Ultrasound as a Useful Imaging Modality for Tumor Detection and Staging

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Abstract

This paper represents an overview of the uses of ultrasound in tumor detection and staging. This modality can detect and define the etiology of a mass and is helpful in staging the neoplasm and in streamlining the diagnostic and/or staging workup. Often a mass can be localized and biopsied or aspirated, leading to prompt diagnosis and treatment. In addition, ultrasound may be used in following tumor progression or regression with treatment as well as secondary effects such as hydronephrosis.

Introduction

Diagnostic ultrasound is one of the newer modalities available to the clinician for evaluating patients for neoplastic processes or for tumor staging. It has several advantages over many other imaging techniques. It is able to present cross-sectional anatomy without radiation in a noninvasive fashion. It is relatively inexpensive compared to other studies and requires little patient preparation, producing little patient discomfort.

The data obtained from the sonographic examination in tumor detection and staging are extensive. First, the presence or absence of a mass can be determined. Multiple or solitary masses can be localized, and their origin, extent, and sonographic characteristics can be defined. A differential diagnosis can be projected based on these findings. If indicated, the demonstrated mass may be localized with ultrasound and a biopsy performed. These all help to streamline the diagnostic workup with prompt and appropriate treatment.

Materials and Methods

All patients were examined with a commercially available static gray scale system using a 2.25- or 3.5-MHz transducer. Transverse and longitudinal scans were performed in supine and/or prone positions, depending on the location of the mass or symptoms. Lateral decubitus positions were used, if indicated, to better evaluate the etiology of some masses. All scans were photographed on film using a multiimager.

Discussion

Tumors evaluated by ultrasound can be divided into 2 groups, palpable masses and nonpalpable masses. The palpable masses can be subdivided into the following: right upper quadrant; left upper quadrant; pulsatile; and right and left lower quadrants. Tumor staging would involve identifying not only the number, location, and extent of masses but also their associated effects such as hydronephrosis.

Tumor Detection

Nonpalpable Mass. An abdominal survey in patients with no palpable masses but with clinical suspicion of neoplasm may reveal no masses. Many times, multiple nonpalpable paraaortic nodes such as those seen with lymphoma or metastatic disease may be identified. These are seen as multiple or solitary relatively echofree masses (lymphoma) or echodense masses (metastatic) bordering the prevertebral vessels (Ref. 22; Fig. 1). Nodes adjacent to the aorta may actually obliterate the boundary between the two (16).

Unsuspected liver metastases may also be identified even without a known primary. Relatively small lesions can be detected because of replacement or distortion of the normal anatomy (11). These may be seen as well-defined echofree, relatively echofree, mixed, or echodense areas within the liver parenchyma (11, 26) or may be seen as an inhomogeneous liver echopattern. Other nonpalpable masses that may be identified with ultrasound are adrenal masses (such as metastases) and retroperitoneal lesions.

Right Upper Quadrant Mass. Masses identified or palpated in the right upper quadrant can generally be identified as relating to the following: the liver, the gallbladder, the kidney, adrenal tissue, the pancreas, the colon, or retroperitoneal tissue.

Hepatic masses are seen as lesions within or extending from the liver (Fig. 2A). Their echopattern varies from echofree, to relatively echofree, mixed, or echodense (11, 26).

The gallbladder can often be confusing to the clinician when it is large enough to present as a palpable mass. On ultrasound, the gallbladder is easily identified by its location, shape, and sonolucency (6, 14, 27).

The clinical value of the ultrasonic examination of renal masses is well established. A simple renal cyst is echofree, is well defined, and exhibits acoustic enhancement (12, 23). The remaining renal masses, which are relatively echofree, mixed, or echodense, may represent such lesions as abscesses, hemorrhagic cysts, cystic tumors, or solid neoplasms (12, 18, 23, 25). These lesions and their renal origin may be best demonstrated on prone scans. Such was the case of the echodense mass seen in Fig. 2B, representing a large diffuse hypernephroma of the right kidney. At times, the mass can be quite large and present as a palpable right upper quadrant mass.

Adrenal lesions generally appear as round to ovoid, well-defined masses suprarenal or anterior to the upper pole of the kidney. They vary from cysts (echofree or sonolucent) (Fig. 2C) to masses that are relatively echofree or echodense (usually tumors) (2). At times, it may be difficult to distinguish renal and adrenal masses unless a cleavage plane is demonstrated.

