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Review

Influence of modifiable risk factors on the incidence of stillbirth/perinatal mortality in dairy cattle

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ABSTRACT

Bovine perinatal mortality is defined as the death of a full-term calf before, during or up to 48 h after calving. Recent studies indicate that the prevalence of bovine perinatal mortality is increasing, particularly in Holstein primiparae. Factors leading to a greater incidence of dystocia are the most important modifiable variables influencing the risk of perinatal mortality. Modifiable predictors are largely (age at first calving, breeding method, sire, calving management, feto-maternal health status and gestational nutrition) or moderately (calf breed, sex, gestation length) under the control of the dairy farm manager. Unlike non-modifiable risk factors, such as primiparity and fetal plurality, these factors can be manipulated to reduce the incidence of perinatal mortality.

Introduction

Perinatal mortality may be defined as death of the fetus or calf before, during or within 48 h of calving at full term (>260 days) (Mee, 2008a). Concerns have been raised recently about high (Hardarson, 2012) and increasing rates of perinatal mortality in Holstein primiparae (Hansen et al., 2004a) and the 'normalisation' of these losses (Mee, 2013). In addition to the detrimental economic effects of perinatal mortality on milk production (Bicahlo et al., 2008), reproduction and maternal survival (Bicahlo et al., 2007), high stillbirth rates have recently been used as indicators of welfare deficits in dairy herd stockmanship and management (Nyman et al., 2011).

While traditionally >50% of perinatal mortality has been directly attributed to dystocia, some recent studies suggest that losses increasingly may be occurring following normal calving (eutocia) (Gustafsson et al., 2007). This raises the question as to whether the risk factors associated with perinatal mortality have changed and would have implications for preventive strategies aimed at modifiable risk factors to reduce the rate of perinatal mortality. Maternal, fetal, environmental and management factors influence perinatal mortality. However, many of these factors are not modifiable on commercial dairy farms: parity, history of previous perinatal mortality, fetal plurality, fetal presentation, herd, herd size, calving day of the week, season and year. The aim of this study was to review the modifiable risk factors associated with perinatal mortality in dairy cattle: age at first calving, breed, breeding method, calving management, fetal sex, feto-maternal health status, gestation length, gestational nutrition and sire.

Materials and methods

A list of modifiable risk factors for stillbirth/perinatal mortality in dairy calves was established. Five databases (Biosis, CAB Abstracts, Embase, Google Scholar and Medline), were searched over a maximum of 80 years (1932–2012). Search terms included 'stillbirth', 'perinatal mortality', 'calf mortality', 'perinatal calf loss', 'calving', 'dystocia', 'bovine', 'dairy', 'Holstein–Friesian', 'modifiable' and 'risk factors' and their combinations. Material referring to non-modifiable risk factors and neonatal mortality (>48 h after birth) were excluded. Peer-review papers were included preferentially; however, where only non-peer review publications were found, e.g. conference proceedings papers, these were also cited. A synoptic summary is included for each risk factor and the strength of the evidence supporting the original authors' findings is presented where available.

Modifiable risk factors

Age at first calving

The risk of perinatal mortality increases as primiparae calve at a younger age, with minimal effect in pluriparae. Most studies have concluded that this risk is greatest in primiparae calving at <24 months of age (Hansen et al., 2004b; Mee et al., 2008; Bleul, 2011). This increased risk is associated with an increased risk of dystocia in these younger primiparae (Mee et al., 2011), particularly for male calves (Steinbock et al., 2006). The increased frequency of dystocia and stillbirth in younger primiparae has been attributed to inadequate pelvic size, since calf size does not vary

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significantly (McClintock, 2004). This risk was quantified by Hansen et al. (2004b); at an age at first calving of 22 months, the probability of stillbirth for male and female calves was 0.29 and 0.21, respectively, whereas, at an age at first calving ⩾28 months, the corresponding values were 0.15 and 0.10. While a curvilinear relationship between age at first calving and dystocia has been established (Simerl et al., 1991), an increased risk of stillbirth in older primiparae has rarely been reported (Auran, 1972). The consensus is that, if the age at first calving is ⩾24 months, there is no increased risk of stillbirth (Ettema and Santos, 2004; Hansen et al., 2004b; Benjaminsson, 2007; Berry and Cromie, 2009). Congruent with these findings, the recommended optimal age at first calving, although variable (22–27 months; Simerl et al., 1991; Brade, 2006), is generally ~24 months (Ettema and Santos, 2004; Haworth et al., 2008). Thus, the age at which primiparae calve influences the risk of stillbirth and this is mediated via pelvic size at calving, but this effect is small within industry norms for age at first calving (23–27 months).

Breed of dam

Rates of bovine perinatal mortality are generally lower in dairy breeds than in beef breeds (Bleul, 2011). Within dairy breeds, low perinatal mortality rates generally have only been achieved in non-Holstein cattle populations with low rates of dystocia, such as the Norwegian Red (3.4% mortality within 24 h of calving; Gulliksen et al., 2009), Scandinavian Red (4.7% vs. 12.7% mortality within 24 h of calving for Holsteins; Heins et al., 2006) and Jersey crosses (5.2% vs. 10.7% mortality within 48 h of calving for Holsteins; Olson et al., 2009). The highest reported primiparous stillbirth rate in the world is in indigenous Icelandic dairy cattle (22.6% mortality within 48 h of calving; Hardarson, 2012). These findings clearly indicate that the breed of the dairy dam influences the risk of stillbirth, with lower rates in non-Holsteins than in Holsteins.

