DIFFERENTIAL DIAGNOSIS OF HYPOECHOIC AND ANECHOIC MASSES WITH GRAY SCALE SONOGRAPHY: NEW OBSERVATIONS

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With the technological advances in gray scale sonography that have permitted the use of higher-frequency transducers and expansion of the acoustic dynamic range, increasing problems in differentiating solid masses and fluid-filled masses have become apparent. These difficulties can be overcome by strict adherence to proper scanning techniques, which involve transducer selection, tissue attenuation compensation, and alterations in patient position. The availability of variable-dynamic-range signal processing and the use of real-time scanning can further increase one's confidence in the correct interpretation of these masses. The primary criteria for determining that a mass is fluid-filled have been expanded to include the presence of reverberation echoes, the "lateral shades" sign, and the presence of septations. In the past, hypoechoic masses with low-level internal echoes were termed "complex." Both fluid-filled masses and solid masses may fall into this category. By use of the sonographic criteria, an attempt should be made to determine whether a mass is primarily fluid-filled or solid. Specific anatomic locations and pathologic conditions in which differential diagnosis may be difficult are illustrated; these include abdominal masses, hepatic and renal masses, and pelvic masses.

Indexing Words: Hypoechoic masses • Ultrasound technology • Tissue attenuation compensation • Ultrasound transducers • Abdominal mass • Pelvic mass • Renal mass

One of the earliest and most accurate applications of diagnostic ultrasound was to determine the solid or cystic nature of a mass (1-4). Following the development of sophisticated technology and equipment capable of expanding the discernible acoustic dynamic range, emphasis has shifted to imaging solid organs with greater resolution. This newer technology has permitted the routine use of higher-frequency transducers (e.g., 3.5 and 5 MHz) for abdominal and pelvic ultrasound examinations. Although these transducers markedly improve resolution, their requirement for increased power to the pulser results in a higher level of background noise. This has led to some difficulty in evaluating hypoechoic and anechoic masses (5).

An attempt will be made to clarify and expand criteria to aid in the differential diagnosis of hypoechoic and anechoic masses. Scanning techniques, general sonographic concepts, and particular anatomic and pathologic problem areas will be discussed.

SCANNING TECHNIQUES

Transducer selection. Modern equipment has been developed to permit optimum use of higher-frequency transducers. Selection of the proper transducer for each patient and each examination may be difficult. In general, the highest frequency that will adequately penetrate the area of interest is suggested. Transducer diameter is important when scanning certain anatomic areas, such as between ribs. The larger the diameter in the higher frequencies, the better the resolution for small reflectors, especially at longer focal zones (5,6).

When evaluating hypoechoic masses, the use of transducers of different frequencies is often required for correct diagnosis. Acoustic enhancement is often better evaluated with a higher-frequency transducer (Fig. 1). Masses with high
attenuation characteristics are best studied with both high- and low-frequency transducers, since attenuation is greater at higher frequencies (Fig. 2). Distinguishing between artifactual echoes and real echoes in a hypoechoic mass is especially difficult when the mass is smaller than 2 cm (1). In order to make this distinction with confidence, one may have to use a lower-frequency transducer (6) (Fig. 3).

**Tissue attenuation compensation.** Proper adjustment of the swept gain with different transducers is essential in obtaining diagnostic scans, especially when evaluating hypoechoic masses. An attempt should be made to obtain echo signals of equal amplitude from equal reflectors at all depths of the object being imaged (3,5,7).

**Dynamic range of signal processing.** In modern gray scale ultrasound displays the echo amplitudes received from the body have a 40-dB range. This range is then compressed into the voltage range to give a full gray scale display. In some cases, varying the range from a full 40 dB to a narrow 10 or 15 dB can help distinguish between cystic and solid hypoechoic masses (5).

