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Failure of Passive Transfer in Calves

Buzağılarda Pasif Transfer Yetmezliği

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ABSTRACT

Newborn calves are born immunologically inadequate due to the absence of immunoglobulin (Ig) transfer to the fetus as a result of the placental structure of the dam, and therefore they must receive an adequate amount of Ig after birth. The transfer of Ig to newborn calves is referred to as passive transfer, and failure of passive transfer (FPT) occurs in calves that do not receive sufficient amounts of Ig. FPT causes high morbidity and mortality rates, leading to economic losses as well as posing an animal welfare concern. Among the main factors affecting the prevalence of FPT are the amount and timing of colostrum administration, its quality, and elements such as dam age, gestation length, and dry period duration. In the diagnosis of FPT, in addition to anamnesis and clinical findings, various tests involving the direct and indirect measurement of IgG concentrations are applied. FPT is not a disease but an immunodeficiency condition that predisposes calves to disease development, and it has been reported to increase susceptibility especially to diarrhea, respiratory diseases, and septicemia. In prevention and management strategies for FPT, evaluation of colostrum quality and the timing and amount of colostrum administration are highly important, and herd-level control programs must also be carefully considered.

Keywords: Calf, Deficiency, FPT, Ig, Immunity

ÖZ

Yeni doğan buzağılar, annelerin plasental yapısı nedeniyle fetüsa immunglobulin (Ig) geçişi olmamasına bağlı olarak immünolojik olarak yetersiz doğarlar ve bu nedenle doğumdan sonra yeterli miktarda Ig almaları gerekmektedir. Yeni doğan buzağılara Ig geçişi pasif transfer olarak adlandırılmakta ve yeterli miktarda Ig alamayan buzağılarda pasif transfer yetmezliği (FPT) meydana gelmektedir. FPT yüksek morbibite ve mortalite oranlarına sebep olarak, ekonomik kayıplara yol açmasıyla birlikte, hayvan refahı sorunu da oluşturmaktadır. FPT prevalansını etkileyen en faktörler arasında; kolostrumun verilme miktarı ve zamanı, kalitesi, anne yaşı, gebelik süresi, kuru dönem uzunluğu gibi unsurlar bulunmaktadır. FPT'nin tanısında, anamnez ve klinik bulguların yanı sıra, IgG konsantrasyonlarının doğrudan ve dolaylı ölçümünü içeren çeşitli testler uygulanmaktadır. FPT bir hastalık değil, hastalık geliştirmesine yatkınlık oluşturan immun yetmezlik durumudur ve buzağılarda özellikle ishal, solunum yolu hastalıkları ve sepsitemiye karşı yüksek duyarlılık oluşturduğu bildirilmektedir. FTP'den korunma ve yönetim stratejilerinde; kolostrum kalitesinin değerlendirilmesi, kolostrumun verilme zamanı ve miktarı oldukça önemliyken, sürü düzeyinde kontrol programlarına da mutlaka dikkat edilmesi gerekmektedir.

Anahtar Kelimeler: Buzağı, Bağışıklık FPT, Ig, Yetmezlik

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Introduction

In newborn calves, the immune system is not sufficiently developed, and therefore protection against infections during the first days of life depends entirely on immunoglobulins (Ig) obtained through colostrum. In ruminants, the placental structure does not permit the transfer of Ig from the dam to the fetus, and thus calves are born agammaglobulinemic (Weaver et al., 2000). Therefore, the intake of colostrum in sufficient quantity and quality is of critical importance for ensuring passive immunity. (Cuttance et al., 2017a; Cuttance et al., 2019). Insufficient ingestion of colostrum, delayed administration, or impaired absorption through the intestinal mucosa results in failure of passive transfer (FPT), which is one of the leading causes of morbidity and mortality in newborn calves and leads to substantial economic losses in both dairy and beef cattle operations (Cuttance et al., 2018; Lombard et al., 2020; O'brien & Sherman, 1993;). Rather than being a disease itself, FPT is an immunodeficiency condition that increases susceptibility to infections (O'brien & Sherman, 1993). Despite the implementation of advanced herd management protocols, the global prevalence of FPT remains high. Studies have reported that 20–40% of newborn calves experience FPT, and 8–25% of calf mortality is associated with FPT (Beam et al., 2009; Gökçe & Erdoğan, 2015; Raboisson et al., 2016). Among the major risk factors contributing to the development of FPT, management related issues such as colostrum quality, quantity, timing, and method of administration are prominent, while environmental and physiological factors such as breed, herd size, season, housing type, and dam age also play a role (Reschke et al., 2017; Roadknight et al., 2022; Sutter et al., 2019;). In this context, optimizing colostrum management, regularly evaluating colostrum quality and monitoring passive transfer represent essential strategies for safeguarding calf health (Godden, 2019; Van et al., 2023).

