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VCSN630 Neonatology and Intensive Care Medicine

Pregnancy and the Periparturient Period in the Mare

NORMAL PREGNANCY

Development of the Conceptus:

Ovulation in the mare occurs approximately 0-48 hours before the end of estrus. Mares should be bred prior to ovulation.

Within minutes after coitus or artificial insemination, there is enough sperm present in the oviducts to fertilize the ovum.

On Day 5-6, a fertilized ova will descend through the oviduct and enter the uterus. Unfertilized eggs are retained in the oviducts and do not descend to the uterus (a mechanism unique to the mare).

The conceptus starts developing and travels freely through the body and both horns of the uterus. It maintains a spherical shape. This mobility is essential for maternal recognition of pregnancy to occur.

Approximately Day 16, fixation of the conceptus occurs at the base of one of the horns. The conceptus is composed of the embryonic disc and the trophoblast. The embryonic disc is located ventrally and will develop into the embryo. The trophoblast will develop into the fetal membranes.

Initially, the embryo develops from the ventral wall of the vesicle (Day 20). Later development of the allantois and regression of the yolk sac pushes the embryo to a more dorsal location, with the umbilicus coming from the dorsal wall of the conceptus.

The mesoderm surrounding the yolk sac develops into the blood vessels. The umbilical cord will be attached dorsally at the base of one uterine horn.

The embryo is referred to as a fetus at the end of the period of organogenesis, which occurs at approximately 40 days.

The fetus occupies the pregnant horn for approximately 70-80 days, after which it spreads into the body of the uterus, normally with the hind legs remaining in the horn. After about 6-7 months, the fetus rarely changes its presentation.

Uterine and Cervical Changes:

Between Days 15 and 21, the uterus becomes tonic and tubular and the cervix closes tightly. These findings permit a tentative diagnosis of pregnancy. At this stage, definitive diagnosis of pregnancy can be made using transrectal ultrasonography.

At approximately Day 28, a bulge can be palpated at the base of the pregnant horn. It is more evident on the ventral aspect of the horn. The bulge grows spherically while the rest of the uterus remains tonic and the cervix closed.

By Day 90, the entire uterus is filled with fluid.

As pregnancy progresses, dry mucus covers the cervix. On speculum examination, it appears closed, pale and dry. After the fifth month of gestation, the cervix becomes shorter and softer, possibly due to high concentrations of circulating estrogens. The cervix may start to relax as much as one month before parturition. It is also within the range of normal for the cervix not to relax until just before time of parturition.

Ovarian Changes:

1. The primary corpus luteum (CL) will not be lysed (as it would have been if the mare were not pregnant) and will be maintained until Day 120.

2. Between Days 40-120, there is extensive follicular activity indicated by multiple ovulations and luteinization of follicles that will develop into the secondary CL.

3. By Day 120-180, the CL regress and the ovaries remain inactive for the rest of gestation.

Endocrine Changes:

1. Progesterone increases after ovulation due to production by the primary CL. After Days 30-40, progesterone concentrations will increase due to:

    a. Stimulation of greater progesterone output from the primary CL, possibly by equine chorionic gonadotropin hormone (ECG), also known as pregnant mare serum gonadotropin (PMSG).

    b. Ovulation and luteinization of follicles forming secondary corpora lutea.

    c. After 60 days, the placenta (conceptus) produces progestogens. The corpora lutea (primary and secondary) regress by Day 120-180 and gestation is maintained thereafter by progestogens produced by the placenta.

2. Estrogens are produced by the fetal gonads and placenta. Plasma concentration is high from Day 100 to Day 300, at which point it declines. Estrone sulfate is an indication of fetal well-being.

3. Equine chorionic gonadotropin hormone (ECG, PMSG) is produced by the endometrial cups after approximately Day 40. Concentrations peak at Days 60-70 and decline by 120 days.

Duration of Pregnancy:

Gestation length averages 330-345 days but is quite variable, ranging from 310 to 370 days or longer. Gestation is frequently longer for mares that conceive early in the year and for mares that carry a male fetus.

PLACENTATION

Day 3-4 (Morula): The embryonic vesicle is composed of a number of cells undergoing rapid mitotic division (blastomeres) and surrounded by a membrane called the zona pellucida.

Day 7 (Blastocyst): Some of the blastomeres accumulate in one pole (embryonic disc), which will develop into the inner cell mass that becomes the embryo. The rest of the cells cover the inner surface of the zona pellucida (trophoblast), which will develop into the fetal membranes. The cavity formed is called the blastocoele.

Days 9-12: The blastocoele is covered by endoderm to form the yolk sac, which is in contact with the primitive gut lumen of the embryo.

Day 14: A mesodermic layer forms from the embryonic disc between the trophoblast (ectoderm) and the yolk sac (endoderm).

Day 16: The mesoderm grows and develops into blood vessels. A cavity called the exocoelom forms within the proximal part of the mesoderm, dividing it into two layers.

Day 21: The allantois starts growing inside the exocoelom and starts pushing the embryo dorsally. At this time the yolk sac starts regressing.

Day 24-25: The allantois become prominent. The union of the allantois and chorion results in the allantochorionic placenta.

By Day 40: The trophoblast cells of the chorionic girdle have invaded the endometrium to form the endometrial cups.

The endometrial cups will produce ECG. The trophoblast cells invade the endometrium and penetrate the basal membrane, infiltrating the endometrial glands. The cups are arranged in ring-like fashion in the caudal portion of the uterine horn and part of the body of the uterus. The cups start regressing at Day 70-100 and regression is complete at approximately 120-130 days.

The placenta of the mare is classified as epitheliochorial, because the uterine epithelium is in contact with the chorion, non-deciduate, because there is no loss of any tissue layer at birth, and diffuse, because interdigitation of villi occurs over most of the placenta.

