked joint.
- The terms congenital articular rigidity and arthrogryposis multiplex congenita are also used to describe this syndrome.
- Arthrogryposis can involve one or more limbs, depending on the underlying neuroectodermal defect.
- Severely affected animals may also have scoliosis, kyphosis, and torticollis, and the limbs or parts of limbs may be rotated, abducted, or curled backwards or forwards in grotesque positions.

# Arthrogryposis and Dysraphism

- Unequivocal links exist between arthrogryposis and the recognizable lesions caused by arrest or delay of neural tube closure **(dysraphism)**.
- Genetic causes are postulated in calves, sheep, and pigs.
- Affected animals may have obvious reduction in mass of affected muscle due to atrophy or hypotrophy.

# Congenital Flexures

- Pastern contracture and immobility by itself can sometimes be part of arthrogryposis.
- If the flexure is combined with some degree of distal limb rotation, the pathogenesis is likely to be associated with neural and muscle changes as a minor expression of arthrogryposis.
- Many lambs, foals, and calves are born with an apparent inability to straighten the fetlock and sometimes other distal joints.
- The problem in these cases seems to relate to the holding of the affected joint or joints in flexion without relief during a period of time in late gestation.

# Muscular Defects

- There are four syndromes of importance affecting muscle that are not associated with lesions in nervous tissue.
- "Splayleg" (myofibrillar hypoplasia) in piglets
- *"Double muscling" (muscular hyperplasia) in cattle*
- *Muscular steatosis*
- *Congenital clefts of the diaphragm*

# *Regeneration and repair of muscle*

- The ability of muscle to repair itself is remarkable considering its high specialization and the great length and great vulnerability of individual fibers.
- The ability to rapidly repair the damaged segment of a fiber, without apparent complication to the rest of the fiber, is without parallel in other cells of the body.
- The major participants in the regenerative sequence are macrophages from the blood, the satellite cells, because only they, within the muscle, have retained the capability for mitotic division, and the basal lamina, which acts as a very efficient scaffold.
- The integrity of the basal lamina determines from the very beginning how effective regeneration will be and whether the outcome will be regeneration of myofibers, fibrous replacement, or a mixture of the two.

# *Regeneration and repair of muscle*

- An intact basal lamina effectively keeps myonuclei, satellite nuclei, and myoblastic cells inside.
- Macrophages dissolve and remove the debris; neutrophils disappear unless infection complicates the process.
- Removal of sarcoplasmic debris leaves some space enclosed within the collapsing sarcolemma; and proliferating satellite cells are seen in the sarcolemmal tube.
- These cells are now termed myoblasts.
- Myoblasts increase in number until a critical myoblastic mass is reached.

# *CIRCULATORY DISTURBANCES OF MUSCLE*

- Skeletal muscle is a highly vascular tissue with an abundant capillary bed that forms an extensive system of anastomoses.
- It is generally not possible to induce muscle fiber necrosis by ligation of, or damage to, intermuscular arteries.
- Naturally occurring examples of ischemic muscle necrosis are most often due to vascular occlusion secondary to pressure.

# *Ischemic Muscle Necrosis*

**It emerges as 4 different syndromes:**

## 1. Vascular occlusion syndrome:

- Occlusion of major arteries such as aortic-iliac thrombosis ("saddle thrombi") can also cause ischemic muscle necrosis.

# *Ischemic Muscle Necrosis*

## 2. Compartment syndrome

- Muscles that are surrounded by either a heavy aponeurotic sheath or by bone and sheath are vulnerable to ischemia when muscle fibers are subjecte to moderately vigorous but not exhaustive contraction.
- This syndrome occurs in well-conditioned athletes.
- It occurs in the supracoracoid muscles of some breeds of broiler chickens and in some breeds of turkeys.
- The so-called *spontaneous rupture of the gastrocnemius muscle of Channel Island breeds of cattle* may represent an example of compartment syndrome leading to ischemia and subsequent rupture.

