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Triplex Doppler evaluation of uterine arteries in cyclic and pregnant domestic cats

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ABSTRACT

The aims were to determine resistance index (RI) and pulsatility index (PI) in the uterine arteries of cyclic and pregnant domestic cats comparing the left and right uterine horns, as well as the majority or minority uterine horns, based on fetus number per horn; to determine the presence or absence of an early diastolic notch (EDN) in the uterine artery of pregnant queens. Ten domestic cats were followed during one cycle and one pregnancy until 63rd days after mating. The estrous cycle length was 16 ± 9.57 days. The uterine horn with the highest number of fetuses (majority uterine horn – MUH) presented 2.0 ± 1.0 fetus and the lower (minority uterine horn – miUH) presentes 0.78 ± 0.67 fetus. There were no differences in indexes between uterine arteries during the cycles and pregnancies. The RI and PI of MUH were lower than miUH ($P < 0.05$). Uterine artery of the MUH presented lower indexes than miUH during the acceptance period ($P < 0.05$). On D14 of pregnancy, uterine artery presented reductions in both indexes for the miUH. On D56, the PI was reduced in the miUH. The indexes depended on the week of pregnancy. EDN was present on the uterine arteries of all cats until D35, but disappeared by D49. The blood flow varied according to the category of horn.

1. Introduction

Duplex Doppler ultrasonography is an important clinical tool that is used in obstetrics and gynecology; this method can provide real-time information about blood flow speed (Panarace et al., 2008) and direction, as well as the arterial or venous nature of the blood flow (Bollwein et al., 2004; Nautrup, 1998).

Over the past ten years, studies using Doppler ultrasonography in veterinary medicine have been reported for different reproductive stages in a number of animal species, including the mare (Bollwein et al., 1998, 2004), cow (Bollwein et al., 2000; Panarace et al., 2006), ewe (Panarace et al., 2008; Reed et al., 1996), bitch (Alvarez-Clau and Liste, 2005; Di Salvo et al., 2006; Köster et al., 2001) and queen (Brito et al., 2010; Scotti et al., 2008).

Efficient uterine perfusion is crucial for a normal pregnancy. In normal human pregnancies, uterine blood flow is proportional to the perfusion pressure and inversely proportional to the vascular resistance (Fratelli et al., 2011). According to El-Mashad et al. (2011), women with normal pregnancies exhibit lower pulsatility index (PI) values than those with recurrent pregnancy loss.

Studies of uterine artery blood flow in humans could elucidate the vascular changes that occur in patients with recurrent pregnancy loss and may help to identify those patients whose losses are caused by poor uterine perfusion (El-Mashad et al., 2011; Habara et al., 2002).Triplex Doppler ultrasonography allows one to perform blood flow assessments in relation to quantitative and qualitative variables (Szatmári et al., 2001). The quantitative variables include the resistance index (RI) and PI of the uterine artery (Mu and Adamson, 2006). The qualitative measures are related

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to the early diagnosis of an early diastolic notch (EDN) in uterine artery flow velocity waveforms (Aardema et al., 2000). Thus, uterine artery evaluation using triplex Doppler is a useful tool for detecting and/or predicting abnormal pregnancies in women (Coleman et al., 2000). According to Miranda and Domingues (2010), Doppler values during normal canine pregnancy would be useful to forecast pregnancy abnormalities even before they could be detected by B-mode ultrasonography.

The ultrasonographic assessment of uterine artery hemodynamics should be performed by serial tests to identify possible vascular changes (Brito et al., 2010). No difference in RI and PI values exists between the right and left uterine horns in bitches (Miranda and Domingues, 2010) and queens (Brito et al., 2010) with normal pregnancies. However, the difference between the uterine horns with respect to the number of fetuses and uterine artery hemodynamics has not been reported. Differences between uterine arteries in relation to the dominant ovary, i.e., the ovary that ovulated more recently, have been reported for the capuchin monkey (*Cebus apella*) (Domingues et al., 2007). Previous studies have not investigated whether the uterine artery hemodynamics of cyclic queens affect the number of embryos that are implanted in the uterine horn when there is better perfusion.

