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Review

Newborn calf vitality: Risk factors, characteristics, assessment, resulting outcomes and strategies for improvement

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ABSTRACT

Dystocia is a stressful and traumatic event for both the cow and calf. As the prevalence of dystocia has increased over time, attention has been focused on maintaining the health and longevity of the cow. Lack of vitality in the newborn calf may go unnoticed and result in short or long-term implications for calf health and performance.

A prolonged or assisted delivery may increase birth stress in calves causing a variety of effects including injury, inflammation, hypoxia, acidosis, pain and an inability to maintain homeostasis. Each of these effects can further contribute to a reduced state of vitality in the newborn calf. Newborn vitality is essential to the health, survival and welfare of the calf. If the calf is not vital at birth, it may be unwilling or unable to get up and suckle colostrum in a timely manner. Early colostrum intake improves passive transfer of immunoglobulins, energy uptake and thermoregulation. Intervention may be required to assist these calves such as respiratory and thermal support, manual feeding of colostrum or the administration of non-steroidal anti-inflammatory drugs to aid health and long-term survival. However, more research is needed to determine ways in which newborn calf vitality can be assessed and improved in order to reduce the increased risk of morbidity and mortality and long-term effects on performance.

Introduction

The process of parturition can be a traumatic and hazardous event in the life of a calf. The process is initiated by a rise in fetal cortisol, followed by a course of endocrine events in the dam that lead to uterine contractions, dilation of the cervix, delivery of the fetus and, finally, expulsion of the placenta (Senger, 1999). Many different factors can disrupt the fetal or maternal systems involved with parturition and result in dystocia (Breazile et al., 1988).

Dystocia can be defined as a difficult or abnormal calving due to a prolonged unassisted parturition process, or due to a prolonged or severe assisted calf delivery (Mee, 2004). However, such a definition is subject to varying interpretations and this can be particularly troublesome in field data collection and comparison of studies. In an attempt to increase agreement between studies, scoring systems to assess the degree of dystocia have been developed. Although the number of categories may vary in different systems, higher scores generally reflect a greater level of assistance. These scores are generally expressed by the number of people assisting or amount of mechanical force required to deliver the calf. The highest scores are assigned to veterinary assisted deliveries, including caesarian-sections (Meijering, 1984).

Factors causing dystocia may include pelvic dimension of the dam, calf size, calf presentation and maternal factors, such as weak labor, insufficient dilation of the cervix and uterine torsion (Meijering, 1984). The most common cause of dystocia is feto-pelvic disproportion, which is a mismatch in dam pelvic size and calf weight (Mee, 2008a). This mismatch occurs largely in primiparous cows delivering bull calves. In general, bulls are heavier at birth than heifer calves, which may be due to longer gestation lengths and higher androgenic hormone production (Holland and Odde, 1992). However, statistical models constructed by Johanson and Berger (2003) showed that calf birth weight was a better predictor of calving difficulty than calf gender alone. It was determined that for every 1 kg increase in birth weight, there was a 13% increased probability of dystocia (Johanson and Berger, 2003). Compared to other dairy breeds, Holsteins have the highest ratio of calf birth weight to dam bodyweight, averaging 7.1% (Holland and Odde, 1992). As a result, Holstein cows have the highest incidence of dystocia (Johanson and Berger, 2003; Heins et al., 2006). However, it is noteworthy that the practice of recording calf birth weights in a non-research setting is limited, especially in the dairy industry. Accurate recording of birth weights is an important component of making advancements in breeding programs to reduce the incidence of dystocia.

Calves that are subject to dystocia due to any of the above listed factors may require human intervention. Inappropriate timing of

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intervention or excessive force applied during delivery may cause fetal trauma, stress, and in extreme cases, stillbirth (Schuijt, 1990). Dystocia can also lead to a cascade of behavioural and physiological responses which may have implications for calf vitality, as well as long-term health and productivity.

Vitality can be defined as having the capacity to live and grow with physical and mental energy and strength. Low calf vitality may result from inflammation, pain, injury, inability to maintain homeostasis, hypoxia and acidosis (Breazile et al., 1988; Besser et al., 1990; Carstens, 1994). These physiological responses can have behavioural repercussions, such as reduced motivation to perform natural behaviours for survival, including standing up and suckling colostrum after birth (Barrier et al., 2012). Not receiving enough colostrum shortly after birth may affect a calf's long term health status and put it at greater risk of disease and mortality (Godden, 2008). It may also have implications on lifetime productivity, such as average daily gain and milk production (Faber et al., 2005).

A scoring system to assess newborn vitality has been developed for use in humans (Apgar et al., 1958). Variations of this scoring system have been studied in other species such as the pig, horse, dog and calf (Randall, 1971; Mulling, 1977; Veronesi et al., 2005, 2009). In recent years, methods have been created to assess newborn calf vitality and it is recognized that low vitality can be detrimental to survival, development and welfare (Riley et al., 2004; Mellor and Stafford, 2004; Baxter et al., 2008). However, information on ways to manage these effects or even prevent them from occurring is limited.

Risk factors and characteristics of poor vitality in the dystocial calf

Management of dystocia on modern dairy herds in North America is largely aimed at maintaining a healthy and fertile cow, whereas little attention is paid to the calf; largely because knowledge of the effects on the calf are limited and rarely have an immediate economic impact. However, it is suspected that the effects on the calf can be numerous, leading to reduced calf vitality followed by compromised health and survival. Awareness and understanding of the impacts of dystocia on calf vitality is essential to minimize both short and long-term implications.

