



Doppler sonographic examination of uterine and placental perfusion in cows in the last month of gestation and effects of epidural anesthesia and isoxsuprine

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ABSTRACT

The massive increase in size of the fetus and uterus in the last trimester is accompanied by an increasing demand for nutrients and oxygen, and it is assumed that this demand is met by increasing uterine and fetal perfusion. The goals of this study were to measure the perfusion of the uterine arteries and the placentomes in the last month of gestation and to investigate the effect of epidural anesthesia and isoxsuprine on perfusion. During the last month of gestation, eight Braunvieh cows underwent nine color Doppler sonographic examinations of the uterine arteries to determine diameter (DM), pulse rate (PR), resistance index, time-averaged maximum blood flow velocity (TAMV), and blood flow volume (BFV), and power-mode Doppler sonography was used to determine perfusion of placentomes. The PR increased ($P < 0.001$), and the BFV and TAMV of the ipsilateral uterine artery decreased between 4.5 and 0.5 weeks prepartum (BFV, 236.8 ± 65.80 and 208 ± 41.52 cm^3/s , $P < 0.01$; TAMV, 140.0 ± 26.53 cm/s and 125.2 ± 18.46 cm/s , $P < 0.05$). After sonographic examination, the cows received epidural administration of local anesthetic (100-mg lidocaine) in the sacrococcygeal space or isoxsuprine (200 mg/cow, iv), and the sonographic measurements were repeated 30 minutes later. After epidural anesthesia, the TAMV and BFV of the contralateral uterine artery increased by 5.4% ($P < 0.05$) and 7.9% ($P < 0.01$). In the placentomes of the gravid uterine horn, the relative placentome perfusion and the color pixel grading (Cp) increased by 10.1% ($P < 0.05$) and 11.5% ($P < 0.01$) after epidural anesthesia. After isoxsuprine, the DM, PR, and BFV increased by 4.7%, 49.3%, and 16.9% in the ipsilateral uterine artery and by 10.8%, 48.7%, and 22.8%, respectively in the contralateral uterine artery. The TAMV of the ipsilateral uterine artery increased by 7.1% ($P < 0.01$), and the resistance index decreased in both uterine arteries (ipsilateral 24.2%, contralateral 14.9%, both $P < 0.00001$). Isoxsuprine increased the relative placentome perfusion and the Cp of the placentomes by 18.1% and 18.3% in the gravid horn and by 10.2% and 24.2% in the nongravid horn. Blood flow variables changed little in the last month of gestation. However, epidural anesthesia and isoxsuprine caused changes in uterine and placentome perfusion that suggest improvement of placental nutrient and oxygen supply to the fetus.

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1. Introduction

The increasing fetal demand for nutrients and oxygen in the last trimester of gestation is met mainly through increased blood flow to the uterus, which in turn increases

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perfusion in the uterus [1]. In the past, invasive techniques were used to measure blood flow in the uterine arteries, which are largely responsible for uterine perfusion in cattle and horses [2,3], but these techniques have been replaced by color Doppler sonography for transrectal measurement of uterine blood flow [4]. Color Doppler sonography has been used to measure blood flow variables in cycling cows and for quantification of uterine blood flow in pregnant cows and mares [4–7]. The resistance index (RI) decreased, and time-averaged maximum blood flow velocity (TAMV), blood flow volume (BFV), and vessel diameter (DM) increased with advancing pregnancy in cows [4]. Another study showed that the birth weight of calves was positively correlated with BFV [8].

The uterine arteries are mainly responsible for blood supply to the maternal placenta, and the umbilical arteries supply the fetal placenta. In addition to uterine blood flow, which was measured transrectally, fetal blood flow was measured transabdominally in an umbilical artery during the last few weeks of gestation [9], but no measurable changes in umbilical blood flow were detected in the last month of gestation. Another study measured umbilical blood flow during parturition using ultrasonographic transducers placed transvaginally on an umbilical artery and vein after rupture of the allantochorion [10]. Mean total blood flow was lower during the 60 minutes before delivery compared with the 30-minute period before, and blood flow decreased transiently during uterine contractions. Furthermore, calves with a blood pH ≥ 7.2 immediately postnatum had a higher total blood flow in the last hour of gestation than calves with a pH < 7.2 , which was interpreted as a direct effect of blood flow on placental gas exchange.

