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Advances in Obstetric Ultrasound

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Ultrasound imaging was first applied in obstetrics during the late 1950s by Ian Donald in Glasgow. Since then, rapid advances have been made in both the imaging capabilities and versatility or ultrasound equipment and in the development of ultrasound diagnosis as an integral part of obstetric management.

A. Technological advances

(a) More sophisticated

The latest generation of ultrasound machines in the upper range have become more complicated. A few machines already have 256 grey levels incorporated into the monitor giving more differentiation between tissues[1]. Three dimensional ultrasound has also arrived at the scene and this is mainly by reconstruction from the scanning data of the fetus. It is hoped that this will be useful in detecting anomalies as well as aid in estimation of fetal weight. With the advent of better software to drive these sophisticated machines the capabilities are enhanced. Currently some machines have 128 channels for incorporation of data from the probes. This may be increased in the near future to give rise to better images. Incorporation of different colours (B colour) to give better resolution to the image has been introduced by an ultrasound company Storage of data can now be done on video in the machine itself in most upper range models but now a model has come out where it is possible to store it on a floppy disc.

(b) New probes

There has been a plethora of probes recently and the move is to make smaller probes with better resolution(spatial and lateral) due to advances in the computer software. The transvaginal probe has remarkably changed gynaecological scanning and has undergone changes from basic 5-7mHz probes to those with capabilities for transvaginal colour doppler incorporation of duplex scanners with doppler mode has enhanced the location of the vessels where sampling is required. With the advent of colour doppler vessels which previously were inaccessible can now be sampled easily. Furthermore visualisation of structural defects particularly in the fetal heart has been enhanced by this modality. Introduction of zoom facilities enhance the visualisation of a suspicious area for structural defects.

B. Advances in fetal monitoring, diagnosis and management

1. USES OF ULTRASOUND IN FETAL MONITORING

(a) Assessment of fetal maturity

Accurate assessment of gestational age plays an important role in the management of a pregnancy and ultrasound plays an integral part of this assessment.

In the first trimester, determination of gestational age based on the crown rump length is the most accurate measurement for dating, with a standard deviation of ± 0.5 weeks[2], but in the absence of a fetus, measurement of gestational sac volume [3] can provide an estimation of the duration of pregnancy.

In the second trimester, standard ultrasound assessment of fetal maturity include measurements of biparietal diameter, abdominal circumference and femur length. Apart from these standard measurements, other fetal parameters may also assist in determining gestational age such as head circumference, outer orbital diameters, transverse cerebellar diameter, other limb lengths, foot length, clavicular length etc. These other measurements have a limited role in certain fetal malformations.

Because of the large variation in fetal growth during the third trimester, similar measurements taken, are of limited value in establishing gestational age of fetus. In this situation multiple measurements may be more useful[4]. However, as the fetus grows in maturity, developmental changes will occur in the various organs. These changes are apparent on ultrasound scan and indirectly may reflect the maturity of the fetus. These are especially apparent in the brain, where well formed gyral patterns may be seen in the late third trimester[5] and in the gastrointestinal tract, where the bowels and bowel contents become obvious in the third trimester[6].

Development of the epiphysis particularly in the femur has been used in grading maturity[7]. The other parameter which has been used is the lung liver echogenicity[8]. All these parameters are still a crude index of maturity.

Ultrasound evaluation of the placenta for maturation has also been described[9], but this is of little value in clinical practice, because of the poor correlation between placental grading and gestational age of the fetus. Correlations with the L/S ratio has also been proposed and this has also been found to be unreliable.

(b) Monitoring of fetal growth

Serial measurements of various fetal parameters is a better indicator of fetal growth than a single reading. In the absence of serial measurements, the use of various ratios eg Head circumference/abdominal circumference or femur length/ abdominal circumference may indicate asymmetrical intrauterine growth retardation.

(c) Assessment of fetal behaviour

Study of fetal behaviour can also be used in the assessment of fetal well being. In the 1980s, realtime ultrasonography was incorporated into fetal surveillance schemes to assess fetal status, as in the fetal biophysical profile. This approach included fetal heart rate in the form of nonstress cardiotocograph with realtime ultrasound parameters, viz fetal breathing, movements and tone as well as amniotic fluid volume[10]. More recent advances in the study of fetal behaviour include looking at eyeball, eyelid and mouthing movements of the fetus[11].

(d) **Amniotic Fluid Index**

For decades, amniotic fluid volume has been known to play a significant role in subsequent fetal outcome. Many techniques of assessing amniotic fluid volume have been devised but these are rather subjective with a large amount of interobserver variations. Amniotic fluid index has been demonstrated to overcome the above dificiencies and this is determined by the summation of the vertical diameter of the largest pocket of liquor in each quadrant[12].