When excessive force is applied during the delivery process, trauma inflicted can cause severe injury and pain (Schuijt, 1990). Injuries to the vertebral column are common following dystocia and include vertebral fractures, myeolmalacia, spinal cord compression or severed spinal cord. In newborn calves with thoracolumbar fractures, hemorrhage in and around the kidneys, adrenal glands and musculature are consistent necropsy findings (Schuh and Killeen, 1988). Fractures of the vertebrae, as well as ribs, may increase the risk of abdominal trauma. Abdominal trauma may subsequently lead to liver rupture and abdominal hemorrhage (Haughey, 1975). Neonatal vertebral fractures occur infrequently and may be diagnosed in 2% of calves (Schuh and Killeen, 1988). Other frequent results of birth trauma in calves include femoral and mandibular fractures (Trent and Ferguson, 1985; Ferguson, 1994). If the injuries are not immediately fatal, calves are usually weak and lack mobility. Calf weakness may interfere with the natural interactions and behaviours that occur with the dam, such as suckling colostrum, promoting health and survival (Mellor and Stafford, 2004).

Acidosis due to premature rupture of the umbilical vessels is another consequence of prolonged dystocia or forced extraction (Szenci et al., 1988; Hammer and Tyler, 1999). Umbilical cord rupture terminates the oxygen supply to the fetus from the placenta. When this occurs prematurely, before the calf is able to regulate its own respiration, oxygen supply diminishes leading to the rapid development of asphyxia and respiratory acidosis (Szenci, 1982). Intense and prolonged labor contractions and trauma during forced extraction can exacerbate this effect, subsequently inducing a state of acid–base imbalance and prolonged hypoxia (Breazile et al., 1988; Szenci et al., 1988; Grove-White, 2000). If the hypoxia is severe enough, fetal tissues will derive energy from anaerobic glycolysis, resulting in the production of lactic acid, inducing a state of metabolic acidosis. Severe respiratory and metabolic acidosis resulting from hypoxia may compromise survival in the newborn calf (Grove-White, 2000; Bleul et al., 2007).

The cascading effects of asphyxia can cause decreased blood flow to the liver and kidneys leading to hepatic necrosis, liver dysfunction and renal tubular necrosis, as seen in neonatal calves and lambs (Mulling, 1977; Ikeda et al., 2000). Other implications in calves include aspiration pneumonia, edema, bleeding, and death (Mulling, 1977; Poulsen and McGuirk, 2009). Schuijt and Taverne (1994) found that calves born from a severe dystocia had more serious acidosis, took longer at achieve a normal pH (>7.2) and had a greater risk of mortality. Furthermore, the ramifications of hypoxia and acidosis may play an important role in a calf's ability to maintain homeostasis and thermoregulation.

Newborn calves are particularly susceptible to environmental conditions at birth. At parturition, the calf moves from a controlled, sterile environment to an adverse external environment, in which the calf must make physiological responses to maintain homeostasis (Carstens, 1994). Maintenance of thermoregulation during the neonatal period is derived by both shivering thermogenesis in muscle tissue and by non-shivering thermogenesis in brown adipose tissue (Carstens, 1994). The ability to mobilize energy reserves from brown adipose tissue to achieve homeostasis can be challenging for a newborn depending on the degree of stress, calving environment and season of birth (Okamoto et al., 1986).

Following dystocia, calves can have an impaired response to environmental stressors such as cold temperature. Bellows and Lammoglia (2000) found that where severe dystocia required a mechanical calf puller, calves were less able to withstand cold stress compared to those born without assistance, with minor manual assistance or by Caesarean section. In other studies, autopsy findings have shown that calves born in temperatures below their thermoneutral zone had signs of cold injury, including subcutaneous edema and hemorrhage of the hind legs, extensive catabolism of fat deposits, and focal hemorrhages in the adrenal cortex (Haughey, 1973, 1975; Olson et al., 1980a). In contrast, Diesch et al. (2004a) found no difference in rectal temperatures or blood metabolites in calves born with or without assistance. However, the degree of assistance applied and stress at calving was not specified in that study.

The reduced heat production found in stressed calves may be due to hypoxia, acidosis, low plasma thyroid hormone concentrations, and subsequent decreased mobilization of body lipids (Vermorel et al., 1983, 1989a). Severe hypoxia can reduce muscle tonicity and prevent shivering following birth (Stott and Reinhard, 1978). Furthermore, hypoxia and acidosis have been associated with decreasing the available energy needed for the metabolic activity of brown adipose tissue during non-shivering thermogenesis (Vermorel et al., 1989a). In addition, other studies have shown that severe hypoxia inhibits cortisol secretion from the adrenal gland after birth (Stott and Reinhard, 1978; Bellows and Lammoglia, 2000). In human infants, one of the purposes of cortisol is to stimulate thyroid activity; fetal plasma concentrations of thyroid hormones rise in tandem with cortisol (Liggins, 1994). Since thyroid hormones regulate lipid mobilization, which plays an important role in thermogenesis, hypoxic calves may have an impaired ability to control body temperature (Vermorel et al., 1989a).

Another method of generating body heat in newborn calves is through physical activity (Vermorel et al., 1989b). Simple natural behaviours such as standing up, walking and consuming colostrum may be challenging for calves with low vitality, especially in temperatures outside of their thermoneutral zone. Diesch et al. (2004b) found that calves born in temperatures <10 °C or in windy and wet conditions were slower to stand after birth than calves born in temperatures >10 °C or in dry conditions. The delay in time to stand was also correlated with assistance at calving (Diesch et al., 2004b). Thus, calves with thermal stress and low vitality have a limited ability to generate heat through natural physical behaviour. Energy and heat acquired through colostrum ingestion may also be delayed or reduced in calves with low vitality (Grove-White, 2000; Barrier et al., 2012).