**Patient position.** When analyzing hypoechoic and anechoic masses it is important to bear in mind that both the patient's position and the location of the mass can affect the sonographic appearance. Positioning the patient so that the mass is as close as possible to the transducer and is centered perpendicular to the transducer face is helpful when high-frequency transducers are used (8) (Fig. 3). Use of the patient's position to demonstrate acoustic enhancement is important when assessing a mass for cystic characteristics. Acoustic enhancement is possible only when there is an anatomic area into which the sound can travel, as illustrated in Fig. 4.
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FIGURE 3. Small renal cyst. A: Decubitus scan of the left kidney (k) with 3.5-MHz transducer. A small mass (m) is noted on the lateral aspect of the kidney, with diffuse low-level internal echoes. The use of the decubitus position places the mass closer to the transducer for improved resolution. B: Scan in same position with 2.25-MHz transducer. Total absence of echoes can now be appreciated within the mass (m), which represents a renal cyst. By use of a lower-frequency transducer, increased attenuation can be used without sacrificing penetration. Acoustic enhancement beyond the cyst can now be appreciated (arrows).

Real time. With both phased-array and linear-array real-time scanners, artifactual echoes and problems of resolution are common, and they are similar to those encountered with contact scanners. However, the use of real-time scanners does permit easier recognition of acoustic enhancement; this is because the transducer can be held still, and subtle changes in angulation can be made without resorting to compound scanning.

GENERAL SONOGRAPHIC CONCEPTS

Primary criteria. The classic sonographic criteria for fluid-filled structures have been well described (1,2,6,9,10). These include an absence of echoes, smooth posterior wall margins, acoustic enhancement, and A-mode confirmation (Fig. 4B). Most hypoechoic and anechoic masses meeting these criteria will be purely cystic.

Secondary criteria. In a small number of cases secondary criteria are necessary to evaluate confusing masses that may be primarily cystic but may contain internal echoes. These echoes may be artifactual or may represent solid components, as in certain cystic masses or necrotic solid masses.

A narrow band of sonolucency can often be visualized posterior to the sides of cystic masses, at the border of the zone of acoustic enhancement. This sign, termed the "lateral shades" sign, when seen in conjunction with acoustic enhancement, is characteristic of fluid; although it can also be seen in association with solid masses, acoustic enhancement will not be present. The sign is caused by refraction of echoes from the wall or capsule of
the mass and their deflection away from perpendicular transmission. This refraction is caused by the marked change in acoustic impedance between the fluid in the mass and its capsule (11, 12) (Fig. 5).

Another sign based on the change in acoustic impedance is the presence of anterior reverberations. This often annoying artifact may prove helpful in distinguishing between cystic and solid masses. Reverberations seen parallel to the path of sound transmission from the transducer are almost always caused by cystic masses. The depth of the reverberations in a cystic mass is the same distance below the strong interface as the interface is below the skin (5–7). On rare occasions reverberations may occur if the tissue anterior to a solid mass has a markedly different acoustic impedance than the mass or if the mass has an unusually thick capsule.

The presence of septations or papillary excrescences projecting into the lumen of an anechoic mass may be taken with confidence as a sign of fluid content. However, these masses may sometimes represent malignant neoplasms (13) (Figs. 6, 7).

Classification of cystic and solid masses. Most authors divide masses into three major categories: cystic, complex, and solid (14–16). Certain cystic masses such as endometriomas, dermoids, or ovarian cysts with blood or hemorrhagic debris may present with diffuse internal echoes that make it difficult to distinguish them from solid masses without careful evaluation of all ultrasound criteria (15–17) (Fig. 7). Other predominantly cystic masses such as pancreatic pseudocysts and intra-abdominal abscesses or hematomas may also present with diffuse high- or low-level echoes (18, 19). Some solid masses, particularly sarcomas, hypernephromas, lymphomas, and adenocarcinomas, may be diffusely hypoechoic or may have localized areas of necrosis or fluid (14, 20, 21) (Figs. 8, 9). The types of masses just described can be termed complex, but such designation adds little to our knowledge of the exact etiology or content of the mass. It is our belief that use of the term complex to describe masses should be avoided. An attempt should be made to determine if a mass is primarily fluid-filled or solid, using the criteria described, and a diagnosis should be made based on this conclusion.