The aim of this review is to evaluate the epidemiology, pathophysiology, diagnostic methods, and clinical significance of failure of passive transfer in newborn calves, and to examine the impact of effective colostrum management strategies for preventing FPT on calf health and farm productivity.

Epidemiology

The process by which healthy newborn calves receive immunoglobulin (Ig) via colostrum is called the passive transfer of Ig. Calves that fail to ingest an adequate amount of Ig develop FPT (Cuttance et al., 2017a). FPT is a common health problem in newborn ruminants resulting from insufficient absorption of colostrum, and it has been reported in various animal species (Cuttance et al., 2018; O'brien & Sawyer et al., 1977; Sherman, 1993). In addition to causing significant economic losses due to high morbidity and mortality rates, FPT also constitutes an important animal welfare concern (Cuttance et al., 2018; Lombard et al., 2020). FPT is not a disease itself but an immunodeficiency condition that predisposes the neonate to disease development (O'brien & Sherman, 1993). This makes FPT a major economic factor for livestock producers (O'brien & Sherman, 1993). Minimizing FPT is essential for optimizing calf health and productivity (Cuttance et al., 2017a). Despite the careful implementation of advanced herd management protocols, FPT prevalence can remain remarkably high (Gökçe & Erdoğan, 2013). Depending on the definition of FPT and livestock production systems, its prevalence among newborn calves ranges from 20% to 40%, while mortality associated with FPT varies between 8% and 25% (Kayasaki et al., 2024; Raboisson et al., 2016). Monitoring and minimizing the prevalence of FPT during the first week of life is critically important for calf health and farm profitability (Van et al., 2023). A study conducted in eastern Hokkaido, Japan, reported an FPT prevalence of 24.41% (Kayasaki et al., 2024). FPT prevalence was also found to be significantly associated with herd size and season, being particularly high in small herds and during winter months (Staněk et al., 2019). Nevertheless, FPT continues to be a major issue in both dairy and beef cattle operations (Raboisson et al., 2016). Recent research has also addressed risk factors associated with FPT (Cuttance et al., 2017a; Reschke et al., 2017). Poor colostrum quality is one of the primary risk factors related to FPT and is influenced by multiple determinants (Lichtmannsperger et al., 2023). Management factors that may influence FPT prevalence on farms include colostrum quality, the amount of colostrum ingested, timing of administration, whether the calf receives colostrum by suckling or manual feeding, the interval between birth and colostrum harvesting, the presence of the dam during milking, colostrum storage practices, and heat treatment procedures (Roadknight et al., 2022; Sutter et al., 2019). Additional risk factors include breed, herd size, housing type, birth month, gestation length, dry period duration, dam age, and farm level differences (Cuttance et al., 2017a; Reschke et al., 2017). Ensuring adequate colostrum intake, maintaining good colostrum quality, optimal timing of feeding, and preventing contamination are critical factors that can reduce the incidence of FPT (Godden et al., 2019).

Pathophysiology

Newborn calves are immunologically inadequate because the placental structure prevents the transfer of Ig to the fetus. FPT may occur through three primary mechanisms: the dam's inability to produce colostrum containing sufficient IgG, inadequate colostrum intake by the calf, or ineffective absorption of colostral IgG across the intestinal mucosa into systemic circulation (Larson et al., 1980). Cows possess a syndesmochorial placenta, in which a syncytium forms between the fetal trophoderm and maternal endometrium. This type of placenta separates maternal and fetal blood circulation, preventing the passage of Ig to the fetus in utero. Therefore, calves are born agammaglobulinemic, meaning they have no Ig at birth (Weaver et al., 2000). Consequently, until the calfs own immune system becomes functional, survival depends entirely on passive transfer of immunity via the ingestion of colostrum rich in maternal Ig (Cuttance et al., 2019). However, the active absorption of large molecules such as IgG ceases 24-36 hours after birth; thus, newborn calves must ingest colostrum before this period to acquire passive immunity (Cuttance et al., 2019; Weaver et al., 2000).

