What are Obstetric Ultrasound Scans?

Obstetric Ultrasound is the use of ultrasound scans in pregnancy. Since its introduction in the late 1950’s ultrasonography has become a very useful diagnostic tool in Obstetrics.

Currently used equipments are known as real-time scanners, with which a continous picture of the moving fetus can be depicted on a monitor screen. Very high frequency sound waves of between 3.5 to 7.0 megahertz (i.e. 3.5 to 7 million cycles per second) are generally used for this purpose.

They are emitted from a transducer which is placed in contact with the maternal abdomen, and is moved to "look at" (likened to a light shined from a torch) any particular content of the uterus. Repetitive arrays of ultrasound beams scan the fetus in thin slices and are reflected back onto the same transducer.

The information obtained from different reflections are recomposed back into a picture on the monitor screen (a sonogram, or ultrasonogram). Movements such as fetal heart beat and malformations in the feus can be assessed and measurements can be made accurately on the images displayed on the screen. Such measurements form the cornerstone in the assessment of gestational age, size and growth in the fetus.

A full bladder is often required for the procedure when abdominal scanning is done in early pregnancy. There may be some discomfort from pressure on the full bladder. The conducting gel is non-staining but may feel slightly cold and wet. There is no sensation at all from the ultrasound waves.

A short history of the development of ultrasound in pregnancy can be found in the History pages.
Why and when is Ultrasound used in Pregnancy?

Ultrasound scan is currently considered to be a safe, non-invasive, accurate and cost-effective investigation in the fetus. It has progressively become an indispensible obstetric tool and plays an important role in the care of every pregnant woman.

The main use of ultrasonography are in the following areas:

1. Diagnosis and confirmation of early pregnancy.

The gestational sac can be visualized as early as four and a half weeks of gestation and the yolk sac at about five weeks. The embryo can be observed and measured by about five and a half weeks. Ultrasound can also very importantly confirm the site of the pregnancy is within the cavity of the uterus.

2. Vaginal bleeding in early pregnancy.

The viability of the fetus can be documented in the presence of vaginal bleeding in early pregnancy. A visible heartbeat could be seen and detectable by pulsed doppler ultrasound by about 6 weeks and is usually clearly depictable by 7 weeks. If this is observed, the probability of a continued pregnancy is better than 95 percent. Missed abortions and blighted ovum will usually give typical pictures of a deformed gestational sac and absence of fetal poles or heart beat.

Fetal heart rate tends to vary with gestational age in the very early parts of pregnancy. Normal heart rate at 6 weeks is around 90-110 beats per minute (bpm) and at 9 weeks is 140-170 bpm. At 5-8 weeks a bradycardia (less than 90 bpm) is associated with a high risk of miscarriage.

Many women do not ovulate at around day 14, so findings after a single scan should always be interpreted with caution. The diagnosis of missed abortion is usually made by serial ultrasound scans demonstrating lack of gestational development. For example, if ultrasound scan demonstrates a 7mm embryo but cannot demonstrable a clearcut heartbeat, a missed abortion may be diagnosed. In such cases, it is reasonable to repeat the ultrasound scan in 7-10 days to avoid any error.

The timing of a positive pregnancy test may also be helpful in this regard to assess the possible dates of conception. A positive pregnancy test 3 weeks previously for example, would indicate a gestational age of at least 7 weeks. Such information would be useful against the interpretation of the scans. Please read the FAQs for more comments.

In the presence of first trimester bleeding, ultrasonography is also indispensible in the early diagnosis of ectopic pregnancies and molar pregnancies.

Fetal body measurements reflect the gestational age of the fetus. This is particularly true in early gestation. In patients with uncertain last menstrual periods, such measurements must be made as early as possible in pregnancy to arrive at a correct dating for the patient. See FAQ. In the latter part of pregnancy measuring body parameters will allow assessment of the size and growth of the fetus and will greatly assist in the diagnosis and management of intrauterine growth retardation (IUGR).