Hippomanes are large flat structures that can be present in the allantoic fluid. They form from deposition of proteinaceous material and minerals into a nucleus of epithelial debris. They are normal structures that can float freely in the allantoic fluid.

NUTRITION OF THE DAM DURING LATE GESTATION

The nutritional requirements of the mare during pregnancy expand to include the requirements for growth and maintenance of the fetus, placenta, uterus and mammary gland. During the first two-thirds of gestation, nutritional requirements for pregnant and nonpregnant mares do not differ significantly. However, during the last trimester of gestation, two-thirds of fetal growth occurs and 85-90% of fetal calcium is accreted from the mare into fetal bone.

The foal is completely dependent upon the dam for all nutrients. Poor maternal nutrition during the last trimester may result in weak newborn foals with decreased storage of glycogen in muscle and liver.

Mares increase their weight by approximately 15% during the last trimester. The amount of feed has to be increased in the same proportion. The period of maximum requirements corresponds with the period of greatest fetal growth. Because there is also reduction of abdominal space, it is not so much the quantity but the quality of the feed that must be increased.

The National Research Council suggests that during the last trimester of pregnancy, mares need 12% more energy. A 450 kg mare would require approximately 17 Mcal of digestible energy. Protein requirements in the ration are increased to at least 10%.

The pregnant mare ration should contain 0.45% calcium and 0.3% phosphorus. Legume roughage is low in phosphorus. Phosphorous can be provided by free access to a salt-mineral mix containing similar amounts of calcium and phosphorus.

Mares kept on grass pastures require additional phosphorus and calcium, and occasionally protein. If the pasture is low in protein, the ratio must be supplemented with concentrate. From 500 to 750 g of concentrate per 100 kg body weight should be fed daily to supplement what is provided by the pasture.

There is a misconception that overfeeding is a major cause of infertility in the mare. It has been shown that mares fed to gain weight during the breeding season have an increased chance of conception. Poor nutrition during gestation will also affect the mare's future fertility. Mares should be fed to gain weight after foaling in order to facilitate the occurrence of normal cyclicity and fertility. Poor levels of nutrition before and after foaling have been implicated in stress and early embryonic death.

CONTROL OF PARASITES

The deworming program is best tailored to the individual farm. Concentration and movement of horses, types of pasture, and geographic area are some of the factors to take into consideration.

Avoid deworming mares during the first 60 days of gestation while organogenesis is occurring. Most anthelmintics are safe to use in pregnant mares, however, it is critically important to read the labels of the products. Organophosphates should not be used during pregnancy because their administration has been associated with arthrogryposis. Cambendazole is contraindicated during the first trimester of pregnancy because it can produce teratogenic effects.

Deworming should be continued about every two months throughout gestation, and mares should be dewormed 1-2 days after foaling to reduce the parasite load, particularly *Strongyloides westeri*. This parasite is transmitted to the foal via colostrum and milk, resulting in the foal suffering from diarrhea and enteritis.

It is thought that anthelmintics should be rotated at intervals of one or two years so that each worm generation is exposed to no more than one class of drug.

Mares should be dewormed for bots in the fall.

Evaluation of the fecal egg count is very useful to determine the efficacy of the deworming program and to identify resistant parasites.

Anthelmintic prophylaxis: Should aim to avoid pasture contamination with worm eggs. Implementation of a prophylactic program helps prevent heavy infestation in horses and decreases the need for larvicidal drugs. Treatment every two months during spring and summer (the time of year when egg counts tend to rise) with Ivermectin will help prevent increases in pasture egg count during the summer and fall. Pasture rotation, control of stocking rate, and pasture harrowing will also help the antiparasite program.

IMMUNIZATION PROGRAM

Like the deworming program, the immunization program is best tailored to the individual farm. Concentration and movement of horses and geographic area are some of the factors to take into consideration.

1. Tetanus

Pregnant mares should receive the annual booster 30 days prior to expected foaling. This results in a strong anamnestic response with high colostrum titers that help provide protection to the newborn. Because passive immunity will persist for 2-3 months, foals that have good transfer do not need to be vaccinated until they reach 2-3 months of age. If failure of passive transfer is suspected, the foal should receive tetanus antitoxin.

2. Rhinopneumonitis

Pneumabort-K® (Fort-Dodge), a killed vaccine, is recommended to prevent EHV-1 abortion in mares. Because the protection is short-term, mares should be vaccinated at 3, 5, 7, and 9 months of gestation.

Prodigy® (Miles-Bayer) - killed vaccine; recommended for broodmares 5, 7, and 9 months.

Rhinomune® (Norden) is a modified live vaccine (MLV). It is commonly used in pregnant mares, but is not labeled to prevent abortion. If used, the first injection should be given after the second month of pregnancy. Although not approved for pregnant mares, uninterrupted vaccination of all broodmares at 2-3 month intervals is reported to hold EHV-1 abortions in check.

3. Eastern, Western and Venezuelan Equine Encephalomyelitis

Because this disease is transmitted by mosquitoes, vaccination should be performed prior to the insect season. The vaccine is available in several combinations: EEE, WEE, VEE and tetanus. An annual booster is usually sufficient to produce adequate protection.

4. Equine Influenza

It is caused by two major strains of Equine Influenza Virus, A-Equi-1 and A-Equi-2. Because immunity developed to one virus does not result in immunity against the other, the vaccine must be prepared from both strains.

Although influenza is usually not a problem for broodmares, it can be a serious problems for foals. The viral particles destroy the respiratory cilia and leave the respiratory tract very sensitive to bacterial infections. Pregnant mares can be vaccinated 30 days prior to parturition so that the foals will receive antibodies via colostrum.

Vaccines: The most common vaccines are Flu-vac® (Fort Dodge), Equi-flu II® (Jen-Sal), and Flumone® (Norden). These are killed vaccines prepared from chicken embryos and the immunity provided lasts between 6-12 months. These vaccines may produce swelling at the injection site.