Implications of poor vitality in the dystocial calf

Dystocia resulting in poor newborn calf vitality may be a major cause of failure of passive transfer (FPT) due to low volume of ingested colostrum (Furman-Fratczak et al., 2011). Beam et al. (2009) found that malpresentation at birth resulted in calves with an increased risk of FPT. Consumption of colostrum in calves with fetal distress can be reduced by up to 74% during the first 12 h (Vermorel et al., 1989a), while severe acidosis was found to reduce colostrum intake by 52% and serum IgG concentration by 35% (Drewry et al., 1999).

The impact of dystocia on FPT may be due to low vigor, decreasing motivation to stand and suckle colostrum. Barrier et al. (2012) found that calves born with assistance took longer to attempt to stand for the first time, to achieve standing, to walk and to reach the udder. These effects are likely to have implications on the amount and timing of colostrum ingestion. Vasseur et al. (2009) found that the quantity of colostrum ingested can be predicted by vigor (measured by the calf's ability to stand without assistance). However, they found that suckling reflex was not related to colostrum intake, being pulled at calving or calf vigor. However, only seven calves in the study were observed to be suckling. Furthermore, the measurement of the actual colostrum intake from the suckling was not possible, thereby limiting the conclusions that can be drawn in the relationship between colostrum intake and suckle reflex (Vasseur et al., 2009). Other studies have shown that dystocia itself may not impact serum IgG concentrations in calves (Stott and Reinhard, 1978; Burton et al., 1989) but these studies did not investigate calf vitality or motivation to consume colostrum.

Environmental stress at birth may also influence the timing of colostrum ingestion and subsequent IgG status. Beam et al. (2009) found that, following dystocia in cold weather, calves not provided heat were 1.6 times more likely to have FPT. Cold stress alone has also been associated with delaying colostrum intake and decreasing the rate of IgG absorption (Olson et al., 1980b). Cold stressed calves are weak and have greater difficulty standing, maintaining balance and bottle feeding (Olson et al., 1980a). Thus, it is not surprising that calves born in cold weather had lower mean serum Ig concentrations than calves born in the summer (Robison et al., 1988). Heat stress in calves has also been associated with low serum IgG concentrations, either through low calf vitality or decreased permeability of the intestine (Stott et al., 1976; Stott, 1980; Donovan et al., 1986).

Compromised immune status resulting from FPT in dystocial calves may be caused by reduced IgG absorption rather than just the quantity of colostrum intake. In particular, studies in calves have shown that dystocia-induced asphyxia is followed by decreased IgG absorption (Boyd, 1989; Besser et al., 1990). There was a significant inverse relationship between venous partial pressure of carbon dioxide at birth and 12 h post feeding serum IgG concentration. This indicates that serum IgG concentration is lower in calves with respiratory acidosis. Other results suggest that acidosis may actually be associated with a delay in gut closure, and therefore, delayed IgG absorption. Tyler and Ramsey (1991) observed that hypoxic calves had substantial IgG absorption after the second colostrum feeding (12 h postpartum), which did not occur in calves without hypoxia. It was found that time to gut closure was increased from a mean of 20 h in calves without hypoxia to 40.5 h in calves with hypoxia. However, despite the difference in absorptive time, the absorptive capacity of the two groups (defined as the highest concentration of plasma IgG obtained) was not statistically different (Tyler and Ramsey, 1991). Thus, the effect of hypoxia on IgG absorption remains uncertain.

In dairy replacement calves, FPT has been linked to increased susceptibility to infectious disease subsequently leading to neonatal morbidity and mortality, as well as long-term decreases in productivity (DeNise et al., 1989; Faber et al., 2005). Low serum IgG concentrations have been associated with reduced average daily gain, decreased milk production in the first and second-lactation and an increased culling rate during the first lactation (DeNise et al., 1989; Faber et al., 2005). Furman-Fratczak et al. (2011) found that dystocia resulting in calves with poor vitality and FPT had a reduced rate of gain and a higher incidence of disease. Occurrences of diseases, such as pneumonia and diarrhea, are more common in calves that have experienced a severe dystocia, along with increased odds of stillbirth and overall mortality (Lombard et al., 2007). In that study, overall mortality included heifer mortalities and stillborn heifer calves. Bull and twin calves were not included, as these animals were commonly sold or lost to follow-up. This loss may produce bias towards the null hypothesis, as bull and twin born calves have higher risks of dystocia and stillbirth than heifers and singletons (Lombard et al., 2007).

Stillbirth (calves that die at birth or within the first 48 h) is more common in calves that have undergone a severe dystocia (Meyer et al., 2001; Tenhagen et al., 2007). Laster and Gregory (1973) found that calves affected by dystocia experience four times the mortality at birth or within 24 h, when compared to calves from normal births. This may be attributed to a number of different factors including FPT. It has been reported that 8.8% of heifer calves die between 1 and 120 days of age, but when combined with stillbirths, 20.6% of heifer calves die before 120 days of age (Lombard et al., 2007). It is clear that the physiological and behavioural implications resulting from dystocia can lead to FPT, morbidity, reduced productivity and mortality, which have profound effects on the cattle industry. Methods to asses and improve calf vitality are essential to lessen these impacts.

Methods to assess the vitality of newborns

In developed countries, human pre and post-natal care programs have resulted in a very high rate of success for prevention of problems in newborn babies. Part of this success is due to a standard requirement for the completion of a health and vigor score within minutes of birth. This method of assessment, commonly termed the Apgar score, was created by Dr. Virginia Apgar in 1953. It has become the standard procedure used for human newborns since that time. In this assessment, five easily observed signs in newborn babies are evaluated. These signs can be assessed without special equipment and taught to delivery room personnel without difficulty. They comprise heart rate, respiratory effort, reflex irritability, muscle tone, and skin color.

