

# APPLICATION OF 3D/4D ULTRASONOGRAPHY IN CANINE GYNAECOLOGY & OBSTETRICS

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## Introduction

Ultrasonography is frequently employed in veterinary medicine using echoes of high frequency sound waves emitted from a transducer to produce an image of subcutaneous structure being examined. Two dimensional (2D) ultrasonography is mostly used in veterinary medicine which gives only two dimensional image of an organ (England *et al.*, 1990). Three and four dimensional (3D/4D) ultrasonography is widely used in human medicine. This gives near real time of the structure being examined. Successful application of 3D/4D in veterinary medicine is not common yet. It may be due to high cost of 3D/4D ultrasound equipment, operational difficulties in non sedated animals & lack of specific knowledge concerning how to perform volume scanning. 3D/4D ultrasound acquisition & post processing techniques have been extensively applied in human medicine to all aspects. Application of this is to be done in veterinary medicine for better understanding of the structures being scanned as well as for the research purposes.

## Principle

In ultrasonography, sound waves of frequency higher than human audible frequency (greater than 20000 Hz) are used. Usually it ranges from 2-13 MHz. Selection of frequency for ultrasound imaging depends on depth of tissue from the scanning surfaces. Three dimensional ultrasonography works on the pulse echo principle like 2D ultrasonography. But instead of the sound waves being sent straight down and reflected back, in three dimensional scanning, they are sent at different angles. As the transducer is kept in close contact with the skin through medium of coupling gel, reflected echo is received by the transducer and are processed by a sophisticated computer program resulting in a reconstructed three dimensional volume image of the structure being scanned. In 4D ultrasound by adding the fourth dimension of time, it gives a dynamic real-time 3D ultrasonography of the

concerned organ with a continuous volume image acquisition and rendering process. (Khurana and Dahiya, 2004).

## Volume probes

Mechanical probe are conventionally used volume probes for 3D/4D ultrasonography. These probes have one dimensional arrangement of piezoelectric crystals and are oscillated with the help of motor housed in the transducer. It takes two dimensional images in different angle using rapid oscillation technology and computer interprets these images and reconstructs the three dimensional image from it with a volume up to 40 volumes / second (Deng and Rodeck, 2004). The new generation two dimensional matrix array probes have piezoelectric crystals arranged in two dimensional arrays. These probes use electronic scanning to sweep an ultrasound beam over the volume-of-interest to produce 3D images in real time. (Gonçalves *et al.*, 2006)

## Scanning procedure

Animals can be restrained in lateral or dorsal recumbency. As there is chance for motion artifacts, it is desired to sedate the animal if possible. But in case of pregnant animals, it is better to be more patient enough to ensure that animal is not panting. To get good volume data, we should first get a good B mode image of the structure being scanned. Further, the region of interest should be selected as small as possible. Sweep of the probe to get an image is defined as the angle of the acquired volume. For to get maximum data with in the volume of interest, wide angle of sweep is to be taken, which will take longer acquisition time. Hence for the better quality, wide angle will be preferred. Before starting volume scanning, required plane of interest should be selected as longitudinal or transverse plane. Three dimensional volumes scanning can be stored and can work with the volume later and four dimensional scanning will give live mode of the structure being scanned. So type of volume ultrasound is to be selected

according to the need.( Khurana A, Dahiya N.,2004).

### **Acquisition**

There are several methods available for acquisition of images in three dimensional (3D) ultrasonography .Freehand acquisition can be done using a conventional 2-dimensional ultrasound transducer with or without position sensing and automated acquisition can be done using mechanical volume probes .In these methods, probes acquire a series of 2D frames that are then reassembled by the ultrasound equipment and are displayed as a 3D volume data set. Currently available mechanical probes have convex array of piezoelectric crystals inside the transducer. These crystals oscillates rapidly with the help of motor attached inside the transducer and acquire up to 40 volumes per second producing 4-dimensional ultrasonographic images but in this technique motion artifacts can easily interfere with the quality of the images obtained if the structure of interest moves faster than the speed at which the volume data set is being acquired. Totality of the volume of interest is not scanned in an instant by these probes. (Deng and Rodeck, 2004). In contrast, 2D matrix array transducers allow acquisition of a pyramidal volume of ultrasonographic data and have the potential to minimize motion artifacts and, provide satisfactory spatial resolution. (Acar *et al.*, 2005)

### **Processing of the images**

After getting a volume data, it can be rotated to see all the sides of volume data superficially and can be translated to see the desired plane in the volume data. Further the data is optimized using different reconstruction and rendering algorithms. A system allows usually two modes at a time. These modes in the volume ultrasound can be used to make the image in better to analyze the different anatomical part. Multiplanar imaging mode shows transverse, sagittal, and coronal view of data, along with the rendered image in the lower right column. Coronal view can be obtained by rotating the acquired volume (Jurkovic, 2002). This can be used for volume calculation where contours of the image traced in both longitudinal and transverse plane can be visualized in the coronal plane. Niche mode is a cut open view of volume