Vaccines against other diseases (i.e., rabies, botulism, Potomac Horse Fever, etc.) may be indicated according to the particular area or farm requirements and annual boosters should be scheduled 30 days prior to foaling.

5. Strangles

This disease is produced by *Streptococcus equi*. Use of a vaccine against strangles is very controversial because its efficacy is questionable and side effects can occur. It can

cause abscesses, soreness and purpura hemorrhagica. Accordingly, this vaccine is only recommended on farms where *Streptococcus equi* is a problem.

Streptococcus zooepidemicus can also produce submandibular abscessing, so it is necessary to differentiate between organisms by culture before recommending vaccination.

Pregnant mares are vaccinated 30 days prior to the expected foaling date. Vaccination of an animal in the incubation stage of the disease is contraindicated.

5. Equine Arteritis Virus (EAV)

Vaccination titers may cause problems for mares that are shipped outside the country or being sent to an EAV negative farm. Its use depends on the farm's status for EAV. Generally, a mare is vaccinated only if she is scheduled to be bred to an EAV positive stallion.

Mares should be vaccinated prior to breeding. Do not vaccinate pregnant mares. Vaccinated horses should be isolated from nonvaccinated horses for 21 days.

PROBLEMS DURING GESTATION

Resorption of the Fetus:

The death of the embryo or the fetus up to approximately the fourth month of gestation usually results in dehydration of the conceptus by absorption of all the fetal fluids into the mare. The solid tissue is dried out and autolyzed by release of cell enzymes. The mare may not show heat for a variable period of time, particularly between 40-120 days after ovulation. For this reason, resorption usually is not discovered until the mare is re-examined in the fall.

Mummification of the Fetus:

This occurs when the fetus has already developed a recognizable skeleton. As in resorption, most fluids are absorbed into the mare, but the bones remain intact. In the mare, this condition only happens in the presence of twins, when one dies and mummifies. Death of a single fetus usually results in abortion.

Hydroallantois: *(accumulation of excessive allantois fluid)*

This condition is rare. Early diagnosis may be difficult. It can result in rupture of the prepubic tendon and shock. In most cases, termination of the pregnancy is necessary to save the mare's life. Treatment consists of perforating the chorioallantois and draining the contents. This should be done slowly to avoid hypovolemic shock. The mare should be prepared for aggressive treatment of shock that is likely to occur. Prognosis is poor.

Uterine Body Pregnancy:

Such mares usually abort at eight or nine months. The chorionic horns are attenuated (22-55 cm long), often with partial obliteration of their lumens, and the fetus is only in the body of the uterus. Fetal growth retardation, congenital deformities, and abnormalities of the internal organs often occur. The conditions giving rise to pregnancy in the uterine body are not known.

Rupture of the Prepubic Tendon/Abdominal Hernia:

Occurs most commonly in draft mares during advanced gestation. This condition is preceded by development of an area of ventral edema associated with pain in the area between the xiphoid and the udder. Mares that develop signs of impending rupture of the prepubic tendon should be confined and permitted only restricted exercise. A support system for the abdomen should be devised, such as a canvas that can be tightened around the back of the animal. Such mares should be monitored closely because they probably will need assistance during parturition. Induction of parturition may be indicated in these cases.

Uterine Torsion:

This condition may occur in mares in late gestation (> 6 months). It accounts for 5-10% of the serious cases of dystocia in mares and is less common in mares than in cows. The low incidence of uterine torsion in mares is attributed to the sublumbar attachment of the ovaries and the dorsal insertion of the broad ligaments in the uterus. It is not known what causes the condition, but it is suspected to relate to sudden, vigorous fetal movements in mares in advanced pregnancy. The uterus twists 90 to 360 degrees on its long axis.

Clinical signs are related to the severity of the torsion and appear similar to an episode of colic, with restlessness, sweating, anorexia, and signs of abdominal pain. Torsion of less than 180 degrees may not require correction because it may not compromise uterine blood flow.

Diagnosis is made by clinical signs and palpation per rectum. The broad ligaments are tense and follow the direction of the rotation. If the twist is counterclockwise, the right broad ligament can be felt stretched to the left over the dorsal surface of the uterus and vice versa. In some cases, speculum examination of the vagina can help to determine the direction of the rotation -- the vagina can be displaced at the cranial end, but usually the cervix is not involved.

Nonsurgical correction of uterine torsion can be attempted. The mare is anesthetized and placed in lateral recumbency on the side of the direction of the torsion. A plank of wood (roughly 2 x 12 inches) is placed on the abdomen to fix the uterus in place. With one person sitting on the middle of the plank, the mare is rolled in the direction of the torsion. The procedure may need to be repeated several times. If this method fails, the torsion can be corrected by a flank laparotomy either in a tranquilized standing mare or under general anesthesia.

The prognosis for the mare and the foal depends on the speed of diagnosis and correction.

Rupture of Uterine Artery:

This can result from trauma during late gestation that causes rupture of a blood vessel in the uterus or the broad ligament. Prognosis is poor. The mare will show signs of hypovolemic shock, increased respiration and heart rate, staggering, sweating, and pale mucous membranes. Afflicted mares should be kept quiet and undisturbed. They may be given blood transfusions immediately. They should not be transported because this can aggravate the condition. Naloxone is reported to help in some cases.

Abortion: *(General consideration: The dehydrated remnants of an early abortion are usually not found if the mare is turned out on pasture.)*

1. Noninfectious Causes:

Twinning:

Twinning is the cause of 20-30% of all observed abortions in mares. About 60-80% of twin fetuses that survive through the fourth month of gestation are aborted. Abortion is caused by fetal death due to placental insufficiency.

2. Infectious Causes:

Bacteria:

The bacterium most commonly associated with abortion in mares are *Streptococcus spp.*, *Escherichia coli, Pseudomonas spp., Klebsiella spp*., and *Staphylococcus spp*.