Therefore, our objectives were: (1) to determine RI and PI in the uterine arteries of cyclic and pregnant domestic cats; (2) to verify the presence or absence of an EDN in the uterine artery; and (3) to evaluate RI and PI of the of uterine arteries during pregnancy in relation to uterine horn with major or minor fetus number.

2. Materials and methods

The experimental protocol (protocol number 09233383-4/62) was approved by the Animal Ethics Committee of the State University of Ceará in accordance with the guidelines for the care and use of laboratory animals established by the Brazilian College of Animal Experimentation.

2.1. Location

The experiments were performed in the experimental cattery of the Laboratory of Carnivore Reproduction of the State University of Ceara, located in Fortaleza city (38440 South; 388340 West). This location has semi-humid equatorial weather, approximately 12 h of light per day, and mean monthly temperature, rain and relative humidity of 28.6 °C, 12.0 mm and 80%, respectively.

2.2. Experimental animals

Sexually mature, healthy mongrel queens were used. The experimental group was included of ten domestic queens (3–5 years old, 3–5 kg) and five domestic tomcats (5–8 years old, 4–4.5 kg).

2.3. Animal welfare conditions

The animals were kept in individual cages in the experimental cattery. They were exposed to a natural photoperiod and regional weather. The animals had access to an outdoor area once a day, during 4 h in the morning, scratchers and cat toys.

Pregnant females were transferred to larger cages that contained litter boxes, nesting boxes and objects for environmental enrichment.

The cats were fed a dry commercial feed (Whiskas™ PEDIGREE, Masterfoods Brasil Alimentos LTDA, Effém™, São Paulo, Brazil) and received water ad libitum. Pregnant queens were fed a dry commercial kitten feed (Whiskas Kitten™, Whiskas™ PEDIGREE, Masterfoods Brasil Alimentos LTDA, Effém™, São Paulo, Brazil) from the second half of pregnancy until weaning.

2.4. Estrus identification

The queens were observed for signs of sexual activity once per day by a trained observer and by presenting them to a tomcat in the presence of the observer. For the former procedure made by the observer, each queen was individually placed on a table, and her hindquarters were stimulated manually to observe signs of estrus, as described by Silva et al. (2006). In order to confirm if the queen was in estrus, she was presented individually to a tomcat in an outdoor area. The queen was considered in estrus when penile intromission attempts by a male were allowed after mounting (Silva et al., 2006).

2.5. Mating management

Queens were placed with a tomcat twice a day (once in the morning and once in the afternoon) on days 2, 3 and 4 of estrus and the last day of mating being considered the first day of pregnancy (Day 1 – Pereira et al., 2011).

2.6. Ultrasonographic evaluations

The queens were evaluated during one estrus without mating and they were mated in the subsequent estrus in order to have the pregnancy evaluated. Before mating and pregnancy, the uterine arteries of the uterine horns of queens were assessed daily by triplex Doppler during one estrous cycle. Assessments started on the first day of estrus, i.e., the first day when acceptance of male cat mating behavior by the cat was detected, but mating was not allowed and then daily until subsequent estrus was manifested.

During pregnancy, ultrasonographic evaluations were performed weekly from day 7 until day 63. The queens were submitted to cesarean sections on day 63 after the final ultrasonographic exam. During each cesarean section, the number of fetuses per uterine horn was counted to determine the uterine horn with the higher number of fetuses, which is referred to as the majority uterine horn (MUH). The horn with fewer fetuses is referred to as the minority uterine horn (miUH). After the determination of MUH and miUH, data related to those uterine horns in the cats before they became pregnant (during ciclicity evaluation) were retrospectively distributed according to that classification.

Evaluations were performed using an ultrasonic device (SonoAce PICO, Medison Co., Ltd., Daechi-Dong,