Colostrum is the first secretion of the mammary gland after parturition and serves as the primary source of Ig, nutrients, growth factors, and other essential components for newborn calves (Bielmann et al., 2010). Bovine colostrum contains various Ig classes, mainly IgA, IgG, and IgM, with approximately 85% consisting of IgG. The predominant Ig in colostrum, IgG_1, represents 80-90% of the total IgG fraction (Larson et al., 1980). The transport of Ig from maternal serum to the mammary gland begins several weeks before calving and reaches its peak 1-3 days prior to parturition (Sasaki et al., 1976). The high concentration of IgG1 in colostrum is mediated by specific receptors located on mammary alveolar epithelial cells (Barrington et al., 1997). With the onset of lactation, these epithelial cells cease expression of these receptors, a process believed to occur in response to increased prolactin levels (Barrington et al., 1997).

It has been demonstrated that colostrum contains not only immunoglobulins but also immunologically active cells and soluble mediators such as lactoferrin, which play a crucial role in shaping neonatal immune function (Lakritz et al., 2000). Immunoglobulins are critical for passive immunity, but colostrum's role extends beyond protection (Yang et al., 2025). Colostrum is rich in non-immune factors, including growth factors (such as IGF-1 and EGF) and hormones (such as insulin), which are crucial for neonatal development (Pańko et al., 2025). These bioactive components play a significant role in stimulating the rapid maturation of the gastrointestinal tract and regulating systemic metabolism (Karakülah et al., 2025). Failure of passive transfer (FPT), therefore, often co-occurs with inadequate intake of these trophic factors, leading to impaired gastrointestinal development and reduced feed intake, which subsequently contributes to the reduced average daily gain observed in FPT calves (Yang et al., 2025). This emphasizes colostrum's dual function as both an immunological agent and a critical metabolic nutrient (Aiello et al., 2025). In calves that did not receive sufficient colostral lactoferrin, neutrophil function was markedly reduced, highlighting the immunomodulatory importance of colostrum derived mediators (Lakritz et al., 2000).

Colostrum ingestion within the first few hours of life is essential for allowing large Ig molecules to pass across the intestinal barrier into the bloodstream (Larson et al., 1980). During the first 24-36 hours of life, neonatal enterocytes have the capacity to absorb protein macromolecules and other colostral components through a non-selective pinocytosis mechanism along the gastrointestinal epithelium (Lorenz et al., 2011). The absorbed material is then transported through the cell to the lymphatics by a process known as exocytosis, eventually reaching systemic circulation via the thoracic duct. The non-selective nature of this mechanism is supported by increased concentrations of additional protein macromolecules and elevated activities of enzymes such as gamma-glutamyltransferase (GGT) following colostrum ingestion (Lorenz et al., 2011). Furthermore, digestive enzyme secretion is minimal at birth and immediately afterward, allowing colostral macromolecules to cross the intestinal epithelium without degradation (Weaver et al., 2000). However, approximately 12 hours after birth, digestive enzyme secretion increases markedly, reducing the ability of IgG to reach systemic circulation intact (Lorenz et al., 2011; Weaver et al., 2000).

The cessation of macromolecule absorption is referred to as gut closure, a process believed to result from the decreased pinocytic capacity of enterocytes along with their replacement by more mature epithelial cells (Lorenz et al., 2011). Gut closure occurs around 24 hours after birth, but may extend to 36 hours if feeding is delayed (Weaver et al., 2000). After gut closure, absorption of large molecules such as Ig is prevented, and if calves do not receive adequate quantity or quality of colostrum prior to this period, failure of passive immunity transfer may occur (Van et al., 2023). The most efficient period for Ig transfer is within the first 4 hours after birth, and absorption declines rapidly after 12 hours (Lorenz et al., 2011; Weaver et al., 2000).