In 1962, a backronym was created to facilitate teaching the five signs of the Apgar score – with Apgar standing for appearance, pulse, grimace, activity, and respiration. A rating of 2, 1, or 0 was given to each sign, assessed at 60 s after delivery, and on a repeated basis following a decision model to determine a course of action until the baby is deemed to be healthy and vigorous. A lower Apgar score meant a less vital infant (Finster and Wood, 2005). The Apgar score was not designed for the purpose of making long-term predictions about future health and growth, but to guide physicians in providing care to individuals that may be at considerable risk after birth. Studies have demonstrated that the Apgar score is a predictor of mortality in newborns (Veronesi et al., 2009), but lacks sensitivity because infants at risk for mortality, neurological defects, or metabolic acidosis can receive high scores. Yet, the score is highly specific, as healthy newborns will not receive a low score (Jepson et al., 1991).

Tests of newborn vigor have been developed for other species including the pig, horse and dog (Randall, 1971; Veronesi et al., 2005, 2009). In each of these studies, a modified Apgar score was created; choosing a few parameters that were easily evaluated without the use of advanced equipment. These studies included variables such as heart and respiratory rate, reflexes, mobility and mucous membrane colour. With the use of this modified 'vitality score', Veronesi et al. (2009) found mortality was increased in pups with a low vitality score and that those puppies were less likely to seek the mammary gland and had weaker suckling/swallowing reflexes (Veronesi et al., 2009). Randall (1971) found that piglets with lower vitality scores were slower to stand, had more difficulty breathing, had slower heart rates, decreased arterial blood pH and increased partial pressure of carbon dioxide, indicating a state of acidemia and hypercapnia (Randall, 1971). Results from these studies analyzing signs of reduced viability, correlate well with many studies looking at the varying conditions of calves after a stressful birth.

A modified Apgar score has been assessed in calves in several German studies (Mulling, 1977; Schafer and Arbeiter, 1995; Herfen and Bostedt, 1999a; Herfen and Bostedt, 1999b). The original calf Apgar score created by Mulling (1977), used signs of asphyxia as the criteria for scoring. This included muscle tone and movement, reflexes, respiration and mucous membrane color. Using this score, Schafer and Arbeiter (1995) found that when stage 2 labor was greater than 2 h in duration, 71% of calves had low-grade depression. Herfen and Bostedt (1999a) also found that the duration of parturition significantly influenced the degree of vitality in the neonate.

Schafer and Arbeiter (1995) found that calves with lower modified Apgar scores, had higher blood concentrations of cortisol and estradiol, larger numbers of granular neutrophils, and fewer lymphocytes. The high cortisol observed in depressed calves in this study is in disagreement with other studies that have suggested lower cortisol concentrations in hypoxic newborn calves (Stott and Reinhard, 1978; Bellows and Lammoglia, 2000). However, although Schafer and Arbeiter (1995) did not measure the degree of hypoxia from blood measurements specifically, Herfen and Bostedt (1999a) showed that the modified Apgar score was only marginally correlated with the results of blood-gas analysis. Following prolonged calving events and Caesarean sections, calf vitality appeared to be worse when measured with the Apgar score than was apparent from the results of laboratory tests such as blood-gas analysis (Herfen and Bostedt, 1999a).

Based on these findings, Herfen and Bostedt (1999b) concluded that Mulling's Apgar score did not accurately assess the vitality status of the calf, and that calves were more appropriately classified into vitality groups based on acid–base status. Further research is needed to develop a newborn calf Apgar score, which can accurately reflect the blood status and true vitality of the calf.

Hypoxia and acidosis may be good predictors of calf vitality and willingness and motivation to get up and suckle colostrum. However, such blood based measures require expensive, inconvenient and invasive laboratory tools. More practical measures are needed. Schulz et al. (1997) found that within 12 h postpartum, healthy vital calves have the physiological ability to stand and suckle without human assistance and to have a frequency of ⩾80 suckling movements/min of suckling time. They recommended that suckling behavior be used to assess vitality alone, or as a part of a modified Apgar score. Schuijt and Taverne (1994) also evaluated suckling reflex and time to sternal recumbency as objective indicators of fetal stress and vitality. Calves that were forcefully extracted took significantly longer to achieve sternal recumbency and had a lower overall state of vitality (Schuijt and Taverne, 1994).

An assessment of newborn calf vitality combining the practical measures from Mulling's score, along with time to standing and suckling reflex, is outlined by Mee (2008b). This assessment uses visual and physical measures that can be easily performed on farm and includes observing the presence of meconium staining, peripheral edema, cyanosis of the mucous membranes, as well as heart and respiration rates, muscle tone, stimulation reflexes, rectal temperature, time to sternal recumbency and attempts to stand and suckle (Mee, 2008b).

Although there have been several attempts to create tools to assess newborn calf vitality and these may identify less vital calves at birth, further research is needed. A practical tool which can be used on farm with ease and accuracy has not yet been validated to assess newborn calf vitality. Research is lacking in investigating and identifying risk factors at birth that can be used to predict morbidity and perinatal mortality. Factors such as these would be of benefit in developing a calf vitality assessment tool in order to prevent the long-term economic consequences associated with calf loss. In addition, a practical decision model should be developed to assist farmers in determining best practices to aid calves with low vitality to improve health and survival.

