Recent Advances in Perinatal Pathology and Physiology

Edited by

D. N. White

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Recent Advances in Perinatal Pathology and Physiology

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Preface

There is probably no other field in Medicine upon which the development of ultrasonic diagnostic techniques has had a greater impact than obstetrics. Only two decades after its discovery, it is now possible to state that every obstetrical department should have up-to-date ultrasonic equipment and expertise and that no women should go through a pregnancy without at least one ultrasonic examination.
It is necessary therefore that every obstetrician and every general practitioner responsible for the pre-natal care of women, should be aware of the benefits available from ultrasonic diagnosis in perinatology. Not every such practitioner will need to acquire the expertise of the skilled ultrasonographer but he or she must know when to seek such expert help. The situation is analagous to X-radiography. Most physicians should be able to interpret simple radiographs but may need expert radiological help in certain circumstances.

This book has been compiled with these objectives in mind. In contrast to the first volume in this Recent Advances series which was largely aimed at the specialised ultrasonographer, the present volume has been written for an audience of obstetricians and general practitioners. After reading its various chapters such practitioners should be well informed of the help that ultrasonic diagnostic techniques can give to their patients and to themselves. The techniques described are however so up-to-date in a field which has evolved rapidly that it may also be read with profit by ultrasonographers and even those who use the techniques described.

We have come a long way from the time, only a few years ago, when parents, after enduring nine months of gestation, were subjected to the heartbreak of giving birth unexpectedly to an anencephalic monster or fetus with other major congenital defects. The benefits resulting

from the use of ultrasonic techniques are so great that it is no wonder that women are among the most enthusiastic advocates of such examinations. It behoves the medical profession to be no less informed how infertility, pregnancy and the health of the unborn child can be improved.

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Introduction

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The impact of diagnostic ultrasound on obstetric practice may be likened to that of the chest x-ray on respiratory medicine and the EKG on cardiology. In essence it has allowed the obstetrician to "see" through the biological iron curtain of the abdominal wall and uterus, and has allowed him to obtain information about the fetus which would be virtually unobtainable using any other technique. In its short history of less than 20 years the clinical application of diagnostic ultrasound in obstetrical practice has grown from an esoteric research tool used by a handful of seeming eccentrics, to one of the major ancillary diagnostic aids available to this specialty, and one to which the vast majority of obstetric hospitals in the Western world have direct or easy access.

In the following chapters detailed descriptions will be given of the established and research techniques in current use, and of their practical and potential application in the field of perinatology. In this introductory section however, an attempt will be made to provide an overview of the impact which diagnostic ultrasound has made on clinical practice, to highlight the areas where it has become the premiere diagnostic aid, and to try to predict where the newer techniques will fit into the routine care of the pregnant patient.

Basically the types of information to be obtained using ultrasound techniques fall into three broad categories, pictorial, measurement and dynamic information.

The great majority of examinations entail the acquisition of information from at least one and usually all three of these categories, indeed accurate measurement information and, to some extent dynamic information, is largely dependent on good pictorial displays. For example, a crown-rump length measurement of a seven week fetus can only be performed if the equipment is sensitive enough to first allow visualisation of such a small structure, and similarly,

studies on fetal blood flow cannot be contemplated unless the appropriate vessels can first be located and their axes determined. Despite these clear interrelationships it is convenient to consider the application and potential development of ultrasound techniques in obstetrics under these three headings.

PICTORIAL INFORMATION

Given only the capability of making two-dimensional echograms it is still possible to obtain a great deal of important information about many aspects of the developing pregnancy. Some of these are listed below as broad general headings.

(a) Diagnosis of pregnancy
(b) Multiple pregnancy
(c) Recognition of non-continuing early pregnancies
(d) Placental localisation and placental appearances
(e) Visualisation of fetal organs
(f) Fetal abnormality
(g) Differentiation of associated masses.