# *Ischemic Muscle Necrosis*

## 3. Downer syndrome:

- Most of the domestic species share a muscle ischemia syndrome that is initiated by external pressure of objects or by pressure created by the weight of body, torso, or head on a limb tucked under the body for prolonged periods.

## 4. Muscle crush syndrome:

- This form of muscle ischemia has characteristics in common with downer syndrome.
- It is usually initiated by acute accidental trauma, often including bone fracture.

# *NUTRITIONAL MYOPATHY*

*(nutritional muscular dystrophy, **white muscle disease**, stiff-lamb disease)*

- Nutritional Muscular Dystrophy is a disease caused by a deficiency of selenium and vitamin E in dietary intake.
- The nutritional deficiencies are principally selenium and vitamin E.
- The adult disease affects animals fed marginalquality rations, such as turnips or poor-quality hay, and can appear as clinical or subclinical disease in animals in very poor condition.
- Nutritional myopathy is a problem around the world but it occurs most often in those countries with intensive livestock agriculture operations.

# *White Muscle Disease*

- This condition often affects young ruminants, such as calves and lambs.
- They infrequently affect carnivores and foals.
- Adult and even older animals can be affected.
- Etkilenen hayvanlarda kas hastalığı klinik olarak şiddetli olmasa da, nutrisyonel myopatili hayvanların hızlı bir şekilde kilo kaybettikleri ve iyi gelişemedikleri görülür

## Pathogenesis:

- Soils that contains low levels of selenium produce forages and grains that are deficient in selenium.
- Similarly, if the forage is of low quality or is not stored properly it may be deficient in vitamin E.
- If an animal consumes this type of diet without additional supplementation they become susceptible to this disease.
- Selenium and vitamin E are antioxidants therefore, deficiencies of these nutrients leads to oxidative damage to cells within the body.
- In many cells, vitamin E- and selenium-containing enzymes are required as physiologic antagonists to a group of chemically varied substances known as free radicals.

**Pathogenesis:**

- Selenium is an essential factor.
- The lipid peroxides are reduced to lactic acid by means of Gulutation peroxidase.
- Harmful effect on the cell membrane is prevented.
- Vitamin E is an antioxidant. It prevents the formation of high concentrations of peroxide from fatty acids.
- If selenium and vitamin E are absent, the peroxide damages the cell membrane, then hyaline degeneration and necrosis develop.
- Free radicals may initiate cellular injury by causing peroxidation of membrane lipids and by causing physicochemical damage to protein molecules including those of mitochondria, endoplasmic reticulum, and cytosol.
- In the formation of the disease, vitamins A, C and some amino acids are also considered to be inadequate.

# *White Muscle Disease*

**Cattle:**

- Nutritional myopathy occurs, sometimes in endemic proportions, in calves, mostly of beef type and 4-6 weeks old.
- It is also common in animals up to 6 months of age and occurs sporadically in older cattle.
- The disease is often related to poor-quality feed.

# *White Muscle Disease*

- ***Postmortem lesions in calves*** *are usually dominated by marked mineralization of necrotic skeletal and~or cardiac muscle.*
- *When* the heart is extensively affected, intercostal muscles and the diaphragm are usually also affected, but other skeletal muscle lesions may not be widespread.
- *Heart lesions in calves usually involve the left ventricle more than the right*.
- Small lesions just under the epicardium or endocardium may appear as scattered white "brush" strokes.
- The mineralized lesions are creamy white and opaque. Small streaks of hemorrhage may also be seen.

# *White Muscle Disease*

- **Lungs** are often filled with pink frothy fluid and an excess of fluid may be present in the thorax indicating heart failure.
- Acute pneumonic changes sometimes develop as a complication of pulmonary edema.
- *In those cases where skeletal muscle lesions predominate, the most extensive lesions can be found in the large weight-bearing muscles of the thigh and shoulder,* but many others are affected and the lesions are bilaterally symmetrical.
- Suckling animals often have extensive lesions in the *highly active tongue and neck muscles,* and occasionally in the voluntary muscles of rectum, urethra, and esophagus.
- Affected muscles are pale, irregularly opaque and yellow to creamy-white.