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Pancreatic pseudocysts appear as rounded, echofree masses in the area of the pancreas in patients with a previous history of pancreatic disease (Refs. 8 and 17; Fig. 2D). Primary tumors of the pancreas appear as lobular masses generally relatively echofree to echodense in the pancreatic area (8, 17). When they present as a palpable mass, dilated intrahepatic and extrahepatic ducts are often seen (Fig. 2E). A cystadenoma and a cystadenocarcinoma may have echoappearances much like that of a pseudocyst (5, 30).

Retroperitoneal masses generally are demonstrated in the posterior abdomen separate from the liver and kidney. If they are quite large, they may appear to be anterior palpable masses. Four different patterns have been identified with these masses: echodense with echofree areas; echodense with a central echofree area; homogeneously echodense; and homogeneously relatively echofree (Ref. 4; Fig. 3B).

Colonic masses, if depicted by ultrasound, may be seen as movable masses separate from the liver, kidney, gallbladder, and pancreas. A colonic lesion may be seen as a relatively echofree mass with a dense center (24).

**Left Upper Quadrant Mass.** Masses found in the left upper quadrant may be classified as splenic, hepatic, renal, adrenal, pancreatic, gastric, colonic, or retroperitoneal in origin. The spleen is easily identified by its shape and location (Fig. 3A). Its echopattern can vary, depending on the disease process involved with it (21).

Hepatic masses, either metastatic or primary (as discussed under right upper quadrant masses), are seen as lesions extending from or within the left lobe of the liver.

A pseudocyst or neoplasm involving the tail of the pancreas may present as a palpable mass (27). The lesions in the tail would look very similar to those in the head (discussed under right upper quadrant masses). At times, it may be difficult to define the origin of the mass (pancreatic tail or adrenal).

An echofree or relatively echofree left upper quadrant mass representing fluid-filled stomach or neoplasm may at times be confused with a retroperitoneal, adrenal, or pancreatic lesion. To exclude the stomach as the possible origin of the mass, the patient may be given some effervescent agent or carbonated drink p.o. (27). Air strongly reflects the sound beam. If the mass is indeed fluid-filled stomach or neoplasm, its sonographic appearance would dramatically change. Gastric masses such as those resulting from primary or secondary cancer or lymphoma may be seen as circular or ovoid relatively echofree masses containing a dense central collection of echoes (19).

Retroperitoneal masses are often large and most often mixed in their echopattern (discussed under right upper quadrant masses) (Fig. 3B). These masses should be demonstrated to be separate from the kidney.

**Pulsatile Mass.** If the patient is evaluated for a palpable pulsatile mass, possible considerations would be a normal aorta, an aortic aneurysm, paraaortic nodes, or masses such as lymphoma or lymphosarcoma.

Lymphomatous nodes may be seen as multiple, relatively echofree paraaortic masses (Figure 1) or may be seen as a large mass encasing the aorta (13). Obliteration of the aortic contour, while the vertebral outline is still preserved, has been proven to be a helpful diagnostic criterion (1).

A normal aorta is often demonstrated in patients with a pulsatile mass. An aneurysm generally is seen as a localized widening of the aorta. A significant advantage of ultrasound is its ability to define accurately the wall of an aneurysm, giving an accurate measurement of its diameter (29). The lumen is seen as the echofree area; the thrombus, clot, or plaque appears as the denser area usually in the anterior portion of the aneurysm (Fig. 4). Not only is the outer wall defined but also the remaining lumen, and the presence and position of the laminated thrombus in the internal aspect of the aneurysm can be determined (29).

**Lower Abdomen Mass.** Masses visualized in the lower quadrants of the abdomen with ultrasound in both sexes (excluding those which are genital in origin) generally are either abscesses, nodal, retroperitoneal or mesenteric in origin. Abscesses, like hematomas, appear as relatively echofree, nonspecific masses (Fig. 5A). The clinical circumstances surrounding these 2 lesions are usually quite different and help to distinguish them. Nodes (lymphomatous or metastatic) appear as multiple relatively echofree to echodense masses along the distribution of the iliopecto muscles (Ref. 16; Fig. 6A). Mesenteric masses are generally changeable in location and position without a specifically consistent echopattern.