The introduction of scan convertor "grey-scale" systems has been a major advance in this aspect of ultrasound diagnosis. Not only has it allowed the more detailed inspection of the early pregnancy, the fetus and placenta, but it has also allowed examinations to be performed more rapidly and diagnoses to be made with greater certainty. This latter comment is particularly apposite to the diagnosis of fetal abnormality where the last few years has seen a plethora of reports on the successful detection of a wide variety of anomalies. (See Chapter 6).

As a group fetal abnormalities account for up to 25 per cent of overall perinatal mortality, and those babies with abnormalities who do not die in the perinatal period constitute a significant portion of the individuals in society with permanent physical and mental handicap. Perforce any technique which permits early diagnosis and selective termination of pregnancy will help reduce this burden on society and on the individual family units. In a more indirect way careful placental localisation in the early second trimester is an important factor in making diagnostic amniocentesis and fetoscopy safer techniques for those pregnancies which are subsequently shown to be normal. (See Chapter 5).

Apart from the more obvious use of ultrasound as a means of diagnosing placenta praevia, studies of "placental tissue appearances" as described by Dr. Garrett in Chapter 5 may well provide valuable additional information in assessing cases of suspected intrauterine fetal growth retardation.

While the problems of spontaneous abortion are not strictly relevant to perinatology per se, the impact which diagnostic ultrasound has made in the field of early pregnancy and its complications deserves particular mention. In

conjunction with established dynamic methods of detecting early fetal life (Doppler, combined section-scan and A-mode) an experienced examiner can make a definitive diagnosis of a continuing pregnancy from as early as six and a half weeks (menstrual age). Conversely, the majority of non-continuing pregnancies can be recognised as such, even before the first signs of bleeding become evident. This facility of early and exact diagnoses has helped dispel much of the mystique which had hitherto surrounded early pregnancy, and has given the obstetrician the option of interrupting a pregnancy which is seen to be non-continuing. Application of this more active approach has resulted in a reduction of the average length of hospital stay for patients "threatening to abort", and has allowed more effective use to be made of available hospital beds. Furthermore, patients are spared the prolonged uncertainty which was previously common when intermittent bleeding occurred in the early weeks of pregnancy.

Before leaving the "pictorial" aspect of ultrasound diagnosis it must be stressed that the quality of ultrasound displays is largely a function of the skill of the operator in the use of his equipment, and the interpretation of the images largely a function of the operator's insight into the problems and pathology of pregnancy.

MEASUREMENT INFORMATION.

It is in the area of measurement that ultrasound diagnosis in obstetrics has made its greatest contribution over the last ten years. However, before discussing the various measurements which are now being performed, and their importance to clinical practice, it is relevant to emphasize once again that without good pictorial displays measurements of the pregnancy and fetus would either be impossible or their accuracy and reliability would be of doubtful value.

Basically, ultrasonic measurements in pregnancy are directed towards the prediction of gestational age and the diagnosis and assessment of intrauterine growth retardation.

Prediction of Gestational Age.

An accurate knowledge of gestational age is fundamental to the management of pregnancy, be it complicated or uncomplicated: almost every decision made during the antenatal period takes "age" into account: the majority of the tests of fetal well-being depend for their optimal interpretation on a knowledge of "age"; and finally, management of many neonatal problems again may vary according to fetal "age".

The ultrasound techniques employed for the assessment of this important parameter, together with their relative accuracies and potential sources of error, are well described in Chapters 2 and 3. From a practical stand-

point the message is quite clear, the earlier the patient is referred for examination the more accurate will be the resulting estimate, with a crown-rump length measurement in the first trimester giving the most reliable data.

While every obstetrician acknowledges the importance of gestational age in clinical practice the proportion of patients which they refer for ultrasound assessment varies considerably. There are those for example, who only refer "high-risk" patients whose "dates" are uncertain. Alternatively, there is a growing body of support for scanning every patient during the first half of pregnancy. Proponents of this latter view consider that up to 75 per cent of the pregnancy population either have some factor in their menstrual histories which would cast doubt on the use of the last menstrual period as a sound base from which to calculate age, and/or, have a past or current problem which might necessitate premature delivery of their pregnancies.

