

DOPPLER ULTRASONOGRAPHY OF THE UMBILICAL ARTERY DURING NORMAL CAPRINE PREGNANCY

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ABSTRACT

This investigation was designed to study the haemodynamic changes in the umbilical artery during normal caprine pregnancy using Doppler ultrasonography. Ten nanny goats were synchronized using 2 intramuscular injections of PGF_{2α} 12 days apart, only six were pregnant. The pregnant goats were examined, between 25-125 days of pregnancy, every 5 to 10 days using a combination of two-dimensional real-time ultrasonography, color Doppler and pulsed wave Doppler ultrasonography. Transrectal scanning was done using a 7 MHz vector transducer between days 25-50 of gestation. Thereafter, transabdominal scanning was performed using a 5 MHz linear transducer. After locating the umbilical cord by real-time ultrasonography, the umbilical artery was defined by color Doppler ultrasonography. Pulsatility index (PI), resistance index (RI) and systolic to diastolic (S/D) ratio in the umbilical artery were measured by using pulsed wave Doppler ultrasonography. The angle of the ultrasound beam to the umbilical artery was 45°. RI and S/D ratio had a significant linear correlation ($r = -0.83$, $P < 0.005$; $r = -0.76$, $P < 0.005$, respectively) with the gestational age. In conclusion, the resistance to blood flow within the umbilical artery decreases with advancement of caprine pregnancy to match the fetoplacental development.

INTRODUCTION

Ultrasonography has provided a non-invasive simple method for evaluation of developing pregnancies. Umbilical blood flow is a basic and an important physiological determinant that has been studied extensively in animal species (Schmidt et al., 1991). With introduction of umbilical artery Doppler velocimetry, a new tool is added to the utensils for fetal surveillance (van Huisseling et al., 1991).

Measurement of umbilical artery blood flow velocity waveform indices has been proposed as a means of non-invasive assessment of fetal well-being during gestation (Irion and Clark, 1990)

and would predict the intra-uterine growth retardation and/or perinatal distress (Erskine and Ritchie, 1986 and Fowler et al., 1987).

Many studies have been proposed to measure the umbilical artery waveform indices during either early or late stages of pregnancy in many species other than the caprine. This study was designed to investigate the haemodynamic changes in the umbilical artery during normal caprine pregnancy using Doppler ultrasonography.

MATERIAL AND METHODS

Animals and breeding :

Ten healthy balady nanny goats, about 2-3 years old, were purchased from Kafr El-Sheikh markets and housed in a well-ventilated hygienic stable, Faculty of Veterinary Medicine, Kafr El-Sheikh, Tanta University. They were fed Alpha-alpha and sufficient amount of concentrates. Four weeks before the experiment they were dewormed. Estrus in these goats was synchronized using two i.m. injections of 1.5 ml of prostaglandin F_{2α} (PGF_{2α}, Lutalase[®] Upjohn International Animal Health, Kalamazoo, USA) 12 days apart (Romano, 1998). Oestrus was checked twice daily using two fertile bucks. The day of mating was considered as day (0) of pregnancy.

Ultrasonographic examination

Ten days after mating, goats were examined daily, using two-dimensional real-time ultrasonography, transrectally using a 7 MHz vector transducer for pregnancy diagnosis. The normal pregnant nanny goats were examined every five to ten days, using a combination of two-dimensional real-time ultrasonography, color Doppler and pulsed wave Doppler ultrasonography (Acuson xp 128/10, U.S.A.), between days 25 to 125 of gestation. Transrectal scanning was done by using a 7 MHz vector transducer between days 25 to 50 of gestation. Thereafter, trans-abdominal scanning was performed using a 5 MHz linear transducer after clipping of the abdominal wall from the udder laterally to the flanks and to the lower edge of the rib cage. After locating the umbilical cord by real-time ultrasonography, the umbilical artery was defined by color Doppler ultrasonography. The Doppler gate of the ultrasound beam was placed by an angle of 45° to the umbilical artery. The Doppler waves were frozen on a video tape and were automatically measured (Fig. 1a & b) according to Nautrup (1998).

The indices of the haemodynamic changes in the umbilical artery were measured as the following:

- 1- Pulsatility index (PI) was measured by defining the systolic peak velocity (S), diastolic peak

velocity (D) and the time average maximum velocity (TAMV).

$$PI = (S - D / TAMV) (m/s)$$

2- Resistance Index (RI) was measured as the following:

$$RI = (S - D / S) (m/s)$$

3- Systolic to diastolic (S/D) ratio = (S/D) (m/s)

Statistical analysis :

The relationship between gestational age in days and the haemodynamic indices (PI, RI and S/D ratio) was statistically analysed by regression coefficient using Statistical Analysis System, SAS (1988).

RESULTS

Six of the ten nanny goats responded to synchronization regime and became pregnant. At day 25, the umbilical artery of pregnant goats was not clearly defined, but was defined in only one goat at day 30 of pregnancy.

The indices in the caprine umbilical artery are given as mean \pm S.E. in table 1.

