

Bovine neonatal survival – is improvement possible?

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ABSTRACT

The answer to this rhetorical question is - in theory, yes, but the inconvenient truth is in practice often, no. This dichotomous answer hints at the enigmatic discord between what is theoretically possible and what actually occurs in practice. Though this view may conflict with received thinking, evidence for this divergence can be found in the disparity between bovine neonatal survival rates (in the first two days of life) internationally and between results from research studies and farm-level data. For example, dairy calf neonatal survival rates in some countries, e.g. Norway, are amongst the highest in the world; in contrast to those in many North American Holstein-Friesian-dominated dairy industries. Whereas experimental and observational studies have identified critical risk factors for improved neonatal survival the results from such studies are not always replicated at farm level. In fact the reverse has occurred in recent years, with a decrease in bovine neonatal survival rates reported in the peer-review literature from many countries around the world. Unfortunately this decline in neonatal survival has not attracted the same degree of interest or research funding as the well documented decline in dairy cow ‘fertility’, of which it is an adjacent problem. The reason for the lack of improvements in neonatal survival stems from de-prioritisation of the issue relative to other animal health and welfare concerns. This has resulted in less funding of research work with consequent downstream atrophy of knowledge metastasis through extension and implementation programmes. While there are knowledge gaps constraining progress towards improved neonatal survival requiring more transdisciplinary research including the ‘omic’ technologies, re-prioritisation of neonatal survival as an important welfare deficiency signal and better communication of existing knowledge are of greater importance in reversing current trends.

INTRODUCTION

Bovine perinatology tends to be one of the less well organised and funded branches of animal reproductive science in contrast to human perinatology where the Stillbirth Collaborative Research Network coordinates research into the cause of stillbirth. Our limited current understanding is evidenced by the comparative paucity of scientific publications in this field compared to the other areas of bovine theriogenology. Perinatal mortality may be defined as fetal death prior to, during or within 48 hours of calving, following a gestation period of at least 260 days, irrespective of the cause of death or the circumstances related to parturition (Mee, 2008). The perinatal period is the most hazardous in the life of all animals. Approximately 75% of perinatal mortality occurs

within one hour of calving with the remainder occurring either pre- (10%) or post-partum (15%). Some 90% of calves, which die in the perinatal period, were alive at the start of calving and so much of this loss is preventable.

However, through de-prioritization of these losses relative to other causes of reproductive wastage, such as early and late embryonic mortality, and under-estimation of the real extent of these losses (Vasseur, et al., 2010) our current understanding of bovine perinatal mortality is limited (Mee, 2011a).

EPIDEMIOLOGY OF BOVINE PERINATAL MORTALITY

Incidence of perinatal mortality

Currently, the average incidence of perinatal mortality in cows and heifers varies between 2 and 20% across dairy industries internationally with the majority of countries between 5 and 8% (Table 1). However, exceptionally high rates have been recorded in some sub-populations, for example among primiparae (25%) (Benjaminsson, 2007) and in twin pregnancies (30%), (Silva del Rio et al., 2007). The variation between national agricultural statistical data averages reflects differences in definitions of perinatal mortality but more importantly, emphasises the differences between those countries which have practised a long-term policy of genetic selection against undesirable functional traits and those which have pursued single trait selection policies and associated dairy breed differences. The most worrying incidence data are those from the US, as these genetics are exported around the world and could influence rates in almost all dairy industries worldwide. The data in Table 1 also highlight the lack of conformity in recording of perinatal mortality and the definitions used to describe it; the need to standardise such definitions is self-evident when attempting to make valid international comparisons.

These average national figures obscure the fact that herd-level statistics follow a right skewed distribution where most herds have none or minimal losses but some herds have 20 to 30% perinatal mortality (Mee et al., 2008). Thus, even within countries with a relatively low incidence rate, problem herds exist. Despite the best efforts of farmers and their veterinarians to manage parturition and newborn calves successfully, perinatal mortality can be a perennial problem on some farms yet only occur sporadically on others. Currently there is little research on the causes of this wide inter-herd variation in stillbirth rates and why certain herds have persistent problems and others do not; well designed transdisciplinary studies are warranted.

