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AN EVALUATION OF B-MODE GREY SCALE REAL TIME ULTRASONOGRAPHY

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ULTRASONIC SCANNING is simple, safe and non-invasive and hence has become increasingly popular over the last two decades. In this article I would like to review the theory and application of this technique based partly on our local experience with a Grey-Scale Real-Time scanner.

THE THEORY OF ULTRASONIC IMAGING

Short pulses of high frequency sound (usually of around 2.25 megahertz) are transmitted and objects (and their relative distance away) are detected from the resulting echo (and the time taken for the echo to arrive).

Piezoelectric crystal transducers are used and these function both as transmitters and receivers. When the transducer is applied to the human body, echoes will be detected from the various organs and tissue planes. The intensity of these echoes is proportional to the difference in the acoustic impedance of the tissues.

Organs are not acoustically homogenous but consist of ramifying ducts, blood vessels etc, hence small intensity echoes will be seen within all organs. Any structure containing fluid (blood, bile or cystic fluid) is acoustically homogenous and will appear as transonic i.e. free of echoes. An ultrasonic examination through the ventricles of the heart may therefore be represented as in Figure 1.

MODES OF DISPLAY

A-Mode (Amplitude Modulation)

In an A-Mode display, the echoes appear as vertical deflections on a horizontal base with the height of the deflection corresponding to the intensity of the echo. A-mode displays are commonly used for echocardiographic studies and in echoencephalography.

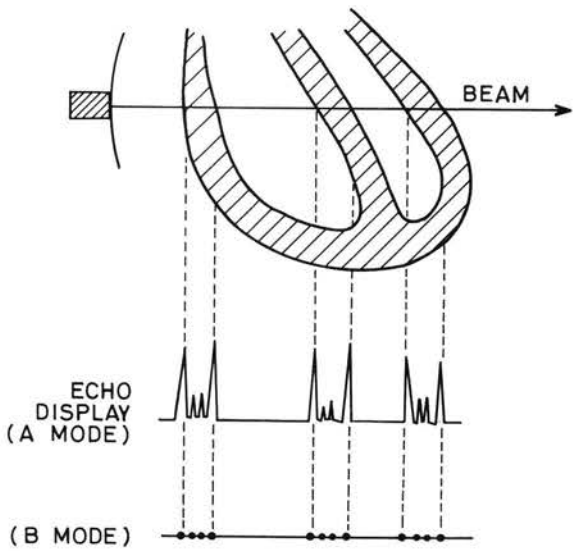

Figure 1: Diagramatic representation of an ultrasonic examination of the ventricles of the heart.

B-Mode

The disadvantage of the A-mode is that two dimensional images cannot be produced. This can be done with B-mode where each echo is only represented by a dot, the intensity of which correlates with the intensity of the echo.

If a storage oscilloscope (one that is designed to retain images for a period) is used, then a two dimensional picture will be obtained by moving the transducer along a plane. The final image is therefore rather like a tomogram at a particular level or plane (See Fig. 2).

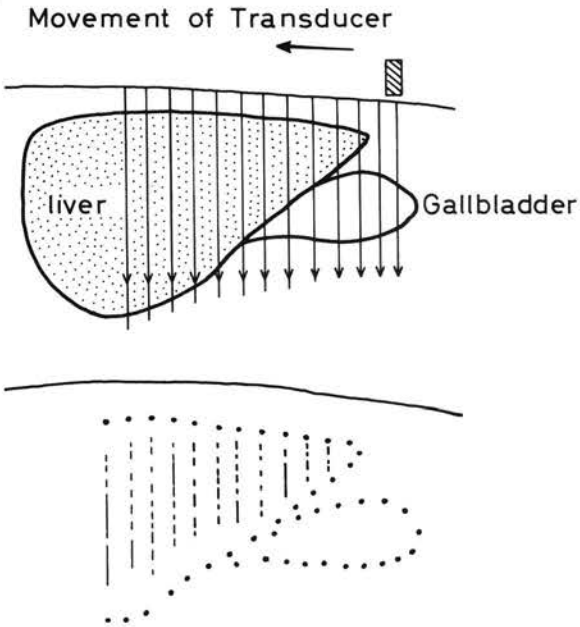

Figure 2: Diagramatic representation of a longitudinal scan of the right upper abdomen. The upper drawing shows the direction of the ultrasonic beam and the direction the transducer is moved. The lower drawing shows the resulting echo image being built up. In actual scans there would not be any gaps between the lines of echoes.

Grey-scale display: Early machines produced pictures in just black and white. Current machines have shades of grey in between. This allows far better visualization of the internal structure of organs.

Real-Time: This is a relatively new facility. Most ultrasonic machines (B-mode) produce just one picture at a time. Real Time machines produce continuous imaging rather like fluoroscopy as opposed to single x-ray plates. Figure 3 shows a real time machine in use.