# Sheep and Goats

- *Nutritional myopathy in* **sheep** *is probably more prevalent in more areas of the world than the disease in cattle.*
- The names white muscle disease, rigid lamb disease, and stiff lamb disease were coined to describe the most frequently encountered clinical patterns **in 2-4-week-old lambs**, which very often are spring lambs, recently turned out onto the first green pasture.
- Thus, in various parts of the world, the disease has been precipitated by stress from bad weather, prolonged winter feeding, subsistence on root crops, or forced activity, as well as feeding on stubble, legume pastures, dry pastures, and pastures with too much copper.

# Sheep and Goats

- Deficiency in sheep is attributed to deficiency of vitamin E or selenium, but seldom of both.
- Bilaterally symmetrical lesions of the thigh muscles may occur but they may predominate in or be confined to the intermediate head of the triceps, or the tensor fascia latae.
- **Microscopically,** the changes seen in affected muscle over a period of several days follow the expected sequence of necrosis, mineralization, phagocytosis, and regeneration characterized by satellite cell proliferation and myoblastformation.

# Sheep and Goats

- In lambs, the disease typically occurs between 3 to 8 weeks of age, but may occur in older lambs as well.
- Progressive paralysis occurs, which is evident through the following symptoms: arched back, difficulty moving and an open shouldered stance.
- Cardiac failure may occur in two forms: sudden heart failure or gradual cardiac failure characterized by lung anemia that causes death due to suffocation.

# Pigs

- *Nutritional myopathy in swine has been reported as a spontaneous disease wherever intensive pig rearing is practiced,* but particularly in northern, central and eastern continental Europe, the UK, the US, and Canada.
- Classical lesions involving only skeletal muscles are less common than some of the other expressions of porcine vitamin E/selenium deficiency such as hepatosis dietetica and mulberry heart disease.
- *Systematic microscopic study of muscles has revealed a much higher incidence of muscle lesions than was thought to exist.*

# *Microscobically;*

The appearance of the lesions is similar to that of calves; however, calcifications are much more severe.

- Microscopic findings:
- - calcification,
- - satellite cell proliferation and
- - myoblastic regenerative repair

# *Muscle repair is examined in 3 periods.*

1. **In the acute period**, The findings related to hyaline degeneration and necrosis are noteworthy.

- The muscle cells are bulging, lost in stripes and have a rough, eosinophilic appearance.
- This is Zenker degeneration (Hyaline degeneration).
- At the end of this period, the core forms picnose and karyorhexis.
- The coagulation necrosis (Zenker's necrosis) occurs when the muscle cells appear completely homogenous pink (eosinophilic) appearance.

**2.Subacute period** is a resorbive period.

- Necrotic muscle cells are phagocytosed by macrophages from the region (intersiticium with monocytes from the blood and histiocytes located in the capillar vein).
- In addition, there are small amounts of neutrophil leukocytes, eosinophil leukocytes and lymphocytes in the region.

**3.Subakut period follows the period of regeneration and reparation.**

**a) Regeneration:**

- If the sarcolemma remains intact, the nuclei in the inner part of the sarcolemma grow, the vesicular shape becomes (active) and divide.
- Thus, multinucleated cells are formed.
- Then the cells around the core are separated and the new cells are shaped (the sarcoma around the nucleus is considered to be the sarcoma).
- The appearance of multinucleated muscle cells indicates regeneration.

## b) Reparation:

- It forms the chronic period.
- If the sarcolemma is destroyed by necrosis, regeneration does not occur.
- The necrosis portions are cleaned as above.
- Afterwards, the cleaned areas are filled with connective tissue (fibroblast, fibrositis) accompanied by capillary vessels from the interstitial region and granulation tissue is formed.
- Other cells such as monocytes, histiocytes, lymphocytes can also be seen in the granulation tissue.
- Over time, collagen yarns are formed and granulate tissue is formed alongside the scar tissue.
- In addition, dystrophic calcification is seen in some muscle strands that are necrotic in the area.

