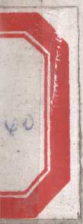


ULTRASONOGRAPHY IN OBSTETRICS AND GYNECOLOGY



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To Karen, Brooke, Melanie, and Andy

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PREFACE

It has been more than five years since the first edition of this text was written. In the interim, I determined to rewrite the entire text on the basis of recent advances in the field rather than simply revise the previous edition.

The success of this text in the past has been due to its practical nature, making it useful to both the novice and the experienced practitioner of ultrasound. Those aims have been maintained in the second edition. In addition to serving as a reference, this text should also be readable enough for each chapter to be read in its entirety. The useful comments of the readers of the first edition have been taken into consideration in the writing of this text.

This text has been enhanced in several ways. First, the number of chapters has been expanded. This allows better coverage of our improved knowledge of both normal and abnormal fetal morphology as well as the newer techniques of Doppler, computed tomography, and magnetic resonance imaging. Second, owing to the complexity and importance of neural axis abnormalities, the chapter on this subject has been significantly expanded. Third, the quality and number of illustrations and line drawings have been increased. The appendix, containing useful tables, has been expanded.

In this undertaking, there are a number of individuals who deserve recognition and my gratitude: the authors, for their excellent, timely, and well-researched contributions to this text; my family, associates, technologists, and colleagues in Obstetrics, for their understanding and support; Lisette Bralow and the people at W. B. Saunders, for their assistance in compiling this text; my secretary, Antoinette Turk, whose tireless efforts and sense of humor kept me going in moments of despair; and last but not least, you, the readers, who have encouraged me to produce this text.

PETER W. CALLEN, M.D.

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THE OBSTETRIC ULTRASOUND EXAMINATION

Peter W. Callen, M.D.

It has been estimated, in some countries, that as many as 90 to 100 percent of women seeking obstetric care will have at least one ultrasound examination during their pregnancy.^{1,2} The increased use of ultrasound during the past several years has prompted inquiries into its safety and quality. As a result of this concern, committees from interested groups such as the National Institutes of Health, the American College of Obstetrics and Gynecology, and the American Institute of Ultrasound in Medicine have established preliminary guidelines for the obstetric ultrasound examination.³⁻⁵

What follows is the author's own bias as to what constitutes an appropriate ultrasound examination. In some respects, this is an expansion of the guidelines previously mentioned. As this multiauthored text is essentially a detailed review of the obstetric ultrasound examination, it is recognized that this chapter and those that follow may reflect differences of opinion.

ULTRASOUND EQUIPMENT AND SAFETY

Equipment

During the past several years, the dramatic improvements in real-time ultrasound

equipment have made it indispensable in the obstetric ultrasound examination because it (1) rapidly, accurately, and safely confirms fetal life; (2) more easily images a moving target such as a fetus; and (3) with its constant feedback of the real-time images and its lesser number of controls, seems more "user-friendly" to many examiners than a static articulated-arm scanner.

With all these advantages, however, this equipment is not without some limitations, its major one being a limited field of view. The small field of view of real-time images makes it more difficult to ascertain fetal lie and presentation, placental relationships to the fetus and uterus, and estimated amniotic fluid volume. In addition, in the real-time examination, the scans tend to be more random and less reproducible than static articulated-arm scans. In an ideal world where cost is not a factor, it might be optimal to utilize both forms of equipment. There have been, however, a number of features made available on real-time scanners to compensate for these deficiencies, e.g., dual-image recording and wider field-of-view transducers.

While the debate over real-time imaging equipment versus articulated-arm scanners has lessened somewhat, there is still controversy regarding sector versus linear array transducers, mechanical versus phased-

array imaging systems, and black on white versus white on black recorded images.

TRANSDUCER SELECTION. When sector transducers first became available, there were a number of problems in obtaining a distortion-free image from which measurements could be made. More recently, most of these problems have been solved. While in most cases the linear array transducer has less distortion and better resolution than sector transducers, the large surface area required for contact of the linear array transducers sometimes makes them problematic.