Arguing that 75 per cent of the population have good and valid indications for an early scan to establish gestational age, it is felt that expansion of the service to cover the remaining 25 per cent who have impeccable dates and low-risk pregnancies is a relatively small step and one which is justified by the occasional detection of an unsuspected multiple pregnancy or missed abortion etc. In addition, it is easier logistically to perform a scan on everyone rather than having to undertake selection. Appreciating the costs involved both in financial terms and in terms of available manpower, the trend seems to be towards integrating an early examination into the early stages of every patient's routine antenatal care. This type of service is already operating in a number of specialised centres.

The Diagnosis and Assessment of Intrauterine Growth Retardation (I.U.G.R.).

Any comment on the efficacy of ultrasound in this area must be viewed against the disappointing pick-up rate of growth-retarded pregnancies by clinicians, being variously estimated at between 25 and 40 per cent. Since the remaining 60 to 70 per cent of patients are never suspected antenatally of having a "small" baby they are therefore seldom referred for ultrasound evaluation unless they have a relevant past or other current problem which the clinician considers might be associated with fetal undernutrition.

The ultrasound techniques and measurements, currently in use for the diagnosis and assessment of suspected IUGR, are considered in depth by Dr. Meire in Chapter 3 and need not be elaborated upon further in this introduction.

There are however, two points of practical philosophy which merit attention. Firstly, while serial measurements of fetal growth (head and/or trunk measurements) are frequently very useful in the management of individual

"high-risk" patients, this approach could not be applied to the population as a whole on purely logistical grounds. Secondly "static" measurements give no indication of when the fetus might be in danger of intrauterine death, and conversely provide no absolute reassurance of fetal well-being.

Bearing in mind these points and the poor rate of clinical suspicion, there might be merit in redirecting the resources of Ultrasound Departments away from time-consuming serial studies on individuals to single screening examinations of larger numbers late in pregnancy. A number of recent reports suggest that a combination of measurements of the fetus and/or uterus might yield an 80 per cent or higher pick-up rate of IUGR pregnancies with a false-positive rate of an acceptable level. However, these studies need to be confirmed and their cost-effectiveness and clinical benefits need to be carefully assessed before they can be commended for general application.

DYNAMIC INFORMATION

Under this heading might be included the following:

(a) Detection of fetal body and fetal heart movements.
(b) Detection of fetal chest wall movements
(c) Timing of fetal cardiac valvular movements
(d) Fetal blood flow studies.

Apart from simple fetal heart movement detection techniques, which are now well established, this area is very much one of the major growth points in obstetrical ultrasound research, and one which is certain to become of considerable importance over the next few years.

The principal drive towards the development of these dynamic techniques has been the need in obstetrical practice for a reliable test or tests of fetal well-being. Ideally the test should not only provide warning of impending intrauterine death given a positive result, but, in the event of a negative result, would also provide reassurance that a fetus was highly unlikely to succumb within the ensuing few days. To paraphrase, the need is for a "crisis indicator".

Unlike antenatal fetal heart rate recording which is now well established as a useful though not infallible test of fetal well-being, the techniques detailed above have not yet passed through the research stages to become practical and routine clinical tools (see Chapter 4). However, considerable hope is held out that one or other of these tests of "dynamic function" will eventually meet the clinician's requirements.

In conclusion, a scenario for the future application to routine obstetrical practice of the various ultrasound techniques described above might be as follows: (a) an examination in the first trimester to establish firmly the age of the pregnancy, to detect twins and to exclude

a missed abortion or blighted ovum; (b) a second examination at around 18 weeks to pick up any major fetal abnormality (thereby allowing selective termination of pregnancy), and to identify patients with low-lying placentas; (c) a third examination at 34 weeks as a screen for unsuspected IUGR, and as a final assessment of fetal "normality" and placental position; and (d) the application of dynamic tests of fetal well-being for those pregnancies identified as being "at risk" at the time of the 34th week examination.