(e) **Fetal Blood Flow Studies**

Processing the doppler signal through spectral analysis has enabled obstetricians to visualise blood flow velocity waveforms from various maternal and fetal vessels. This has now become part of the obstetrician's armamentarium for fetal monitoring. Normograms of various ratios calculated from blood flow velocity waveforms of various maternal and fetal vessels have been established. The various circulations that have been studied (some with colour doppler) include the umbilical vessels, uteroplacental circulation (arcuate artery), fetal aorta, internal carotid, anterior cerebral artery and renal artery[13]. The relative ease with which these vessels can be identified on colour Doppler has made them amenable to these studies.

Although it is reasonable to conclude that any reduction of blood flow would imply reduced perfusion and ultimately fetal compromise, it must be remembered that the calculations of sensitivity and specificity of Doppler velocimetry can sometimes be misleading in an individual patient as many fetal organs have a large "reserve" capacity. The positive predictive value of umbilical Doppler at 30 weeks for intrauterine growth retardation is only around 50%, whereas the predictive value of uterine artery Doppler at 26 weeks for pregnancy induced hypertension is in the region of 80%.

Colour addition to the realtime image has enabled development of a new technique of Colour Doppler, whereby moving objects within the field of scanning are converted into various shades of red or blue depending upon the velocity of the object and direction of movement. Colour doppler has improved the ability to locate various vessels for Doppler studies.

II USE OF ULTRASONOGRAPHY IN ANTENATAL DIAGNOSIS

(a) **Transabdominal ultrasonography**

High resolution ultrasound examination is now capable of detecting most structural anomalies of the fetus. Detection of anomalies by ultrasound is based on direct visualisation of a structural defect (e.g. anencephaly), the demonstration of a pathological process due to the defect (e.g. dilated stomach in cases of duodenal atresia) or the demonstration of abnormal growth rates (e.g. short limbs in dwarfism). With the advent of newer machines particularly with zoom facilities structural anomalies are easily diagnosed.

Fetal cardiac scanning requires more skill than scanning most other organs. The "4 chamber view" is the basic view used to study the fetal heart and allows visualisation of the two ventricles, the atrioventricular valves and the two atria. Gross cardiac anomalies can be excluded in the presence of a normal "4 chamber

view"[13]. Although other views can be used to visualise various parts of the heart and great vessels this needs experience. The outflow tract should also be studied in the basic examination of the fetal heart. Colour flow mapping also plays an important role in diagnosing fetal anomalies which cannot be detected by ordinary ultrasound[14].

As well as the detection of anomalies, ultrasound plays an important role in the early diagnosis of multiple pregnancies (particularly IVF) thereby allowing closer scrutiny and intervention (fetal reduction) in selected cases.

(b) **Transvaginal ultrasonography**

The application of solid state technology has enabled the conversion of what was formerly a bulky mechanical sector scanning head into a rather smaller and sleeker scanning probe. This has enabled easy insertion of the probe into the vagina for visualisation of the pelvic organs. As the pelvic organs are now very much closer to the scanning head, higher frequencies can be used viz 5 and 6.5mHz, thus resulting in images with resolution. Visible signs of pregnancy may be observed as early as four to five weeks amenorrhoea. Complications of pregnancy may also be confirmed and treated at an earlier stage, thereby reducing maternal complications and morbidity, eg. anencephaly may be diagnosed on vaginal scanning in the first trimester and suction termination may be performed with minimal risk to the mother. With newer machines many fetal abnormalities eg. omphalocele, limb deficiencies etc can be diagnosed in late first trimester and early second trimester[15].

Diagnosis of placenta praevia can also be made more accurately with the use of the vaginal proble, especially in cases of posterior placenta, without any additional risk to the mother. This has revolutionised the diagnosis of posterior Type 2 praevias which formerly was difficult to visualise clearly[16].

With the introduction of colour doppler to the vaginal probe, advances obtained from the usage of colour doppler in abdominal ultrasound technique may now be employed in vaginal ultrasound scanning[17]. Cardiac anormalies can now be diagnosed with the colour doppler in the first trimester, resulting in greater options for the parents and easier obstetric decision making.

(c) **Echocardiography**

The possibility of cardiac anomaly is the most common indication for fetal echocardiography. M mode echocardiography has also proved to be a valuable tool in the evaluation of fetal arrythmia. It has also been found to be useful in IUGR where ventricular size can be measured accurately and the ratios of the 2 ventricles compared[18]. Colour doppler assessment of the fetal heart can also be used to complement conventional ultrasound and M mode studies and should be an integral part of cardiac examination to clarify structure as well as function.

(d) **Ultrasound in prenatal diagnostic procedures**

Ultrasound contributes to the detection of fetal abnormality, as a guide to many

diagnostic procedures namely, chronic villus sampling, amniocentesis and cordocentesis. These techniques would have been dangerous, if not impossible prior to the advent of ultrasound scanning.

