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Perinatal mortality: A summary of current literature prepared for the dairy cattle Code Development Committee

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Summary:

1. **The perinatal period is a time of high risk for calf mortality. Key risk factors for perinatal mortality include dystocia, age and size at first calving, calving management, and twinning.**
    a. **Many of these risk factors are modifiable on Canadian dairy farms.**
2. **Dystocia is the most important risk factor for perinatal mortality, but risk can be reduced. Heavier calves born to cows with a body condition ≥ 3.5 are more likely to experience dystocia.**
3. **The timely management of cows during calving is key to reducing perinatal mortality. Moving cows during stage 1 of parturition, later intervention, and no or delayed physical exam of the calf all represent higher areas of risk for perinatal mortality.**

Introduction

There is increasing interest in calf mortality as consumers are becoming more considerate of animal welfare when making food purchasing decisions (Verbeke, 2009) and due to the economic cost to farms. The perinatal period, defined as the period from birth to 48 hours of age, is one of the highest risk periods for calf mortality, which has been found to have increased significantly over the past decades (Compton et al., 2017). In March of 2018, Cuttance and Laven (2019a) completed a literature search to estimate the level of perinatal mortality in dairy calves, where they defined "perinatal mortality" as a full-term calf that dies at birth or within the first 48 hours. Across the 26 studies completed, the overall level of perinatal mortality ranged from 2.4% to 9.7% with an average level of 6.7%. In Canada, only producer estimates are available to provide information on the level of perinatal mortality. In the National Dairy Survey, completed in 2015, 1,375 producers reported an average farm-level incidence of perinatal mortality of 4.9%; however, this is likely an underestimate (Winder et al., 2018).

Causes of perinatal mortality

It is estimated that 90% of calves that die in the perinatal period were alive at the start of calving, suggesting that much of the loss is a preventable welfare problem (Mee, 2013). Causes of perinatal mortality are described by Mee (2013; 2020) and are highlighted in Table 1.

Table 1. Necropsy-diagnosed causes of death (%) for calves dying in the neonatal period from 2000–2011 (Mee, 2013).

Main cause of death	**%**
Dystocia	35%
Anoxia	30%
Congenital defects	5%
Infection	5%
Other*	15%
Unknown	25%

*Includes death related to omphalorrhagia (umbilical cord haemorrhage), premature placental separation, trace element disorders, intrauterine growth retardation (IUGR), prematurity with surfactant deficiency, placental insufficiency, twins, placental dysfunction, sire-specific genetic weakness, prolonged stage one parturition, prolonged stage two parturition with uterine atony, nitrate toxicity, and accidents.

Welfare concerns surrounding perinatal mortality

From a welfare perspective, pain is likely one of the major welfare issues arising in calves that died during the perinatal period. Pain experienced by a calf due to traumatic injuries (e.g., fractured leg, mandible, ribs, spine, ruptured internal organs or diaphragm, or severe internal haemorrhage) or prolonged or forceful traction, suffered during and immediately after calving from forced extraction (with a mechanical calving aid), is considered a serious welfare challenge. An additional welfare concern is the inability to get oxygen (anoxia) or breathlessness that results in a high-level of perinatal mortality and often occurs concurrently in cases of dystocia (Mee, 2020).

Risk factors for perinatal mortality

Researchers have identified many factors that increase the risk of perinatal mortality. A review of the literature was conducted by Cuttance and Laven (2019b) and Mee et al. (2014) and identified specific risk factors for perinatal mortality, which include:

(1) Assistance at calving

Dystocia is the most important risk factor for the occurrence of perinatal mortality. Specifically, the risk of perinatal mortality is up to six times higher when a dystocia occurs. The higher the grade of dystocia (easy pull to moderate pull to hard pull to veterinary assistance to caesarian

section), the higher the risk of perinatal mortality. It is also worth noting that even slight calving assistance was associated with perinatal mortality.

Additional consequences of dystocia beyond perinatal mortality

There are many consequences of dystocia beyond an increased risk of perinatal mortality. Table 2 reviews the primary impacts of dystocia, as described by Dematawena and Berger (1997) and Mee (2008).

Table 2. Impact, effects, and proportion of costs of dystocia on dairy farms (Dematawena & Berger, 1997; Mee, 2008).