- ***Nutritional myopathy of horses***
- The usual age range is 1 day to 12 weeks and it may be present at birth.

- **Nutritional myopathy of other species**
- *Nutritional myopathy is unusual in carnivores and primates.*
- A number of *zoo animals* appear to be susceptible.

# *TOXIC MYOPATHIES*

- **Ionophore toxicosis (***monensin, lasalocid, salinomycin, narasin, and maduramicin)*
- ***Cassia spp. toxicity- ruminants***
- ***Cassia spp. toxicity- swine***
- ***Gossypol toxicity***

# *Gossypol Toxicity*

- *Gossypol is a yellow, pigmented, polyphenolic substance present in cottonseeds.*
- It is toxic to **swine**, and toxicosis occurs when swine are fed cottonseed cake or meal at a concentration of 10% or more of rations to which it is added as a protein supplement.
- The toxic effects are **cumulative.**
- Gossypol is toxic to experimental lambs and calves at concentrations of less than 450ppm in the feed (the level of free gossypol permitted in human and some animal foods).

# *Gossypol Toxicity*

- Lesions are present in several organs, including the heart, skeletal muscles, liver, and lungs, and death is due to cardiac failure, which causes fluid accumulation in body cavities.
- Histologically, segmental necrosis of skeletal muscle and myocardium is present, the liver has centrilobular necrosis and the lungs are congested and edematous.
- Affected animals are pot-bellied and poorly grown, and most die acutely.

# *Cassia spp. toxicity- ruminants*

- In the southern USA, mature cattle and goats on pasture may ingest the beans or coffee senna plant.
- Animals develop diarrhea, show evidence of weakness, and display a swaying, stumbling gait that is related to the developing muscle lesions.
- The disease progresses rapidly and most of the animals affected become recumbent and develop myoglobinuria.
- Postmortem lesions in recumbent animals consist of ill-defined pallor of much of the muscle mass.
- Histologic changes are typically monophasic multifocal myopathy.

# *Monensin Toxicity*

- Monensin, an antibiotic produced by the fermentation of Streptomyces cinnamonensis, has a growth-promoting effect in ruminants.
- It is an efficient coccidiostat in birds and other animals.
- Many episodes of monensin poisoning have been caused by mixing errors in packaged, pelleted, commercial animal feeds.
- It has put hundreds or thousands of animals at risk.
- Clinical signs of lethargy, stiffness, muscular weakness, and recumbency occur within 24 hours.

# *Monensin Toxicity*

- Horses in the early stages, to show marked signs of colic, apprehension, shifting or fidgeting, sweating, myoglobinuria, and muscle tremors.
- Dogs show apprehension and progressive weakness.
- Myofiber nuclei and satellite cell nuclei as well as endomysial cells apparently survive acute toxicity, and the early stages of regeneration.
- Myocardial lesions in monensin toxicity are not reparable.

# *EXERTIONAL MYOPATHIES*

- **Exertional myopathy is indicative of myofiber damage occurring due to exercise stress.**
- The initiation of abnormal excitation-contraction coupling, inadequate energy metabolism, ionic imbalance, or simply the mechanical stresses occurring during contraction are thought to lead to myofiber damage of predisposed muscle.
- Historically, the syndrome of passage *of myoglobin-pigmented urine (myoglobinuria)* was recognized long before it was determined that massive *skeletal muscle necrosis (rhabdomyolysis)* was the cause.

# ***Exertional myopathy (rhabdomyolysis) in the horse (azoturia,*** *black water,* ***paralytic myoglobinuria, Monday-morning disease****, set fast, and tying up)*

- Muscle injury severe enough to result in myoglobinuria, profound weakness, and recumbency is common in heavy horse breeds, hence the terms azoturia, black water, and paralytic myoglobinuria.
- Exertional myopathy in light horse breeds is typically less severe, resulting in episodic muscle pain, sometimes associated with swelling, and reluctance to move, hence the names set fast and tying up.