Table 1. Prevalence of perinatal calf mortality in dairy heifers and cows in 20 countries internationally (2000-2011).

Country	Breed of dam	Heifers (%)	Heifers and cows (%)	Definition of calf mortality
Australia	Holstein-Friesian	10.8	5.1	Death within 48 hours of a singleton calving
Austria	Holstein-Friesian	8.7	5.9	Death within 48 hours of calving
Canada	Holstein-Friesian	9.0	9.6 ^a	Dead at birth
Denmark	Holstein-Friesian	9.0	NR ^b	Death within 24 hours of calving
Germany	Holstein-Friesian & HFx Blackpied	NR	9.3	Death within 24 hours of calving
Iceland	Indigenous	16.0	15.0	Stillbirth
India	Jersey	NR	3.8	Foetal death
Israel	Holstein-Friesian	7.2	5.0	Death within 24 hours of calving
Iran	Holstein-Friesian	4.3	3.5	Death within 1 hour of calving

Ireland	Holstein-Friesian	7.7	4.3	Death within 24 hours of calving
France	Holstein-Friesian & Normande	NR	7.4	Death within 24 hours of calving
Hungary	Holstein-Friesian	12.3	9.3	Death within 24 hours of calving
The Netherlands	Holstein-Friesian	11.4	6.9	Death within 24 hours of a singleton calving
New Zealand	Holstein-Friesian, Jersey and their crosses	7.4	7.2	Death within 48 hours of calving excluding inductions.
Norway	Norwegian Red	3.0	2.0	Death within 24 hours of calving
Portugal	Holstein-Friesian, Montbelliarde, Swedish Red	NR	20.0	Death within 48 hours of calving
Sweden	Swedish Red	3.6	2.5 ^a	Death within 24 hours of a singleton calving
Switzerland	Dairy, Beef & Crossbreeds	5.9	2.4	Death within 24 hours of calving
UK	Holstein-Friesian	10.9	5.3	Death within 48 hours of a singleton calving
USA	Holstein-Friesian	12.1	8.0	Dead at birth

^a cows only, ^b not recorded.

Temporal trends in perinatal mortality

Recent published studies in Denmark, The Netherlands, North America and Sweden indicate that the prevalence of perinatal mortality is increasing, particularly in Holstein primiparae (Meyer et al., 2001, Steinbock et al., 2006). Much of this increase has been attributed to North American Holstein introgression, or introduction of particular Holstein sires' genes, into indigenous cattle populations. The resultant calves have a longer gestation length, are larger and heavier at birth, suffer more dystocia and consequently are at greater risk of perinatal mortality (Hansen et al., 2004, Steinbock et al., 2003). Recently Bricknell et al., (2007) reported that stillbirth rates had changed very little on UK dairy farms in the past 10 years, and at 8% now accounted for over twice as much calf mortality as neonatal losses.

Risk factors for perinatal mortality

The majority of perinatal mortality has been attributed directly to dystocia particularly in heifers which frequently require assistance at calving. Parity has been shown to be the best predictor variable for perinatal mortality followed in primiparae by dystocia and in pluriparae by dystocia and gestation length (Meyer et al., 2000). Other significant animal-level factors, also common to dystocia, include age at first calving, particularly in heifers less than 24 months old (Benjaminsson, 2007), primiparity (Pryce et al., 2006), twinning (Silva del Rio et al., 2007), fetal gender (Steinbock et al., 2006), shorter or longer gestation length (Meyer et al., 2000) and sire predicted transmitting ability (PTA) for perinatal mortality (Mee et al., 2008). In recent years, the interplay between genotypic and environmental risk factors has received more scientific attention. Crossbreeding studies have now illustrated the differences in perinatal mortality between different dairy and dual purpose breeds (Heringstad et al., 2007). The increase in perinatal mortality with increasing proportion of Holstein-Friesian genes in both the calf and in the dam has been demonstrated (Hansen et al., 2004). In addition, the role of inbreeding as a significant risk factor for perinatal mortality has only recently been documented (McParland et al., 2007), and though the effects are small and mainly confined to primiparae, they were consistently unfavourable.