Assessment of pain in newborn calves following dystocia

Experimental work has verified that the neural pathways of pain sensation are similar in animals and people (Hudson et al., 2008). Nevertheless, although it is well known that the process of birth is painful in women, little attention has been given to the pain experienced by cattle during parturition (Gregory, 2004; Rushen et al., 2008). Studies have shown that dystocia is one of the most painful conditions in adult cattle (Huxley and Whay, 2006; Kielland et al., 2009; Laven et al., 2009).

There has been virtually no research on the pain experienced by the newborn calf following dystocia, perhaps because the effect of dystocia on the cow is perceived as being more painful than in the calf. In a survey of UK veterinarians, the median score given to the severity of pain following dystocia (without analgesia) in adult dairy cattle was 7 (0–10 scale), whereas it was only rated 4 in newborn calves (Huxley and Whay, 2006). These same ratings were given in a separate survey of New Zealand veterinarians (Laven et al., 2009).

Despite this perception, recent evidence has suggested that pain may be experienced more intensely in newborn than in older animals because awareness and or consciousness are suppressed until immediately after birth (Mellor and Gregory, 2003). The rapid activation of awareness at birth caused by increased blood oxygen and estrogen concentrations, as well as somatosensory stimulation, may lead to greater cerebral cortical responses to afferent pain impulses than might occur as the newborn gets older (Mellor and Gregory, 2003; Mellor and Stafford, 2004).

Research on the methods to assess pain in newborn calves following dystocia is non-existent. Pain is a subjective experience that is not possible to measure directly. However, basic behavioral and physiological measurements can provide indirect evidence of pain. Behaviors such as withdrawal reflex and movement after birth, as well as physiological measurements including heart rate, respiration rate and body temperature, have been shown to be indicators of pain in farm animals (Molony and Kent, 1997). Interestingly, many of these measurements have been used to assess calf vitality in modified Apgar scores. Thus, it is possible that calf vitality scores are directly correlated with the degree of pain experienced by a newborn calf. However, further research is needed to identify whether these measurements are truly indicators of pain newborn calves.

Strategies to improve vitality in dystocial calves

Intervention strategies should be in place to mitigate the effects of severe pain and trauma on the health and survival of the newborn calf. In dams carrying valuable calves, or when dystocia is suspected, birth trauma may be the result of inappropriately early intervention (Bleul and Kahn, 2008). In other research, approximately 90% of calf losses are attributed to a delay in receiving assistance or the amount of difficulty and time required to remove the calf (Laster and Gregory, 1973). Knowing when intervention is required and when to call for professional veterinary assistance can greatly increase the calf's chances of survival (USDA, 2007).[1]

Losses in calves can be prevented by good supervision at calving (Mee, 2004). It has been shown that insufficient monitoring around parturition can have a negative effect on the duration of stage 2 labor and, indirectly, on perinatal mortality (Gundelach et al., 2009). While monitoring calving progress, decisions to intervene, when to intervene, how to intervene, and whether to acquire veterinary assistance should be addressed by the farm personnel (Mee, 2004). Gundelach et al. (2009) suggested that intervention should be considered when stage 2 labor lasted longer than 2 h. Signs of reduced vitality in the neonate, including peripheral edema, scleral hemorrhages, cyanosis of the mucous membranes or reduced responsiveness to stimulation, can also be a good indication that intervention is required (Mee, 2004). At birth, an additional vitality assessment using a modified Apgar score, may indicate the need for further intervention or special attention to improve long-term survival of the calf.

Conventional intervention methods for newborn calves attempt to reduce the immediate impacts of dystocia-induced respiratory and metabolic acidosis, thereby improving vitality and reducing calf loss (Mee, 2008b). Intervention strategies may include artificial respiration, respiratory stimulants, oxygen, buffer therapy for acidosis, thermal support and umbilical treatment (Mee, 2004, 2008b). In addition, if the calf is too weak to stand and suckle, feeding warm colostrum by esophageal feeder is recommended (Grove-White, 2000). Energy from colostrum in the hours following birth is essential for metabolic processes including heat production and fatty acid oxidation as well as providing the newborn with protective antibodies (Mellor and Cockburn 1986; Grove-White, 2000; Mellor and Stafford 2004).

A more novel strategy to improve newborn calf vitality and survival could be the administration of non-steroidal anti-inflammatory drugs (NSAIDs) for the alleviation of pain and inflammation following dystocia (Laven et al., 2012). The mode of action of NSAIDs is through the inhibition of cyclo-oxygenase (COX) enzymes to reduce prostaglandin synthesis (Hudson et al., 2008). In addition, NSAIDs have anti-endotoxic and anti-pyretic effects in cattle (Hudson et al., 2008; Laven et al., 2012). Side effects associated with NSAIDs, notably gastric ulceration and renal disease, are not well recognized in farm animals (Hudson et al., 2008). Lack of side-effects may be because of their short term use these species. This may also be true for use in calves following dystocia, as they would likely require only one dose following calving.

Research on the use of NSAIDs for dystocia has primarily been focused on the cow. There is currently no published literature on the use of NSAIDs in calves following dystocia (Laven et al., 2012). However, it is interesting that 39% of dairy cattle veterinarians in the UK indicated that they used NSAIDs in calves following dystocia, at least occasionally - in contrast to 66% who reported using NSAIDs in some cows following dystocia (Huxley and Whay, 2006). Yet, in the majority of dystocia cases, veterinarians are not called for assistance, and the producers themselves are responsible for calving management and decisions regarding the administration of analgesia to the cow and/or calf. As such, these decisions are often influenced by cost (Hudson et al., 2008). Consequently, the reported use of analgesics following dystocia in either cows or calves is probably greater than the actual rate of use.