If a male is evaluated for a palpable pelvic mass, etiologies to be considered would be nodes (metastatic or lymphomatous), hematomata, abscesses (uncommon), retroperitoneal or the bladder. Multiple nodes, whether metastatic or lymphomatous, in the pelvis would appear as rounded, lobular, or sausage-shaped masses distributed along the iliac vessels anterior to the iliopecto muscles (20). Single or multiple nodes may be seen anterior to the psoas or iliopecto and/or impinging on the lateral or posterior aspects of the bladder (Ref. 20; Fig. 5B). Retroperitoneal nonlymphoid masses are generally mixed to echodense and are usually well defined. Both hematomata and abscesses could appear as relative echofree masses; differentiation is highly dependent on history and physical findings (Fig. 5A). At times, a distended bladder may present as a palpable pelvic or abdominal mass at physical examination. This structure is easily identified by its configuration (round to square, sonolucency, and location (extending from the level of the symphysis) (Ref. 20; Fig. 5C). If there is a question of the etiology, postvoid views can be obtained which should show some change in size. In many cases of a large bladder, an enlarged prostate can be identified as a retrovesical mass posterior and inferior to the bladder (Ref. 20; Fig. 5C).

The sonographic differential diagnosis of pelvic masses in the female is based on size, location, internal consistency, and definition of the borders (7, 10, 15). These masses are usually described as uterine or adnexal and are classified according to echopattern as to whether they are cystic or solid. Uterine masses are those which appear contiguous with the uterus, the most commonly seen being either fibroids (Fig. 5D) or intrauterine pregnancies. The majority of myomas display a homogeneous or mixed echopattern (7). Adnexal masses are those separate from the uterus. Differentiation of tubal from ovarian masses most of the time is difficult. If the mass is purely cystic, it may be an ovarian cyst, an ectopic pregnancy (if history suggests this possibility), a tuboovarian abscess, or endometriosis (Ref. 10; Fig. 5E). If it is mixed, an ovarian neoplasm, a chronic ectopic pregnancy, and a tuboovarian abscess would be considered (10). A solid mass would be consistent with ovarian neoplasm or tuboovarian abscess (10). Ultrasound is a valuable technique both to screen patients with possible...
pelvic masses and to evaluate those with known masses (28). A specific diagnosis is frequently possible.

Tumor Staging

Once a mass is identified and a specific diagnosis is made, ultrasound can be helpful in staging patients. As in the patient with lymphoma in Fig. 1 and the one with metastatic nodes in Fig. 6A, multiple nodes could be identified both in the abdomen and pelvis. It is possible to detect 2-cm lymph nodes in the retroperitoneal area (3). Lesions or metastatic involvement can be detected in the liver as in Fig. 2A and in the kidney as in Fig. 2B.

Secondary effects by the nodes or masses may also be demonstrated with ultrasound. Ultrasound has been shown to be a sensitive technique for excluding urinary obstruction (9). Thus, hydronephrosis due to obstruction of a ureter or both ureters may be detected. The patient in Fig. 6, B and C, had carcinoma of the cervix with a large uterine mass obstructing the right ureter which led to hydronephrosis. The dilated ureter was seen as an echofree mass posterior to the uterine mass in Fig. 6C.

Limitations

Sonographic examination for tumor detection and staging does have limitations. In large patients and in those with a large amount of bowel gas, there is poor penetration of the sound beam and poor resolution. In some cases of liver metastases, no lesions may be demonstrated. This may be due to minimal differences in acoustic impedance between the liver and metastases. Patients with an iliostomy, a colostomy, an incision, or the like may be difficult to examine, as is the uncooperative patient.

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References

Fig. 1. Nonpalpable mass. Lymphoma. Transverse supine scan 8 cm above the umbilicus, demonstrating multiple relatively echofree paraaortic nodes (n). In this patient, hydronephrosis (H) of the left kidney was found, demonstrated by the echo-free area within the kidney. R, right; L, liver; K, kidney; S, spine; M, midline; A, aorta.