Both RI and S/D ratio decreased with advancement of pregnancy as shown by the regression coefficients.

Then, regression coefficient showed a significant ($P < 0.005$) inverse correlation between gestational age and both RI ($r = -0.83$) and S/D ratio ($r = -0.76$).

DISCUSSION

In this investigation, failure of 4 nanny goats to respond to synchronization regime may be due to short estrous cycles. Consequently, the second injection was administered in an unresponsive phase of the estrous cycle (Bosu et al., 1978). Short estrous cycle is a natural phenomenon in goat reproduction observed principally at the onset and the end of breeding season (Jainudeen and Hafez, 1987), after superovulation (Battye et al., 1988) and after $PGF_{2\alpha}$ administration for estrous synchronization or induction of abortion (Bretzlaff et al., 1988). On the other hand, Greyling and vanNierker (1986) reported that conception rate in Boer goats declined as the dose of cloprostenol increased.

The results of this study showed a highly significant ($P < 0.005$) negative correlation between gestational age in caprines and both RI ($r = -0.83$) and S/D ratio ($r = -0.76$) in goats. These results are similar to those obtained in ewes through the last trimester of pregnancy (Irion and Clark, 1990a & b). In humans, in spite of the fact that the gestation period is approximately twice that of the goats, the waveforms obtained externally were decreased with progress of gestation (Thompson et al., 1988). Irion and Clark (1990a) reported a lower correlation coefficient between gestation and waveform indices that may be due to the relatively short period of time over which they computed waveform indices. In addition to the relatively few animals used in their investigation.

Throughout the normal pregnancy, there is a progressive increase in end diastolic velocity in the umbilical circulation that results in a decrease in the computed values of the three waveform indices. Similar results were obtained by Irion and Clark (1990a). This increase in diastolic velocity in relation to peak systolic velocity is often attributed to progressively greater vascularization and diminishing vascular resistance in the fetoplacental circulation (Cohen-Overbeck et al., 1985). Support for this hypothesis comes from pathological correlations, as Giles et al. (1985) reported that abnormal waveforms occur in association with sclerosis and obliteration of tertiary villus arterioles. Also McCowan et al. (1987) found a significant negative correlation ($r = -0.71$) between waveform indices and the number of small arterioles observed in fetoplacental circulation.

In many cases, abnormalities in umbilical artery waveforms can be detected before deviations in other non-invasive indices of fetal well-being, such as fetal heart rate (Cohen-Overbeck et al., 1985 and Al-Ghazali et al., 1988). Thereby, Irion and Clark (1990a) concluded that, the clinical usefulness of waveform analysis may lie more in its ability to detect abnormalities in the size or function of the fetoplacental vascular bed rather than strictly changes in umbilical blood flow.

In conclusion, the resistance to blood flow within umbilical artery decreases with progressing of pregnancy in caprine to match the fetoplacental development.

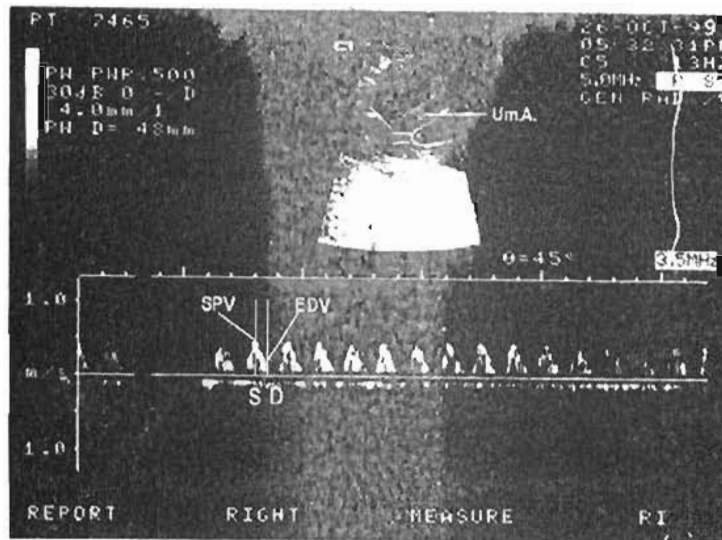


Fig. 1 a. Waveforms of caprine umbilical artery (Um.A.) 14 weeks after breeding, where SPV means systolic peak velocity, EDV means end diastolic velocity, S means systole and D means diastole.