Contents

CHAPTER 1

Uterine Anatomy and Function

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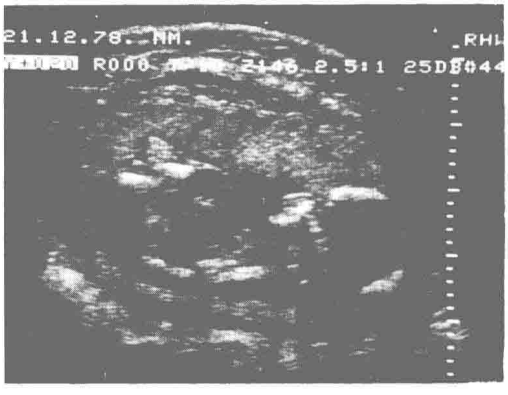
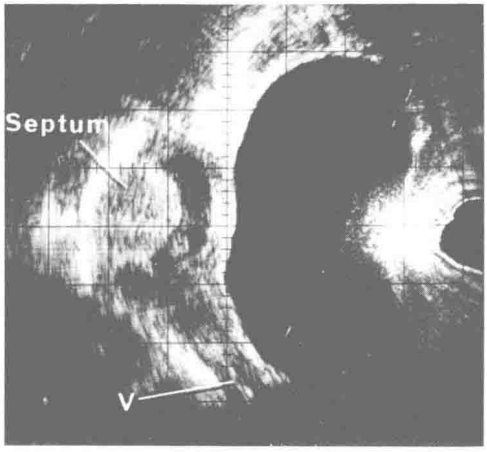
Outer longitudinal and inner circular layers of plain muscle are characteristic of virtually all hollow viscera except the uterus. The uterus is remarkable in having the thickest muscular wall in the body and in being capable of massive distension of physiological hypertrophy. To a casual glance, the distinct muscular layers seen in the gut are not present in the uterus and under the microscope the uterine muscle cells seem more primitive than their counterparts in the alimentary canal. There is a longitudinal midline fasciculus of plain muscle on the serosal aspect of the anterior uterine wall marking the line of fusion of the Mullerian ducts which is best seen at the end of a Caesarean section after ergometrine has been given. Apart from the fasciculus an orderly pattern of the distribution of the muscle is not obvious.

Goerttler (1930) made thick sections of fresh fetal and adult uteri and examined both pregnant and non-pregnant specimens. The sections were dehydrated and gently stretched before dusting with bronze and graphite dust. The excess dust was removed and the distribution and course of the muscle fibres could then be discerned under a strong light. With this technique Goerttler described two separate interlacing spiral systems of musculature, a superficial and a deep. The superficial layer contains both circular and longitudinal fibres whereas the deep layer is very much more complex with fibres running in oblique planes on several axes. In fixed museum specimens two layers may be discerned and in pregnant specimens where shrinkage has occurred a layer of vascular sinuses appears to mark the division between them.