Routes of suspected infection:

a. Ascending infection occurs most commonly due to cervical incompetence and poor perineal conformation. This will typically cause ascending placentitis at the cervical pole. The chorion may be thickened and discolored with villous loss and exudates. A small area may be affected, or it may affect up to 25% of the chorion. If abortion does not occur, fetal growth may be retarded due to reduction of the functioning chorionic surface.

b. Hematogenous: Although in many cases the infection is restricted to the chorion, infection can also occur hematogenously through the umbilical veins. In these cases, the fetus may have focal inflammatory lesions in the liver. With amniotic spread, there may be pulmonary lesions. Organisms can be isolated from the stomach and lungs.

c. Bacteria present in the uterus at the time of breeding: Although a possible route, it is not supported by pathological evidence.

Fungal Disease:

The most common fungus causing abortion in mares is *Aspergillus fumigatus*. Infection most commonly occurs via the ascending route through the cervix, but may occur by the hematogenous route. Abortion usually occurs after the tenth month of gestation. The fetal membranes have a dry, thick and leathery aspect. Diagnosis is based on identification of the organism on smears or histologic examination of the chorion.

Virus:

a. Equine Herpes Virus

There are two types of Equine Herpes Virus that can produce abortion: EHV-1 and EHV-4. EHV-1 can produce respiratory disease, abortion, neonatal disease, and neurologic disease.

EHV-4, previously called EVH-1 sub 1, can produce respiratory disease. It can also produce abortion, but this is extremely rare. It does not produce neonatal or neurologic disease.

Pathogenesis:

EVH-1 enters through the nasopharynx, goes to the lymph node, infects leukocytes and is carried into the blood stream (viremia). The placenta and the fetus are next. Many organs are affected, especially the lungs. It can also go to the nervous system causing paralysis, neurologic signs and death.

EHV-4: It can multiply in the vascular endothelium, but does not replicate in the leukocytes, therefore, it does not produce viremia.

EHV-1: It cause abortion most frequently between 7 and 11 months. Abortion occurs most commonly 3-4 weeks after infection, but can occur at any time from 2-12 weeks. Abortion occurs without premonitory signs. The aborted fetus is fresh. It does not affect the genital tract or produce subsequent infertility.

When it affects neonates, they are abnormal from birth, being weak, jaundiced, and dyspneic. Death usually occurs within 1 to 3 days.

Sources of EHV-1: Aborted fetus, membranes, fluids. Foals and older mares shed the virus when in the acute stage of infection (respiratory tract). The carrier horse can shed the virus from the nasopharynx.

Diagnosis:

1) Gross and histologic examination.

   Histologically, EHV-1 abortion is characterized in the fetus by focal hepatic necrosis, bronchiolitis, and intranuclear inclusion bodies within the areas of necrosis.

   Although there are no specific pathologic changes, more than 1/3 of the placentae from mares with EHV-1 infections have edematous, overweight chorions (more than 4 kg) and 30% of the mares with EHV-1 abortion have no rupture of the cervical star. In over 50% of such abortions, the fetus is found still attached to the membranes. In many cases, premature separation of the placenta occurs, and the fetus is found inside the intact membranes.

2) Immunofluorescent antibody.

3) Isolation of virus. False negatives are possible.

b. Equine Arteritis Virus

Etiology: Produced by a RNA virus, *Togaviridae arterivirus*. It has its own replication characteristics that differ from the other members of the group.

Clinical Signs: The incubation period is 3-14 days. Signs include fever, depression, anorexia, limb edema, stiffness, conjunctivitis, periorbital edema, nasal discharge, skin rash (it may be on the neck or generalized), and abortion. Abortion is the single most significant sign and may occur from as early as 2 months of gestation to term. It can also produce edema of the scrotum and prepuce, mammary gland, and intermandibular space and beneath the sternum. Although not very common, it can also produce papular eruption of the mucous membrane inside the upper lip.

Pathogenesis: It initially enters the host through the respiratory tract, replicates on macrophages and spreads to the bronchial lymph nodes. Three days after experimental infection, the virus is everywhere in the body. The virus can also replicate in the endothelial cells, causing vasculitis.

Prevalence: It has been found that 80% of the Standardbred population in Kentucky is seropositive. Only 20% of the Thoroughbred population has a positive titer.

Epidemiology: The disease can be presented acutely. In the acute stage of the disease, affected animals will shed the virus through both the respiratory and genital tract for 7 to 21 days after initial exposure. This is true for both mares and

stallions. Venereal transmission of the virus is also possible in stallions in the early convalescent period (2 to 12 weeks after exposure).

An important factor in the epidemiology of this disease is that a proportion of the stallions infected can become short, medium, or long term carriers of the virus. It is estimated that 20 to 40% of infected stallions can become carriers. Stallions that shed the virus may do so for only 1-5 weeks, up to 3 years, or in some cases longer (6 years). It is not known whether some stallions could be shedders of the virus for life. It has not been possible to identify mares that are carriers.

The frequency of the carrier state in stallions is estimated between 0 and 47%. The carriers shed the virus persistently. It is usually not present in the respiratory tract, blood or urine; the carrier transmits the disease venereally.

In the carrier state, the virus is not harbored in the testicles. After 21 days of exposure, the virus is eliminated from the genital tract except for the accessory glands. The greatest amount of virus can be isolated from the ampullae. The virus is only present in the sperm-rich fraction of the ejaculate. The virus is superficially located in the accessory glands with extremely low lesions and no inflammation. It almost appears that the virus is immunologically protected.

Diagnosis:

1) Virus isolation:

   It can be obtained from nasopharyngeal swabs, tissues from necropsy, semen, and urine. This disease is usually not lethal unless neonates are infected in utero.