Breeding method

The breeding method used can significantly influence the risk of stillbirth. For example, calves produced by embryo or nuclear transfer had a higher stillbirth rate than those produced by artificial insemination (Kruip and den Daas, 1997). Calves produced by natural service may also have a higher stillbirth rate than those from artificial insemination, particularly in primiparae, although this may be confounded with inadequate calving supervision due to a less accurate prediction of calving date in calves born from natural service (Benjaminsson, 2007; Hardarson, 2012). Calves produced following timed artificial insemination had a higher rate of stillbirths than those produced after artificial insemination at spontaneous oestrus (Ambrose et al., 2006). Whilst no differences were found between fresh and frozen semen, the stillbirth rate was significantly higher in cows following repeat artificial insemination (Wijeratne and Stewart, 1970). These findings indicate that the breeding method can be a risk factor for perinatal mortality in dairy herds, with lower rates in calves bred by artificial insemination.

Calving management

Pre-calving movement

The timing of the movement of pregnant animals to the calving unit can influence the risk of stillbirths. Traditionally, movement to the calving unit 1–2 days prior to the predicted calving date has been recommended (Mee, 2008a). If cows have not been moved prior to calving, recent studies have shown the benefit of postponing movement until stage 2 of calving; cows moved during stage 2 of calving were 2.5 times less at risk of stillbirth than those moved during stage 1 of calving (Carrier et al., 2006). The benefits of this 'just-in-time' calving protocol in reducing dystocia were confirmed by the findings of Kristula and Smith (2011). These findings indicate that the timing of movement at calving to the maternity unit can influence the risk of stillbirth, with lower rates in cows moved during stage 2 compared to stage 1 of calving.

Calving location

The environment in which cows calve is also a risk factor for perinatal mortality. Calving at pasture is associated with a higher risk of stillbirth (Streit and Ernst, 1992; Vernooy et al., 2007). This may be due to lack of calving supervision (Hodge et al., 1982), since calving at pasture is associated with lower rates of dystocia (McDermott et al., 1992). Confinement of primiparae in a pen was associated with higher rates of dystocia and stillbirth than leaving them in a large yard or in a paddock (Dufty, 1981). Calving in tie stalls has been associated with a lower stillbirth rate than calving in free stalls (Gulliksen et al., 2009), although this may reflect an interaction with calving supervision (Hoedemaker et al., 2010). In contrast, lower stillbirth rates were found in loose housed cows compared to tethered cows and this was associated with a lower rate of dystocia (Dolezal, 1991). Vernooy et al. (2007) found no association between individual or group maternity accommodation and the risk of stillbirth. Therefore, the association between calving location and stillbirth is highly dependent upon the adequacy of calving supervision and the occurrence of dystocia.

Calving supervision

The extent and method of observation of the preparturient animal can influence the risk of stillbirth. Introduction of a camera surveillance system reduces the incidence of stillbirths (Vernooy et al., 2007; Szenci et al., 2012). Numerous farm labour issues affect the stillbirth rate; for example, a bonus payment to farm staff reduced perinatal mortality (Szenci et al., 2012), calving management training and the obstetrical skills of the farmer were associated with a reduction in the rate of stillbirths (Drew, 1988; Kausch, 2009; Scheunemann et al., 2011a) and work shift changeovers were associated with prolonged stage 2 of calving and hence an increased risk of stillbirth (Gundelach et al., 2009). Increased frequency of observation of the preparturient animal, particularly at night, on Sundays and 'bank holidays', reduces the rate of stillbirths (Hodge et al., 1982; Szenci and Kiss, 1982; Drew, 1988; Vernooy et al., 2007). These findings indicate that the quality of calving supervision, in particular the frequency of observation pre-calving, can have a significant influence on the risk of stillbirth.

Calving intervention policy

The timing of assistance during stage 2 of calving can influence the risk of stillbirth. A longer duration of calving is associated with a greater the risk of stillbirth (Berglund et al., 1987). This is most evident >2 h, with every additional hour in stage 2 of calving (onset of stage 2 defined as presence of feet at the vulva) increasing the odds of stillbirth by 30% (Carrier, 2007). This apparent viability threshold of 2 h is supported by the increased perinatal mortality in calves born following more than 2 h into stage 2 of calving (onset of stage 2 defined as rupture of the allantoic/amniotic sac) (Gundelach et al., 2009); hence the 'two feet-two hours' rule of thumb to reduce the risk of stillbirth (Mee, 2008a; Gundelach et al., 2009). Recently Scheunemann et al. (2011b) reduced the rate of stillbirths by assisting cows without progress at ~80 min after the onset of stage 2 of calving (onset of stage 2 defined as appear-