Study of Fetal Anatomy using Ultrasound Images: A Systematic Conceptual Review

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ABSTRACT

Ultrasound imaging has widespread applications in medical field, especially for the study and assessment of fetus in the womb of pregnant woman. This paper highlights the background information regarding basics of ultrasound imaging, the various anatomical terminologies related to human body and fetus, and various steps to identify the organs of fetus using ultrasound images with major emphasis on the fetus heart detection. The paper serves as an information source for any engineering person from non-medical background to carry out his/her research in fetal ultrasound image analysis.

Keywords: Anatomy, Fetus, Gestation, Image Analysis, Ultrasound

INTRODUCTION

Ultrasound imaging is done during pregnancy over many decades. It has is one of the very useful diagnostic procedures. There is no convincing evidence for any danger from ultrasound during pregnancy (Gregory et al.) Ultrasound scanning is considered very safe and non-invasive to mother and baby, also accurate (from the help of modern technology) and a cost effective method. Ultrasound imaging is considered as a most effective screening tool during gestation period. Firstly, the most important and obvious reason to be considered for scanning is the diagnosis and confirmation of the pregnancy. The gestational sac can be seen as early as 4 weeks of pregnancy, and the yolk sac as early as 5 weeks. The embryo can be observed and monitored from at least five and a half weeks, which can be of great use to women who have not been successful in pregnancy before; for example, have experienced miscarriages or have trouble conceiving. Ultrasound scans can also confirm the site of the pregnancy, and discover ectopic pregnancies from an early stage (Gustavo et al.) Another important reason for ultrasound scans during pregnancy is determining the viability of the
embryo, and to investigate vaginal bleeding in early pregnancy. Heartbeats can be determined by around 6 weeks of pregnancy and usually clearly depictable by 7 weeks. Around 5-8 weeks is where the embryo is at most risk from miscarriage and if the embryo’s heartbeat is below that of 90bpm, it is associated with a very high risk of miscarriage. Ultrasound scans are accurate at detecting these heartbeats and help the parents and doctors to determine the best course of action for the pregnancy. Ultrasound scans also are a good instrument to determine gestational age and the assessment of the size of the foetus, especially in early gestation (around 5-11 weeks). Four measurements are usually made whilst performing the scan; firstly, the crown-rump length (CRL, measured at 7-13 weeks) and gives very accurate information of the age of the embryo/foetus. Secondly, the Bi-parietal Diameter is taken after 13 weeks, which measures the diameter between the two sides of the head. Thirdly, the femur length can be measured; the longest bone in the body reflects the longitudinal growth of the foetus. Fourthly, the abdominal circumference can be measured, the most important measurement in late pregnancy. Lastly, malformations of the foetus can be diagnosed and monitored by ultrasound scans. These are usually made before 20 weeks and with most recent ultrasound equipment, cleft lips and cardiac abnormalities can be detected. Ultrasound scans are of great usefulness in other areas as well. Intrauterine death can be detected and confirmed through this fetal movements procedure, tone and breathing can be monitored in a Biophysical Profile, and scans can also diagnose uterine and pelvic abnormalities during pregnancy, for example an ovarian cyst. Such a continuous procedure helps to closely monitor the well-being of the mother and baby during pregnancy period.

Quantitative analysis of Ultrasonic imaging plays a crucial role for biomedical engineering community. The reason is due to the fact that most of the current imaging procedure involves 3-D and 4-D scanning modes thereby generating volume of information. Hence, providing engineering solutions to the clinician thus forms the challenging tasks and there is a need to understand the foundation pertaining to the fetal anatomy and its relevancy to the research study. A researcher belonging to a non-medical background, he may find difficult to analyze these ultrasound images. To the best knowledge of the authors, attempts have been made to understand the basic traits and Hence, this paper gives a brief informational background about the various terminologies associated with ultrasound scanning modality, the human body anatomical terminologies so that a researcher find it easy to start working with these images. The rest of the paper is organized as follows: section II deals with basics of ultrasound scanning, section III with the anatomical terms and definitions related to fetal anatomy, section IV deals with the detailed study of fetal heart, section V with the conclusions and finally the script ends with few references.

**BASICS OF ULTRASOUND SCANNING**

Ultrasound image is obtained by first transmitting sound waves into the body and analyzing the intensity of the reflected echoes. This is achieved by using a hand held probe, which contacts the body via gel. The probe contains a large number of transmitter set in a line along its length. Typically up to five of these transmitters firing simultaneously, generate a short pulse of ultrasound signals that travels in a narrow column away from the probe. The transmitters then act as receivers and record the intensity of the reflected sound. The process is repeated sequentially along the length of the probe. The time taken for an echo to revert is used to determine the distance from the probe and is calculated assuming that the sound has a constant speed. The strength of the echoes returning from any point is represented by the brightness of that point on the screen. There may be two types of reflection: specular and scattering. Specular reflection is responsible for the bright appearance of fibrous structures such as tendons and of boundaries between different
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