Diagnosis

FPT diagnosis can be based on the patient's history, clinical findings, and ante mortem testing (Lakritz et al., 2000). FPT is diagnosed when the serum IgG concentration or total protein in the calf falls below specific threshold values within the first few days after birth (Van et al., 2023). Inadequate maternal IgG absorption or failure of passive transfer is defined as a serum IgG concentration of <10 mg/mL within 24-48 hours after birth (Godden, 2008). Serum IgG and total protein can be reliably tested for FPT assessment up to day 9 postpartum (Wilm et al., 2018). Performing FPT tests in calves is an important step in evaluating the effectiveness of colostrum management programs and addressing ongoing calf health issues (Godden, 2008). Besides serum samples, other sample types such as centrifuged plasma or filtered plasma are also suitable for FPT evaluation, and the advantage of using filtered plasma is the ability to collect and analyze a larger number of blood samples without the need for centrifugation (da Costa Corrêa Oliveira et al., 2019). Measurement of serum IgG concentration is one of the most reliable indicators for assessing the adequacy of passive transfer (Cuttance et al., 2017b). Various methods either direct or indirect have been developed to determine IgG levels and identify calves with FPT (Renaud et al., 2020).

Direct Measurement of IgG Concentrations

Radial immunodiffusion

The radial immunodiffusion (RID) test directly measures serum IgG concentration and is considered the gold standard; however, it is labor-intensive, costly, requires substantial laboratory time (18–24 hours), and must be performed by trained personnel (Cuttance et al., 2019; Godden, 2008). Therefore, it is not routinely used in diagnostic laboratories and is instead preferred primarily in research settings (Godden, 2008).

Automated turbidimetric immunoassay

The automated turbidimetric immunoassay, developed using anti-bovine IgG, enables accurate measurement of IgG concentrations within 15 minutes; however, samples must still be processed in the laboratory (Cuttance et al., 2019). More recently, the turbidimetric immunoassay has been adapted for use in a portable analyzer, allowing rapid field diagnosis of FPT, though the requirement to purchase the portable device still renders it relatively expensive (Cuttance et al., 2019). This test is less costly than RID but remains generally laboratory-based and comparatively expensive (Cuttance et al., 2017b).

Enzyme linked immunosorbent assay

An alternative method for the direct measurement of serum IgG concentrations is the enzyme-linked immunosorbent assay (ELISA). This technique allows automation and therefore reduces the required time to one-fifth and the cost to one-tenth of that of the RID test (43). It has been suggested that ELISA may be used as both a screening and confirmatory test when serum IgG concentrations are <5 g/L, but should be used only as a screening test when concentrations are ≥5 g/L (Cuttance et al., 2019).

Fourier transform infrared spectroscopy

It has been evaluated by Elsohaby et al., 2014 for the direct measurement of IgG concentrations, and this technique does not require physical separation of the sample nor the use of reagents; therefore, the procedure is relatively rapid and inexpensive (Elsohaby et al., 2014). This method has been reported to be effective both for assessing IgG concentrations in bovine serum and for diagnosing FPT (Cuttance et al., 2019).

Indirect Measurement of IgG Concentrations

Indirect measurements of IgG concentrations are widely used in the diagnosis of FPT because they are less expensive and, for some tests, more practical for field use (Cuttance et al., 2017b). Immunoglobulins constitute a major portion of the circulating proteins in the serum of newborn calves, and the levels of non-immune proteins remain relatively constant among calves (Cuttance et al., 2017a). Therefore, tests based on estimating total protein (TP) concentrations in serum or plasma are commonly used in FPT diagnosis (Godden, 2008). These tests include measurement of TP or total solids in serum or plasma, determination of γ-glutamyl transferase (GGT) activity, total solids assessment using a Brix refractometer, and turbidimetric tests employing zinc sulfate or sodium sulfite (Cuttance et al., 2019).