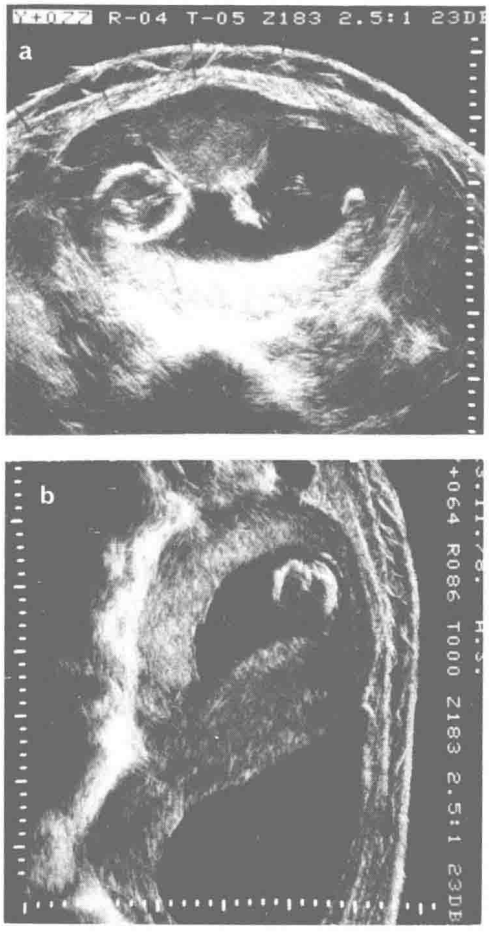
The two layers of the uterine wall may be distinguished in high resolution gray scale echograms in the pregnant uterus. They give a different echo pattern as seen in Figure 1 where the outer more muscular layer returns very few echos compared to the inner layer which here returns high level echoes and is



(Figure 1) Transverse section of the uterus at the 18th week of amenorrhoea showing the two layers of musculature in the uterine wall. The inner more complex layer returns higher level echoes.



(Figure 2) Transverse section of the uterus at 9 weeks amenorrhoea showing a posterior uterine wall septum and crescentic gestation sac (V = vagina).



(Figure 3) An anterior uterine wall septum at 15 weeks not extending to the fundus and showing the two muscular layers,
a. transverse section,
b. longitudinal section.

presumably related to the different muscular content (Schwalm and Dubrauszky, 1966). This picture was obtained on a UI Octoson using two transducers only so the tissue information is accentuated rather than the gross anatomic information which is characteristic of a full compound eight transducer scan. The two transducer technique is a sort of binocular simple scan which is commended for such examinations. Indeed, without this technique it may be difficult to display the two layers in the "normal" uterus which shows virtually no line of Mullerian duct fusion.

The uterine wall is not always of even thickness and it is not uncommon to see a marked myometrial thickening of the anterior or posterior uterine wall. Such thickenings are always in the line of fusion of the Mullerian duct. The distortion of the uterine cavity produced by the thickenings is immediately obvious in early pregnancy when the gestation sac may take on a reniform or crescentic shape as seen in Figure 2.

As pregnancy advances such muscle thickening may persist as a classical bicornuate uterus (*vide infra)* but more commonly remains as an isolated thickening which does not extend to the fundus. These thickenings are usually ovoid in shape with the long axis in the long axis of the uterus. In the early days of ultrasonic echography the thickened areas which I have called septa were mistaken for fibromyomata, but careful examination shows that the two muscle layers described by Goerttler can be seen within them. A typical example on the anterior uterine wall is shown in Figure 3. The gestation sac is reniform in transverse section and the dent on the anterior uterine wall is muscular. It is divided into deep and superficial layers which are continuous with a deep and superficial layers of the adjacent uterine wall. The superficial layers return slightly lower level echoes than the deep layer but this is not so marked as in Figure 1. The echograms in Figure 3 are full compound scans. The septum itself is two-thirds deep layer and one-third superficial layer whereas the musculature of the adjacent uterine wall is approximately half deep layer and half superficial. Confusion with small fibromyomata is understandable but in practical terms is not very important. Confusion of a uterine muscle septum with the placenta or with a succenturiate lobe should not occur with high quality echography. The placenta returns a characteristic gray scale pattern according to the stage of pregnancy (Chapter 5) which should be immediately recognisable.