It is possible that the limited usage of NSAID therapy following dystocia in cows, and even more so in calves, is due to the lack of scientific evidence of the benefits of NSAIDs following dystocia. Although it is clear that the physiological repercussions from dystocia reduce newborn calf vitality, it is uncertain whether there is pain, since this cannot be directly measured (Molony and Kent, 1997; Mee, 2008b). If the symptoms of reduced vitality are associated with pain, it is plausible that the administration of NSAIDs to calves following dystocia can improve the time to standing, increase colostrum uptake, improve health and overall calf survival and welfare (Laven et al., 2012). However, more research is needed to verify the benefits before treating dystocial calves with NSAIDs can be widely recommended.

Conclusions

It is well known that birth trauma dramatically decreases newborn calf vitality and increases the risk of stillbirth and neonatal mortality. The goal of the dairy and beef industries to maintain healthy cattle could benefit from the development, validation and implementation of useful methods for determining the vitality of the calf following parturition. Currently, there is no standard, validated protocol for monitoring newborn calf vigor. Behavioural and physiological measures of vitality such as responsiveness, time to standing, suckling reflex, heart rate, respiration rate, body temperature, mucous membrane colour, or more invasive measurements such as blood-gas analysis for acidosis, may provide a good indication that the calf requires further intervention. However, there is currently a lack of published data supporting these observations. More research is needed to validate signs of reduced vigor and to relate them to the future health and productivity of the animal. There is also very little published data on the pain experienced by the newborn calf following dystocia and relief through appropriate therapeutic interventions. Alleviation of this pain and distress following calving through the administration of NSAIDs may have important benefits for improving the behavioral and physiological status of the calf, total colostrum intake and success of passive transfer, all leading to a reduction in morbidity and mortality.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

References

Apgar, V., Holaday, D.A., James, L.S., Weisbrot, I.M., Berrien, C., 1958. Evaluation of the newborn infant-second report. Journal of the American Medical Association 168, 1985–1988.

Barrier, A., Ruelle, E., Haskell, M., Dwyer, C., 2012. Effect of a difficult calving on the vigour of the calf, the onset of maternal behaviour, and some behavioural indicators of pain in the dam. Preventive Veterinary Medicine 103, 248–256.

[1] See: http://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy07/Dairy07_ir_CalfHealth.pdf (accessed 10 September 2012).

Baxter, E., Jarvis, S., D'Eath, R., Ross, D., Robson, S., Farish, M., Nevison, I., Lawrence, A., Edwards, S., 2008. Investigating the behavioural and physiological indicators of neonatal survival in pigs. Theriogenology 69, 773–783.

Beam, A., Lombard, J., Kopral, C., Garber, L., Winter, A., Hicks, J., Schlater, J., 2009. Prevalence of failure of passive transfer of immunity in newborn heifer calves and associated management practices on US dairy operations. Journal of Dairy Science 92, 3973–3980.

Bellows, R., Lammoglia, M., 2000. Effects of severity of dystocia on cold tolerance and serum concentrations of glucose and cortisol in neonatal beef calves. Theriogenology 53, 803–813.

Besser, T.E., Szenci, O., Gay, C.C., 1990. Decreased colostral immunoglobulin absorption in calves with postnatal respiratory acidosis. Journal of the American Veterinary Medical Association 196, 1239–1243.

Bleul, U., Kahn, W., 2008. Monitoring the bovine fetus during stage II of parturition using pulse oximetry. Theriogenology 69, 302–311.

Bleul, U., Lejeune, B., Schwantag, S., Kahn, W., 2007. Blood gas and acid–base analysis of arterial blood in 57 newborn calves. Veterinary Record 161, 688–691.

Boyd, J.W., 1989. Relationships between acid–base balance, serum composition and colostrum absorption in newborn calves. The British Veterinary Journal 145, 249–256.

Breazile, J.E., Vollmer, L.A., Rice, L.E., 1988. Neonatal adaptation to stress of parturition and dystocia. The Veterinary Clinics of North America – Food Animal Practice 4, 481–499.

Burton, J.L., Kennedy, B.W., Burnside, E.B., Wilkie, B.N., Burton, J.H., 1989. Variation in serum concentrations of immunoglobulins G, A, and M in Canadian Holstein-Friesian calves. Journal of Dairy Science 72, 135–149.

Carstens, G.E., 1994. Cold thermoregulation in the newborn calf. The Veterinary Clinics of North America – Food Animal Practice 10, 69–106.

DeNise, S., Robison, J., Stott, G., Armstrong, D., 1989. Effects of passive immunity on subsequent production in dairy heifers. Journal of Dairy Science 72, 552–554.

Diesch, T., Mellor, D., Stafford, K., Ward, R., 2004a. Blood metabolites and body temperature of single calves between 1 and 4 days of age in a dairy herd in New Zealand. New Zealand Veterinary Journal 52, 256–260.

Diesch, T., Mellor, D., Stafford, K., Ward, R., 2004b. The physiological and physical status of single calves at birth in a dairy herd in New Zealand. New Zealand Veterinary Journal 52, 250–255.

Donovan, G., Badinga, L., Collier, R., Wilcox, C., Braun, R., 1986. Factors influencing passive transfer in dairy calves. Journal of Dairy Science 69, 754–759.

Drewry, J.J., Quigley 3rd, J.D., Geiser, D.R., Welborn, M.G., 1999. Effect of high arterial carbon dioxide tension on efficiency of immunoglobulin G absorption in calves. American Journal of Veterinary Research 60, 609–614.

Faber, S., Faber, N., McCauley, T., Ax, R., 2005. Case study: Effects of colostrum ingestion on lactational performance. The Professional Animal Scientist 21, 420–425.

Ferguson, J.G., 1994. Femoral fractures in the newborn calf: Biomechanics and etiological considerations for practitioners. Canadian Veterinary Journal 35, 626–630.