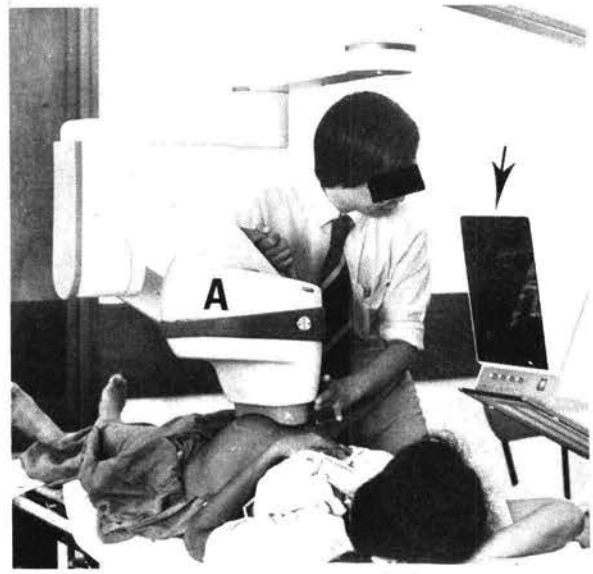

Figure 3: A real-time ultrasonic B-mode scanner in use. The transducer (A) is applied to the patients body and the image appears on the screen (arrowed).

DIAGNOSTIC ULTRASOUND IN MAN

Diagnostic ultrasound is currently used for the examination of:-

1. The brain (mid-line shifts and ventricle size, etc.)
2. The eye (retinal lesions, ocular tumours foreign bodies etc.)
3. The Heart and blood vessels.
4. Obstetrical and gynaecological conditions.
5. Abdomen: particularly the liver, biliary tree and kidney.

We are currently not doing cerebral or ocular examinations, and so will not discuss these further.

Echocardiography cannot be covered within the context of this paper. Suffice to say, it has proved exceedingly useful particularly in the detection and quantitation of mitral stenotic lesion and in the diagnosis of pericardial effusions and cardiomyopathies.

Gyncaeological Studies

Uses include detection of uterine or ovarian tumours and intra-uterine contraceptive device.

Cystic ovarian tumours are particularly easily detectable by this technique.

Obstetrical Studies

In many centers, ultrasonic examination in pregnancy is routine. We have conducted studies here mainly for:-

1. Early diagnosis of pregnancy. The gestational sac may be visualized from about the 5th week. (MacVicar and Donald, 1963). (See Fig. 4).

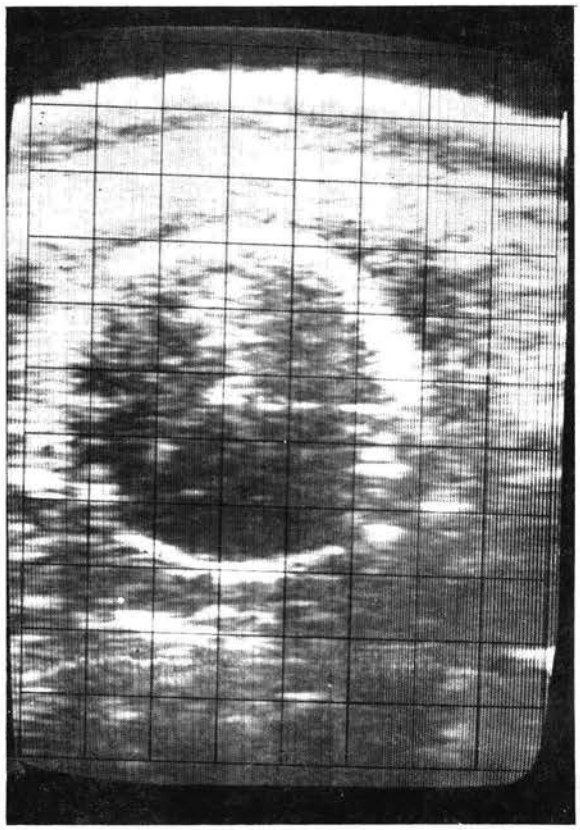

Figure 4: The foetal skull with a clearly defined midline echo. The BPD can be measured from this.

2. Foetal growth (especially in patients with threatened abortions).

3. Estimating foetal age. Foetal dimensions are measured for example the Biparietal Diameter (BPD). (See Fig. 5).

4. Abnormal pregnancies. Experience elsewhere has shown that ultrasound is extremely useful in the diagnosis of molar pregnancies, multiple pregnancies and ectopic pregnancies.