Fig. 2. Right upper quadrant mass. A, metastatic liver disease. Longitudinal supine scan at 4 cm to the right of midline. A "bull’s-eye" lesion is noted extending from the inferior aspect of the right lobe of the liver (M). Arrows, outward bulge of the skin line produced by a palpable mass; K, kidney; U, umbilicus. B, renal neoplasm. Prone longitudinal scan at 11 cm to right of the spinous process. A large solid, echodense mass (M) is identified. Normal kidney is not seen. C, iliac crest. C, adrenal cyst. Prone longitudinal scan 7 cm to right of spinous process, demonstrating an echofree suprarenal mass (M) which represents an adrenal cyst. Note the cleavage plane between the kidney (K) and the adrenal mass (arrows). C, iliac crest. D, pancreatic pseudocyst. Supine transverse scan 10 cm above the umbilicus. A large, well-defined, echofree mass (P) is seen in the region of the pancreatic head. R, right; K, kidney; IVC, inferior vena cava; A, aorta; S, spine; GB, gallbladder; M, midline; L, liver. E, pancreatic carcinoma. Supine longitudinal scan 2 cm to the right of midline. A solid, echodense mass (M) is seen inferior to the dilated common bile duct (CBD). PV, portal vein; HV, hepatic vein; IVC, inferior vena cava; U, umbilicus; L, liver.
Fig. 3. Left upper quadrant mass. A, splenomegaly. Transverse supine scan at 4 cm above the umbilicus. The spleen is not normally seen at this level in the abdomen. S, spleen; K, kidney; L, liver; R, right; M, midline; SP, spine. B, retroperitoneal leiomyosarcoma. Transverse supine scan 6 cm above the umbilicus. The large retroperitoneal mass (M) is echodense with relatively echofree areas. K, kidney; S, spine; L, liver; gb, gallbladder; R, right.

Fig. 4. Pulsatile mass. A, aortic aneurysm. Longitudinal supine scan in the midline of the abdomen, demonstrating an aortic aneurysm. The aortic lumen (AL) is seen as the echofree area, and the thrombus or clot is seen as the relatively echofree area (C) anterior to the lumen. U, umbilicus; L, liver. B, aortic aneurysm (same patient as in A). Transverse supine scan at 1 cm above the level of the umbilicus. A large aneurysm is seen with the lumen (AL) represented by the echofree circle and the clot or thrombus (C), being the slightly more echodense area, borders the lumen. S, spine; M, midline; R, right.
Fig. 5. Lower abdominal mass. A. Appendiceal abscess. Supine transverse scan at 9 cm above the symphysis. A relatively echofree mass (A) is seen anterior to the right psoas (P) muscle. M, midline; R, right; S, spine; I, ilium. B, male. Metastatic lymphomatous mass. Supine transverse scan 4 cm above the symphysis. A well-defined, relatively echofree, solid mass (M) is seen impinging on the right (R) lateral wall of the bladder (B). C, male. Distended bladder. Supine longitudinal scan in the midline, demonstrating a markedly distended bladder (B) which extends above the level of the umbilicus (U). An enlarged prostate (P) is seen as an echodense mass in a retrovesicular location. L, liver; X, xyphoid; S, symphysis. D, female. Uterine fibroid. Supine longitudinal scan at 1 cm to right of midline. A large mass (M) of mixed echopattern is seen which is contiguous with the uterus, lower uterine segment, and cervix (C). B, bladder; S, symphysis. E, female. Ovarian cyst. Supine transverse scan 6 cm above the symphysis. An echofree adnexal mass (M) is seen. In this case, it was an ovarian cyst. B, bladder; U, uterus; R, right.
Fig. 6. Tumor staging. A, metastatic nodes from carcinoma of the cervix. Transverse supine scan at 4 cm above the umbilicus. Multiple lobular masses (n) of mixed echodensity are seen, representing the enlarged nodes with metastatic involvement. S, spine; M, midline; R, right. B, hydronephrosis. Prone transverse scan at 4 cm above the level of the iliac crest. The right kidney (RK) is noted to be hydronephrotic (H) by the large echofree area in the region of the collecting system. LK, left kidney; S, spine; L, left. This is the same patient as in C who had a large mass in the pelvis obstructing the right ureter. C, hydroureter with uterine mass. Transverse, supine scan at 4 cm above the symphysis in the patient in B. The patient had cervical carcinoma with a large uterine mass (UM) which was obstructing the right ureter. The ureter is the echofree area (U) posterior to the uterine mass. B, bladder; R, right.
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