Theriogenology 87 (2017) 9–15

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Pre-breeding beef heifer management and season affect mid to late gestation uterine artery hemodynamics

Amanda J. Cain [a], Caleb O. Lemley [b], F. Kevin Walters [a], David L. Christiansen [a], E. Heath King [a], Richard M. Hopper [a,*]

[a] Department of Pathobiology and Population Medicine, Mississippi State University College of Veterinary Medicine, Mississippi State, Mississippi, USA

[b] Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State University, Mississippi State, Mississippi, USA

ARTICLE INFO

Article history:
Received 28 January 2016
Received in revised form 15 July 2016
Accepted 29 July 2016

Keywords:
Fetal programming
Blood flow
Uterine artery
Heifer development
Seasonality

ABSTRACT

The objective of the present study was to evaluate the effects of beef heifer development practices and the influence of season on uterine artery hemodynamics during mid to late gestation. Metrics of uterine artery blood flow (BF) of fall calving and spring calving crossbred beef heifers ($n = 27$) developed on either a low-input (LOW|FALL $n = 6$; LOW|SPRING $n = 6$) or a conventional (CON|FALL $n = 9$; CON|SPRING $n = 6$) heifer development scheme were evaluated. Heifer body weight (BW) was measured every 30 days, and uterine BF, arterial diameter (AD), pulsatility index (PI), and resistance index were measured for uterine arteries ipsilateral and contralateral to the conceptus on days 180, 210, and 240 of gestation. Calf birth weight was assessed at parturition. Repeated-measures ANOVA was performed. There were significant treatment × season ($P = 0.0001$) and season × day ($P = 0.003$) interactions on heifer BW. Main effects of season ($P = 0.04$) and gestational day ($P = 0.0001$) were observed on contralateral BF, and there was a season × day interaction ($P = 0.03$) on ipsilateral BF. As such, there was a season × day interaction on total blood flow (TBF; $P = 0.05$), whereby TBF increased as gestation progressed and spring calving heifers displayed increased TBF. However, when adjusted for BW, an additional main effect of treatment was observed ($P = 0.0007$) in which LOW heifers had increased TBF compared with CON heifers. Correspondingly, LOW heifers displayed increased AD compared with CON heifers, and spring calving heifers had greater AD than fall calving females. There was also a main effect of season on calf birth weight ($P = 0.02$). It was concluded that developing replacement heifers with low-input management schemes does not yield compromised uteroplacental hemodynamics compared with traditionally developed females when nutrition during gestation is adequate. Furthermore, spring calving 2-year-old heifers have increased uteroplacental BF compared with their fall calving counterparts. Our results imply that producers who seek to decrease development costs by feeding replacements to lighter target breeding weights may do so without compromising mid to late gestation uterine BF when heifers are not nutrient restricted during pregnancy.

1. Introduction

Under unfavorable economic conditions, some beef producers may opt for low-input, forage-based replacement heifer management programs to mitigate the feed

* Corresponding author. Tel.: (662)325-2194; fax: (662)325-4548.
E-mail address: hopper@cvm.msstate.edu (R.M. Hopper).

0093-691X/$ – see front matter © 2016 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.theriogenology.2016.07.031

costs associated with developing heifers. Consequently, these heifers will be lighter at breeding than their conventionally managed contemporaries reaching only 50% to 55% of expected mature body weight (BW) at breeding as opposed to the traditionally recommended target weight of 60% to 65% of expected mature BW. Although the development of replacement heifers with minimal post-weaning supplemental nutrition may be economically advantageous, no research has been conducted to evaluate potential alterations in uteroplacental hemodynamics in pregnant low-input heifers. As uteroplacental blood flow (BF) is largely responsible for the transportation of waste, nutrients, and respiratory gases between dam and fetus, factors that alter uteroplacental hemodynamics may have profound effects on the both the placenta and the developing calf [1,2]. It has been demonstrated that the fetal system may be programmed by conditions of the uterine environment. Negative effects on offspring are typically dependent on both the severity of the maternal insult and gestational stage and may result in permanent dysfunction. Dam maturity, environment, and, most notably, nutrition during pregnancy have been shown to alter the postnatal health, growth, body composition, and reproductive traits of offspring (reviewed in Redmer et al. [3] Wu et al. [4], and Funston and Summers [5]). Mechanisms by which fetal programming occurs include epigenetic alterations, impaired placental growth and function, and compromised uteroplacental BF (reviewed in Reynolds et al. [2], Wu et al. [4], and Vonnahme and Lemley [6]). Additionally, adverse fetal programming outcomes associated with suboptimal pre- and peri-conceptional nutrition have also been evaluated in human epidemiologic studies and in both rodent and ovine models (reviewed in McMillen et al. [7], Fleming et al. [8,9] and Sinclair and Watkins [10]). However, the authors are not aware of any studies that evaluate the effects of low-input beef heifer development on uterine artery hemodynamics and fetal programming outcomes.

