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**Failure of passive immunity and potential sequelae – a review of achieving passive transfer in cattle and current industry standards. Practice treatment of infected joints**

Calves are immunologically naïve at birth due to the synepitheliochorial placentation separating the fetal and maternal blood supplies preventing transmission of immunologic components from the dam to the fetus. Acquisition of passive immunity through colostrum intake helps protect calves from disease in the neonatal period.

Currently failure of passive immunity (FPI) is classified as serum IgG <10 mg/mL at 24 h of age. Efficiency of absorption of colostrum decreases with age. Osaka et al (2014) reported calves fed within 1, 1 to 6, 6 to 12, and 12 to 18 h after birth have apparent efficiency of absorption values of 30.5, 27.4, 23.7, and 15.8%, respectively. Intestinal permeability decreases by 12 h and ceases at 24 h post partum.

Lombard et al. (2020) introduced the new transfer of passive immunity (TPI) standard to account for immunity that is transferred in colostrum but not the absorption of immunoglobulins. They defined 4 categories of serum IgG: excellent, good, fair, poor with serum levels of IgG at ≥ 25.0, 18-24.9, 10-17.9, and <10mg/mL respectively. They also suggested that on a herd level, >40, 30, 20, 10% calves should fall into these groupings respectively. As serum IgG concentrations increase above 15 mg/mL the incidence of respiratory disease, morbidity rates and growth rates improved in beef cattle.

Good quality colostrum from the dam is the best source of IgG. Heat treatment of colostrum has been found to enhance IgG absorption and increase plasma IgG concentration by 18.4% and is helpful in reducing bacterial contamination when done carefully. Colostrum is considered good quality when its IgG concentration is > 50 mg/mL, bacterial count is <100000 cfu/mL, and coliform counts are < 10000 cfu/mL. Colostrum Brix percentages <24% and ≥ 30% are optimal for indicating IgG concentrations of <100g/L and ≥150g/L, respectively in beef cow colostrum (Gamsjager et al 2020).

Commercial colostrum products are considered replacements if they provide >100g IgG per dose. Those containing <100g IgG per dose are considered supplements. In order to achieve satisfactory passive immunity a calf must consume at least 150 -200g IgG at birth (Chigerwe et al., 2008) while Godden et al., (2019) suggests feeding masses of 300g.

Analysis of IgG – Radial immunodiffusion (direct measure) and ELISA (an indirect measure) are considered reference standards and are not always practical in the field.
Serum total protein (STP) measurement by refractometer has been used to estimate IgG concentration, however the STP correlation can vary in calves fed colostrum replacer attributed to the different IgG to total protein ratios in maternal colostrum versus replacers. Lopez et al (2020a) found the mean STP levels in calves fed a low-casein colostrum replacer were below the

FPI threshold of 5.2g/dL even if their mean serum IgG were above 10 mg/mL. A range of STP cutpoint between 5.2 and 5.5g/dL provide the best measure of adequate TPI (Buczinski et al 2018) done on calves 1 to 6 days of age. This correlates to 7.8 – 8.5% on a Brix refractometer (Zakian et al 2018, Hernandez et al 2016).

***To prevent FPI the goal is to feed colostrum with a concentration of ≥ 50 mg/mL of IgG (Brix > 22%), to achieve a total mass of 150 -200 g IgG, within 2 h birth.
This would equate to about 10% body weight in colostrum at first feeding.****

**Good quality colostrum**

| Method | Good quality | Mass of IgG | Volume to feed |
|---|---|---|---|
| Colostrometer | >50 g/L | 150 – 200 g | ~3-4 L |
| Brix refractometer | >24%<br>>30% | 100g/L<br>>150g/L | ~2 L<br>~1 L |

Feed 10% body weight in first 2 hours life
Goal to feed 150-200g IgG

**Transfer of passive immunity measured days 1-6 of life**

| Category | Serum IgG | Proportion of calves in herd | Serum total protein g/dL | Brix % |
|---|---|---|---|---|
| **Excellent** | ≥25 mg/mL | >40 % | ≥ 6.2 | ≥ 9.4 |
| **Good** | 18.0 - 24.9 mg/mL | 30% | 5.8 - 6.1 | 8.9 - 9.3 |
| **Fair** | 10.0 - 17.9 mg/mL | 20% | 5.1 - 5.7 (4.9 g/dL from CR) | 8.1 - 8.8% |
| **Poor** | < 10 mg/mL | <10% | < 5.1 | < 8.1% |

CR – colostrum replacer

## Septic joints

Three types of arthritis have been described in cattle (Smith et al 1989). Primary arthritis when infection is introduced through a puncture wound, secondary attributed to infections spreading from adjacent tissues (i.e. foot rot leading to pedal arthritis) and tertiary from septicemia. Localization of infection in joints of neonates can be a sequelae of failure of passive transfer preventing spread of infection from the umbilicus, lungs or GIT.
Clinical signs are often acute onset of non-weight-bearing lameness, joint swelling, and pain and heat on palpation and manipulation. There may be a fever and decreased appetite present. Polyarthritis is commonly associated with dissemination of bacteria via blood which is not uncommon in calves. The most commonly affected joints in calves are carpus, tarsus, stifle and fetlock.
Differential diagnoses for non-weight bearing lameness should be ruled out, i.e. foot disease, luxation, fracture, tendon injury, nerve damage, septic tenosynovitis etc.