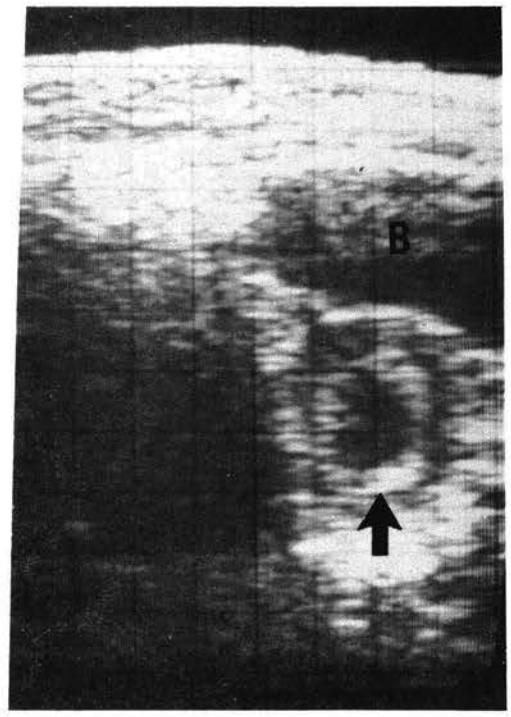

Figure 5: An early gestational sac (arrowed) in the uterus. The bladder (B) lies anteriorly. It is too early to see any foetal parts.

5. Placental localization.

Liver and Biliary Diseases

Taylor and McCready (1976) report good results in the diagnosis of liver diseases (Cirrhosis and tumours) with Grey-Scale ultrasonography. Our own experience has so far been disappointing. This may be related to the resolution and type of transducer used.

However, our results in the diagnosis of obstructive jaundice have been excellent. (See Fig. 6). This is in line with other reports (Stone *et al.*, 1975). Real-time machines have an advantage here in allowing easy differentiation of portal veins and bile ducts.

Other Abdominal Studies

We have found ultrasonic imaging to be very useful in the confirmation of splenomegaly and in the diagnosis of abdominal masses and renal lesions.

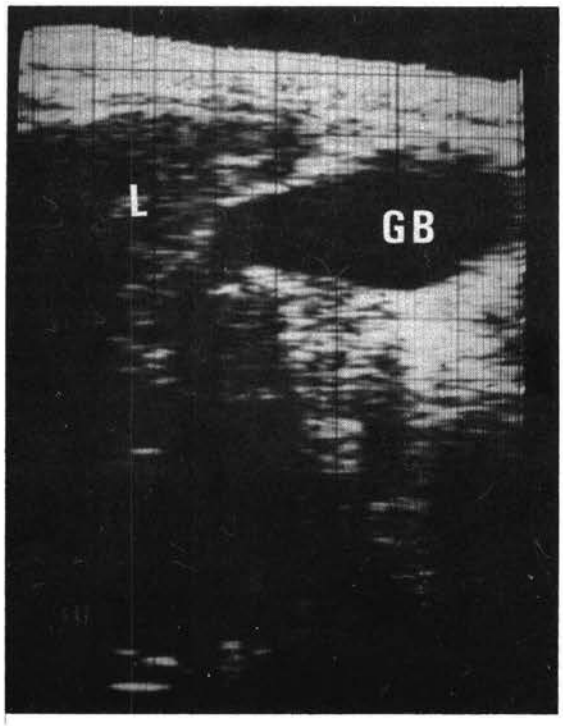

Figure 6: Longitudinal right upper abdominal scan showing part of the liver (L) and a dilated gallbladder (GB).

However gross obesity and the presence of abdominal gas often interfere with the scans. Gas causes absorption and scatter of the sound beam and this explains why the lung cannot be ultrasonically examined.

SAFETY

The great attraction of ultrasonic techniques is their safety. It should be pointed out that it is possible to cause cellular disruptions and chromosomal changes in vitro (MacIntosh and Devey, 1970; Serr *et al.*, 1970). However, these occur at very high energy levels. No such changes have been observed at normal diagnostic energy levels. What is particularly reassuring is that studies have not revealed any increased incidence of abnormalities in the children of mothers who were ultrasonically examined during pregnancy.

CONCLUSION

We have found that ultrasonic imaging to be extremely useful in resolving diagnostic problems in our hospital, particularly for obstetrical patients because of its safety and also for very ill patients who would not able to tolerate any invasive investigative procedures. The additional real time facility of our machine allowed more rapid studies and easier orientation even by relatively inexperienced staff.

What does the future hold? As far as machines are concerned we can expect even better resolutions and more compact devices. As far as its application in this country is concerned, it is expected that many hospitals will eventually acquire ultrasonic scanners. Their initial cost is not too expensive (around $100,000 to $200,000) and running costs are relatively negligible, and technicians can be readily trained to operate the machines.

ACKNOWLEDGEMENT

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