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BLOOD FLOW TO THE UTERUS

Sherrill E. Echternkamp¹ and Stephen P. Ford

Summary

Pattern of blood flow to the bovine uterus was determined by using electromagnetic blood flow probes during the estrous cycle and early pregnancy to evaluate the effect of the early bovine conceptus on uterine blood supply. Pattern of blood flow through the middle uterine artery of pregnant and nonpregnant cows was similar until day 14 after mating or estrus. Between days 14 and 18 of pregnancy, blood flow to the uterine horn containing the conceptus increased two-to-threefold, whereas blood flow to the other uterine horn in these cows remained constant. By day 19 of pregnancy, blood to the pregnant horn had returned to the level on day 13. Blood flow to both uterine horns of pregnant cows was low from days 19 to 25 and then increased to the pregnant horn through the remainder of pregnancy. Uterine blood flow during the estrous cycle of nonpregnant cows was positively associated with systemic concentrations of estradiol, whereas during pregnancy blood flow was positively related with progesterone concentration. These data indicate local control of uterine blood flow by the bovine conceptus, which may function to create optimal conditions for the continuation of pregnancy.

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Introduction

Maternal recognition of pregnancy in the cow requires the presence of a conceptus on day 15 to 17 after mating. The mechanism responsible for maintenance of the corpus luteum during early pregnancy, and the way in which the embryo influences the process, are not clearly understood but may involve a local effect of the conceptus on uterine blood flow. This experiment was conducted to see if the embryo does indeed stimulate synthesis of a factor that increases blood flow to the uterus.

Procedure

In an effort to determine if the early bovine conceptus could affect uterine blood supply, as well as characterize bloodflow pattern to the uterus during the estrous cycle, blood flow transducers were chronically implanted around both middle uterine arteries of six multiparous Hereford cows.

The flow transducer probes were surgically implanted around a segment of the middle uterine artery (from which a 1 cm segment of adventitia was removed), supplying each uterine horn before its first division in the mesometrium. The electrical connector of each flow transducer was exteriorized from the abdominal cavity through a small flank incision, attached to the skin over the incision site, and connected to a square-wave electromagnetic flow meter that displayed blood flow measurements (ml/min) at 15-sec intervals. Daily blood flow estimates were obtained by averaging the 15-sec measurements obtained during a daily 30-min monitoring period.

The cows were housed in stanchions except for daily AM and PM estrous detection. All cows were mated at the first estrus after placement of the probes. The cows were slaughtered after their return to estrus 21 days later (nonpregnant) or if no estrous activity, on day 30 to 35 after mating (pregnant). Pregnancy and placement of flow transducers were verified at slaughter. The uterine artery supplying blood to the uterine horn adjacent to the ovary with the corpus luteum was referred to as the ipsilateral artery, whereas the uterine artery supplying the other uterine horn was referred to as the contralateral artery. Jugular vein blood samples were collected daily via an indwelling cannula from each cow after the daily monitoring of uterine blood flow to determine serum estradiol 17 and progesterone by radioimmunoassay.

Results

Nonpregnant cows. Rates of uterine blood flow through the ipsilateral and contralateral uterine arteries did not differ significantly on any day during the estrous cycle in the nonpregnant cows; therefore, the ipsilateral and contralateral uterine arterial blood flow curves were pooled for the nonpregnant cows. Blood flow to the uterus of the three nonpregnant cows (Fig. 1) was highest from 2 days before onset of estrus to 1 day after estrus. Blood flow had decreased by day 2 (estrus = day 0) and gradually declined to day 6. All three nonpregnant cows exhibited two transient increases in uterine blood flow between days 7 to 15 of the cycle, followed by a decline on day 16, which preceded the rise in uterine blood flow 2 days before the subsequent estrus.

Serum concentrations of estradiol (Fig. 2) were highest at estrus, and two transient increases were observed during the luteal phase of the estrous cycle in all cows. The increases in serum estradiol coincided with increases in blood flow to the uterus, resulting in a positive relationship between serum estradiol and uterine blood flow in the nonpregnant cow. The positive relationship between serum estradiol and uterine blood flow may have resulted from the vasodilatory action of estradiol.

Pregnant cows. The pattern of blood flow to the uterus of pregnant cows was similar to that of nonpregnant cows until day 13 after mating (Fig. 3). Between days 14 and 18 of pregnancy, blood flow through the uterine artery supplying the pregnant horn increased two to threefold, whereas blood flow through the contralateral uterine artery remained constant. By day 19 of pregnancy, blood flow through the ipsilateral uterine artery had returned to a flow rate similar to that observed on day 13. Blood flow to both uterine horns of the pregnant cows remained constant from day 19 until day 25, when blood flow to the pregnant horn increased markedly to day 30. In contrast, blood flow through the contralateral uterine artery exhibited a progressive decline from day 24 to day 30.

