PREGNANCY MONITORING USING FOUR-DIMENSIONAL (4D) ULTRASONOGRAPHY IN BITCHES

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ABSTRACT

The study was conducted on pregnant bitches at Small Animal Gynaecology Ward, Department of Clinics, Madras Veterinary College, Chennai- 600007, Tamil Nadu to evaluate the use of four-dimensional (4D) ultrasonography in staging embryonic and fetal development and for predicting the pregnancy outcome and to study the fetal anomalies and fetal resorptionin bitches. Twelve pregnant bitches of different breeds of 10 to 40 kg body weight were the experimental animals for the study. All the twelve pregnant bitches were subjected to both 2D and 4D ultrasound examinations at days 30, 40, 50 and 60 post breeding. The accuracy of gestational age prediction based on gestational sac diameter and head diameter using 4D ultrasound was studied and compared with 2D (two-dimensional) ultrasound. The present paper reports the use of 4D ultrasonography in diagnosing fetal activity, fetal anomalies and fetal resorption in bitches.

Key words: Foetal anomalies, Bitches, Development, Four-dimensional (4D) ultrasonography

INTRODUCTION

The use of ultrasound as a tool in small animal reproduction has expanded from its initial role in the evaluation of pregnancy in the female to its current use in monitoring fetal development, timing gestation and predicting parturition, diagnosis and management of reproductive tract disease and in supplementing breeding soundness examinations. Ultrasonography is frequently employed in veterinary medicine using echoes of high frequency and sound waves emitted from a transducer to produce an image of subcutaneous structure being examined.

Two-dimensional (2D) ultrasounds have been widely applied for pregnancy characterization in cats and dogs, which gives only two-dimensional image of an organ (England *et al.,* 1990; Moriyoshi *et al.,* 1996; Luvoni and Grioni, 2000; England and Russo, 2007). Three-dimensional (3D) ultrasound and 4D *i.e*., real time 3D is a natural development of the imaging technology that gives near real time with

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very fast reconstructions of the different planes and volumes of the structure being examined. 3D/4D imaging technology available since the mid-1990s has been systematically pioneered so that it has now become the standard in human obstetrics (Merz *et al.,* 1995; Hartung *et al.,* 2004).

In human obstetrics, 3D/4D is widely used to identify fetal anomalies (Tonni *et al.,* 2005; Dyson *et al.,* 2005), the problem in uterus or any part of reproductive system, in search for cancers of uterus and ovaries as it gives clear images of the size of the tumors. Increased diagnosis of fetal anomalies has been reported by this technique compared with conventional sonography in human practice (Merz and Welter, 2005). The technology also offers advanced information about pregnancy status and birth prediction and increased the diagnostic confidence.

Since, the application of 3D and 4D ultrasound offers a new, not fully explored field for the intra-uterine assessment of the health in canine pregnancies (Hilderbrandt *et al*., 2009), more research on basic 4D ultrasonography is needed to explore its applicability in the veterinary practice in general and canine pregnancy in particular. Keeping the advantages of the 4D real time ultrasound over the 2D conventional ultrasound, the aim of the present study was to investigate the potential advantages of the 4D ultrasound for comparing it with the 2D ultrasound for the different stages of the canine pregnancy.

MATERIALS AND METHODS

Place of study: The study was conducted on pregnant bitches at Small Animal Gynaecology Ward, Department of Clinics, Madras Veterinary College, Chennai, Tamil Nadu, India.

Experimental design: Two-dimensional (2D) and three/four-dimensional (3D/4D) ultrasound scan were performed in 12 pregnant bitches with the known date of last mating. The age of the bitches varied from 1 year 4 months to 4 years 8 months. Each animal had ultrasound examinations performed around 30, 40, 50 and 60 days of estimated pregnancy. The bitches were trans-abdominally examined in dorsal or in lateral recumbency without any sedation but with moderate manual restraint.

Pregnancy was confirmed and estimation of fetal age was carried out using a B-Mode scanner (ALOKA) equipped with multi-frequency trans-abdominal probe of 3.0-5.7 MHz (2D, Fig. 1) and for 3D/4D ultrasound (Esoate mylab70) system. The 3D/4D ultrasound machine was equipped with 3D/4D volume probe (Fig. 2).