2) Immunofluorescent antibody:

   Performed on the aborted fetus. Abortion usually occurs 7 to 10 days after acute onset. The fetus is usually autolyzed. The typical arteritis lesion is not found on the aborted fetus.

3) Serologic examination:

   The carrier stallion has a major role on the epidemiology of the disease. Usually the stallion (carrier) transmits the disease venereally to mares that are not vaccinated or are seronegative. These mares then transmit the virus laterally to pregnant mares.

Control:

1) Identification of carrier stallions.

2) Vaccination of at-risk stallion population. Note: Consult local regulations on vaccination recommendations before vaccinating stallions and broodmares. Animals with a positive titer may be prohibited for export or breeding to negative animals.

3) Vaccination of mares.

4) Separate pregnant mares from ones that are being bred to prevent lateral transmission.

Vaccination: There is a modified live vaccine (MLV) from Fort Dodge. It has been proven to be safe with no adverse sequelae. A vaccinated stallion will develop titers within 5-8 days of vaccination. The vaccine is safe for stallions, but should not be used on pregnant mares. Occasionally, multiplication of the virus vaccine to a limited extent is detected, which is not surprising because it is a live vaccine.

Foals should not be vaccinated before 6-8 weeks of age. A second dose is administered 10-11 weeks later, followed by annual re-vaccination. Stallions should not be vaccinated less than one month prior to breeding. Maiden and barren mares should not be vaccinated less than 3 weeks prior to being bred. Mares in late gestation should never be vaccinated. Vaccinated horses should be isolated from those not vaccinated for 21 days.

PARTURITION

Endocrine Control:

Parturition occurs rapidly in the mare, and the endocrine control is poorly understood. Parturition in the mare, unlike in other species, is preceded by a decrease in circulating estrogens concentrations and an increase in progesterone.

Prostaglandin concentrations are low during most of gestation. They start rising 7-10 days before foaling. Prostaglandin concentrations increase abruptly during the second stage of parturition when the fetus passes through the vagina.

Oxytocin concentrations are low during gestation and the first stage of parturition. Concentrations increase abruptly during the second stage and are responsible for the strong uterine contractions at this stage.

Maternal control over the time of parturition has been demonstrated. Most foalings occur at night when barn activities are minimal.

Preparation of the Environment:

The mare should be taken to the foaling area 3 to 4 weeks before her expected foaling date so she can build up antibodies to the pathogens present in the environment. These antibodies will be passed to the newborn via colostrum.

Foaling box-stalls should be roomy (at least 3.5 x 3.5 m). The foaling area should have good ventilation and be well bedded with clean, dry straw. The walls should be of solid construction and free of sharp edges. Observation of the mare should be done without disturbing her.

Predicting Time of Parturition:

Evaluation of the signs that precede parturition is useful but does not permit precise prediction of the time it will occur.

The mammary gland starts developing 3 to 6 weeks before foaling and distends with colostrum in most mares 2-3 days before parturition. Colostrum drips from the teats and forms a waxy material at each teat orifice. This "waxing" occurs in about 95% of mares 6-48 hours before foaling, but in some cases it does not occur at all or it precedes parturition by many days. The wax usually remains for 12-24 hours, then falls off and milk starts dripping from the teats. There is an increase in the calcium and potassium content of udder secretions before foaling, and a fall in sodium. At about 24 to 48 hours before parturition, concentrations of potassium and sodium in the udder secretions become comparable (approximately 40 mmol/liter).

A score system can be used to evaluate the mare's udder:

0 No significant development

\+ Some enlargement and filling of teats with clear-colored fluid

++ Further enlargement of udder with some edema; the mammary secretion is now cloudy and straw colored

+++ Maximum development of udder at full term; beads of wax present on teat ends; udder and teats distended and containing cloudy viscous colostrum.

Stages of Parturition:

It is critical to understand the normal progression of events during the parturition process. This permits identification of abnormal events and sound decisions to be made as to when and how to intervene in a given situation.

For descriptive purposes, the parturition process is divided into three stages.

First Stage:

The first stage is characterized by signs of abdominal pain and restlessness due to uterine contractions. Patches of sweat commonly appear in the flank area and behind the elbows, usually about 4 hours before foaling, and increase in intensity as foaling approaches. Other signs during the first stage are relaxation and dilation of the cervix and onset of uterine contractions that are painful. The sacrosciatic ligaments are relaxed and there is edema of the vulva.

The fetus has to change its position before parturition. It is usually in a dorso-pubic position, and must rotate to a dorso-sacral position before delivery. Mares may roll during the first stage, which is thought to facilitate the rotation of the fetus.

The mounting pressure in the uterus causes the allantochorion to protrude through the internal os of the cervix. The allantochorion over the cervix does not have microvilli and it is thinner than the rest of the membranes. This area is called the cervical star. The allantochorion usually ruptures at the cervical star, and this marks the end of the first stage of parturition.

Occasionally, first-stage signs are interrupted and parturition is delayed for several days.

Second Stage:

Starts with the rupture of the allantochorion and finishes when the fetus is delivered. It usually takes between 10 and 30 minutes.

After rupture of the allantochorionic membrane, uterine and abdominal contractions push the fetus through the cervix into the vagina. Most pressure is accomplished by the abdominal musculature. The allantoic fluid plays a very important roll in lubricating the canal, facilitating expulsion of the amnion and fetus. Vaginal distention causes release of oxytocin and further myometrial and abdominal contractions. The amniotic membrane appears between the vulvar lips as a white, fluid-filled structure. The straining efforts of the mare consist of 3-4 strong contractions, followed by a short period of rest. The mare usually assumes lateral recumbency during delivery with her limbs extended. One front hoof of the foal usually precedes the other, facilitating passage of the elbows and shoulders through the pelvic canal. The greatest effort on the dam's part is associated with passage of the foal's head. After expulsion of the head, the mare may stand (and even eat) or roll to shift the position of the foal. Usually the foal's chest and hips pass through the canal more easily. The foal is usually born with the cord intact and covered by the amnion, which is ruptured by movements of the mare or the foal. If left undisturbed, the mare may lie for some time with the foal's hind limbs in her vagina.