Diagnosis:
Arthrocentesis is done aseptically in a standing or lying sedated animal. If septic arthritis is of low suspicion use a 20 G to 22 G needle (or spinal needle with stylet) to reduce risk of contamination. However, if infection is highly likely, larger-diameter needles are useful as the high and cell and protein content make aspirating the thick synovial fluid difficult. Use an 18 G or 20 G 1.5- inch needle. (14 G if lots of fibrin).
Routine bacterial culture and specific anaerobic and mycoplasma cultures should be requested. Analyze samples asap. Culture success is reported in about 60% of cattle cases (Desrochers et al 2014).
Cytology can be useful if there is only subtle macroscopic changes in the fluid. If total protein is >4.5g/dL the of septic arthritis are 4 times greater than non-septic arthropathy.
Radiographic changes need to be interpreted in light of history since it can take 10-14 days to see lesions. Ultrasound can be used to assess soft tissues and to assess quality of synovial fluid.
The goals of treatment are to decrease the bacterial load, control inflammation and pain i.e. antibiotics, anti-inflammatory drugs and joint lavage.
Antibiotics are the main course of treatment for septic arthritis. Selection should be based on culture and sensitivity. However, in the interest of economics, empirical treatment is usually applied based on the most common pathogens (*Trueperella pyogenes*, *Fusobacterium necrophorum*, *Bacteroides*, *Mycoplasma*, Coliforms). The characteristics of the antibiotic chosen should ensure that it can attain therapeutic concentrations in the synovial tissues and fluid. The narrower the spectrum the better, hence the advantage of culture and sensitivity results. Cost, FDA approval and withdrawal periods are major considerations in food animals and severely limit our choices. Currently no antimicrobials are labelled for septic arthritis use.
Intraarticular antibiotics are controversial. Use of appropriate systemic antibiotics (macrolides, florfenicol) that give adequate and constant drug levels without the risk of intraarticular injections is preferred. Duration of treatment is often empiric. Typically, a 3-4 week course is recommended. If there is no bone involvement the course may be shortened (Desrochers et al 2014). Regional limb perfusions with 1.5g ampicillin-sulbactam found concentration remained above MIC in the synovial fluid for 18.9h on average (Depenbrock et al 2017).
Anti-inflammatories are useful for pain management and control of the deleterious effects of the inflammatory response. Flunixin meglumine (1.1mg/kg IV q 12-24h) and Meloxicam (0.5mg/kg PO q 12-24h) have been demonstrated to be effective in controlling pain associated with synovitis and amputation, respectively (Desrochers 2014). Corticosteroid use is controversial due to their immunosuppressive properties and risk of deleterious effect on clearance of bacteria.
Adjunctive therapy with gabapentin (10mg/kg PO q 12h) or acupuncture may aid pain control.

There are several methods for evacuation of fibrin, microorganisms and inflammatory products – tidal lavage, through and through, arthroscopy and arthrotomy. The least invasive technique should be applied based on clinical presentation. Unfortunately we see more chronic presentations in cattle after failed medical treatment. *T. pyogenes* stimulates fibrin production that makes lavage with a needle difficult.
Surgical drainage, under sedation or anesthesia, of the infected joints can be useful adjunctive therapy in severe cases. Drainage and irrigation via needles placed in the joint may be helpful in mild cases. The primary purpose of irrigation is to remove the products of inflammation incited by the infecting agent and prevent continued inflammation and cartilage destruction. Irrigating

solutions should be non-irritating and bactericidal. An isotonic electrolyte solution (Plasmalyte, Ringers, or 0.9% saline) has been proven to be as effective as 0.1% povidone-iodine solution for flushing joints. The main effect of irrigation is the mechanical removal of cellular debris and other harmful products of inflammation (Smith et al 1989).

Tidal irrigation uses one needle and 3-way stop-cock. Fluid is flushed in and out the same needle until it is clear of fibrin and debris. This works well in a small joint without pockets like the coxofemoral joint.

Through-and-through lavage uses two needles spaced far from each other. Flush under pressure (up to 300mm Hg) with a minimum of 1 liter. Bandage (sterile) for 12 h after. Up to 3 washes in a 24 h period may be required. Prolonged treatments can create inflammation and delay healing.

Arthrotomy is used after failed medical treatment of the joint is filled with fibrin or pus that won't flow through needles. Local anesthetic can be used at incision sites. Avoid the synovial bursa and tendon sheaths when entering the joint. It is helpful to distend the joint with irrigation solution to aid visualization of the joint space. A stab incision is made through the skin and joint capsule. A preplaced needle can be used as a guide. A blunt instrument is inserted into the joint space. Typically, more than one incision is necessary to access the entire joint cavity. Fibrin is removed with atraumatic forceps and then lavage is performed to remove loose debris. Post operatively the incisions are covered with a stent or bandage. Additional lavage can be performed on subsequent days if needed. The incisions are usually closed in 24-48 hours. Joint lavage is performed until synovial fluid is clean and fibrin is negligible. Cover the incisions for at least days with a clean bandage.

The final option for treatment is arthrodesis. This is indicated when there is extensive capsule fibrosis and joint motion cannot be restored, with radiographic evidence of extensive irreversible osteomyelitis.
The prognosis for recovery from joint infection is guarded unless the onset is acute and there are no radiographic boney lesions. If more than 2 joints are affected the prognosis is poor.

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