Measurement of total protein concentration

Immunoglobulins constitute a major portion of the circulating proteins in the serum of neonatal calves, and because the levels of non-immune proteins remain relatively constant among calves, tests based on estimating serum or plasma TP concentrations are widely used for diagnosing FPT (Godden, 2008). Two main methods are used to determine TP concentrations in cattle. The first is the Biuret method, a colorimetric technique based on color change. The second is the use of a refractometer, in which the refractive index of serum or plasma is measured and then converted to TP concentration using a specific conversion factor (Deelen et al., 2014; Morrill et al., 2013). Measurement of TP concentration has two important limitations: the effect of dehydration on accuracy and the influence of age (Cuttance et al., 2019). Therefore, when performed in healthy calves less than one week old and at least 6 hours after colostrum intake, this test has been found useful for herd-level investigations of FPT (Cuttance et al., 2019). Threshold values used in the diagnosis of FPT range between 50–55 g/L, and this variation depends on the strength of the TP–IgG correlation and whether researchers prioritize sensitivity or specificity (Godden, 2008). Serum TP concentrations can be measured in the laboratory but can also be estimated using a refractometer (Morrill et al., 2013). Refractometry is a practical, rapid, and low-cost method for the indirect measurement of TP (Cuttance et al., 2019). In addition, because refractometry can be performed on non-centrifuged blood samples, it offers a practical and economical approach for identifying calves with FPT in field conditions (Cuttance et al., 2017b). Measurements can be carried out using optical or digital Brix refractometers, which determine either direct TP values (g/dL) or total solids expressed as Brix percentage (%Brix) (Deelen et al., 2014). In refractometric assessment, serum protein concentrations >5.5 g/dL indicate adequate passive transfer, values <5.2 g/dL are associated with FPT, and results between 5.2–5.5

g/dL are considered borderline (Hogan et al., 2015). Studies have reported that Brix values of <7.8–8.4% are indicative of FPT (Deelen et al., 2014; Morrill et al., 2013). In one study comparing TP measurement with RID, Brix refractometry, and GGT activity, TP measurement showed the highest agreement with IgG concentrations (Cuttance et al., 2017b).

Measurement of gamma-glutamyl transferase activity

Gamma-glutamyl transferase is synthesized by the ductal epithelial cells of the mammary gland, is present in high concentrations in bovine colostrum, and has been reported to be more than 60 times higher in the serum of colostrum fed calves compared with calves that received no colostrum (Thompson & Pauli, 1981). Because macromolecule absorption through the small intestine is non-selective during the first 24 hours of life, GGT like IgG is absorbed; however, the increase in GGT activity is more transient, and its absorption is less efficient than that of IgG (Parish et al., 1997). Measurement of GGT activity is considered a useful indicator of colostrum intake and thus of IgG concentrations, although unlike IgG and TP concentrations, which remain relatively stable during the first week after birth, GGT activity declines over time postpartum (Braun et al., 1982). For this reason, threshold values used to define FPT must be adjusted according to calf age (Parish et al., 1997). In a study of 71 calves, age-dependent GGT cut-off values were established for diagnosing FPT using an IgG threshold of <10 mg/mL. According to this study, the cut-off values were GGT <200 IU/L in 1-day-old calves, <100 IU/L in 4-day-old calves, and <75 IU/L in 1-week-old calves. Additionally, for calves younger than 14 days, GGT <50 IU/L is considered indicative of FPT. However, only a moderate correlation was found between GGT activity and IgG concentrations, and the sensitivity and specificity of these threshold values were not determined (Parish et al., 1997). Despite this limitation, these thresholds are widely used in New Zealand diagnostic laboratories for interpreting GGT results, although they are generally applied according to age ranges rather than fixed values (Cuttance et al., 2017b). Because GGT levels show only moderate correlation with serum IgG and do not directly measure IgG, they should not be used as the sole indicator of passive transfer (Hogan et al., 2015).

Zinc sulfate turbidity test

The zinc sulfate turbidity test (ZST) is based on the precipitation of immunoglobulins upon reaction with metal salt solutions. Metal salts react with Ig present in serum, causing the formation of a precipitate that produces turbidity, which can then be evaluated visually or quantitatively using colorimetric methods expressed in turbidity units (Hogan et al., 2015). Standardizing the ZST is challenging because the resulting turbidity varies depending on the duration of the reaction before measurement, the concentration of the test solution, and the wavelength of light used for reading the reaction (Hudgens et al., 1996). In an attempt to standardize the test, one study compared sensitivity and specificity across different durations, concentrations, and wavelengths, and reported that using a 350 mg/L zinc sulfate solution, a 550 nm wavelength, and a 60-minute reaction time maximized specificity when the cut-off value was set at 20 units (Hogan et al., 2015). However, the samples used in that study were obtained from colostrum-deprived calves (Hogan et al., 2015). The reported high sensitivity depends on threshold values that vary according to zinc sulfate concentration, reaction duration, and wavelength used for turbidity measurement. Therefore, the ZST has limited usefulness compared with simpler tests such as TP concentration measurement (Cuttance et al., 2019).