# *Exertional myopathy (rhabdomyolysis) in the horse*

- The most common cause of exertional rhabdomyolysis in many breeds of horses, including Quarter Horse, Warmblood, draft, Arabian, Standardbred, Tennessee Walker, Morgan, and Welsh pony-related breeds.
- Etiologies proposed for equine exertional rhabdomyolysis have included muscle lactic acidosis, hypothyroidism, electrolyte imbalance, and vitamin E and/or selenium deficiency.
- Only electrolyte imbalance, in particular hypokalemia, is still considered possible.

# *Exertional myopathy (rhabdomyolysis) in the horse*

- Almost all horses with recurrent exertional rhabdomyolysis respond positively following a diet change to one that is high in fat, high in fiber, and low in starches and sugars.
- *Weakness and~or pain in the hindlimbs occur suddenly,* and the animal soon becomes unable or very reluctant to move.
- This may be accompanied by sweating and generalized tremors.
- The affected muscles, which are typically those of the *gluteal, femoral, and lumbar groups*, may be swollen and board-like in their rigidity.

# *Exertional myopathy (rhabdomyolysis) in the horse*

- *Muscles may be moist, swollen, and dark, and streaks of pallor may be visible in the more extensively involved muscles.*
- *Myoglobinuria* can appear early in the disease, causing **dark red-brown discoloration of the urine**.
- That is often a prelude to death from **myoglobinuric nephrosis.**
- Damaged fiber segments generally undergo hypercontraction and hyaline degeneration followed by coagulative necrosis.
- Mineralization is not typically seen.

# *Capture Myopathy*

- Of spedal interest is exertional myopathy occurring in wild animals following capture and~or immobilization, an entity known as "capture myopathy."
- Clinically affected animals can exhibit dyspnea, weakness, muscle tremors or muscle rigidity, hyperthermia, collapse, and, often, death.
- Cardiac lesions, when present, are most often acute, although animals that survive capture myopathy may die acutely at a later date due to myocardial fibrosis.
- Myoglobinuric nephrosis may be seen.

# MYOSITIS

- **Myositis** means inflammation of muscle.
- The cause of myositis is often not evident except in the obvious cases.
- **Suppurative myositis**
- **Malignant edema (gas gangrene)**
- **Blackleg**
- **Pseudo-blackleg**
- **Granulomatous myositis➔**
- ***Staphylococcal granuloma***
- ***Roeckl's granuloma of cattle***

# *Suppurative myositis*

- Abscesses in muscle may sometimes be hematogenous in origin, but more often they result from ***inoculation*** (penetrating wound, contaminated injection, contamination of surgical site or laceration), or **by *extension from a suppurative focus*** in adjacent structures, such as joints, tendon sheaths, or lymph nodes.
- The most common causes of abscesses in muscle are *Arcanobacterium (Actinomyces, Corynebacterium) pyogenes* in cattle and swine, *Corynebacterium pseudotuberculosis* in sheep, goats, and horses, and *Streptococcus equi* in horses.

# *Suppurative myositis*

- The early stage consists of local, ill-defined, cellulitis.
- Healing may take place after this with a minimum of scarring, or it may proceed to the formation of a typical abscess with a liquefied center, a pyogenic membrane, and an outer fibrous sheath.
- The lesion may slowly organize if it is effectively sterilized, expand if it is not or, alternatively, fistulate to the surface, collapse, and heal.