From 0 to 19 days of pregnancy, concentrations of progesterone in the systemic blood followed a pattern similar to that observed during the estrous cycle of nonpregnant cows (Fig. 4). Instead of declining to a low level, as observed in nonpregnant cows on day 20, progesterone concentrations of pregnant cows remained high and relatively constant for

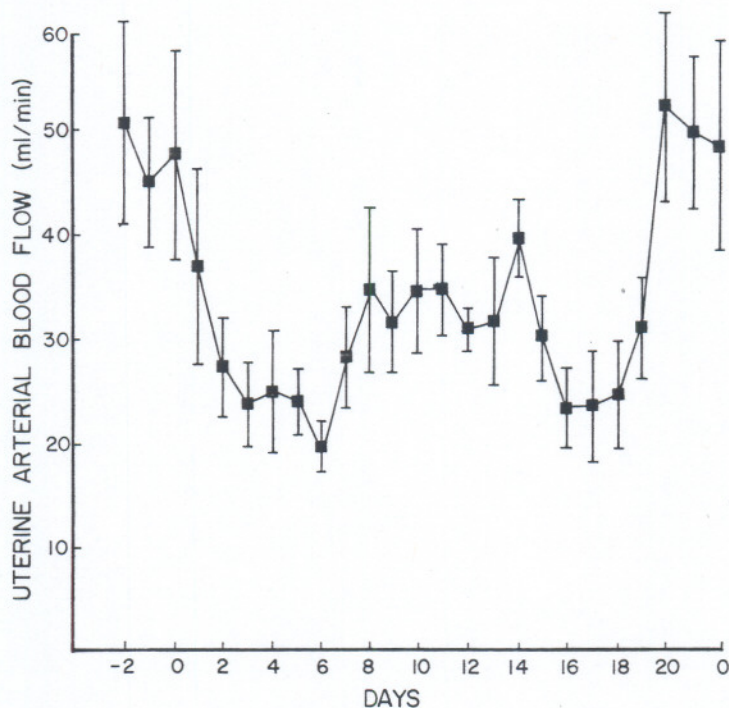


Figure 1.—Pattern of blood flow to uteri of 3 nonpregnant cows throughout the estrous cycle (day 0 = estrus). Each point represents the mean \pm s.e.m. of 6 uterine arteries (3 ipsilateral and 3 contralateral).

the remainder of the 30-day monitoring period. As observed in the nonpregnant cows, estradiol concentrations in the blood of pregnant cows were highest at estrus followed by two transient peaks between days 5 and 8 and between days 14 and 17 of pregnancy. Concentrations of estradiol remained relatively constant from day 19 to day 30 of pregnancy.

Unlike the nonpregnant cows, no association could be demonstrated between blood flow through the ipsilateral or contralateral uterine arteries of pregnant cows during the first 30 days of pregnancy and systemic concentrations of estradiol. However, a positive correlation was observed between blood flow to the pregnant uterine horn and systemic concentrations of progesterone. In addition, the concentration of progesterone in the systemic blood of pregnant cows was higher than that of nonpregnant cows from day 14 to 18 after mating. Since blood concentrations of progesterone are a reliable measure of luteal function and blood flow to the corpus luteum, the conceptus-induced increases in blood flow to the pregnant uterine horn may be accompanied by increased blood flow through the corpus luteum, resulting in increased secretion of progesterone and a positive relationship between blood flow to the pregnant uterine horn and serum progesterone concentrations in the pregnant cow.

The results of this study indicate local control of uterine blood flow by the early bovine conceptus. Failure of the contralateral uterine artery to exhibit a corresponding increase in blood flow on days 14 to 18 of pregnancy may reflect a unilateral signal initiated by the bovine conceptus and a differential sensitivity, or both, of the two uterine arteries for the signal that reduced constriction of the uterine artery supplying the pregnant horn. Also, blood flow to the pregnant horn of cows increased on the days critical for ensuring prolongation of life-span of the corpus luteum required for maintenance of pregnancy. Thus, it appears that the conceptus produces or stimulates uterine synthesis of a factor that dilates the utero-varian vasculature on the pregnant side, thus creating optimal conditions for continuing pregnancy.

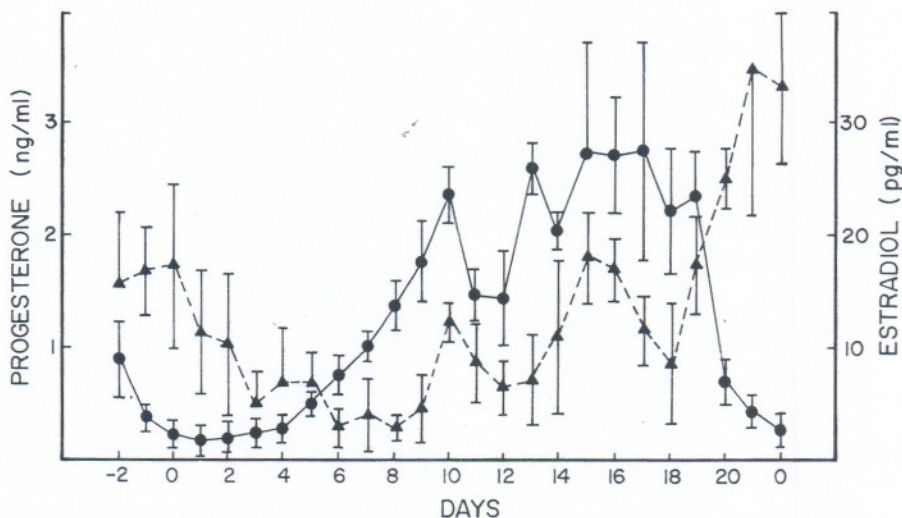


Figure 2.—Concentrations of progesterone (●-----●) and estradiol-17β (▲-----▲) in systemic blood throughout the estrous cycle of 3 nonpregnant cows. Each point represents the mean \pm s.e.m. Day 0 = estrus.