Significant herd-level risk factors for perinatal mortality include herd (Silva del Rio et al., 2007), year (Johanson and Berger, 2003), season of calving (Johanson and Berger, 2003), larger herd size (Gulliksen et al., 2008) and calving management (Vernooy et al., 2007). While deficiencies of micro-nutrients (iodine, selenium, copper and zinc) have been associated with high stillbirth rates (Murray et al., 2008, Enjalbert et al., 2006), results from randomised clinical trials do not necessarily support a causal relationship (McCoy, et al., 1997, Mee et al., 1995). Excess body condition prior to calving, particularly in heifers (Chassagne et al., 1999), has been associated with reduced appetite as calving approaches with resultant mobilisation of fat reserves; also it may reduce magnesium availability, and the ensuing sub-clinical hypocalcaemia could produce uterine atony which is observed clinically as 'slow calving syndrome' where fetal death occurs in the absence of dystocia (non-visible dystocia or bradytocia).

Management of calving plays a critical role in perinatal mortality in dairy or beef herds (Mee, 2011b). For example, increased duration of second stage calving beyond two hours, poor abdominal contractions, use of mechanical calf pullers and changes in the calving supervision all increase significantly the risk of perinatal mortality (Hoedemaker et al., 2008).

In addition to these accepted risk factors, there is now evidence that an increasing proportion of perinatal mortality occurs at unassisted calvings where placental dysfunction and low birth weight may be causative factors (Benjaminsson et al., 2007, Berglund et al., 2003, Kornmatitsuk et al., 2004). Idiopathic stillbirth or weak calf syndrome is particularly associated with heifer calvings. In both cattle and sheep neonatal vigour is correlated with placental function related to placentome number and placental weight (Dwyer et al., 2005).

AETIOLOGY OF PERINATAL MORTALITY

The major proximate causes of perinatal mortality are trauma and anoxia as a consequence of dystocia, and, to a much lesser extent, congenital defects, infections and other causes (Table 2). The variation in the proportions of necropsy-diagnosed causes of death reflects variations in the causative risk factors such as dystocia (Mee et al., 2011) but also variations in diagnostic definitions and the number and selection criteria for calves and herds examined.

Traumatic lesions found in stillborn calves associated with dystocia include fractured ribs (13-23%), fractured spine (3-25%), fractured legs (2%), diaphragmatic tears (4%), hepatic rupture, and collapsed trachea (Schuijt 1990). Anoxic lesions, often found following clinical dystocia and 'non-clinical dystocia' (clinically undetectable prolonged or abnormal stage one or two of calving), include pulmonary atelectasis, scleral, epicardial, endocardial and meningeal petechiation, meconium aspiration syndrome (MAS) and meconium staining or passage (et al., 2008b, Schuijt 1992, Mee, 1991a). Meconium staining of the coat has been recorded in 16-30% of vaginally and caesarean-derived calves and occurs more often where death is preparturient, gestation is prolonged, birthweight is heavier and the calf is female or of a beef type (Mee, 1991a, Schuijt, 1992). Unfortunately, calves dying following acute anoxia often have unremarkable gross pathological findings.

Perinatal mortality following eutocia or 'weak calf syndrome' may be associated with intrauterine growth retardation (IUGR), prematurity with surfactant deficiency (Jahn,

1982), congenital defects, infections, precalving nutrition, dysmaturity, twins, placental dysfunction or sire-specific genetic weakness. Prolonged stage one with premature placental separation, prolonged stage two with uterine atony, nitrate toxicity and accidents also contribute to eutocic stillbirth. Premature placental separation is associated with premature birth and maldisposition (Mee, 1991b). Anecdotally, pharmacological induction of parturition, excessive selenium supplementation and subclinical hypocalcaemia have also been implicated.

Table 2. Necropsy-diagnosed causes of death (%) for calves dying in the perinatal period internationally (2000-2011).