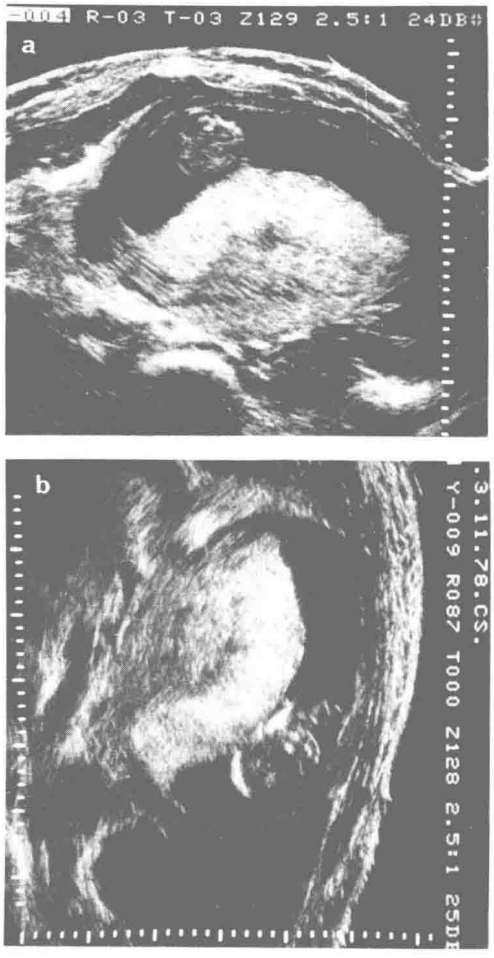
In the longitudinal section (Fig.3b), the extent of the septum is obvious. Unlike a bicornuate or arcuate uterus the septum does not reach to the fundus and at this stage it extends to the internal os. These pictures were taken at the 15th week of amenorrhoea in a

primigravida before the uterine isthmus had unfolded (Ivy, 1942). In cases such as these, the placenta on the posterior wall may have its fetal surface pressed against a septum on the anterior wall and be confused with a central placenta praevia.

The line of Mullerian fusion may be equally prominent on the posterior uterine wall and a similar septum may occur there. The septum in a bicornuate uterus has the well known reputation of being avascular and to this fact is attributed the high rate of spontaneous abortion when the fertilised ovum implants on the septum. Its deficient blood supply is also noted at Strassman's operation when there is almost complete lack of bleeding as the septum is incised. The septa which I have described lower on the anterior and posterior uterine wall appear to have normal vascularity. It is not uncommon to have the placenta implanted on them and such pregnancies appear to be perfectly normal without increased incidence of abortion. In the example given in Figure 4, the two muscle layers can be discerned in the full compound scan. The uterine septa tend to become less marked as pregnancy progresses and many appear to flatten out by the ninth month.

The mechanism of uterine contraction has been much discussed. Malpas (1944) described contractions beginning near the uterine cornua and extending towards the midline down the uterine body in the mid-trimester with the abdomen open under spinal anaesthesia. He found this wave of contractions not obvious at term but Alvarez and Caldeyro (1954) were able to detect it with intramuscular balloon recordings and the disparate views based on pharmacological evidence were shown to have a common background (Garrett, 1959). As the wave of contractions passes over the uterus, intrauterine pressure rises and falls symmetrically, and Buttery (1978) has noted that the uterine septa I have described in late pregnancy thicken considerably during contraction and may almost entirely disappear as the contraction wears off.

Incomplete fusion of the Mullerian ducts may lead to various degrees of bicornuate uterus. This is commonly symmetrical and may be associated with transverse lie with the head in one cornu and the feet in the other. In reporting on echograms showing transverse lie with the spine presenting, it is essential to state whether a fundal septum is present or not as failure to do so may lead the obstetrician into undertaking a very dangerous external version (Garrett, Robinson and Kossoff, 1966). A transverse lie with the spine uppermost and the feet presenting is most commonly seen in multiparous patients with an excess of amniotic fluid and a large floppy abdomen. Occasionally it is associated with a bicornuate uterus with the septum holding the fetal head to one side and a shoulder to the other. Asymmetrical bicornuate uterus is less common and generally is



(Figure 4) A posterior uterine wall septum at 14 weeks not extending to the fundus and showing an overlying placenta,
a. transverse section,
b. longitudinal section.