Third Stage:

Expulsion of the fetal membranes.

Normally, placental separation occurs rapidly (within three hours) after expulsion of the foal. The weight of the amnion and cord results in the allantochorion separating from the endometrium at the point where the cord is attached to the allantochorion. Progressive traction by the amnion and powerful uterine contractions originating at the tip of the horn cause complete separation of the allantochorion, which may become inverted during the process.

INDUCTION OF PARTURITION

It is very important to first evaluate the mare carefully and be sure that several criteria are met.

Advantage:

Ensures the presence of professional assistance for mares with a history of complications or that have experienced problems during gestation.

Disadvantages:

To be successful, several criteria must be met. Poorly timed induction of parturition can result in a premature foal and/or dystocia.

Indications:

1. Mares that have previously produced dead or severely hypoxic foals due to premature placental separation associated with delayed parturition.

2. Mares that have suffered problems during a previous foaling(s) such as dystocia, tears or injuries, and that require professional assistance.

3. Mares in which gestation is (1) prolonged beyond 365 days and (2) associated with a very large fetus. Usually, mares that prolong gestation over 365 days have small or normal size foals.

4. Mares in which there is impending rupture of the prepubic tendon, hernia, or hydrops.

5. In mares that have produced icteric foals (neonatal isoerythrolysis), to prevent the newborn foal from ingesting colostrum before its red blood cells can be checked against the mare's serum.

6. Nurse mares.

Criteria for Induction:

1. Length of gestation: Induction should only be performed when the fetus is mature enough to adapt to the environment outside the uterus. A minimum of 330 days increases

the likelihood of adequate fetal maturity at the time of induction if all other criteria are fulfilled.

2. Enlargement of udder and presence of milk: The udder should be enlarged and the teats distended with an ample supply of colostrum. A sufficient amount of colostrum in the udder is the most important indicator of fetal maturity.

3. Relaxation of the sacrosciatic ligaments: Maximum relaxation occurs very close to foaling and is also accompanied by relaxation of the vulva.

4. Relaxation of the cervix: The cervix should be soft, easily compressed and starting to dilate.

Methods of Induction:

1. Oxytocin

Oxytocin is the most commonly used agent for induction of parturition. Parturition will occur rapidly and safely with small doses of oxytocin. Oxytocin (5-10 IU IV or 20 IU IM) is effective to initiate parturition in the mare. Some clinicians infuse 60 IU in 1 liter of physiologic saline intravenously at a rate of 1 IU oxytocin/minute until delivery is complete.

The signs observed after induction of parturition resemble closely the ones in normal parturition. Retention of fetal membranes beyond 3 hours is not common.

2. Prostaglandins

A synthetic prostaglandin F-2α (fluprostenol) can be used to induce parturition in the mare. Doses of 1000 micrograms for mares and 250 micrograms for ponies administered intramuscularly are effective, with signs starting within 30 minutes of the injection. Birth usually occurs within two hours.

3. Corticosteroids

Large doses of corticoids are necessary to induce parturition in the mare. Daily administration of 100 mg of dexamethasone for 4 days starting after Day 321 will induce parturition between 6.5 and 7 days after initiation of treatment.

PROBLEMS DURING PARTURITION

Dystocia

The foal is normally delivered in anterior presentation and in dorso-sacral position with the head, neck and forelimbs extended.

Approximately 50% of equine fetuses are in posterior presentation in early gestation, but by 6-7 months most have rotated to anterior presentation.

One of every 500 equine fetuses is reported to be in posterior presentation at the time of delivery.

The incidence of dystocia among Thoroughbreds is approximately 4%. It can be caused by an abnormality of the fetus (fetal dystocia) or an abnormality of the dam (maternal dystocia).

The most common cause of fetal dystocia is postural abnormality, particularly flexion of the carpus and lateral flexion of the neck.

Maternal causes of dystocia include uterine inertia (which may be caused by systemic disease) and factors that reduce the pelvic canal, such as pelvic fractures, sacroiliac luxation, and tumors.

When parturition is not progressing normally, manual examination per vagina is indicated to determine whether intervention is needed.

Restraint of the Mare During Examination:

The amount of restraint necessary will depend on the temperament of the mare. Stocks are not advisable because many mares will lie down during the examination.

A nose twitch may be necessary to restrain the mare.

If chemical restraint is necessary, acepromazine maleate (0.04-0.08 mg/kg IV) can be used.

Hygiene:

Cleanliness and ample lubrication are essential to any obstetrical examination.

The mare's tail should be wrapped and tied out of the way.

A complete scrub of the perineal area should be performed prior to any invasion of the genital canal.

The operator should wear clean sleeves and use ample amounts of lubricant.

In Case of Malpresentation:

Epidural anesthesia with lidocaine (2%) may help to relieve pain and decrease abdominal contractions.

Occasionally, short term general anesthesia is necessary to correct malpresentation. A combination of xylazine (1 mg/kg IV) and ketamine (2 mg/kg IV) after the xylazine has taken effect provides 10-15 minutes of muscle relaxation and analgesia.

Cesarean Section under general anesthesia may be the best choice in difficult obstetric cases.

Fetotomy. In cases when the fetus is already dead and the malpresentation cannot be corrected manually, fetotomy is indicated. It should be performed very carefully because injuries during this procedure can jeopardize future fertility of the dam. If more than 2 cuts are required, cesarean section is recommended.

Premature Separation of the Placenta

Premature separation of the placenta is characterized by the appearance of the bright red, unruptured (intact) chorioallantois between the vulvar lips prior to delivery of the foal. The chorioallantois must immediately be broken and the foal manually delivered or the foal may asphyxiate.