Country	Calves (No.)	Dystocia	Anoxia	Congenital defects	Infection	Other	Not determined
Canada*	560	40.2	NR**	4.3	2.9	31	21.6
Finland	148	43	***	10	10	8	29
Germany	87	0	NR	11.5	8	NR	NR
Iceland	129	34	37	NR	12	13	3.9
Ireland	40	35	5	12.5	0	38	10
Netherlands	180	***	41	4.4	6.6	5.6	48
Sweden	76	46.1	NR	5.3	2.6	10.5	35.5
USA	60	25	28.5	3.3	5	6.6	31.6

*Beef calves; all others are dairy calves, **NR=not recorded, *** Anoxic and dystocic lesions combined

Respiratory distress syndrome (RDS) in calves has conventionally been associated with prematurity. However, recent research indicates that RDS in mature Belgian Blue calves may be associated with trace element deficiency-induced surfactant insufficiency; specifically, deficiencies of selenium, copper, zinc and iodine (Guyot, 2008). Classical deficiency of trace elements, for example selenium, is still associated with high perinatal mortality rates in individual herds, particularly in heifers (Murray et al., 2008).

Despite these findings, recent research indicates that the proportion of perinatal mortality in both dairy and beef breeds attributable to dystocia and other traditionally diagnosed causes of perinatal mortality may be decreasing (Muskens, 2008, Berglund et al., 2003). A recent pilot study in Dutch dairy herds failed to link high perinatal losses with these traditional causes (Muskens, 2008). Recent Swedish research indicates that increased perinatal mortality in Holstein-Friesian primiparae cannot be attributed to increased dystocia and that calf vitality may be a critical factor (Gustafsson et al., 2007). A genetic predisposition has been posited due to the large variation in perinatal mortality in the daughters of different sires. Further investigations suggested placental dysfunction may explain such genetic differences (Kornmatitsuk et al., 2004).

In many cases the aetiology is undetermined. Diagnostic rates in veterinary laboratories are often less than 25% indicating the need for a new approach to perinatal loss investigation (Mee, 2010). Additionally, as the incidence of idiopathic perinatal mortality appears to be increasing there is a need for renewed research focus on this cohort of calves to determine the modifiable risk factors and aetiology of this syndrome. A clear case definition, intensive anamnestic, clinical and pathological investigation, generation of plausible hypotheses and testing of such tentative diagnoses in designed, prospective, multisite, population-based field trials will lead to a clearer understanding of the

causation of this syndrome. The role of evidence-based veterinary medicine (EBVM) here is self evident.

IS IMPROVEMENT POSSIBLE?

There are a few foci of veterinary scientists active internationally who will continue to produce advances from breeding to birth contributing to our understanding of bovine neonatology. Likely future breeding developments include the use of genomic selection, exploiting the recently mapped bovine genome, to breed for reduced dystocia and stillbirth using sharper phenotypes. Gestational advances include use of biomarkers to detect placental dysfunction, ultrasonographic monitoring of fetal size and heart rate, ultrasonic transit-time measurement of umbilical blood flow and impulse oscillometry respiratory function monitoring. Prepartum developments include vitality assessments of the fetus and its annexes and parturient ethograms combined with point-of-care sensor technologies to accurately predict onset of parturition. Intrapartum developments include continuous fetal monitoring during parturition to detect reduced vitality by, for example, capillary blood gas analysis, pulse oximetry or cardiography. Refinement of current perinatal therapeutic protocols will assist resuscitation of compromised neonates and improve periparturient maternal pain management. Development of a more forensic necropsy protocol will increase our understanding of the 'unexplained stillbirth' phenomenon. While the development of cloned calves has added application impetus to this research, many of the technologies used for such valuable animals and in research protocols are not directly transferrable to general practice.

Thus for the immediate future veterinary practitioners and their farmer clients need to implement current best practice more widely to effect change in neonatal loss rates. A recent international survey found that veterinary practitioners attributed the incidence of perinatal mortality primarily to the availability, skills and education of farmstaff (Mee, 2009). There was unanimity amongst respondents regarding the action farmers could take to reduce its incidence: better calving management. This included supervision of the late pregnant cow prior to and during calving, use of correct obstetrical techniques, modern calf resuscitation methods and critically, calling the veterinary practitioner at the correct time. When asked how the veterinary practitioner could reduce perinatal mortality rates, respondents agreed that veterinary practitioners needed to focus on client education related to calving management. This is an often neglected area of a stockman's education, particularly on large farms. The salient findings from this survey indicate that much could be done to improve perinatal welfare at farm level by veterinary practitioners and their farming clients applying existing knowledge more widely.

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