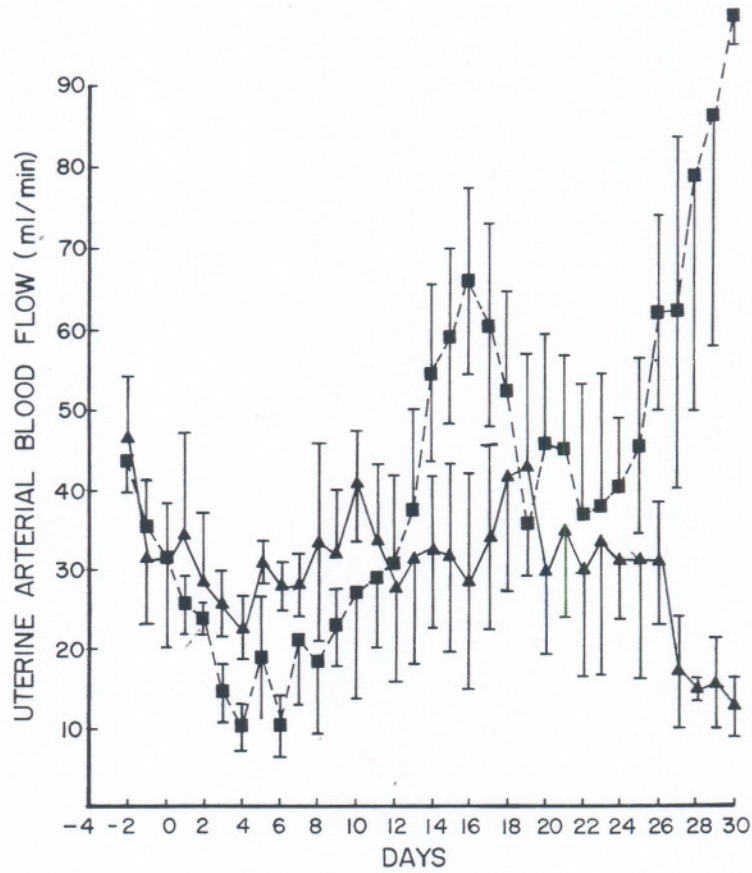


Figure 3.—Pattern of blood flow to both uterine horns of 3 cows throughout the first 30 days of pregnancy (day 0 = day of mating). Each point represents the mean \pm s.e.m. for 3 gravid uterine horns (■-----■) and 3 non-gravid (▲-----▲) horns.

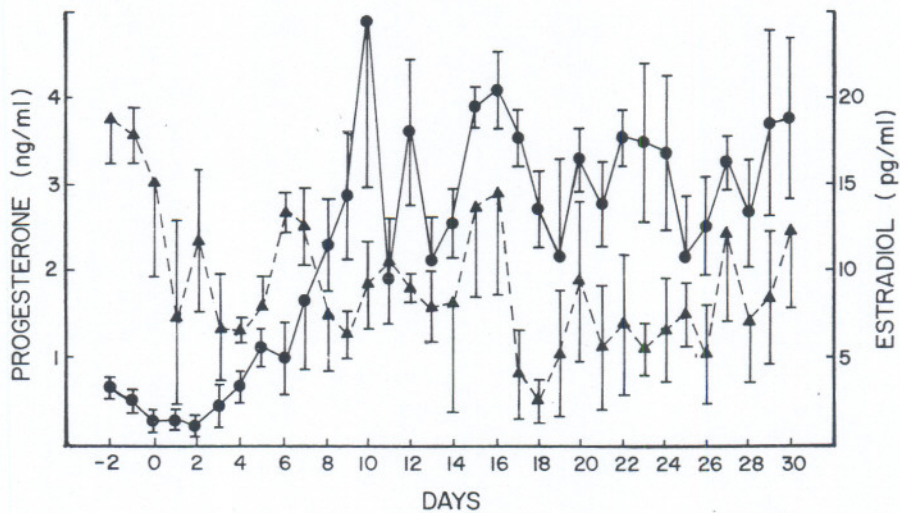


Figure 4.—Concentrations of progesterone (●-----●) and estradiol-17 β (▲-----▲) in systemic blood of 3 cows throughout the first 30 days of pregnancy (day 0 = day of mating). Each point represents the mean \pm s.e.m.