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An economic evaluation of management strategies to mitigate the negative effect of twinning in dairy herds

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ABSTRACT

Our objectives were to develop an economic model to estimate the economic impact of twinning in dairy cows and to evaluate management strategies to mitigate the negative economic impact of twinning in dairy herds. A probabilistic tree considering spontaneous embryo reduction, early pregnancy loss, abortion, metritis, retained placenta, and culling rate at 120 d of the second, at the end of the second, and at the end of the third lactation was developed for a single pregnancy; we also developed 3 management options upon diagnosis of a twin pregnancy, including (1) do nothing, (2) induction of abortion using $PGF_{2\alpha}$, or (3) attempting manual embryo reduction. A value was given to each branch of the tree by simulating cow states on a farm for 1,400 d to encompass 4 consecutive lactations. The incomes considered in the simulations included milk income over feed cost, income from calves, and slaughter value upon culling. The expenses taken into account depending on each branch included additional inseminations and synchronization protocols, embryo reduction, induction of abortion, replacement heifers, and costs due to metritis and retained placenta. The gross value for a singleton pregnancy and the 3 management options upon diagnosis of a twin pregnancy were calculated by adding the value of all braches multiplied by their probability. The costs for the 3 management options were calculated by subtracting its gross value minus the gross value of a singleton pregnancy. The negative economic impact of a twin pregnancy ranged from $97 to $225 depending on the type of twin pregnancy (unilateral vs. bilateral), parity, and DIM when the twin pregnancy occurred. The overall negative economic impact of twinning on dairy farm profitability in the United States was estimated to be $96 million per year. Attempting manual embryo reduction early during gestation upon diagnosis of a twin pregnancy was the optimal management strategy for mitigating the negative economic impact of twinning under a wide variety of scenarios.

Key words: economic modeling, reproductive management

INTRODUCTION

Cattle are monotocous, meaning that, under most circumstances, a successful pregnancy results in the birth of a single calf. Occasionally, however, the reproductive process in cattle, as with many other monotocous species, results in the birth of twins. Twinning in dairy cows is undesirable because it decreases the overall profitability of a dairy farm through combined negative effects on cows calving twins as well as on calves born as twins (Fricke, 2001). Cows calving twins are at greater risk for many reproductive disorders, including retained placenta, dystocia, and metritis, as well as metabolic disorders, including displaced abomasum and ketosis (Markusfeld, 1987; Nielen et al., 1989), all of which increase the risk of culling (Eddy et al., 1991). The incidence of abortion, stillbirth, neonatal calf mortality, and reduced birth weight are greater among calves born as twins than singletons, probably due to reduced gestation length and increased incidence of dystocia among cows calving twins (Nielen et al., 1989). Taken together, these negative effects on reproduction, periparturient disorders, and calf health have a negative economic impact on dairy farm profitability (Eddy et al., 1991; Beerepoot et al., 1992).

Reported rates of twinning in dairy herds have increased over time, concurrent with increases in milk production (Kinsel et al., 1998; Silva del Rio et al., 2007), and this trend for increased twinning over time will likely continue into the future (López-Gatius et al., 2017). Several studies have been undertaken to mitigate or prevent the negative effect of twinning (Fricke, 2015; López-Gatius et al., 2017). Potential strategies include genetic selection against twinning (Johanson et

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al., 2001), increasing circulating progesterone during a synchronized follicular wave to decrease the incidence of double ovulations and dizygous twinning through the use of hormonal synchronization protocols (Wiltbank et al., 2000; Fricke, 2015), or differential dry period feeding strategies for cows carrying twin pregnancies during late gestation (Silva del Río et al., 2010).