Ultrasound examination is used to select the site for amniocentesis. Ultrasound guided puncture of the umbilical cord (Cordocentesis) is the current method of fetal blood sampling. The indications for fetal blood sampling have evolved from primarily the prenatal diagnosis of hereditary disorders to the prenatal diagnosis of fetal hypoxia and the prenatal treatment of fetal anaemia. However placental biopsy (chronic villous sampling) under ultrasound guidance, together with recombinant DNA techniques can now be used in the first trimester of pregnancy to diagnose the majority of those genetic conditions that previously required second trimester fetal blood sampling. Biopsies of various fetal organs can also be carried out under ultrasound guidance.

III ULTRASOUND ASSISTED INTRAUTERINE THERAPY

High resolution ultrasound has enabled the detection of congenital anomalies in the prenatal period. Attempts have been made to treat these conditions in utero to minimise or obviate the damage. Ventriculo-amniotic shunts have been performed for hydrocephalus and vesico-amniotic shunts for urethral obstruction. The outcome of these procedures has been evaluated and preliminary results are disappointing[19].

Intrauterine intravascular transfusion in cases of rhesus isoimmunisation however has become standard treatment and the outcome in such cases has improved in recent years as a result of this new technique.

In conclusion with the advent of better computer technology and probe design ultrasound machines are becoming more sophisticated and are a great boon in the diagnosis and management of the Obstetric patient.

References

1. Peisner DB. Transvaginal Sonography: Equipment. In: Timor-Tritsch I.E. and Rottem S. (eds) Transvaginal Sonography. New York: Elsevier, 1991:29-59

2. Robinson H. Sonar measurement of fetal crown rump length as means of assessing maturity in the first trimester of pregnancy. Br Med J 1973; 4:28

3. Robinson HP. "Gestational Sac" volumes as determined by sonar in the first trimester of pregnancy. Br J Obstet Gynaecol 1975; 82:100-107

4. Bezjian AA, Salman F, Borok K. Sonographic evaluation of fetal maturity. In: Berkowitz RL, Chohen CJ and Kase NG. (eds) Obstetric Ultrasonography, New York: Churchill Livingstone, 1988;

5. Dorovini-Zis K, Dolman CL. Gestational development of the brain. Archives of Pathology and Laboratory Medicine 1977;101:192

6. Zilianti M, Fernandez S. Correlation of ultrasound images of fetal intestine with gestational age and fetal maturity. Obstet Gynaecol 1983; 62:569

7. McLeary RD, Kuhns LR. Sonographic evaluation of the distal femoral epiphyseal ossification center. J Ultrasound Med 1983; 2:427

8. Fried AM, Farry K, Mohammed AU et al. Echogenicity of fetal lung: relation to fetal age and maturity. Am. J. Radiology 1985; 145:59

9. Granmum P, Berkowitz R, Hobbins JC. The ultrasonic changes in the maturing placenta and their relation to fetal pulmonic maturity. AM J Obstet Gynaecol 1979; 133:915

10. Manning FA, Harman CR, Lange IR. Fetal assessment by biophysical profile scoring: 1985 update. Eur J Obstet Gynaecol Reprod Biol 1986; 21:331

11. Nakano H. Ultrasound real-time B-mode as a tool for comprehensive study on fetal behaviour. Abstracts XIIIth Asian and Oceanic Congress of Obstetrics and Gynaecology 1991;55.

12. Phelan JP et al. Amniotic Fluid Index Measurement During Pregnancy. The Journal of Reproductive Medicine. 1987; 32:601-04.

13. Copel JA, Pilu G, Green J et al. Fetal echocardiographic screening for congenital heart disease: the importance of the 4 chamber view. AM. J. Obstet Gynaecol 1987;157: 648-655

14. Kurjak A. The use of Doppler ultrasound flow measurement in fetal monitoring. In: E Saling (Ed), Triangle - Current topics in Obstetrics. 1990;29:161-169

15. Bronshtein M, Timor-Tritsch IE, Rottem S. Early detection of fetal anomalies. In: Timor-Tritsch IE and Rottem S (Eds). Transvaginal Sonography. Elsevier, New York 1991; 327-371

16. Farine D, Oppenheimer LW, Timor-Tritsch IE. The use of the vaginal probe in the diagnosis of Placenta Praevia In: Timor-Tritsch IE and Rottem S (Eds). Transvaginal Sonography. Elsevier, New York 1991; 211-223

17. Kurjak A, Zalud I. Transvaginal colour Doppler Sonography In: Timor-Tritsch IE and Rottem S (Eds). Transvaginal Sonography. Elsevier, New York 1991;451-462

18. De Vore GR. Examination of the fetal heart in the fetus with IUGR using M-Mode echocardiography In: Creasy RK and Warshaw JB (eds). Seminars in Perinatology, Philadelphia: Grune and Stratton, 1988; 12:66-79

19. Manning EA, Harrison MR, Rodeck CH. Fetal Surgery: Report of the International fetal surgery registry 1985. In: Berkowitz RC, Cohen CJ and Kase NG (eds), Obstetric Ultrasonography, New York, Churchill Livingstone 1988;95-113