After visualizing the foetus, using B-Mode the parameters such as gestational sac diameter, foetal head diameter, spine, vertebral column, ribcage, thorax, heart lung, and stomach were examined in 2D ultrasound mode. Whereas using 3D/4D ultrasound the foetal structures were visualized using multi-planar and skeleton or glass body mode.

Fig. 1. 2D Ultrasound

Fig. 2. 3D/4D ultrasound

RESULTS AND DISCUSSION

The rapid body movements of the foetus were a major problem while visualizing the foetus in 3D/4D mode. It took approximately 15 to 25 minutes oftotal scanning time to get a better-quality 3D and 4D data sets. Eleven bitches had all foetuses viable. The multiplanar mode was the typical of 3D ultrasound data presentation (Fig. 3).

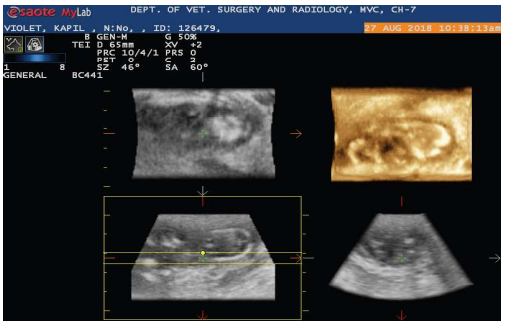

Fig. 3. Multiplanar mode 3D/4D ultrasound image of a canine foetus

The surface mode/ glass mode/ skeletal mode/ volume rendering with maximum intensity projection mode presented the data within a volume of selection with a contrast-enhanced surface algorithm (Fig.4). This mode was applied for evaluating the embryonic and foetal developmental and congenital abnormalities. Accurate diagnosis of fetal anomalies has been reported by this technique compared with conventional sonography in human practice (Merz and Welter, 2005).

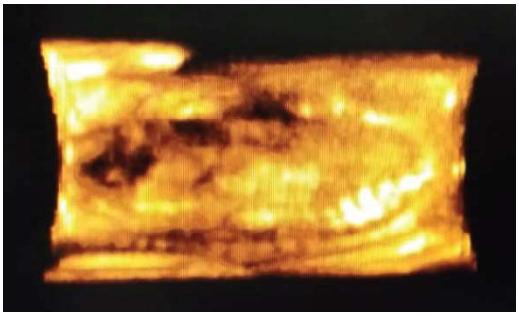

Fig. 4. Skeletal/ glass/ volume rendering mode of a foetus

Estimation of gestational age

Following ultrasonographic confirmation of pregnancy, measurements of either gestational sac or fetal head (depending on the stage of pregnancy) (Fig. 5 and 6) were taken to calculate the gestational age. When measuring the gestational sac, two transverse plane measurements were taken at 90° angles to each other and these values averaged before using the formulas. Head diameters were measured in the transverse plane. When taking measurements of the Inner Chorionic Cavity (ICC) or Biparietal (BP) diameter at least two distinct fetuses or gestational sacs were measured whenever possible and the measurements averaged before applying them to formulas as follows:

A. Formula for calculation of gestational age and prediction of date of parturition in bitches using ultrasonographic measurements of Inner Chorionic Cavity (ICC) diameter.

   Gestational age = [ICC (cm) × 6] + 20

   Predicted date of parturition (days) = 65 - Gestational age

B. Formula for calculation of the gestational age and prediction of the date of parturition in bitches using ultrasonographic measurements of Biparietal diameter (BP). Gestational age = [BP diameter (cm) × 15] + 20 predicted date of parturition (days) = 65 - Gestational age