Phased-array imaging systems likewise suffered initially from poor image quality but now are setting the standard for high-resolution images. The lack of moving parts, and thus the infrequent downtime, as well as the ease of changing image quality by altering only the software, have made them extremely desirable. The major limitation of these systems presently is their high cost compared with mechanical sector systems; however, this is likely to decrease in the future.

The controversy over the best method to interpret images, white on black versus black on white, may never be resolved. This is obviously a matter of viewer preference, and no rigid rules exist in this area. There should be no issue, however, that documentation using "hard-copy" film occurs in every examination.

Safety

The debate over the safety of the obstetric ultrasound examination has intensified during recent years and is likely to continue. The wide and possibly excessive use of this technique has prompted questions concerning safety and the appropriateness of the ultrasound examination. This has led to numerous meetings specifically addressing these issues. Without elaborating on all of the historical background and individual studies concerning safety and efficacy, on the basis of these hearings, it is reasonable to conclude the following:

1. Despite the fact that ultrasound has been in use for over 25 years, there have been no reported instances of adverse effects to the patient or operator from commercially available equipment at diagnostic levels.⁵

2. Animal studies showing a deleterious effect of ultrasound have used energy levels

higher than commonly used diagnostically, and the results of many of these studies have not been reproduced by other investigators. However, the possibility that some information from these studies may be applicable to humans makes it mandatory that well-designed long-term studies be carried out to determine absolutely the effect of in utero ultrasound exposure on the fetus.⁴

Although one may obtain some reassurance of ultrasound's safety from the above two statements, until good long-term studies are carried out, ultrasound, like any other medical test, should be performed only when there are sound clinical indications. The following is the list of indications for obstetric ultrasound based upon the NIH panel that convened in 1983:⁴

- Estimation of gestational age by ultrasound for confirmation of clinical dating for patients who are to undergo elective repeat cesarean delivery, induction of labor, or elective termination of pregnancy.
- Evaluation of fetal growth (when the patient has an identified etiology for uteroplacental insufficiency, such as severe preeclampsia, chronic hypertension, chronic significant renal disease, severe diabetes mellitus, or for other medical complications of pregnancy where fetal malnutrition, i.e., intrauterine growth retardation [IUGR] or macrosomia, is suspected).
- Vaginal bleeding of undetermined etiology in pregnancy.
- Determination of fetal presentation when the presenting part cannot be adequately assessed in labor.
- Suspected multiple gestation.
- Adjunct to amniocentesis.
- Significant uterine size/clinical dates discrepancy.
- Pelvic mass detected clinically.
- Suspected hydatidiform mole.
- Adjunct to cervical cerclage placement.
- Suspected ectopic pregnancy.
- Adjunct to special procedures.
- Suspected fetal death.
- Suspected uterine abnormality.
- Intrauterine contraceptive device localization.
- Ovarian follicle development surveillance.
- Biophysical profile for fetal well-being after 28 weeks of gestation.

- Observation of intrapartum events (e.g., version/extraction of second twin, manual removal of placenta, etc.).
- Suspected polyhydramnios or oligohydramnios.
- Suspected abruptio placentae.
- Adjunct to external version from breech to vertex presentation.
- Estimation of fetal weight and/or presentation in premature rupture of membranes and/or premature labor.
- Abnormal serum alpha-fetoprotein value for clinical gestational age when drawn.
- Follow-up observation of identified fetal anomaly.
- History of previous congenital anomaly.
- Serial evaluation of fetal growth in multiple gestations.
- Estimation of gestational age in late registrants for prenatal care.

THE FIRST TRIMESTER ULTRASOUND EXAMINATION

Identification of an Intrauterine Pregnancy

The primary goal of ultrasound evaluation in the first trimester is to determine whether the pregnancy is intrauterine and whether the embryo is living, if possible. With present-day equipment, both of these tasks should be readily accomplished at very early stages of gestation. The same care taken in concluding that a later pregnancy has a lethal malformation should be applied in deciding that an early pregnancy is nonviable. If there is a reasonable doubt about the viability, a repeat examination in as little as seven to ten days will invariably make the conclusion unequivocal.