Clinical Significance

FPT has been reported to be associated with increased susceptibility to diarrhea, respiratory diseases, and septicemia in young calves (Virtala et al., 1999). In one study, the prevalence of septicemia in calves younger than 45 days decreased linearly as STP concentration (measured at 2-8 days of age) increased from 40 to 80 g/L, and the risk of mortality during the 0–6-month period decreased as STP increased from 40 to 60 g/L, with no significant reduction above this level (Donovan et al., 1998). FPT is also associated with inadequate gastrointestinal development and lower feed intake, which results in reduced average daily gain during the growth period (Donovan et al., 1998). In another study evaluating FPT outcomes, it was reported that calves with FPT had a 1.6-fold higher risk of requiring treatment for disease before weaning and exhibited a 0.06-kg reduction in daily live weight gain (Kara & Ceylan, 2021). Additional studies show that calves with FPT are twice as likely to die, 1.8 times more likely to require treatment for respiratory disease, and 1.5 times more likely to require treatment for diarrhea compared with calves without FPT. Furthermore, calves with sIgG <10 g/L had twice the likelihood of developing diarrhea, otitis media, or requiring antibiotic treatment before weaning, and also had lower average daily weight gain (Atkinson et al., 2017; Raboisson et al., 2016). Overall, the available evidence indicates that calves receiving better immune protection from colostrum have a lower likelihood of developing disease and a higher likelihood of survival and faster growth (Cuttance et al., 2018).

Prevention and Management Strategies

In prevention and management strategies, evaluating colostrum quality, optimizing the timing and amount of colostrum administration, and implementing herd-level control programs are highly important.

Evaluation of Colostrum Quality

Colostrum quality depends on several factors such as the volume produced, the timing of milking, Ig concentration, and bacterial load (Godden, 2008). Factors related to the dam including lactation number, genetic parameters, length of the dry period, prepartum milk leakage, colostrum yield, metabolic status, and udder health have been reported to influence colostrum quality (Immler et al., 2022). Environmental factors such as calving season and the temperature–humidity index have also been shown to affect colostrum quality (Lichtmannsperger et al., 2023). High-quality colostrum is defined as colostrum with high Ig concentrations (≥50 g/L) and low bacterial contamination (total bacterial count <100,000 cfu/mL; coliform count <10,000 cfu/mL) (Godden et al., 2019). Meeting these targets should provide the 150–200 g of IgG required for adequate passive transfer (Chigerwe et al., 2008), although more recent research suggests that approximately 300 g of IgG may be necessary (Godden et al., 2019). It has been demonstrated that every 10 g/L increase in colostral IgG results in a 1.1 g/L increase in serum IgG concentration, indicating that higher-quality colostrum is associated with more successful passive immunity transfer (Godden et al., 2019). Calves fed low-quality colostrum have a 15.422-fold higher risk of developing FPT (Kara & Ceylan, 2021).

Timing and Amount of Colostrum Administration

Ensuring that calves consume an adequate amount of colostrum within the first few hours after birth is a highly effective way to reduce FPT and associated disorders (Raboisson et al., 2016). For successful passive immunity transfer, the calf must receive colostrum immediately after birth (Weaver et al., 2000). One of the primary recommendations to reduce the risk of FPT in calves is to provide colostrum by hand-feeding at an amount equal to 10–15% of body weight within 2–3 hours postpartum (Godden, 2008). Fischer et al., 2018 reported that IgG absorption is significantly higher when feeding occurs within the first 2 hours after birth (Fischer et al., 2018), while Shivley et al., 2018 found that each hour of delay in colostrum administration decreases serum IgG concentration by 0.32 g/L (Shivley et al., 2018). These findings indicate that even a 4-hour delay can have a substantial impact on IgG absorption (Renaud et al., 2020). For adequate passive immunity transfer, the calf must receive >100 g of IgG in each feeding, and serum IgG concentration must exceed 10.0 g/L by 24 hours after birth (Quigley et al., 2001).