Impact	**Effects**	**% of Costs**
Production	Decreased milk production	41%
Fertility	Increased days to first estrus, days to first service, and services per conception Decreased conception rate, delayed uterine involution, and delayed onset of luteal activity postpartum	34%
Culling and mortality	Increased risk of the cow being culled and increased calf and cow mortality	25%

In addition, dystocia will also increase the risk of disease in cows, including retained placenta, uterine disease, mastitis, and hypocalcaemia (Mee, 2008). For the calf, beyond perinatal mortality, dystocia has been associated with an increased risk of respiratory disease, diarrhea, and mortality up to 30 days of age (Lombard et al., 2007).

Risk factors for dystocia or assistance at calving

Dystocia is a risk factor that is modifiable, meaning we can influence its occurrence and, with proper management, can reduce the risk of perinatal mortality. Many of the factors that influence dystocia are associated with creating feto-maternal disproportion where the pelvic diameter of the cow is not large enough to allow easy passage of the calf. The specific factors associated with dystocia (Fenlon et al., 2017; Mee, 2008) are:

1. **Calf birth weight**
    - One of the most important predictors of dystocia risk; the odds of dystocia increase by 13%/kg increase in body weight.

- Most influenced by gestational length (> 285 d gestation associated with increased risk of dystocia and stillbirth), followed by parity of the dam (higher parity of the dam results in increased calf birth weight), fetal gender (male calves are typically larger), size and dam breed, maternal nutrition, and climate in the last trimester of gestation.

2. **Calving body condition score (BCS)**
    - Found to have the highest importance in ranking by Fenlon et al. (2017).
    - When BCS is $\geq$ 3.5, the risk of dystocia was found to be highest, likely due to the build-up of adipose tissues in the birth canal leading to a reduced diameter.

3. **Genetics**
    - Genotype, whether parental or maternal, can have a significant influence on birthweight and subsequent dystocia risk.

4. **Parity**
    - There is a significant influence of parity with respect to dystocia, where first time calvers experiencing dystocia have a greater risk of perinatal mortality when compared to calves born from a dystocia in older cattle.
    - More discussion can be found below on the influence of parity on perinatal mortality risk, however, weight at service, age, and condition at calving for first lactation animals are important influencers of dystocia risk.

5. **Abnormal fetal position**
    - Abnormal fetal position, most commonly presenting as backwards presentation, foreleg malposture, and breech position, is the most common cause of dystocia in older dams.
    - Abnormal fetal position is most influenced by the presence of twins.
    - Although not particularly modifiable, having excellent calving supervision and providing appropriate intervention in a timely manner will lead to a reduced risk of perinatal mortality and other consequences of dystocia.

(2) Age at first calving/parity

The highest risk for perinatal mortality is in calves born to primiparous cattle. Calves born to multiparous dams have been found to be 60% less likely to suffer perinatal mortality compared to calves from primiparous dams (Brickell et al., 2009). This is likely related to first time calvers having the highest risk of dystocia due to the greater risk of feto-maternal disproportion.

The risk of perinatal mortality in first time calvers is highest for very young heifers (< 24 months); Ettema and Santos (2004) showed no effect between age at first calving and risk of

dystocia for 2 and 3 year old heifers. This increased risk is likely due to smaller pelvic size at calving (Mee, 2008), due to reduced growth occurring prior to parturition. To ensure that first time calvers are not more likely to birth a calf at risk of experiencing perinatal mortality, producers should ensure that heifers are bred at appropriate sizes, which is recommended to be 55 to 65% of mature bodyweight at first service (Mee, 2008), and not look solely at the age of the heifers at first breeding. If producers want to have heifers calve younger than 24 months of age, they will need to ensure they are providing heifers a high plane of nutrition and minimize disease to optimize growth and performance.

(3) Calving management

Ideally, calving protocols should be readily available and explained to all staff to highlight critical areas for monitoring and opportunities to intervene and/or prevent problems in the parturition process. This is of the utmost importance because calving management directly correlates to the success of the calving process and calf mortality. Written protocols for calving management were only found on 7% of Canadian farms visited in a recent survey, and of those that had a protocol only 50% were developed with a veterinarian (Villettaz-Robichaud et al., 2016). Calving management protocols should include information on pre-calving movement, calving location, calving supervision, calving intervention, and post-calving management of the calf, each of which are described below.