# *Malignant edema (Gas Gangrene)*

- The muscles are highly susceptible to bacteria of the genus Clostridium, when they proliferate, are highly *toxigenic and cause extensive necrosis of muscle, with blood-stained edema and the formation of gas.*
- *Death occurs as a result of systemic intoxication.*
- *Since the pathogenic clostridia are frequently found in soil and feces, any contamination of an open wound is likely to introduce those potential pathogen.*

# *Malignant edema (Gas Gangrene)*

- These bacteria (Clostridium) are gram-positive bacilli, to a greater or lesser degree anaerobic.
- They exist in the environment as resistant spores.
- Germination of the spores and vegetative growth requires fairly precise local conditions, chiefly a low oxidation-reduction potential and an alkaline pH.
- These conditions are best produced by deep penetrating wounds and the lesions that result from the activity of the anaerobes are called *"malignant edema,""gas gangrene,«* and *"anaerobic cellulitis."*

# *Malignant edema (Gas Gangrene)*

- **The species of the genus Clostridium that are of most importance as the agents of gas gangrene are**
- **C.septicum, perfringens, novyi, chauvoei**
- **These organisms not only cause gas gangrene, which is usually a mixed infection,**
- ***C. Chauvoei* - bacterial myositis – blackleg in ruminants.**
- ***C. novyi* - black disease,**
- ***C. Septicum* – *braxy*,**
- ***C. perfringens* - *the clostridial enterotoxemias***

# *Malignant edema (Gas Gangrene)*

- Ruminants, horses, and swine are highly susceptible to these infections.
- Since deep wounds are the ones most suitable to the development of gas gangrene, the common causes of such susceptible wounds in animals are castration, shearing, penetrating stake wounds, injuries to the female genitalia during parturition and, especially in swine, inoculation sites.

# *Malignant edema (Gas Gangrene)*

- The distinctive characteristics of these local infections are:
- *severe edema,*
- *the formation of gas bubbles that give crepitation,*
- *discoloration of the overlying skin,*
- *coldness of the affected part, and,*
- *in particular, the constitutional signs of profound toxemia with prostration,*
- *circulatory collapse, and*
- *sudden death.*

# *Malignant edema (Gas Gangrene)*

- Malignant edema is more typically a cellulitis than a myositis, and the muscles may escape significant injury even in fulminating, highly toxigenic infections of the sort that are fatal in 48 h.
- One factor that is probably of much importance in determining whether the inflammation will be confined to the connective tissues (malignant edema) or will directly involve muscle (myositis) is the adequacy of the blood supply to the muscle.

# *Malignant edema (Gas Gangrene)*

- If the muscle is devitalized by the initial trauma, or subsequently as a result of toxic injury to the blood vessels, the development of true gangrene is in order;
- in this manner, **malignant edema or anaerobic cellulitis may develop into gangrene**.

# Blackleg

## (Black quarter and Emphysematous gangrene)

- Blackleg is a gangrenous myositis of ruminants caused by C. chauvoei and characterized by the activation of latent spores in muscle.
- **This definition of blackleg separates it from gas gangrene.**
- Blackleg in cattle primarily affects animals **9 months to 2 years of age.**
- It affects animals in good condition, and often selectively causes death in the best-grown or best-fattened animals in a group.
- Blackleg is chiefly a disease of pastured animals with a tendency to be seasonal in summer.

# Blackleg

- Blackleg, in spite of a worldwide distribution, peculiarly localized to regions, and within regions to farms.
- The muscle lesion produced is not distinctive for the blackleg pathogenesis, nor is the presence of C. chauvoei in a typical gangrenous lesion, because C. Chauvoei can also be a wound contaminant.
- C. septicum proliferates rapidly after death while C. chauvoei does not.

# Pathogenesis

- *The infection is acquired by the ingestion of spores,* and either these spores, or spores produced following one or more germinative cycles in the gut, are taken across the intestinal mucosa in some way.
- Macrophages may be responsible for this passage, but it may be possible for the spores to enter natural or transient apertures at tips of villi or in lymphoid crypts or be taken in by lymphoepithelial cells of the ileal domes by endocytosis.
- *Spores are distributed to tissues where they may be stored for long periods in phagocytic cells.*

# Blackleg

- *The latent spores in muscle are stimulated to germinate when a local event creates muscle damage or low oxygen tension.*
- Color and watery exudate drips from cut surfaces.
- *The odor which emanates from the muscle is sweet and butyric, like rancid butter.*
- The initial bacterial lesion in blackleg is cellulitis with copious edema and hemorrhage.
- Degeneration of the muscle fibers is caused by both diffusing toxin and injury to blood vessels.