The following measurements are usually made:

a) **The Crown-rump length** (CRL)

This measurement can be made between 7 to 13 weeks and gives very accurate estimation of the gestational age. Dating with the CRL can be within 3-4 days of the last menstrual period. (Table) An important point to note is that when the due date has been set by an accurately measured CRL, it should not be changed by a subsequent scan. For example, if another scan done 6 or 8 weeks later says that one should have a new due date which is further away, one should not normally change the date but should rather interpret the finding as that the baby is not growing at the expected rate.

b) **The Biparietal diameter** (BPD)

The diameter between the 2 sides of the head. This is measured after 13 weeks. It increases from about 2.4 cm at 13 weeks to about 9.5 cm at term. Different babies of the same weight can have different head size, therefore dating in the later part of pregnancy is generally considered unreliable. (Chart and further comments) Dating using the BPD should be done as early as is feasible.

c) **The Femur length** (FL)

Measures the longest bone in the body and reflects the longitudinal growth of the fetus. Its usefulness is similar to the BPD. It increases from about 1.5 cm at 14 weeks to about 7.8 cm at term. (Chart and further comments) Similar to the BPD, dating using the FL should be done as early as is feasible.

d) **The Abdominal circumference** (AC)

The single most important measurement to make in late pregnancy. It reflects more of fetal size and weight rather than age. Serial measurements are useful in monitoring growth of the fetus. (Chart and further comments) AC measurements should not be used for dating a fetus.
Other important measurements are discussed here.

The weight of the fetus at any gestation can also be estimated with great accuracy using polynomial equations containing the BPD, FL, and AC. Computer softwares and lookup charts are readily available. For example, a BPD of 9.0 cm and an AC of 30.0 cm will give a weight estimate of 2.85 kg. (comments)

4. Diagnosis of fetal malformation.

Many structural abnormalities in the fetus can be reliably diagnosed by an ultrasound scan, and these can usually be made before 20 weeks. Common examples include hydrocephalus, anencephaly, myelomeningocele, achondroplasia and other dwarfism, spina bifida, exomphalos, Gastrochisis, duodenal atresia and fetal hydrops. With more recent equipment, conditions such as cleft lips/ palate and congenital cardiac abnormalities are more readily diagnosed and at an earlier gestational age. (Also see the FAQ and Anomalies pages).

First trimester ultrasonic 'soft' markers for chromosomal abnormalities such as the absence of fetal nasal bone, an increased fetal nuchal translucency (the area at the back of the neck) are now in common use to enable detection of Down syndrome fetuses.

Read also: Soft Markers - A Guide for Professionals and Ultrasonographic "soft markers" of fetal chromosomal defects.

Ultrasound can also assist in other diagnostic procedures in prenatal diagnosis such as amniocentesis, chorionic villus sampling, cordocentesis (percutaneous umbilical blood sampling) and in fetal therapy.

5. Placental localization.

Ultrasonography has become indispensible in the localization of the site of the placenta and determining its lower edges, thus making a diagnosis or an exclusion of placenta previa. Other placental abnormalities in conditions such as diabetes, fetal hydrops, Rh isoimmunization and severe intrauterine growth retardation can also be assessed.
6. Multiple pregnancies.

In this situation, ultrasonography is invaluable in determining the number of fetuses, the chorionicity, fetal presentations, evidence of growth retardation and fetal anomaly, the presence of placenta previa, and any suggestion of twin-to-twin transfusion.

7. Hydramnios and Oligohydramnios.

Excessive or decreased amount of liquor (amniotic fluid) can be clearly depicted by ultrasound. Both of these conditions can have adverse effects on the fetus. In both these situations, careful ultrasound examination should be made to exclude intrauterine growth retardation and congenital malformation in the fetus such as intestinal atresia, hydrops fetalis or renal dysplasia. See also FAQ and comments.

8. Other areas.

Ultrasoundography is of great value in other obstetric conditions such as:

a) confirmation of intrauterine death.

b) confirmation of fetal presentation in uncertain cases.

c) evaluating fetal movements, tone and breathing in the Biophysical Profile.

d) diagnosis of uterine and pelvic abnormalities during pregnancy e.g. fibromyomata and ovarian cyst.

Transvaginal Scans

The transvaginal probe

With specially designed probes, ultrasound scanning can be done with the probe placed in the vagina of the patient. This method usually provides better images (and therefore more information) in patients who are obese and/or in the early stages of pregnancy. The better images are the result of the scanhead's closer proximity to the uterus and the higher frequency used in the transducer array resulting in higher resolving power. Fetal cardiac pulsation can be clearly observed as early as 6 weeks of gestation.

Vaginal scans are also becoming indispensable in the early diagnosis of ectopic pregnancies. An increasing number of fetal abnormalities are also being diagnosed in the first trimester using the vaginal scan. Transvaginal scans are also useful in the second trimester in the diagnosis of congenital anomalies. Read one of my presentations at OBGYN.net-Ultrasound.
Doppler Ultrasound

The doppler shift principle has been used for a long time in fetal heart rate detectors. Further developments in doppler ultrasound technology in recent years have enabled a great expansion in its application in Obstetrics, particularly in the area of assessing and monitoring the well-being of the fetus, its progression in the face of intrauterine growth restriction, and the diagnosis of cardiac malformations.