Pre-calving movement

When using individual calving areas, animals will need to be moved at particular times surrounding parturition. Research has identified that there can be consequences when cows are moved at inappropriate times. Movement around the time of parturition will not be an issue when cows are moved prior to the onset of stage 1 of parturition (period defined by dilation of the cervix with signs of viscous, bloody mucus or contractions), or at stage 2 of parturition (when the feet or amniotic sac are present at the vulva) (Carrier et al., 2006; Proudfoot et al., 2013). When cows are moved during stage 1 of parturition, it may lead to a longer duration of calving, higher levels of dystocia, and a higher risk of perinatal mortality (Proudfoot et al., 2013).

When evaluating pre-calving movement on 262 Canadian dairy farms, 25% of respondents moved cows when the first signs of calving were detected (Villettaz-Robichaud et al., 2016). The calving signs used for movement included anything from restlessness and udder fill to bloody mucus, presentation of the amniotic sac, or part of the calf emerging from the vulva. As indicated above, some of these signs relate to stage 1 of parturition, and improved education is necessary on when to move cows at the appropriate time to reduce dystocia. Producers using individual calving pens were most likely to move them into a calving pen when the first signs of calving were detected, whereas those using a group pen or tie-stall most often moved cows at the beginning of the dry cow period or 3 weeks prior to the expected calving date.

Calving location

The main types of calving areas, from a survey of calving management practices on 236 dairy farms in Alberta, Ontario, and Quebec (Villettaz-Robichaud et al., 2016), are highlighted below in Table 3.

Table 3. Proportion of farms that used each type of calving area as their main calving area on 236 dairy farms surveyed in Ontario, Quebec, and Alberta (Villettaz-Robichaud et al., 2016).

Type of calving area	**Total %**
Individual calving pen	30.1%
Group calving pen	34.7%
Specially adapted tie-stall	8.9%
Regular tie-stall	16.5%
Regular free-stall	1.3%
Other (bedded pack, dry lot, pasture)	3.4%
2 types of calving areas used equally	5.1%

There has not been a significant amount of work conducted with respect to the impact of calving location, however, Mee et al. (2014) summarized the main findings of literature completed to date. They found that calving at pasture was associated with a higher risk of perinatal mortality, likely due to a lack of supervision. Calving in tie-stalls was found to have a lower stillbirth rate than calving in free-stalls; however, lower stillbirth rates were found in loose housed cows in pens compared to cows that were tethered. The use of tie-stalls for calving has, however, been suggested to negatively impact dam welfare (Vasseur et al., 2010; Fishwick, 2011; Villettaz-Robichaud et al., 2016), as tie-stalls reduce the freedom of movement and the ability to find comfortable positions for delivery, which is even more important for primiparous cattle. A lack of hygiene has also been cited as a potential concern because calves can be born in the manure gutter behind tie-stalls (if not covered) and/or have a higher risk of coming into contact with manure, urine, and the placenta after birth (if not moved immediately). However, very little research has been published on this subject.

Calving supervision

The quality of calving supervision can have a significant influence on the risk of perinatal mortality. Increased frequency of observation of animals close to calving, particularly at night,

reduces the rate of perinatal mortality (Mee et al., 2014). Use of camera surveillance has also been associated with a reduction in perinatal mortality (Mee et al., 2014).

From the Canadian survey conducted by Villettaz-Robichaud et al. (2016), the average reported number of times the calving area was checked during the day was 6.3 times (95% Confidence Interval: 5.6–7.0); however, it was checked only 1.7 (95% Confidence Interval: 1.5–1.8) times during the night (either by camera or by live observation). This suggests that supervision is lacking at night. In the survey, about 18% of farms used cameras to monitor cows during calving, which could be used to better surveil cows in the evening. In order to improve supervision of parturition, the use of monitors that evaluate body temperature, behavioural indicators of parturition, tail movements, and feeding and rumination time could be used to provide more active surveillance of calving (Saint-Dizier & Chastant-Maillard, 2015). However, with these monitors producers are still required to provide appropriate intervention to improve the success of calving outcomes.