From a clinical perspective, twin pregnancies can accurately be diagnosed by d 30 of gestation using transrectal ultrasonography (López-Gatius and García-Ispierto, 2010; López-Gatius and Hunter, 2017). Pregnancy loss during the early fetal period (d 28–90 of gestation) for cows carrying twins is 3 to 7 times greater than for cows with a singleton pregnancy and 5 to 9 times greater for unilateral than for bilateral twins (Silva del Río et al., 2009; López-Gatius et al., 2017). Upon diagnosis of twins, veterinarians can decide to do nothing or to induce abortion using $PGF_{2\alpha}$ to avoid problems associated with calving twins despite the economic losses associated with early pregnancy loss (Cabrera, 2014). Natural or spontaneous embryo reduction from an initial diagnosis of twins for cows that continue gestation ranges from 11 to 28% (Silva del Río et al., 2009; López-Gatius and Hunter, 2017; López-Gatius et al., 2017). Because the presence of a dead co-twin is detected in some of these cows at pregnancy diagnosis, the best time for an embryo reduction approach should be immediately after confirming that both twins are alive based on transrectal ultrasonography.

Because the rate of twinning can exceed 18% in some herds (Silva del Rio et al., 2007; Andreu-Vázquez et al., 2012a), a method for induced embryo reduction has been developed and assessed. Manual rupture of the amniotic vesicle or transvaginal ultrasound-guided aspiration of allanto-amniotic fluid or intraluteal instillation of $PGF_{2\alpha}$ in 1 of the 2 corpora lutea have been proposed as methods to decrease twinning in dairy cows from d 28 to 41 of gestation (López-Gatius, 2005; Andreu-Vázquez et al., 2011, 2012b; López-Gatius and Hunter, 2016). Manual embryo reduction aims to eliminate 1 embryo by manually crushing the amniotic vesicle of 1 of the embryonic vesicles without damaging its co-twin during early gestation, when most spontaneous embryo reduction events occur (Silva del Río et al., 2009; López-Gatius and Hunter, 2017). An embryo reduction is considered successful when the remaining co-twin becomes a viable single pregnancy. Success rates up to 71.4% in bilateral and 46.2% in unilateral twin pregnancies have been reported for manual embryo reduction (Andreu-Vázquez et al., 2011).

The objective of the present study was to develop an economic model to estimate the negative economic impact of twinning in dairy herds and to evaluate 3 management strategies upon diagnosis of a twin pregnancy in a commercial dairy herd. The 3 management options modeled included (1) do nothing (**DN**), (2) induction of abortion using $PGF_{2\alpha}$ (**PG**), and (3) attempt manual embryo reduction (**ER**).

MATERIALS AND METHODS

Overview of the Economic Model

An economic model was developed in Microsoft Excel (Microsoft Corp., Redmond, WA) to evaluate 3 management options upon diagnosis of a twin pregnancy early during gestation. Options evaluated were (1) do nothing, (2) induce abortion by treating with $PGF_{2\alpha}$, or (3) attempt manual embryo reduction. A probabilistic tree considering spontaneous embryo reduction, early pregnancy loss, abortion, metritis, retained placenta, and culling rate at 120 d of the second, at the end of the second, and at the end of the third lactation was developed for a singleton pregnancy and the 3 management options for a twin pregnancy (Figure 1). Probabilities were derived from the scientific literature and expert knowledge from the field (Table 1). A value was given to each branch of the probabilistic tree by simulating a cow state (**CS**) on a farm for 1,400 consecutive days to encompass the time required for a cow to complete four 305-d lactations assuming a 60-d dry period. The gross value of every management option (GV_i) was calculated as

$$GV_i = \Sigma p_i \times V_i,$$

where p_i = probability of every branch and V_i = value of every branch. Finally, the net cost of different management strategies was the result of subtracting the value of a single pregnancy from the value of the 3 potential management decisions for a twin pregnancy.

Calculation of Branch Value

The incomes considered in the simulation model included milk income over feed cost (**IOFC**), income from calves born, and slaughter value when culling occurred. The extra expenses taken into account depending on each branch included additional inseminations and synchronization protocols, embryo reduction, induction of abortion, replacement heifers, and costs due to metritis and retained placenta.

Calculation of Milk IOFC

The IOFC for each case was calculated by subtracting the feed costs from the milk value produced during the 1,400-d simulation period.