Fetal Number

There is no question that, with a careful examination, the true number of embryos can be accurately determined in the first trimester. The literature has emphasized that it is important not to overestimate the number of developing gestations by misinterpreting findings such as a "double sac sign," fluid in the uterine cavity, or the presence of the amnion as evidence of multiple sacs and thus multiple gestations. However, one

may be just as likely to underestimate the number of developing gestations and embryos if a thorough evaluation of the gestational sac is not made for all embryos. It is the author's feeling that when multiple gestations are missed using ultrasound, it is usually from a less than optimal first trimester examination. It is for these reasons that some investigators prefer that if one ultrasound examination is to be done concentrating on fetal number, then it should be in the early to middle second trimester of pregnancy.

Estimating Gestational Age

This subject will be covered in detail in Chapter 4. Suffice it to say that some estimate of gestational age should be performed: measurement of the gestational sac in very early pregnancies and the crown-rump length thereafter. It should be emphasized that the terms "menstrual age" and "gestational age" will be used interchangeably in this text. They both represent the age of the pregnancy based on counting from the first day of the last normal menstrual period. The term "fetal age," representing the age of the fetus from the presumed day of conception (approximately two weeks less than the menstrual or gestational age), will not be used. (See below under Assigning Gestational Age and Weight.)

Placenta

In very early pregnancies, it may be difficult to ascertain the site of the developing placenta. If, however, one can confidently identify the site of placentation, either anterior or posterior, this information should be documented. There are a number of cases in which the early first trimester ultrasound is the only examination obtained during pregnancy. Later in pregnancy, if either an amniocentesis or a cesarean section is planned and no ultrasound equipment is available, it would be helpful to know the location of the placental site from an earlier exam.

Uterus and Adnexa

The maternal uterus should be carefully examined for evidence of uterine anomalies,

particularly in high-risk patients. Late in pregnancy, these anomalies may be extremely difficult to detect. If myomas are detected, their size, site, and relationship to the cervix should be recorded. It should be remembered that transient myometrial contractions may simulate myomas.

The adnexa should be carefully searched for the presence of cysts as well as ovarian neoplasms, both benign and malignant. Again, later in pregnancy, the adnexal areas may be extremely difficult to evaluate adequately.

THE SECOND AND THIRD TRIMESTER ULTRASOUND EXAMINATION

Fetal Number and Fetal Life

Though evaluating the number of fetuses may be difficult during early pregnancy, it should be extremely easy and accurate in the second and third trimesters. The increased perinatal morbidity and mortality of multiple gestations make it mandatory that a "surprise twin" at delivery be a rare event in any patient who has had second or third trimester ultrasound. The major potential error in determining the number of fetuses is underestimation. This mistake, when made, is likely due to either not evaluating the fundal region or not making sure that the fetal head is associated with its body rather than that of a twin. When a multiple gestation is identified, it is important to determine, if possible, the number of placentas and the number of gestational sacs (the chorionicity and amnionicity). This subject will be covered in the discussion of the placenta.

In the ultrasound report, a statement should be made that the fetus was living, if this was the case, by virtue of cardiac motion being identified. Even in a setting where only static scanners are available, positioning the transducer over the thorax and observing under M-mode ultrasound will verify the presence of fetal life. The diagnosis of fetal demise ideally should be confirmed by more than one examiner based on the absence of fetal or cardiac motion for at least three minutes.

Fetal Position

Once fetal life and number have been identified, it is the task of the sonographer to determine the fetal lie and presenting part. Fetal lie refers to the relationship of the long axis of the fetus to the long axis of the uterus. Presentation defines the presenting fetal part closest to the cervix. The most common fetal lie is longitudinal, and the most common presenting part is the fetal head. Fetal lies or presentations other than these are referred to as malpresentations. Their significance lies in increased perinatal morbidity during delivery.

The advent of real-time ultrasound has placed an additional demand upon the ultrasonographer. If the people interpreting the examination have not performed it themselves, they must be able to deduce the lie and presentation from several images rather than from a single one. This may be done only by understanding the normal fetal anatomy and applying it to the scanning position (Figs. 1-1, 1-2). Likewise, congenital anomalies will be recognized only fortuitously if a structure is identified as abnormal by virtue of its abnormal position related to the lie and presentation of the fetus.