Finster, M., Wood, M., 2005. The Apgar score has survived the test of time. Anesthesiology 102, 855–857.

Furman-Fratczak, K., Rzasa, A., Stefaniak, T., 2011. The influence of colostral immunoglobulin concentration in heifer calves' serum on their health and growth. Journal of Dairy Science 94, 5536–5543.

Godden, S., 2008. Colostrum management for dairy calves. Veterinary Clinics of North America: Food Animal Practice 24, 19–39.

Gregory, N.G., 2004. Physiology and Behaviour of Animal Suffering. Blackwell Publishing, pp. 94–130.

Grove-White, D., 2000. Resuscitation of the newborn calf. In Practice 22, 17–23.

Gundelach, Y., Essmeyer, K., Teltscher, M.K., Hoedemaker, M., 2009. Risk factors for perinatal mortality in dairy cattle: Cow and foetal factors, calving process. Theriogenology 71, 901–909.

Hammer, C.J., Tyler, H.D., 1999. Effects of early rupture of the umbilical vessels in Jersey calves. Journal of Dairy Science 82, 49.

Haughey, K., 1973. Cold injury in newborn lambs. Australian Veterinary Journal 49, 554–563.

Haughey, K., 1975. Meningeal haemorrhage and congestion associated with the perinatal mortality of beef calves. Australian Veterinary Journal 51, 22–27.

Heins, B.J., Hansen, L.B., Seykora, A.J., 2006. Calving difficulty and stillbirths of pure Holsteins versus crossbreds of Holstein with Normande, Montbeliarde, and Scandinavian Red. Journal of Dairy Science 89, 2805–2810.

Herfen, K., Bostedt, H., 1999a. Correlation between clinical and laboratory diagnostic evaluation of the vitality of newborn calves under particular consideration of length and type of parturition. Wiener Tierärztliche Monatsschrift 86, 255–261.

Herfen, K., Bostedt, H., 1999b. The acid–base-status in bovine neonates during the first days of life considering different states of vitality. Berliner und Münchener Tierärztliche Wochenschrift 112, 166–171.

Holland, M., Odde, K., 1992. Factors affecting calf birth weight: A review. Theriogenology 38, 769–798.

Hudson, C., Whay, H., Huxley, J., 2008. Recognition and management of pain in cattle. In Practice 30, 126–134.

Huxley, J., Whay, H., 2006. Current attitudes of cattle practitioners to pain and the use of analgesics in cattle. Veterinary Record 159, 662–668.

Ikeda, T., Murata, Y., Quilligan, E.J., Parer, J.T., Murayama, T., Koono, M., 2000. Histologic and biochemical study of the brain, heart, kidney, and liver in asphyxia caused by occlusion of the umbilical cord in near-term fetal lambs. American Journal of Obstetrics and Gynecology 182, 449–457.

Jepson, H.A., Talashek, M.L., Tichy, A.M., 1991. The Apgar score: Evolution, limitations and scoring guidelines. Birth 18, 83–92.

Johanson, J., Berger, P., 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. Journal of Dairy Science 86, 3745–3755.

Kielland, C., Skjerve, E., Zanella, A., 2009. Attitudes of veterinary students to pain in cattle. Veterinary Record 165, 254–258.

Laster, D.B., Gregory, K.E., 1973. Factors influencing peri- and early postnatal calf mortality. Journal of Animal Science 37, 1092–1097.

Laven, R., Chambers, P., Stafford, K., 2012. Using non-steroidal anti-inflammatory drugs around calving: Maximizing comfort, productivity and fertility. The Veterinary Journal 192, 8–12.

Laven, R., Huxley, J., Whay, H., Stafford, K., 2009. Results of a survey of attitudes of dairy veterinarians in New Zealand regarding painful procedures and conditions in cattle. New Zealand Veterinary Journal 57, 215–220.

Liggins, G.C., 1994. The role of cortisol in preparing the fetus for birth. Reproduction, Fertility and Development 6, 141–150.

Lombard, J.E., Garry, F.B., Tomlinson, S.M., Garber, L.P., 2007. Impacts of dystocia on health and survival of dairy calves. Journal of Dairy Science 90, 1751–1760.

Mee, J.F., 2004. Managing the dairy cow at calving time. The Veterinary Clinics of North America – Food Animal Practice 20, 521–546.

Mee, J.F., 2008a. Prevalence and risk factors for dystocia in dairy cattle: A review. The Veterinary Journal 176, 93–101.

Mee, J.F., 2008b. Managing the calf at calving time. Proceedings of the American Association of Bovine Practitioners 41, 46–53.

Meijering, A., 1984. Dystocia and stillbirth in cattle – A review of causes, relations and implications. Livestock Production Science 11, 143–177.

Mellor, D., Cockburn, F., 1986. A comparison of energy metabolism in the newborn infant, piglet and lamb. Quarterly Journal of Experimental Physiology 71, 361–379.

Mellor, D., Gregory, N., 2003. Responsiveness, behavioural arousal and awareness in fetal and newborn lambs: Experimental, practical and therapeutic implications. New Zealand Veterinary Journal 51, 2–13.

Mellor, D., Stafford, K., 2004. Animal welfare implications of neonatal mortality and morbidity in farm animals. The Veterinary Journal 168, 118–133.

Meyer, C., Berger, P., Koehler, K., Thompson, J., Sattler, C., 2001. Phenotypic trends in incidence of stillbirth for Holsteins in the United States. Journal of Dairy Science 84, 515–523.

Molony, V., Kent, J.E., 1997. Assessment of acute pain in farm animals using behavioural and physiological measurements. Journal of Animal Science 75, 266–272.