**FIGURE 5.** Breast cyst with “lateral shades” sign. A sector scan over a breast mass demonstrates an anechoic mass with cystic characteristics (c). There is a narrow band of sonolucency posterior to and on each side of the mass (arrows).

**FIGURE 6.** Cystadenocarcinoma of pancreas with ascites. Transverse scan in the upper abdomen. A large hypoechoic mass is identified in the region of the pancreatic tail. There are septations within the mass (arrows) indicating fluid content. The low-level echoes indicate floating solid material. Ascites is present (curved arrows) because of extensive peritoneal metastases. At surgery the mass was found to be a fluid-filled but malignant lesion. L: liver; m: mass.

**FIGURE 7.** Ovarian endometrioma. Supine sagittal scan of the pelvis with empty bladder. A large hypoechoic mass with smooth borders, acoustic enhancement, and anterior reverberations is identified. There is a septum inferiorly (arrows). There are diffuse low-level echoes within the mass that persist with lower-frequency transducers and represent particles from hemorrhage. Knowledge of this phenomenon and the otherwise cystic appearance of the mass led to the correct diagnosis.
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plus knowledge of the anatomic location of the mass and the clinical presentation of the patient.

SPECIFIC ANATOMIC AND PATHOLOGIC PROBLEM AREAS

In addition to general criteria, there are specific anatomic locations and pathologic conditions in which certain criteria are characteristic and may be helpful in determining the etiology of a hypoechoic or anechoic mass.

In the abdomen, lymphomas, adenocarcinomas (Fig. 8), and sarcomas (Fig. 9) may be hypoechoic or anechoic and may contain areas of necrosis (14,20,22–24). Careful evaluation of these masses may be necessary to determine whether they are cystic or solid. Absence of acoustic enhancement most often will suggest that the mass is solid (Figs. 8, 9), but occasionally a solid mass will demonstrate prominent acoustic enhancement (24) (Fig. 10).

In the liver, metastatic sarcomas, adenocarcinomas, and other cell types have been noted to be hypoechoic or anechoic, thus allowing for confusion with hepatic cysts or abscesses. However, in many cases another pattern of neoplasm will be present in the liver, thus confirming the presence of metastatic disease (21,25).

Renal masses may present with confusing sonographic findings. A sign defining hypoechoic or anechoic masses as cystic, as compared with the kidney or other organ to which they are adjacent or are within, is often reliable (3). Since solid renal masses usually contain some internal echoes, and renal neoplasms are very rarely cystic, an anechoic mass in the kidney will be a cyst in more than 90 percent of cases. However, for a confident diagnosis, it is important that the mass satisfy all criteria for a cyst. Overlap of cystic and solid criteria will be especially troublesome in masses measuring 2 cm or less (1,10).

When evaluating pelvic masses, the bladder and uterus can be used for comparison in distinguishing cystic and solid masses. Hemorrhagic ovarian cysts or endometriomas may contain many internal echoes and may mimic solid masses (15–17) (Fig. 7).

Because of their homogeneity, uterine leiomyomas are often hypoechoic or anechoic, especially with higher-frequency transducers. Such a mass can attenuate sound so much that the far wall of the mass may be difficult to visualize. Use of a lower-frequency transducer will diminish the amount of attenuation and produce further internal echoes. This manipulation can be diagnostic of a uterine leiomyoma (Fig. 2).
In rare instances hypoechoic or anechoic masses may be encountered that cannot be evaluated correctly with ultrasound. In such cases percutaneous aspiration biopsy techniques with thin needles, using ultrasound guidance for needle placement (26), can be used to make or confirm the correct diagnosis.

REFERENCES