Though a spring calving season is often preferred by cattle producers, differences in reproductive efficiency and calf performance have been observed between spring and fall calving herds, particularly in the southeastern United States where high-quality cool season forages are often available for fall and winter grazing. Fall calving cows had shorter postpartum anestrus intervals and increased conception rates compared with spring calving females [11]. Additionally, fall born calves have been reported to be heavier at weaning than similarly managed winter or spring born calves [12,13]. Although increased gain in fall born calves is usually attributed to postnatal nutrition, it is possible that seasonal effects on the uterine environment may also contribute to the superior performance of fall born calves via alterations in uteroplacental BF. To our knowledge, there are no studies that evaluate seasonal differences in beef cattle uteroplacental hemodynamics.

Thus, the objective of the present study was to evaluate the effects of both heifer development practices and season on uterine artery hemodynamics during mid to late gestation of nulliparous beef females. It was hypothesized that low-input heifer development protocols resulting in light weight heifers at breeding may cause compromised uterine BF during pregnancy compared with traditionally developed females, even when nutrition during gestation is equivalent. Furthermore, it was posited that fall calving females may display increased uterine BF compared with spring calving heifers.

2. Materials and methods

All procedures were approved by Mississippi State University Institutional Animal Care and Use Committee (Protocol #13–029). This project was conducted from March 2013 to April 2014, at H. H. Leveck Animal Research Center at Mississippi State University. Heifers were raised at Mississippi State University Experiment Stations.

2.1. Animals and management

Fall and spring calving crossbred beef heifers ($n = 28$) managed through one of two heifer development programs were bred via natural service at approximately 15 months of age (15.4 ± 0.2 months of age) to calving ease bulls. Heifers from the low-input (LOW, $n = 13$) heifer development program received little or no supplemental feed and accordingly achieved 45% to 55% of expected mature BW at breeding. Heifers from the conventional (CON, $n = 15$) development program were fed to achieve 65% to 70% of projected mature BW at breeding. All heifers were similar in genetic makeup and were managed under identical health management and vaccination protocols. Heifers born in both the fall of 2012 and the spring of 2013 were used. Therefore, heifers were managed in two groups (a fall calving group and a spring calving group) to yield a total of four treatments: fall calving heifers developed with low-input (LOW|FALL, $n = 6$), conventionally developed fall calving heifers (CON|FALL, $n = 9$), spring calving heifers developed with low-input (LOW|SPRING, $n = 7$), and conventionally developed spring calving heifers (CON|SPRING, $n = 6$). After confirmation and staging of singleton pregnancy (approximately 30–45 days of gestation) via transrectal palpation and transrectal ultrasound by a board-certified theriogenologist, heifers were transported to H. H. Leveck Animal Research Center (Mississippi State, MS, USA), comingled, and managed on a forage-based management program in which all heifers were afforded equivalent, adequate nutrition. BW and body condition score (BCS) were assessed on arrival (approximately 45–60 days of gestation) and every 30 days thereafter until calving. A 9-point scale with 1 = emaciated and 9 = obese was used to estimate BCS [14]. Two calves (one CON|FALL and one CON|SPRING) died at parturition as a result of dystocia of unknown cause. Birth weights were not available from these individuals; therefore, they were excluded from all calf data analyses. Proportions of male and female calves were equal between LOW and CON groups (31% male calves and 69% female calves in both LOW and CON treatment groups).

2.2. Color Doppler ultrasonography

Doppler measurements of uterine artery hemodynamics were obtained on days 180, 210, and 240 of