EXAMINATION OF THE PLACENTA

It is very important to be familiar with the normal anatomic features of the placenta in order to be able to recognize abnormalities, and/or retention of small pieces in the uterus. After expulsion, the placenta is studied by spreading it on a flat clean surface, with the villous (chorionic surface) outermost. This has a red, velvety appearance with different degrees of intensity. The intensity will depend on the density and height of the tufts and the amount of residual blood. The area between the two horns where the cord attaches is especially dark due to the dense, tall villi.

There are several areas devoid of villi where the surface is smooth. The most prominent of these areas is the cervical star. Other avillous areas are the remnants of the endometrial cups and oviduct papilla. Areas where the allantochorion is folded on itself will also be avillous. These areas are normal.

The amnion has a white translucent appearance and contains many tortuous blood vessels. Near the base of the amnion, a small area of exocoelom can be found that extends along the cord for a short distance. Small, pale amniotic plaques can be seen along the umbilical cord.

A proportion of fetal and neonatal foal deaths are associated with pathologic changes present in the fetal membranes. Integrity of the junction between the fetal and maternal components of the placenta is essential for normal fetal development. Because the mare has a diffuse epitheliochorial type of placentation, it reflects like a mirror the presence of abnormalities in the endometrium.

Umbilical Cord:

The umbilical cord is usually attached to the greater curvature of the fetal placenta (corresponding to the dorsal wall of the uterus) near the junction of the two horns.

The two portions of the umbilical cord can be easily identified. The amniotic portion contains two arteries, one vein, and the urachus. The regressed yolk sac may appear as a hard bony sphere at the base of the umbilical cord. The urachus connects the fetal bladder with the allantoic cavity.

The allantoic portion of the umbilical cord is covered by the epithelial lining of the allantoic cavity. It contains the prominent umbilical vessels.

When the umbilical cord is allowed to separate naturally, the vein and urachus break at the naval stump, while the two arteries break within the foal near the apex of the bladder.

Infectious Conditions: *See infectious causes of abortion*.

Noninfectious conditions:

Twins:

In the case of twins, the endometrial surface available for chorionic attachment is shared by both placentae, which leads to placental insufficiency. There is always growth retardation of the fetuses. There is characteristically a totally avillous area in each chorion at the site of apposition.

Umbilical Cord Abnormalities:

Obstruction of blood flow: Cords that are too long (more than 80 cm) have a tendency to twist and loop around fetal parts, which can result in compression of the umbilical veins and fetal death. Examination of the fetus shows signs of local edema, tearing, hemorrhage and constriction.

Obstruction of urachal urinary flow:

Usually does not cause fetal death unless associated with obstruction of blood flow. It can produce bladder and abdominal distention. This can result in dystocia or rupture of the bladder at parturition.

Premature cord rupture during parturition:

Can occur when the cord is too short (less than 40 cm). The foal dies from asphyxiation.

Noninfective lesions of the villous surface of the chorion:

Histologic examination is necessary to determine the true nature of areas of discoloration.

Villous atrophy:

Focal placental separation may cause degeneration and atrophy of previously normal villi, with accumulation of endometrial secretions. This is a consistent finding in normal placentae at the edematous tip of the pregnant horn at term and at the cervical star, but only affects fetal health when it is extensive. It is seen in cases in which excessive twisting of the cord causes poor vascular perfusion of villi.

Villous hypoplasia:

The villi are short and simple rather than branched; there may be areas of total villous aplasia. A reciprocal hypoplasia of the maternal microcotyledons is present, and the conduit is probably associated with endometrial disease. Neoplasia is very rare.

Amniotic lesions:

Multiple foci of calcification (associated with hippomane material), adherence of innocuous fetal debris, focal edema and parturient hemorrhage occur on the amnion of normal foals. Extensive green staining of the amnion occurs with fetal diarrhea. Such foals may be born alive but, if they inhale meconium, may develop pneumonia and require intensive care.

During pregnancy, perforation of the amnion may occur associated with traumatic lesions or with conditions that lead to accumulation of urine within the amniotic cavity. When allantoic and amniotic fluid mix, there is a diffuse inflammation of the allantois (allantoitis) with shrinkage, and fibrosis; sometimes there is eversion of the amnion and intra-amniotic adhesions. Prolonged contact with allantoic fluid may be detrimental to the fetus.

POSTPARTUM PROBLEMS

1. Vulvar and Perineal Trauma

Bruises of the vagina, vestibule and vulva are very common during parturition. Tears of the vulvar lips and/or perineum are easily recognized. They can result from a Caslick's suture that was not removed before parturition. Damage to the vagina and vestibule can be diagnosed by manual examination per vagina. Suturing of these tears can be performed immediately without local analgesia if the mare has foaled within a couple of hours. Lacerations may need to be reevaluated after tissue swelling has resolved.

2. Rectovaginal Fistula

Occurs when a foal's hoof perforates the vaginal roof and rectal wall, and then, after relaxation between expulsive efforts, re-enters the vagina. It results in fecal contamination of the vagina and uterus. Diagnosis can be made by careful palpation per vagina.

3. Perineal Laceration

Can occur as a result of continuous straining and trauma. Surgical treatment must be delayed until the laceration has healed by second intention and the extent of the problem can be assessed. Surgery is performed with the mare standing under heavy sedation and/or epidural block. In many cases, several attempts are necessary to complete the repair.

4. Cervical Laceration

Not an uncommon finding. It can only be diagnosed by careful palpation of the cervix per vagina. The index finger is inserted in the external cervical os and the wall is palpated between the index and thumb. Evaluation of the laceration must be performed while the cervix is closed (after foal heat ovulation while under the influence of progesterone). If the magnitude of the laceration is sufficient to compromise cervical competency, surgical repair is indicated. Surgical repair is performed in the standing mare under heavy sedation and/or epidural block.

