Placental vascular development throughout gestation in beef heifers

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Placental vascular development is essential for transplacental exchange of nutrients, respiratory gases and metabolic wastes between the maternal and fetal systems to ensure optimal fetal growth and development. While research has quantified placental vascular development in several mammalian species, studies in cattle are limited. This study sought to enhance our comprehension of placental vascular development in beef heifers by analyzing the expression of CD31 and CD34 (endothelial cell markers). A total of twenty-six primiparous, pregnant, crossbred, Angus beef heifers were included in the study, with placental samples collected at four gestational time points: days 63 (n=6), 83 (n=6), 161 (n=7), and 250 (n=7) (length of gestation approx. 280 days). Placentome samples were processed by fixation, embedding, and sectioning at 5 μm. Immunofluorescence staining for CD31 and CD34 was conducted, followed by analysis with Image-Pro Premier software. Vascularity was assessed through analyzing capillary area density (CAD) and capillary number density (CND) in fetal cotyledon (COT) and maternal caruncle (CAR) regions. Data were analyzed with PROC GLM and PROC REG of SAS, with heifer as the experimental unit. Significance was determined at $P \leq 0.05$ and tendency at $P = 0.10$. The CAD serves as a determinant of resistance and thus placental blood flow capacity. Differences in CAD were observed on days 83 and 161 of gestation, with CAR greater than COT (23.61±1.43 vs. 15.25±0.47 at day 83, $P = 0.05$; and 34.39±0.97 vs. 23.87±1.05 at day 161, $P = 0.02$). However, on day 250, CAD of COT tended to be greater than that of CAR (53.50±1.09 vs. 44.75±1.53 at day 250, $P = 0.11$). Similarly, CND, which reflects capillary branching, was greater for CAR vs. COT early in gestation (0.89±0.01 vs. 0.62±0.01 at day 63, $P = 0.001$; and 1.05±0.04 vs. 0.70±0.03 at day 83, $P = 0.03$). In late gestation, the CND of COT was slightly greater than in the CAR, but again this difference was not significant (1.81±0.02 vs.1.63±0.03 at day 250, $P = 0.15$). Moreover, CAD exhibited cubic increases for both CAR and COT throughout gestation ($R^2 = 0.687$ and 0.898, respectively; $P < 0.01$), with COT showing a greater proportional rate of increase (3.9-fold) compared to CAR (2.7-fold). The CND of CAR displayed a cubic increase ($R^2 = 0.720$; $P < 0.01$) with a smaller increase (1.8-fold) compared with COT (2.9-fold), which also demonstrated a cubic increase throughout gestation ($R^2 = 0.872$; $P < 0.01$). This study establishes the patterns of placental vascular development throughout gestation in primiparous beef heifers. For CAR, both CAD and CND exhibited notable increases in early pregnancy, followed by a slower rise in late pregnancy. Conversely, in the COT, there was a pronounced increase in CAD and CND in late pregnancy. These findings deepen our understanding of placental vascular development in beef heifers.

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