Mulling, V.M., 1977. Asphyxia of newborn calves. Der Praktische Tierarzt 58, 78–80.

Okamoto, M., Robinson, J., Christopherson, R., Young, B., 1986. Summit metabolism of newborn calves with and without colostrum feeding. Canadian Journal of Animal Science 66, 937–944.

Olson, D., Papasian, C., Ritter, R., 1980a. The effects of cold stress on neonatal calves. 1. Clinical condition and pathological lesions. Canadian Journal of Comparative Medicine 44, 11–18.

Olson, D., Papasian, C., Ritter, R., 1980b. The effects of cold stress on neonatal calves. II. Absorption of colostral immunoglobulins. Canadian Journal of Comparative Medicine 44, 19–23.

Poulsen, K.P., McGuirk, S.M., 2009. Respiratory disease in the bovine neonate. Veterinary Clinics of North America: Food Animal Practice 25, 121–137.

Randall, G., 1971. The relationship of arterial blood pH and pCO_2 to the viability of the newborn piglet. Canadian Journal of Comparative Medicine 35, 141–146.

Riley, D., Chase Jr., C., Olson, T., Coleman, S., Hammond, A., 2004. Genetic and nongenetic influences on vigor at birth and preweaning mortality of purebred and high percentage Brahman calves. Journal of Animal Science 82, 1581–1588.

Robison, J., Stott, G., DeNise, S., 1988. Effects of passive immunity on growth and survival in the dairy heifer. Journal of Dairy Science 71, 1283–1287.

Rushen, J., de Passillé, A.M., von Keyserlingk, M.A.G., 2008. The Welfare of Cattle. Springer Verlag, pp. 129–130.

Schafer, S., Arbeiter, K., 1995. Relations between parturition, vitality and some blood parameters of the neonatal calf. Wiener Tierärztliche Monatsschrift 82, 271–275.

Schuh, J.A.C.L., Killeen, J.R., 1988. A retrospective study of dystocia-related vertebral fractures in neonatal calves. The Canadian Veterinary Journal 29, 830–833.

Schuijt, G., 1990. Iatrogenic fractures of ribs and vertebrae during delivery in perinatally dying calves: 235 cases (1978–1988). Journal of the American Veterinary Medical Association 197, 1196–1202.

Schuijt, G., Taverne, M., 1994. The interval between birth and sternal recumbency as an objective measure of the vitality of newborn calves. Veterinary Record 135, 111–115.

Schulz, J., Plischke, B., Braun, H., 1997. Sucking and drinking behavior as criteria of vitality in newborn calves. Tierärztliche Praxis 25, 116–122.

Senger, P.L., 1999. Placentation, the endocrinology of gestation and parturition. In: Pathways to Pregnancy and Parturition. Current Conceptions Inc., pp. 232–247.

Stott, G.H., 1980. Immunoglobulin absorption in calf neonates with special considerations of stress. Journal of Dairy Science 63, 681–688.

Stott, G., Reinhard, E., 1978. Adrenal function and passive immunity in the dystocial calf. Journal of Dairy Science 61, 1457–1461.

Stott, G., Wiersma, F., Menefee, B., Radwanski, F., 1976. Influence of environment on passive immunity in calves. Journal of Dairy Science 59, 1306–1311.

Szenci, O., 1982. Correlations between muscle tone and acid–base balance in newborn calves: Experimental substantiation of a simple new score system proposed for neonatal status diagnosis. Acta Veterinaria Academiae Scientiarum Hungaricae 30, 79–84.

Szenci, O., Taverne, M.A., Bakonyi, S., Erdodi, A., 1988. Comparison between pre- and postnatal acid-base status of calves and their perinatal mortality. Veterinary Quarterly 10, 140–144.
Tenhagen, B.A., Helmbold, A., Heuwieser, W., 2007. Effect of various degrees of dystocia in dairy cattle on calf viability, milk production, fertility and culling. Journal of Veterinary Medicine Series A 54, 98–102.
Trent, A., Ferguson, J., 1985. Bovine mandibular fractures. The Canadian Veterinary Journal 26, 396–399.
Tyler, H., Ramsey, H., 1991. Hypoxia in neonatal calves: Effect on intestinal transport of immunoglobulins. Journal of Dairy Science 74, 1953–1956.
Vasseur, E., Rushen, J., de Passillé, A., 2009. Does a calf's motivation to ingest colostrum depend on time since birth, calf vigor, or provision of heat? Journal of Dairy Science 92, 3915–3921.
Vermorel, M., Vernet, J., Saido, Dardillat., Demigné, C., Davicco, M.J., 1989a. Energy metabolism and thermoregulation in the newborn calf; effect of calving conditions. Canadian Journal of Animal Science 69, 113–122.
Vermorel, M., Vernet, J., Dardillat, C., Saido, Demigné, C., 1989b. Energy metabolism and thermoregulation in the newborn calf; variations during the first day of life and differences between breeds. Canadian Journal of Animal Science 69, 103–111.
Vermorel, M., Dardillat, C., Vernet, J., Saido, Demigné, C., 1983. Energy metabolism and thermoregulation in the newborn calf. Annals of Veterinary Research 14, 382–389.
Veronesi, M.C., Riccaboni, P., Faustini, M., Battocchio, M., Cairoli, F., Villani, M., 2005. Potential association between placental features and Apgar scores after normal parturition in the thoroughbred horse. Journal of Animal and Veterinary Advances 4, 965–970.
Veronesi, M.C., Panzani, S., Faustini, A., Rota, A., 2009. An Apgar scoring system for routine assessment of newborn puppy viability and short-term survival prognosis. Theriogenology 72, 401–407.