We are not aware of any reports on the direct measurement of placental circulation and specifically on blood flow in the placentomes, which prompted us to measure placental blood flow at the end of gestation using power-mode Doppler sonography. Color Doppler sonography describes blood flow on the basis of the frequency shift of a flow volume, whereas power-mode Doppler sonography displays the strength of the Doppler signal in color by determining all moving particles in the blood, which allows recording of blood flow independent of blood flow velocity and direction. This is crucial for the quantitative and semiquantitative assessment of blood flow in tissues with low blood flow velocity and numerous blood vessels [11] such as placentomes. The goals of this study were to investigate whether blood flow in placentomes can be assessed quantitatively on the basis of the size of the perfused area and to what extent the color differences in the power-mode Doppler image are suitable for the semiquantitative determination of the number of all cells in the blood per unit of area.

Recently, studies showed the effects of drugs on uterine and placental blood flow in cows [7,9]. In human medicine, intrauterine resuscitative measures are used to improve placental perfusion when abnormal fetal heart rate patterns are recognized with the goal of preventing fetal hypoxia and subsequent acidosis [12]. Two of these measures are the administration of a uterine relaxant drug and

epidural anesthesia. We are not aware of any studies investigating the effect of such measures on placental perfusion in cows except for one investigation of changes in uterine perfusion induced by various drugs in the last month of gestation [9]. The latter study showed that the uterine relaxant drug isoxsuprine increased uterine BFV by 5% and epidural anesthesia by 6%. Our hypothesis was that these two treatments also affect perfusion of the placentomes.

The purposes of the study were to increase our knowledge of Doppler sonographic changes in semiquantitative and quantitative blood flow variables in the uterine arteries and placentomes in the last month of gestation and to determine the effect of isoxsuprine and epidural anesthesia on these variables.

2. Materials and methods

2.1. Cows

Eight Braunvieh cows, which ranged in age from 4 to 14 years and had normal singleton pregnancies, were used. Lactation numbers ranged from 3 to 11. The cows were admitted to our clinic 1 month before the calculated due date. They were kept in tie stalls, bedded with straw, and fed hay, grass silage, and water ad libitum and had daily access to an exercise yard.

The use of animals for this study was approved by the cantonal veterinary office of Zurich (permit number 213/2010).

2.2. Study design, B-mode, and Doppler sonography of the uterine arteries

The cows were examined twice a week by the same investigator (C.K.-E.) starting 1 month before the calculated date of birth. In total, nine examinations per cow were included into the final analysis. After the clinical examination, both uterine arteries and the placentomes were examined sonographically using a portable ultrasound machine (LOGIQ e; General Electric Medical System, Glattbrugg, Switzerland). Transabdominal B-mode sonographic examination of the placentomes was carried out followed by transabdominal power-mode Doppler sonography using a 4-MHz convex probe (4C-RS; General Electric Medical System). Two placentomes in the gravid horn and one in the nongravid horn were examined from the left and right ventral flanks cranial to the udder. The sites of examination were marked on the skin and kept constant for each cow. Scanning of the placentomes was repeated several times, and the images were saved, and four measurements per placentome were then selected for analysis.

Transrectal B-mode and Color Doppler sonography of the ipsilateral (pregnant horn) and contralateral uterine arteries was then carried out using a 10-MHz linear probe (I739-RS; General Electric Medical System). Both uterine arteries were examined and identified as described [4,5]. First, the external iliac arteries were identified at the point where they branch off the aorta. Following the external iliac artery ventrally, the uterine artery was identified

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