Doppler ultrasound is presently most widely employed in the detection of fetal cardiac pulsations and pulsations in the various fetal blood vessels. The "Doptone" fetal pulse detector is a commonly used handheld device to detect fetal heartbeat using the same doppler principle.

Blood flow characteristics in the fetal blood vessels can be assessed with Doppler flow velocity waveforms. Diminished flow, particularly in the diastolic phase of a pulse cycle is associated with compromise in the fetus. Various ratios of the systolic to diastolic flow are used as a measure of this compromise. The blood vessels commonly interrogated include the umbilical artery, the aorta, the middle cerebral arteries, the uterine arcuate arteries, and the inferior vena cava.

The use of color flow mapping can clearly depict the flow of blood in fetal blood vessels in a realtime scan, the direction of the flow being represented by different colors. Color doppler is particularly indispensable in the diagnosis of fetal cardiac and blood vessel defects, and in the assessment of the hemodynamic responses to fetal hypoxia and anemia.

A more recent development is the Power Doppler (Doppler angiography). It uses amplitude information from doppler signals rather than flow velocity information to visualize slow flow in smaller blood vessels. A color perfusion-like display of a particular organ such as the placenta overlapping on the 2-D image can be very nicely depicted. Doppler examinations can be performed abdominally and via the transvaginal route. The power emitted by a doppler device is greater than that used in a conventional 2-D scan. Its use in early pregnancy is therefore cautioned.

Doppler facilities are generally an integral part of modern ultrasound scanners. They merely would need to be switched on to function. One does not need to 'go' to another machine for the doppler investigations.
3-D and 4-D Ultrasound

3-D ultrasound can furnish us with a 3 dimensional image of what we are scanning. The transducer takes a series of images, thin slices, of the subject, and the computer processes these images and presents them as a 3 dimensional image. Using computer controls, the operator can obtain views that might not be available using ordinary 2-D ultrasound scan. 3-dimensional ultrasound is quickly moving out of the research and development stages and is now widely employed in a clinical setting. It too, is very much in the News. Faster and more advanced commercial models are coming into the market. The scans requires special probes and software to accumulate and render the images, and the rendering time has been reduced from minutes to fractions of a seconds.

A good 3-D image is often very impressive to the parents. Further 2-D scans may be extracted from 3-D blocks of scanned information. Volumetric measurements are more accurate and both doctors and parents can better appreciate a certain abnormality or the absence of a certain abnormality in a 3-D scan than a 2-D one and there is the possibility of increasing psychological bonding between the parents and the baby.

An increasing volume of literature is accumulating on the usefulness of 3-D scans and the diagnosis of congenital anomalies could receive revived attention. Present evidence has already suggested that smaller defects such as spina bifida, cleft lips/palate, and polydactyl may be more lucidly demonstrated. Other more subtle features such as low-set ears, facial dysmorphia or clubbing of feet can be better assessed, leading to more effective diagnosis of chromosomal abnormalities. The study of fetal cardiac malformations is also receiving attention. The ability to obtain a good 3-D picture is nevertheless still very much dependent on operator skill, the amount of liquor (amniotic fluid) around the fetus, its position and the degree of maternal obesity, so that a good image is not always readily obtainable.

More recently, 4-D or dynamic 3-D scanners are in the market and the attraction of being able to look at the face and movements of your baby before birth was also enthusiastically reported in parenting and health magazines. This is thought to have an important catalytic effect for mothers to bond to their babies before birth. What are known as 're-assurance scans' and the rather misnamed 'entertainment scans' have quickly become popular.

Most experts do not consider that 3-D and 4-D ultrasound will be a mandatory evolution of our conventional 2-D scans, rather it is an additional piece of tool like doppler ultrasound. Most diagnosis will still be made with the 2-D scans. 3-D ultrasound appears to have great potential in research and in the study of fetal embryology. Whether 3-D ultrasound will provide unique information or merely supplemental information to the conventional 2-D scans will remain to be seen.

Click here for some good sample images courtesy of Dr. Bernard Benoit. Visit the GE 4D site for more pictures and information. Dr. Najeeb Layyous's 3-D and 4-D website also has many more pictures and clips. Read also the FAQ page.
The Schedule

There is no hard and fast rule as to the number of scans a woman should have during her pregnancy. A scan is ordered when an abnormality is suspected on clinical grounds. Otherwise a scan is generally booked at about 7 weeks to confirm pregnancy, exclude ectopic or molar pregnancies, confirm cardiac pulsation and measure the crown-rump length for dating.