As mentioned above, the most common presenting part is the fetal head: cephalic presentation. (The author prefers the use of the term "cephalic," rather than "vertex," as "vertex" may also be used to describe a location on the fetal head.) When the head is adjacent to the lower uterine segment, it is likely that the fetus is in cephalic presentation; however, one must see all images before coming to that conclusion. The fetal body may also be low in the uterus with the fetal head, and thus the fetus would be in a transverse lie rather than in cephalic presentation.

Fetal malpresentations require that the sonographer extend the examination to answer two additional questions important to the referring obstetrician. First, what specifically is the presenting part, i.e., foot, the buttocks, or both in case of a breech presentation or a face or shoulder in the case of a fetus in longitudinal lie (Figs. 1-3, 1-4)? Second, is there an associated fetal malformation or placental abnormality that may be causally related to the abnormal lie?⁶

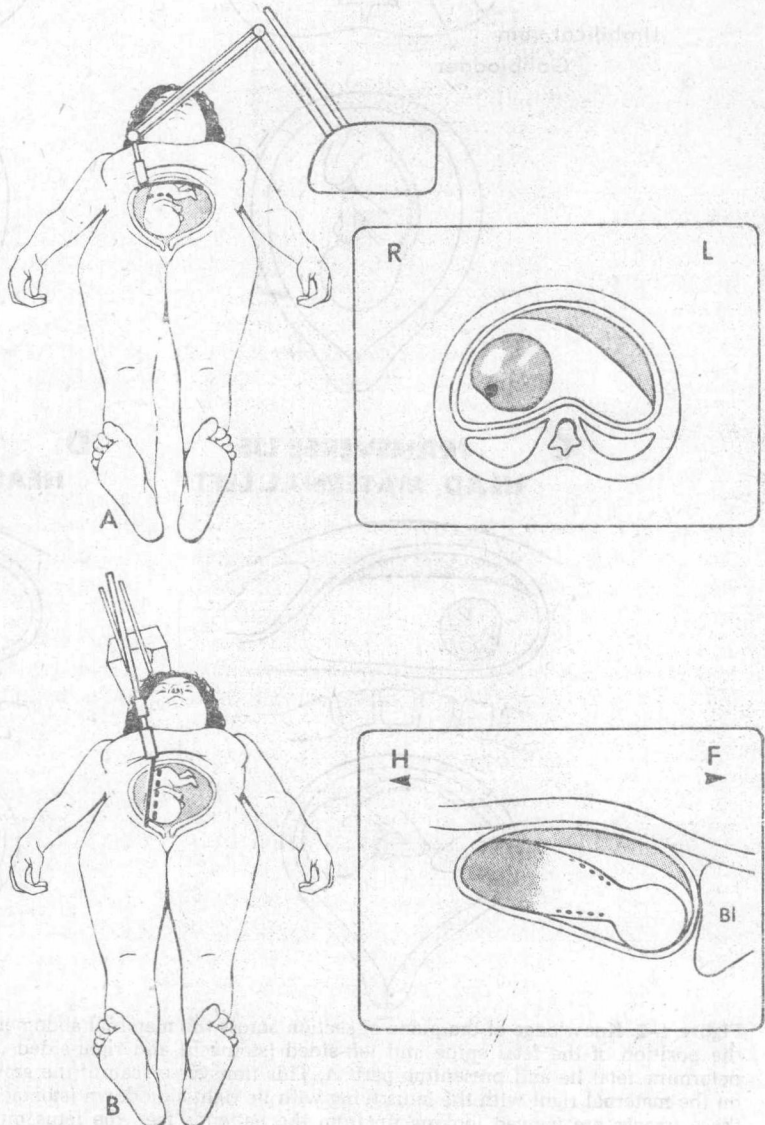


Figure 1-1. A, Illustration of a transverse plane of section of the gravid uterus. As the fetus is in a cephalic presentation, this scan transects the fetal abdomen transversely. B, Longitudinal plane of section of the same fetus. These are viewed with the maternal head to the left of the recorded image.

