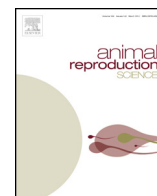




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Animal Reproduction Science

journal homepage: www.elsevier.com/locate/anireprosci

Doppler ultrasonographic assessment of maternal and fetal arteries during normal feline gestation

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ARTICLE INFO

Article history:

Received 8 November 2013

Received in revised form 27 January 2014

Accepted 2 February 2014

Available online 15 February 2014

Keywords:

Doppler

Ultrasound

Uterine artery

Umbilical artery

Pregnancy

Cat

ABSTRACT

The aim of this study was to describe Doppler parameters of uterine, umbilical, fetal abdominal aorta, fetal renal and fetal internal carotid arteries, as well as fetal heart rate (FHR), during normal feline gestation. Fifteen, 1–4 years of age, weighing 2.5–3.9 kg, domestic short-hair pregnant queens, which were born in our institutional cat colony were included in this study. Color and pulsed-wave Doppler evaluations of uterine arteries were performed every 10 days (Day 0, 10, 20, 30, 40, 50, 60) from mating. Fetal Doppler and M-mode ultrasonography were performed to assess umbilical, fetal abdominal aorta, fetal renal, fetal internal carotid arteries and FHR. Both peak systolic velocity (PSV) and end diastolic velocity (EDV) of uterine artery increased up to parturition ($P < 0.01$), while resistance index (RI) decreased from Day 10 onwards ($P < 0.01$). From Day 40 onwards, RI of umbilical artery diminished, while PSV and EDV augmented ($P < 0.01$). Fetal abdominal aorta ($P < 0.01$), renal ($P < 0.01$) and internal carotid ($P < 0.01$) arteries diminished their RI from Days 40, 60 and 40 onwards, respectively. Both PSV and EDV of these three arteries increased progressively. Fetal heart rate was first registered on Day 20 when it began to increase up to Day 40 and then diminished to the end of gestation ($P < 0.01$). It is concluded that blood flow of uterine, umbilical, fetal abdominal aorta, fetal renal and fetal internal carotid arteries progressively increased during normal feline pregnancy, while FHR rose to mid gestation and then decreased up to parturition.

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1. Introduction

Doppler ultrasound is a non invasive useful tool to evaluate gestation in many mammalian species. This technique permits the examination of placental and fetal vessels providing information of fetoplacental health. As gestation progresses, the increasing density of fetal membranes and placental capillaries induces a rising blood flow of

the involved vessels (Papageorgiou et al., 2004; Reynolds et al., 2006).

Doppler ultrasound measures absolute velocities within an artery, from which resistance index (RI) is calculated. This index decreases during normal gestation in uterine, umbilical and other fetal arteries in many mammalian species (Bucca et al., 2005; Blanco et al., 2008).

In human and canine pregnancy, it has been reported that the absence of RI decrease of uterine, umbilical and fetal renal arteries is associated with adverse outcome (Coleman et al., 2000; Acharya et al., 2005; Blanco et al., 2011). For this reason, in pregnant women, Doppler has become a routine technique for identifying fetal compromise associated with an abnormal uteroplacental or fetal circulation.

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In the queen, Doppler reports in obstetrics are controversial. While Scotti et al. (2008) found a decrease of RI of uteroplacental arteries along with gestation, Pereira et al. (2012a) stated that the index remained unchanged. Furthermore, in one report, the RI of uterine arteries was found to peak between Days 33 and 43 and then diminished up to Day 48 (Brito et al., 2010), and to progressively decrease in the uterine horn containing the lower number of fetuses in another study (Pereira et al., 2012b).

Concerning umbilical artery velocimetry, Scotti et al. (2008) described that its RI diminished progressively during the second half of gestation. Conversely, Brito et al. (2010) stated that this index only decreased in two periods: between Days 22 and 40 and between Days 41 and 50 of gestation.

Fetal aorta was described during the last 5 weeks of feline pregnancy presenting a decrease of its RI (Scotti et al., 2008), and there is no information about this vessel during early gestation. In human fetuses, oligohydramnios with prolonged hypoxia is probably a consequence of decreased renal perfusion, evidenced by Doppler assessment of fetal renal artery (Mari et al., 1993). Additionally, RI of the fetal internal carotid artery is predictive for the development of an abnormal fetal heart rate trace (Groenenberg et al., 1993). In pregnant cats there are no reports of fetal renal and carotid arteries.