5. Uterine Rupture

Occurs due to uterine contractions during a normal parturition or a dystocia. If there is eventration of the abdominal viscera, diagnosis is easy. If this is not the case, diagnosis requires careful manual examination of the uterus. Prognosis is poor because of internal bleeding, hypovolemic shock, and peritonitis.

6. Hematomas

It is not uncommon for small vessels to bleed into the space between the myometrium and its serosa. Resolution of hematomas occurs slowly but they usually do not affect future fertility. Extensive hemorrhage may be fatal.

7. Uterine Prolapse

Rare in the mare. It occurs immediately after parturition, due to traction on the fetal membranes or straining. The inverted endometrium is very vascular and, if damaged, can result in extensive hemorrhage. Before replacement of the uterus, the fetal membranes should be detached, and the endometrium rinsed with saline. Supportive treatment includes antibiotics and nonsteroidal anti-inflammatory drugs.

8. Hypocalcemia

This condition is rare in the mare and typically occurs immediately after parturition. It is related more to stress than to calcium concentrations. The mare shows severe tetanic spasms. Mild cases involve slight hyperesthesia and dry feces. The treatment of choice is slow infusion of calcium borogluconate (250-500 ml - 50% solution IV) to effect with continuous monitoring of cardiac activity.

9. Postpartum Endometritis

Some degree of contamination of the uterus is unavoidable during parturition. In most cases, the resulting endometritis resolves spontaneously. For this reason, therapy is usually not instituted unless the uterus fails to involute and expulsion of uterine contents does not occur. In such cases, the uterus can be lavaged with 3-7 liters warm physiologic saline. Oxytocin can be administered to help contract the uterus and empty the uterine contents. Gentle exercise will also help to mechanically empty the uterus.

10. Retained Placenta

Fetal membranes that are not expelled within 3 hours of parturition are considered to be retained. The mare will stand with the amnion hanging from the vulva at the level of the hocks or below. The membranes should be tied above the hocks to keep the mare from damaging them.

The amnion and cord should not be cut because they provide the tension necessary for placental separation and expulsion to occur.

Membranes not passed within 3 hours are considered to be pathological, and can lead to laminitis and metritis, with fatal results. Accordingly, it is prudent to treat the condition as potentially serious. Retained placenta with associated laminitis and metritis is more likely to occur in heavy horses.

Early Treatment (3-8 hours):

Oxytocin: Repeated small doses intravenously (20 IU every 15 minutes) until the placenta is passed. Discontinue if the mares shows severe signs of colic or discomfort. Milking or suckling will also stimulate endogenous oxytocin.

Treatment after 8 hours should also include:

Antibiotics - broad spectrum.
Nonsteroidal anti-inflammatory Drugs: Flunixin meglumine or phenylbutazone.

UTERINE INVOLUTION AND THE EARLY POSTPARTUM PERIOD

Uterine involution is characterized by expulsion of the placental membranes and contraction of the uterus, cervix and broad ligaments to normal nongravid dimensions. In addition to gross changes in the genital organs, the endometrium of the uterus also must repair itself to a pregravid state. Histologic changes of the endometrium associated with involution in the mare include removal of microcaruncles and resolution of cystic gland distention. Histologically, this process is complete 7 to 10 days after parturition.

Progesterone and estrogen drop to basal levels after parturition. Estrogen concentrations increase during the first estrous period and progesterone concentrations increase after the first ovulation. In mares, uterine tone is affected by ovarian steroids.

FERTILITY OF THE FOAL-HEAT BREEDING

The maximum reproductive efficiency in a broodmare situation is achieved when a foal is produced every year. Horses have an average gestation length of approximately 340 days. This leaves only 25 days for the mare to become pregnant again, if an interval of 12 months between foalings is to be maintained.

In order to accomplish this goal, many breeders have their mares bred on "foal heat", which commences 5-10 days after foaling in 93% of mares. There has been a great deal of controversy about whether mares should be bred on foal heat. The conception rate at this heat varies. Some authors have not found any difference between conception rates during or incidence of early embryonic death between mares bred on the foal heat or subsequent cycles. Other authors have noted an approximately 10% lower pregnancy rate. Several factors have been proposed as the cause of an increased incidence of embryonic death in mares bred at foal heat. Some of the factors are: delayed or incomplete uterine involution, presence of bacteria associated with poor uterine involution, lactation stress, nutrition, uterine infections (it is impossible to eliminate all contamination incurred at the time of breeding), intraluminal uterine fluid, sire factors, hormonal imbalances, and chromosomal defects in the embryos.

Mares should not be bred on foal heat if they experienced dystocia or retained membranes.

Pregnancy rates for mares bred on foal heat are higher if the mares are bred after Day 10 post partum. Several treatments have been attempted to increase the fertility of the first breeding:

1. Prostaglandin:

Prostaglandins (Lutalyse, 10 mg IM) are used at approximately 6 days after the foal heat ovulation (approximately Day 16 to 20 after parturition) to shorten the cycle. The mare is bred on the second ovulation that occurs approximately 23 days after parturition. In one study, this resulted in a higher pregnancy rate (81% versus 60%) and a lower early embryonic death rate (17% versus 4%).

2. Progesterone and Estradiol 17 β:

Daily administration of 150 mg of progesterone and 10 mg of estradiol 17 β have been used to delay the onset of foal heat and allow a longer period of time for the endometrium to repair. Progesterone and estrogen cause a consistent inhibition of secretion of gonadotrophins. When the treatment is discontinued, there is an increase in follicular activity. To be effective, treatment should start within 24 hours of parturition. Ovulation usually occurs 10-14 days after cessation of treatment. Studies using electron microscopy have shown a more uniform appearance of the endometrium at Days 10-11 when mares were treated in this manner.

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