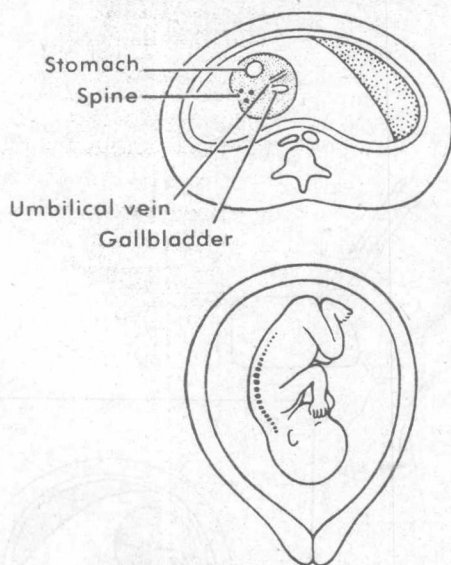
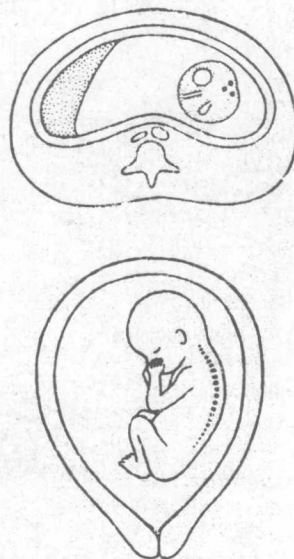
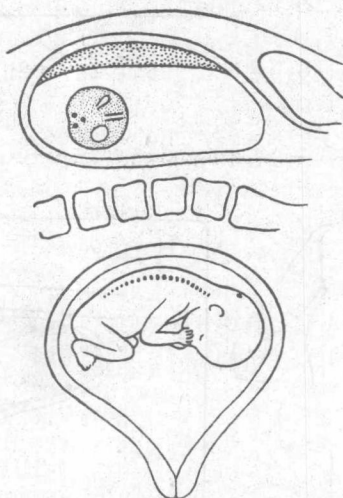
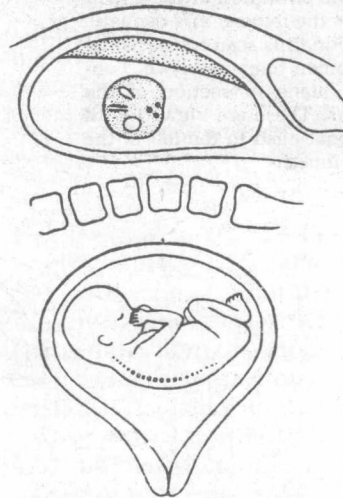
**A LONGITUDINAL LIE
CEPHALIC PRESENTATION****B LONGITUDINAL LIE
BREECH PRESENTATION****C TRANSVERSE LIE
HEAD, MATERNAL LEFT****D TRANSVERSE LIE
HEAD, MATERNAL RIGHT**

Figure 1-2. Knowledge of the plane of section across the maternal abdomen (longitudinal or transverse) as well as the position of the fetal spine and left-sided (stomach) and right-sided (gallbladder) structures can be used to determine fetal lie and presenting part. A, This transverse scan of the gravid uterus demonstrates the fetal spine on the maternal right with the fetus lying with its right side down (stomach anterior, gallbladder posterior). Since these images are viewed looking up from the patient's feet, the fetus must be in longitudinal lie and cephalic presentation. B, When the gravid uterus is scanned transversely and the fetal spine is on the maternal left with the right side down, the fetus is in a longitudinal lie and breech presentation. C, When a longitudinal plane of section demonstrates the fetal body to be transected transversely and the fetal spine is nearest the uterine fundus with the fetal left side down, the fetus is in a transverse lie with the fetal head on the maternal left. D, When a longitudinal plane of section demonstrates the fetal body to be transected transversely and the fetal spine is nearest the lower uterine segment with the fetal left side down, the fetus is in a transverse lie with the fetal head on the maternal right. Although real-time scanning of the gravid uterus quickly allows the observer to determine fetal lie and presenting part, this maneuver of identifying specific right- and left-sided structures within the fetal body forces one to determine fetal position accurately and identify normal and pathologic fetal anatomy.