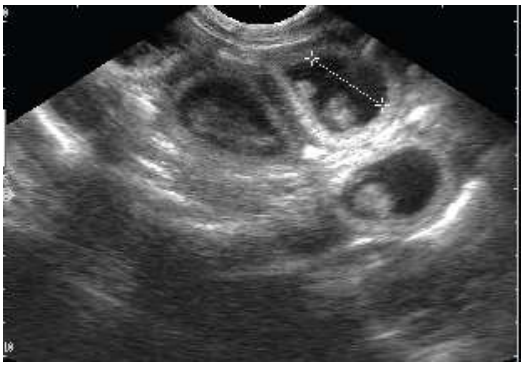

Fig. 5. Gestational Sac Diameter

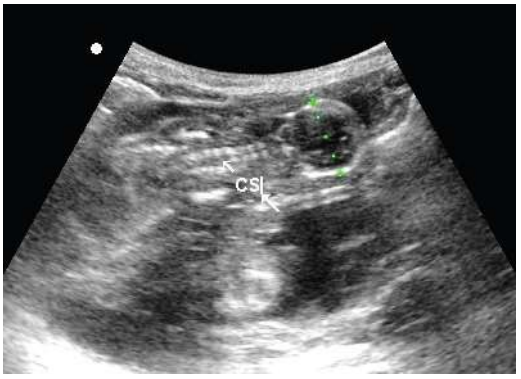

Fig. 6. Head Diameter

There was difference in assessing the gestational age by calculating the gestational sac diameter and head diameter both in 3D/4D ultrasonography.

Evaluation of the foetal face

Examination of fetal face by 3D ultrasound was performed using both multiplanar and rendered displays (Pretorius *et al.,* 2001). The multiplanar display allows the accurate location of any anatomic abnormalities in the face. In the present study, 3D/4D ultrasound using this skeletal mode did not reveal presence of any abnormal developmental defects in the examined foetus (Fig. 7 and 8).

Fig.7. Ultrasound image of a 47 days foetus face and spine by 2D sonogram

Evaluation of the Foetal Spine

The foetal spine was scanned by 3D Ultrasound using multiplanar and volume rendering (Fig. 9) with maximum intensity projection mode (skeletal mode) as per Johnson *et al.,* (1997). The clear bony structures and entire spine was visualized compared to the 2D sonography. Several investigators have reported on human prenatal diagnosis of anomalies affecting the foetal spine by 3D Ultrasound including scoliosis, hemivertebrae and neural tube defects (Lee *et al.,* 2002).

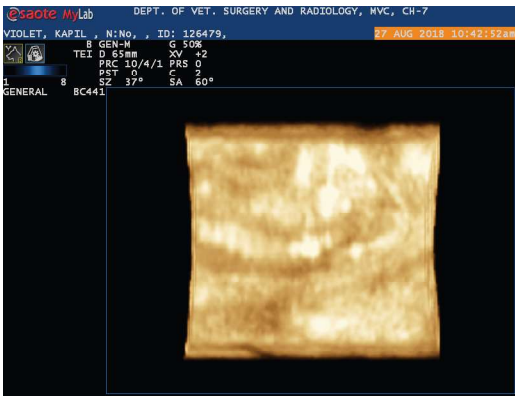

Figure 8. Ultrasound Image of a 47 days foetus face and Spine by 3D sonogram

Fig. 9. Spine of a 45 days old foetus in 2D and 4D mode

4-Dimensional ultrasound

The 4D volume ultrasound is a real time visualization of the foetus in a video format. They were imaged in surface mode and saved as digital video sequence (Fig.10).

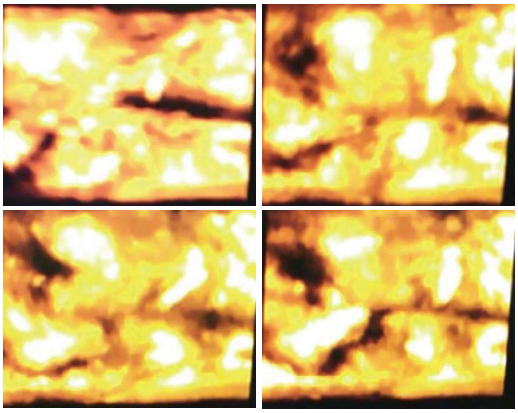

Fig. 10. Four sequential sonograms of a 4D video sequence showing the foetal moments in a 41 days gestation

It allowed the visualization of the structural changes over short time periods and the movements of the foetus associated with various intra-uterine behaviour. This can help in clinical diagnosis of behavioural disorders (Hildebrandt *et al.,* 2007).

CONCLUSION

The 3D/ 4D ultrasound is an additional tool for detailed structural analysis of

canine and feline pregnancy development. Technical problems such as the 3D and 4D ultrasound offered a new but not fully explored field in the intra-uterine assessment of the health in canine pregnancies. Follow-up studies are required to fully utilize this new technology for veterinary medicine.

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