Fetal heart rate (FHR) can be first ultrasonographically detected between Days 16 and 17 of feline gestation (Zambelli and Prati, 2006), and it has been reported to remain unchanged in the course of this period (Verstegen et al., 1993). Considering that this parameter is widely used to monitor fetal health (Lopate, 2008; Traas, 2008; White, 2012), it is also interesting to determine eventual gestational variations as have been found in other species (Verstegen et al., 1993; Breukelman et al., 2006; Nagel et al., 2011). Physiological changes of Doppler parameters and FHR during feline gestation should be known so that unfavorable fetal conditions could be recognized.

To unveil the previously described controversies, the aim of this study was to describe Doppler parameters of uterine artery, umbilical artery, fetal abdominal aorta, fetal renal and fetal internal carotid arteries, as well as FHR, during normal feline gestation.

2. Materials and methods

2.1. Animals

Fifteen, 1–4 year-old, weighing 2.5–3.9 kg, domestic short-hair pregnant queens, which were born in our Institutional cat colony were included in this study. The animals were exposed to a 10 h dark, 14 h light photoperiod, fed with dry commercial premium cat food and water *ad libitum*.

Estrus cycle was monitored three times a week, based on behavior and vaginal cytology (Johnston et al., 2001). Queens were mated on the third or fourth day of estrus (Day 0) by fertile male cats. Considering all the animals, the whole period of mating was 1 month. This study was reviewed and approved by the Animal Care and Use Committee of the Veterinary School of the National University

of La Plata, Argentine and all experiments were conducted under the guidelines established in The Guide for The Care and Use of laboratory Animals, USA.

2.2. Study design and ultrasonographic evaluations

Pregnancy was confirmed in all the cases using two-dimensional ultrasonographic examination (Toshiba Core Vision Pro, Japan) with an 8-MHz linear-array transducer (England, 1998). Color and pulsed-wave Doppler evaluations of uterine arteries were performed every 10 days from mating day in all the queens, *i.e.* Days 0, 10, 20, 30, 40, 50, 60. The female cats were positioned in lateral recumbency without sedation and the hair of the ventral skin was clipped after 5 min of acclimatization. Acoustic gel was applied to the transducer and coupled directly to the skin. Two-dimensional ultrasonography was used to identify the uterine body in a transversal axis. Uterine arteries were localized at both sides of the uterine body with color flow mapping and pulsed-wave Doppler was used to obtain the waveforms (Alvarez-Clau and Liste, 2005).

Fetal Doppler and M-mode ultrasonography were performed in the most caudal fetus of the right uterine horn, according to previous reports (Di Salvo et al., 2006; Scotti et al., 2008). Umbilical artery, fetal abdominal aorta, fetal renal artery and fetal internal carotid artery were assessed by color and pulsed-wave Doppler from their first possible detection up to parturition (Scotti et al., 2008). To perform Doppler ultrasonography of the fetal renal artery, a longitudinal view of the fetal kidney was obtained. The renal artery was subsequently detected in the renal hilum of the fetus (Blanco et al., 2011). The fetal internal carotid artery was detected at each side of the deep portion of diencephalo-telencephalic vesicle (Beccaglia et al., 2008; Blanco et al., 2011). To minimize variability, three uniform consecutive waveforms were recorded by a trained operator. Measurements having an angle of insonation $>20^\circ$ were disregarded. Peak systolic velocity (PSV) and end diastolic velocity (EDV) were measured. Resistance index [(PSV–EDV)/PSV] was automatically calculated in all vessels (Dickey, 1997). Fetal heart rate was obtained with M-mode ultrasound as previously described (Verstegen et al., 1993). In all the queens, ultrasonographic evaluations were performed in periods no longer than 30 min.

2.3. Statistical analysis

Peak systolic velocity, EDV and RI of the left and right uterine arteries were compared using a Student's *t*-tests. Repeated measures ANOVA followed by Tukey test was carried out to evaluate the effect of time on PSV, EDV and RI of each artery and FHR, using litter size as a covariate (SPSS 18.0; SPSS, Chicago, IL, USA). The level of significance was set on $P < 0.05$.

3. Results

Parturition occurred normally 65 ± 1.6 (mean \pm SEM) days from mating in all the females. Litter size ranged from 2 to 5 healthy kittens, without having an effect on the analyzed parameters ($P > 0.1$).

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