# Blackleg

- Gangrenous lesions expand longitudinally with the long axis of muscles more readily than in a lateral direction, but "skip" areas may create necrotic zones that are highly irregular in contour.
- The expansion is enhanced by the edema fluid between fibers.
- The exudate and gas bubbles separate bundles of fibers and individual fibers.
- These undergo necrosis with preservation of striations in the center of the focus, and fatty and granular degeneration towards the periphery.
- Leukocytes are sparse, being destroyed by diffusing toxins.

- The lesions of blackleg are usually found in the large muscles of the pectoral and pelvic girdles.
- They may be found in any striated muscle including the myocardium.
- Lesions in the crura of the diaphragm and in the tongue are quite common.
- <u>The other lesions;</u>
- Severe parenchymatous degeneration of liver, kidney, and endocrine glands,
- Fibrinohemorrhagic pleuritis
- Emphysematous myocarditis and necrosis
- Fibrinohemorrhagic pericarditis

# *Staphylococcal granuloma*

- Chronic granulomas of muscle or connective tissue caused by staphylococci, and referred to as **botryomycosis**
- They occur, particularly in the *horse and pig.*
- Infection by ***Staphylococcus aureus***
- **In horses, lesions are most frequent on the neck and pectoral region ("breast boils"), while in the pig, castration wounds and the mammary glands are the most common sites.**

# *Staphylococcal granuloma*

- The lesion begins as a microabscess around a small colony of organisms and progresses rapidly, sometimes to a very large size.
- The fully formed granuloma is a hard, nodular, gray-white mass of dense, fibrous tissue, irregularly cavitated by small abscesses.
- The abscesses may be joined by tracts or they may fistulate to the surface.
- They contain a small quantity of thick, orange-yellow pus, which in turn contains minute granules.
- Variable numbers of neutrophils, lymphocytes, and plasma cells are present in the loose fibrous tissue outside of the club colony.

# PARASITIC DISEASES

- ***Trichinellosis***
- **Sarcocystosis**
- **Eosinophilic myositis of carte and sheep**
- **Toxoplasma and Neospora myositis**
- **Cysticercosis**
- **Hepatozoonosis**
- **Chagas' disease (American trypanosomiasis)**

# *Trichinellosis*

- Muscle is the habitat for encysted larvae of the nematode Trichinella spp., which may survive there for many years.
- Trichinellosis is a zoonotic disease.
- The muscle belongs to the animal that earlier harbored the adult worm in its duodenum.
- Since animal-to-animal transmission of infection is accomplished by the consumption of infected muscle.
- Man, dogs, wild Canidae, cats, wild Felidae, pigs, rats, mustelids,bears, raccoons, and mice become hosts to the adult and their persistent larvae.
- Horse and birds may become infected when muscle tissue is included in their feed.

# *Trichinellosis*

- Humans become infected when they consume uncooked or incompletely cooked meats.
- **The parasitic cycle for T. spiralis begins with ingestion of infected meat fibers.**
- Gastric juices liberate the encysted larvae.
- Maturity is reached in about 4 days following ingestion, the adults copulate and the male dies.
- The ovoviviparous females penetrate via the crypts of Lieberkuhn to the submucosal lymphatics where they deposit 0.1 mm long larvae into lymph vessels.