Herd Level Control Programs

Despite the extensive research on the importance of passive transfer, FPT still causes significant economic and welfare losses in dairy farms (Atkinson et al., 2017). Preventing FPT and ensuring calf health are essential for maintaining profitability, particularly for dairy producers. Therefore, monitoring and minimizing the prevalence of FPT in calves are highly important (Van et al., 2023).

Risk factors for FPT have been evaluated, and the most influential factors are those related to colostrum management (Godden et al., 2019). Strategies aimed at improving calf immunity through colostrum intake can lead to improvements in animal health, survival rates, and growth performance (Cuttance et al., 2018). Producers should minimize the time between birth and colostrum milking to maximize IgG concentration and reduce bacterial contamination by shortening the time colostrum remains in the bucket before feeding (Haggerty et al., 2021).

It has been reported that calves receiving a higher amount of colostrum at birth have higher STP levels and lower FPT rates, whereas calves born through dystocia, cesarean section, or malpresentation have lower STP levels and higher FPT rates. Depending on the method of colostrum administration, feeding with a bottle followed by switching to an esophageal tube feeder has been shown to reduce the success of passive immunity transfer (Renaud et al., 2020). Given the importance of passive immunity, these factors must be considered during the administration of colostrum to calves (Renaud et al., 2020).

Farmers are advised to feed newborn calves colostrum at an amount corresponding to 10–15% of their body weight during the first feeding to reduce the risk of FPT (Haggerty et al., 2021). Natural suckling is the most common method of colostrum intake in beef breeds. Calves that fail to stand and suckle within 2 hours after birth should be evaluated for FPT and given colostrum (Hogan et al., 2015). In dairy breeds, bottle-feeding is more common, and at least 2 L of colostrum should be administered within 6 hours after birth, followed by an additional 2 L within 12 hours. With the esophageal tube method, commonly used in dairy breeds, 3–4 L of colostrum per 45 kg body weight minimizes FPT incidence (Hogan et al., 2015).

Calves receiving a second colostrum meal have a lower likelihood of FPT; in a study of 4,336 calves, 9.4% of those receiving two meals experienced FPT, compared with 22.2% of calves receiving a single meal (Abuelo et al., 2021). Another study showed that providing high-quality colostrum after birth and allowing calves to suckle can be effective strategies to minimize FPT. However, the success of these strategies largely depends on each farm's conditions. If farmers cannot ensure that colostrum is of high quality and hygienic, frequent collection and feeding of colostrum have little benefit, since colostrum quality has a linear effect on FPT meaning the lower the quality, the higher the likelihood of FPT (Mason et al., 2022).

It is recommended that all calves be evaluated for FPT within the first 12–24 hours after birth and at least once more during the first days of life (Hogan et al., 2015). STP concentrations provide a reasonable estimate of IgG levels, and testing healthy calves younger than 1 week old at least 6 hours after colostrum intake is useful for herd-level FPT monitoring (McGuirk, 2008).

Herd-level standards have also been reported to reduce morbidity risk (Lombard et al., 2020). These standards categorize serum IgG concentrations into ≥25.0, 18.0–24.9, 10.0–17.9, and <10 g/L; the proportion of calves in each category should be >40%, >30%, >20%, and <10%, respectively. A higher IgG threshold than the traditional 10 g/L has been proposed to reduce morbidity risk (Lombard et al., 2020). In cases detected after gut closure, administration of commercial plasma (20 ml/kg IV) is recommended. For high-value calves, 1–3 L of whole blood transfusion from the dam may be administered, and although cattle have numerous blood groups, transfusion reactions are rare, so cross-matching is generally unnecessary (Hogan et al., 2015). Colostrum replacers, which contain ≥150 g IgG per liter and are rich in proteins, vitamins, and minerals, can be used when colostrum is unavailable. However, colostrum supplements only enhance low-quality colostrum and cannot replace colostrum because they cannot raise IgG levels above 10 mg/mL (Hogan et al., 2015).

Conclusion and Recommendations

In conclusion, failure of passive transfer (FPT) is a significant health issue closely associated with disease incidence, mortality rate, and growth retardation in newborn calves. Prevention of FPT is possible through proper management of colostrum quality, timing, and quantity. Therefore, effective colostrum management and routine herd-level monitoring practices should be considered essential strategies for protecting calf health and improving farm productivity.

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