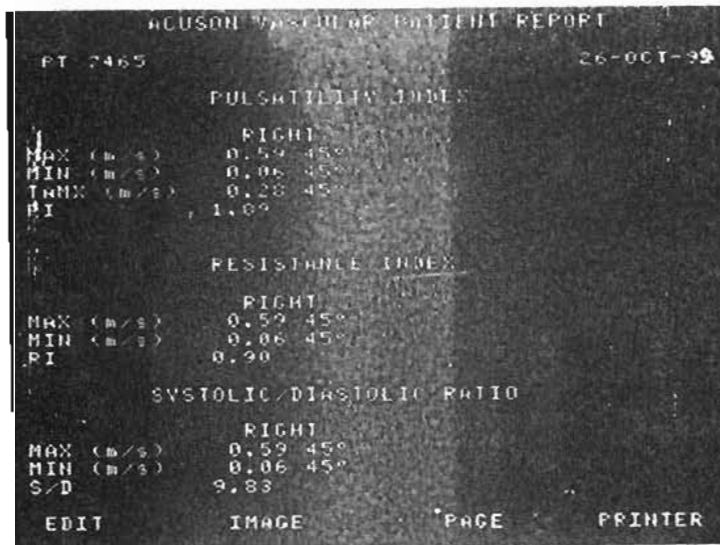


Fig. 1b. Automatic measurement of waveform indices of caprine umbilical artery at 14 weeks of pregnancy.

Table 1. Indices of the umbilical artery in pregnant goats.

Gestation age in days	30	40	45	50	55	60	65	70	75	85	100	105	110	125
PJ														
Mean \pm SE	1.46	1.46 \pm 0.040	1.50 \pm 0.028	1.68 \pm 0.125	1.67 \pm 0.049	1.38 \pm 0.191	1.80 \pm 0.035	1.74 \pm 0.058	1.53	1.42 \pm 0.050	1.30 \pm 0.020	1.63 \pm 0.180	1.02 \pm 0.087	1.33
n	1	3	2	4	5	3	4	5	1	4	6	6	3	1
RI														
Mean \pm SE	0.84	0.87 \pm 0.035	0.83 \pm 0.007	0.84 \pm 0.020	0.89 \pm 0.130	0.80 \pm 0.012	0.84 \pm 0.027	0.85 \pm 0.012	0.79	0.78 \pm 0.040	0.75 \pm 0.029	0.78 \pm 0.029	0.60 \pm 0.035	0.66
n	1	3	2	4	5	3	5	6	1	4	6	6	3	1
S/D ratio														
Mean \pm SE	6.33	8.82 \pm 1.865	5.75 \pm 0.247	6.37 \pm 0.660	9.14 \pm 0.935	4.92 \pm 0.318	6.88 \pm 1.073	6.78 \pm 0.698	4.75	5.03 \pm 0.905	4.12 \pm 0.323	5.03 \pm 0.706	2.53 \pm 0.214	2.97
n	1	3	2	4	5	3	5	6	1	4	6	6	3	1

Mean \pm S.E. = average \pm standard error.

n = number of animals.

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المفحص المرعى

فحص الشريان السرى أثناء الحمل الطبيعي للماعز باستخدام جهاز الدوبلر للموجات فوق الصوتية

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صممت هذه الدراسة لدراسة التغيرات الديناميكية الدموية في الشريان السرى أثناء الحمل الطبيعي للماعز باستخدام جهاز الدوبلر للموجات فوق الصوتية، فقد تم إدخال عشر إناث ماعز في الشبق في آن واحد بعقبتها عضلياً بجرعتين من البروستاجلاندين أ1- $2 \mu\text{g}$ ألفاً بفصلهما إثني عشر يوماً، وقد إستجابت ستة إناث ماعز من المشرة المستخدمة وأصبحت عشار، وقد قلنا بفحصها كل من 5-10 أيام باستخدام مزيج من المفحص بالموجات فوق الصوتية ثنائي الأبعاد في آن واحد والدوبلر الملون ودوبلر الموجات فوق الصوتية ذات الموجه النبضية وذلك في الفترة من 25-125 يوماً من الحمل. وقد تم المفحص في الفترة من 25-50 يوماً من الحمل بالفحص عن طريق الشرج باستخدام موصل موجات فوق صوتية موجه عند تردد موجي 7 ميجاهرتيز، ثم بعد الخمسين يوماً الأولى من الحمل تم المفحص عن طريق البطن باستخدام موصل موجات فوق صوتية خطي عند تردد موجي 5 ميجاهرتيز.

وبعد تحديد مكان الخليل السرى باستخدام المفحص بالموجات فوق الصوتية ثنائي الأبعاد في آن واحد، تم تحديد موضع الشريان السرى بالفحص الدوبلر الملون للموجات فوق الصوتية، وقد تم قياس معامل النبض ومعامل المقارومة ونسبة التقلص للايسساط الشرياني في الشريان السرى بالفج الدوبلر الملون للموجات فوق الصوتية ذر الموجه النبضية، حيث كانت زاوية سفوط حزمة الأشعة فوق الصوتية على الشريان السرى 94.5° .

وقد اتضح أن معامل المقارومة ونسبة الانقباض للايسساط الشرياني الخاصة بالشريان السرى ذات ارتباط خطي معنوي عكسي مع عمر الحمل بالأيام (الارتباط = $-0.83r$ عند مستوى معنوي أقل من 0.005 . والارتباط = $-0.76r$ عند مستوى معنوي أقل من 0.005 . على التوالي).

نستنتج من ذلك أن المقارومة لتدفق الدم خلال الشريان السرى تقل مع تقدم الحمل في الماعز لتطابق النمو الجنيني - المشيمي.