# *Trichinellosis*

- Usually parasitic infestations of muscle are asymptomatic.
- **Heart muscle is sometimes involved, but not heavily; the muscles most involved are tongue, masseter and laryngeal muscles, diaphragm, intercostal muscles, and muscles of the eye, but no striated muscle is exempt.**
- Within the muscle fiber, the larva grows, coils and enlarges a segment of the host muscle fiber, which is induced to develop some unusual changes as the "nurse cell."
- Nuclei enlarge, myofibrils are greatly reduced, the basal lamina is very greatly increased in its thickness and number of folds around the affected segment of muscle fiber, and the sarcoplasmic reticulum, which is in intimate contact with the worm, proliferates.

- **There is usually one per fiber.**
- **Larvae are not normally visible by naked eye inspection of muscles unless they are old and mineralized.**

# *Trichinellosis*

- On routine microscopic examination of muscle, larvae lie in bulging glassy segments of muscle fiber that may be loosely encircled by eosinophils, and in due course, by a scattering of lymphocytes, plasma cells, and macrophages.
- If the parasitized muscle segment degenerates, the larva is exposed and soon dies to become the center of a more acute inflammatory, but still predominantly eosinophilic, reaction.
- Segments of muscle fiber adjacent to the encysted larva may show evidence of degeneration or subsequent regenerative repair with basophilia and centrally located nuclei.

# *Cysticercosis*

- A few have aspecial predilection for skeletal muscles and myocardium.
- **Taenia solium:**
- resident in the intestinal tract of humans.
- The larvae usually develop in the pig or wild pig.
- Most of the larvae in the pigfind their way to heart, masseter, tongue, or shoulder muscles.
- **Taenia saginata:**
- resident in the intestinal tract of humans.
- larval form (Cysticercus bovis) infests heart and masticatory muscles in cattle.
- **Taenia ovis:**
- found in dogs and wild carnivores,
- larval form, has a cysticercus (Cysticercus ovis) that develops in the heart and skeletal muscles of sheep and goats.

# *Sarcocystosis*

- Sarcocystis spp. are protozoal parasites of animal muscle that in many respects resemble coccidia, the main difference being their obligatory development in two hosts.
- The sexual stages develop in a predator host, while the asexual phases develop in the prey animal.
- Histologically, Sarcocystis organisms are rarely accompanied by an acute inflammatory reaction, and schizonts in endothelial cells cause little or no evidence of endothelial cell destruction.

# Eosinophilic myositis of cattle and sheep

- Eosinophilic myositis is a relatively rare condition in cattle and sheep of all ages that has some significance for meat inspection because the lesions are usually discovered in skeletal muscle and myocardium of animals slaughtered for human consumption.
- Eosinophilic myositis in sheep and cattle may be caused by degeneration of Sarcocystis spp.
- **The gross lesions** of eosinophilic myositis in cattle are characteristic, being well-demarcated, green, focal stripes or patches that fade to off-white when exposed to air.
- Individual lesions may be 2-3 mm to 5-6 cm in diameter.
- **Histologically,** The reaction is characterized by large numbers of eosinophils, and it is these that impart the green color to the lesion.

# *Toxoplasma and Neospora Myositis*

- ***Neospora Caninum Toxoplasma Gondii***
- *Two* apicomplexan parasites, *Toxoplasma* and *Neospora,* produce myopathy in several species.
- Toxoplasma gondii infections, particularly in puppies and kittens, or in any species of farm animal naturally immunosuppressed, or in animals on immunosuppressive therapy, may massively involve skeletal muscle fibers.
- Myositis with mononuclear leukocytic infiltration, myofiber necrosis, and myofiber atrophy is accompanied by polyradiculoneuritis.

# *NEOPLASTIC DISEASES OF MUSCLE*

- Primary tumors of striated muscle are uncommon.
- **Rhabdomyoma**
- **Rhabdomyosarcoma**
- **Leiomyoma**
- **Leiomyosarcoma**
- **Nonmuscle primary tumors of muscle**
- These tumors arise from supporting mesenchymal tissues of muscle. Malignant tumors are far more common than benign tumors.
- *Poorly differentiated sarcomas* and *giant cell sarcomas*
- *Hemangiosarcoma*
- *Malignant lymphoma*