A second scan is performed at 18 to 20 weeks mainly to look for congenital malformations, when the fetus is large enough for an accurate survey of the fetal anatomy. multiple pregnancies can be firmly diagnosed and dates and growth can also be assessed. Placental position is also determined. Further scans may be necessary if abnormalities are suspected.

Many centers are now performing an earlier screening scan at around 11-14 weeks to measure the fetal nuchal translucency and to evaluate the fetal nasal bone (and more recently, to detect tricuspid regurgitation) to aid in the diagnosis of Down Syndrome. Some centers will do blood test biochemical screening at the same visit.

Further scans may sometimes be done at around 32 weeks or later to evaluate fetal size (to estimate the fetal weight) and assess fetal growth. Or to follow up on possible abnormalities seen at an earlier scan. Placental position is further verified. The most common reason for having more scans in the later part of pregnancy is fetal growth retardation. Doppler scans may also be necessary in that situation.

The total number of scans will vary depending on whether a previous scan has detected certain abnormalities that require follow-up assessment. What is often referred to as a Level II scan merely indicates a "targeted" examination where it is done when an indication is present or when an abnormality is suspected in a previous examination. In fact professional bodies such as the American Institute of Ultrasound in Medicine does not endorse or encourage the use of these terms. A more "thorough" examination is usually done at an a perinatal center or specialised clinic where more expertise and better equipments may be present.

One should not dwell too much on the definitions or guidelines for a level II ultrasound scan. The prenatal sonologist should always try very hard to look for and assess any abnormality that may be present in the fetus. It is not very meaningful to be talking about level III or even level IV scans.

That a pregnancy should be scanned at 18 to 20 weeks as a rule is gradually becoming a matter of routine practice. Please go to the FAQ page and News page for other discussions. A rather thorough discussion paper on Ultrasound screening in pregnancy can be found here. Read also the RCOG’s paper on routine screening in pregnancy.
What about Safety?

It has been over 40 years since ultrasound was first used on pregnant women. Unlike X-rays, ionizing irradiation is not present and embryotoxic effects associated with such irradiation should not be relevant. The use of high intensity ultrasound is associated with the effects of "cavitation" and "heating" which can be present with prolonged insonation in laboratory situations.

Although certain harmful effects in cells are observed in a laboratory setting, abnormalities in embryos and offsprings of animals and humans have not been unequivocally demonstrated in the large amount of studies that have so far appeared in the medical literature purporting to the use of diagnostic ultrasound in the clinical setting. Apparent ill-effects such as low birthweight, speech and hearing problems, brain damage and non-right-handedness reported in small studies have not been confirmed or substantiated in larger studies from Europe. The complexity of some of the studies have made the observations difficult to interpret. Every now and then ill effects of ultrasound on the fetus appears as a news item in papers and magazines. Continuous vigilance is necessary particularly in areas of concern such as the use of pulsed Doppler in the first trimester.

The greatest risks arising from the use of ultrasound are the possible over- and under-diagnosis brought about by inadequately trained staff, often working in relative isolation and using poor equipment.

A discussion on the various possible effects of ultrasound on the human fetus can be found here. Ultrasound scans should best be performed when there is a clear indication to do so. When there is, safety considerations should not be an issue to prevent its prudent use.

⚠️ It should be borne in mind that prenatal ultrasound cannot diagnose all malformations and problems of an unborn baby (reported figures range from 40 to 98 percent), so one should never interpret a normal scan report as a guarantee that the baby will be completely normal. Some abnormalities are very difficult to find or to be absolutely certain about.

Some conditions, like for example hydrocephalus, may not have been obvious at the time of the earlier scan. The position of the baby in the uterus has a great deal to do with how well one sees certain organs such as the heart, face and spine. Sometimes a repeat examination has to be scheduled the following day, in the hopes the baby has moved.

Images tend also to be strikingly clear in skinny patients with lots of amniotic fluid, and frustratingly fuzzy in obese women, particularly if there is not much amniotic fluid as in cases of growth restriction. As in almost every endeavor, there is also a wide difference in the skill, training, talent, and interest of the sonographer or sonologists. The improvements in equipment has also lead to the earlier detection of abnormal structures in the fetus bringing along with it "false positives" and "difficult-to-be-sure-what-will-happen" diagnosis that could generate huge amount of undue anxiety in patients.