image. Hildebrandt *et al* (2009)used this mode to visualize the data inside the volume in a particular plane and applied for study of the placental investigation in canine pregnancy. Surface mode shows the data in the volume superficially. These can be used for evaluating the embryonic and foetal integrity in canines. Tomographic ultrasound imaging gives three dimensional ultrasound volumes in 2D presentation. In this mode volume data is cut into number of equal parts and represented in two dimensional representations. The width of each slice and number of the images at a time in the monitor can be adjusted by the operator. It allows topographic identification of the volume of interest (Hildebrandt *et al.*, 2009). Transparency mode allows visualization of echo poor or echo rich structures and the spatial relationship within ultrasound volume. According to echogenesity of the structures to be scanned, it can be mainly of two types. In maximum transparency mode echo rich structures are visualized. It can be obtained by scanning with reduced gain. In minimum transparency mode the organs with high transparency are highlighted against more echogenic area. But overlapping of hypo echoic structures can be come as artifacts (Lee *et al.*, 2002). If used along with color Doppler, transparency mode can be used for the study of three dimensional architecture of growing mammary complex in pregnant bitches (Hildebrandt *et al.*, 2009). Bones can be visualized by decreasing the ultrasound gain to suppress the muscles and soft tissue from the images being displayed with x ray mode (Lee, 2003)

In 2D matrix array, 360° rotation and examination of selected structures can be done by maintaining the transducer in a fixed position and rotating the volume using the system trackball. So an object with its two sides can be visualized in real time with better spatial resolution. Four-dimensional images of bones can be obtained by decreasing gain settings only, with no need for cropping. With color Doppler imaging, four-dimensional reconstruction of vascular structures is possible with this new technology. (Goncalves *et al.*, 2006).

### **Applications**

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 a 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 3D/4D technology offered advanced information about pregnancy status and birth prediction and improved the diagnostic confidence. Fetal resorption in animal can be better studied. ectopic pregnancy, can be easily identified. (Hildebrandt *et al.*, 2009) and also aid in better visualization of needle during biopsy(Won.,*et al.*, 2003) .Soft tissue like heart, kidneys, liver, pancreas, gall bladder, eye, and thyroid (Slapa *et al.*, 2011) can also be better visualized. More precise measurement of volume of irregular structures either in study of tumors in the follow-up therapy or in the fetal weight estimation is obtainable by this imaging technique.

#### **Advantages**

Major advantage is the availability of virtual planes which cannot be obtained in conventional two dimensional ultrasonography. With experience and skill, examination procedure can be made faster and store the data which can be worked out later also. The ability to give better qualitative and quantitative information helps in effective diagnosis. With the improved understanding of normal fetal anatomy, precise identification of the nature, size and location of certain fetal defects will be possible. Precise volume measurement of organs with irregular shape will help in the detection of progression of the diseases and response to the treatment. This may have applications in follicle monitoring in the future (Goncalves *et al.*, 2006). A variety of fetal volume evaluations including the urinary bladder, stomach or cyst is much more accurate. With four dimensional ultrasonography, movement of the internal structures and improved visualization of biopsy devices by more perceptible information on the spatial relationship between the biopsy needle and the target lesion can be obtained(Won.,*et al.*, 2003). 2d matrix array may become an attractive alternative to examine anatomic structures of the adult as well as fetuses, especially fetal hearts(Goncalves *et al.*,2006). The system also

allows beam steering and focusing in the 3D volume data set, making it possible to simultaneously examine 2 different planes of section of the same structure, in real time, without resolution loss. Contrast-enhanced 4D-US can be done for the visualization of the staining of the tumors and the blood flow of surrounding organs three -dimensionally.

#### **Limitations**

3D cannot see what the B mode cannot see and problems of B mode imaging are always carried into 3D/4D imaging. False positives can be increased if we ignore this. In animal practice, problems with breathing and motion artifacts make difficulty to get a clear image with three dimensional ultrasonography. While the artifacts with the breathing movements are not affected by the four dimensional ultrasonography. Till now no three dimensional / four dimensional ultrasound machines are available only for veterinary practice and hence slow acquisition time and software settings optimized for the human body hinders the resolution of the data obtained. Available Trans abdominal volume probes are bulkier posing some handling difficulty. 4D ultrasound scanner with transvaginal probes are available but are costlier (Hildebrandt *et al.*, 2009).

In the 4D ultrasonography with 2D matrix array probe, due to lower transducer frequencies it gives lower resolution than mechanical volumetric transducers and has narrow volume display (Goncalves *et al.*,2006).

#### **Conclusion**

Three dimensional and four dimensional ultrasonography developed much in human practice and researches are continuing on this topic. Still it is considered as an adjunct to conventional 2D ultrasonography (Bega *et al.*, 2001). Due to higher cost of the machine, unawareness about the operational skills and difficulty in managing the motional artifacts in the animal, development of this imaging technique in veterinary practice is still in its childhood stage. Reduced amount of fetal fluid in the small animal like bitches (compared to human fetus) hinders the clarity of the images again as these machines are presently intended for human practice. By generating volume data sets much faster, this technology offers a new

opportunity to overcome breathing artifact in canine and moderate animal patient co-operation during 3D/4D scanning (Hildebrandt *et al.*, 2007). More research on basic 4D ultrasonography is needed in this area in veterinary to explore its applicability in the veterinary practice in general and canine in particular.

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