Calving intervention

The timing of assistance during stage 2 of parturition (defined as the presence of feet or the amniotic sac at the vulva) can influence the risk of perinatal mortality. The odds of stillbirth greatly increase if the second stage of labour is longer than 2 hours (Gundelach et al., 2009), where every additional hour in stage 2 of calving increases the odds of stillbirth by 30% (Mee et al., 2014). In addition, Scheunemann et al. (2011) identified that the rate of stillbirths can be reduced by assisting cows without progress 80 minutes after the onset of stage 2 of calving and recommended early intervention to prevent perinatal mortality. This recommendation was further solidified by Villettaz-Robichaud et al. (2017), who reported that calves who had late assistance, where assistance was provided more than 1 hour after the onset of stage 2 of parturition, had a higher risk of being stillborn compared to calves with early assistance (assisted within 15 minutes of the onset of stage 2 of parturition) or no assistance and born within an hour. Hence, providing early assistance during calving will not adversely affect the calf, and may reduce their risk of perinatal mortality. When evaluating Canadian data, the average wait time from the onset of stage 2 of parturition until examination or assistance was 81 minutes, with a range of 5 minutes to 360 minutes (Villettaz-Robichaud et al., 2016). This suggests that some producers may wait too long prior to intervening on some cows, which could increase the risk of perinatal mortality.

On some farms, it may not be practical to base timing of intervention on the onset of stage 2 of parturition, as it is not possible to get an exact estimate of when this occurs. Hence, when cows are initially observed in stage 2 of parturition, completing an examination to evaluate the contents of the amniotic sac, vigour and size of the calf, and degree of dilation is recommended (Mee, 2004). An intervention should be implemented at first examination if the amniotic fluid is brown, red, or fetid; cotyledons are present; tongue, head or feet are swollen or cold; or there is

malposition of the calf, presence of twins, or reduced fetal reflexes (Mee, 2004). In contrast, if everything is normal at first examination, it is recommended to monitor for progression every 15 to 30 minutes without disturbing the cow, and if progress ceases or the calf shows signs of poor vigour, an intervention should be applied (Mee, 2004; Scheunemann et al., 2011). In Canada, only 16% of producers routinely examine cows when initially identified in stage 2 of parturition, with this practice being completed most frequently on tie-stall farms (Villettaz-Robichaud et al., 2016).

Post-calving management of the calf

Approximately 60% of perinatal mortality occurs within the first hour after birth, making the time period immediately after birth critical. The calf should be assessed for poor or absent reflexes, poor muscle tone, and abnormal respiration to determine if resuscitation is necessary (Mee, 2018). If necessary, a focus should be placed on ensuring that the airways are patent by removing fetal membranes and clearing amniotic fluid from the nostrils and mouth. After ensuring airway patency, the focus should shift to establishing normal breathing. This can be accomplished by nasal (poking the nasal septum with straw or another object) or hypothermal (cold water on ear/head) stimulation, which induces a gasp reflex leading to the onset of respiration. If these measures fail, physical resuscitation may be necessary. Once respiration is established, calves should be placed in sternal recumbency, which will increase lung expansion and gas exchange. Finally, if a calf has no heartbeat, thoracic compressions can be applied to establish normal circulatory function.

Beyond the initial care of calves following calving, pain management may also be necessary. Specifically, in calves born from a difficult calving, it has been shown that providing injectable meloxicam will improve calf vigour, suckling reflex, milk intake, and health (Murray et al., 2015; 2016). Hence, the provision of a nonsteroidal anti-inflammatory drug (NSAID) to calves that went through a dystocia is warranted. However, blanket use of NSAIDs may not be beneficial, and in a 2015 study Murray et al. found negative consequences to calves treated with an NSAID when their calving was observed, but not assisted. Pain management for dystocia is further discussed in the Scientific Committee's report (chapter 4; NFACC, 2020).

Calves born from a dystocia are at a much higher risk of hypothermia, especially when exposed to low environmental temperatures. Hence, drying the haircoat, providing warm colostrum as soon as possible following calving, placing in clean, deep straw bedding and under a heat lamp will reduce the consequences associated with hypothermia (Mee, 2018).

(4) Twinning

Twin-born calves have been consistently shown to be at a higher risk of perinatal mortality. Brickell et al. (2009) have shown that twins were twice as likely to die at birth or within the first 48 hours compared to singleton calves.

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