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*The value of ultrasound harmonic imaging in the diagnostics
of the abdomen*

In recent years diagnostic ultrasound has greatly improved due to numerous technological developments that enable displaying of new information. The tissue harmonic imaging (THI) is one of new techniques introduced recently. It was introduced in 1997 and is today available in almost all modern ultrasound apparatus. The harmonic imaging is based on nonlinearity of tissue. Ultrasound is generally considered to be conducted in a linear manner whereby the waveform of the pulse is preserved with depth. In fact this is not quite true and nonlinear propagation is an important phenomenon in which the sine wave shape of the original pulse emanating from the transducer becomes so distorted that it comes to contain higher frequency components or harmonics (4,5). In the harmonic imaging the fundamental frequency (usually 2 MHz) is generated by the transducer and the harmonic frequency, usually the second harmonic is received. The fundamental frequency is filtered out, the pure second harmonic is used to generate image (6,8,9).

The harmonic imaging is characterized by narrower beam cross-section than that of the fundamental transmitted by the transducer. The reduced second harmonic beam width can lead to improved lateral resolution (6). The beams generated by an ultrasound transducer not only have a main lobe but also additional, lower level, side lobes. Scattering structures within these side lobes return additional energy to the transducer which gives rise to reverberation or clutter, which makes it harder to distinguish the real structures being imaged. The second harmonic has reduced side-lobe levels resulting in reduction of image noise (1,2,6,8).

In normal imaging multiply reflection from the layers within the body wall near the transducer can give rise to secondary pulses that follow the main transmission. They can be the sources of additional clutter in the image. In harmonic imaging very close to the transducer very little harmonic is generated, thus influences of reverberations in the superficial tissue layers are suppressed (1,5,6,8,9).

The penetration of ultrasound is dependent on frequency. In some situations visualization of deeper regions may be poor. The harmonic imaging allows to use the lower frequencies for transmission, the visualization of deep structures is frequently improved (9).

The aim of the study was to assess the value of harmonic imaging of normal organs of the abdomen and their pathologies.

MATERIAL AND METHODS

The material comprised 85 patients complaining of abdominal pain, in which the ultrasound examination of the abdomen was performed in both normal and harmonic mode. The

examination was performed with the ultrasound apparatus Antares by Siemens, equipped with the proper transducers and the software enabling harmonic imaging.

RESULTS

In 32 patients the presence of the pathology in the abdominal organs was found. In 23 patients the gallbladder stones were seen. In 5 of them the deposits were localized in the cervix of the gallbladder, and in normal mode they were seen only in 2 patients (Fig. 1A, B). In harmonic mode the cervical stones were seen in all 5 patients. In other cases of the gallbladder concrements, they were seen in both imaging modes, standard and harmonic, but in harmonic mode the images were sharper, without artifacts inside the gallbladder. The walls of the gallbladder and the stones were clearer in harmonic mode.



Fig. 1. Concrement in the gallbladder cervix (A – normal mode; B – TH1)

In one patient the cancer of the gallbladder was found. In harmonic mode, the quality of image of the pathology was better. In 7 patients the presence of inspissated bile was found in normal mode, but in harmonic mode it was present only in 5 of them. In the other 3 cases, artifacts in normal mode were responsible for the bad diagnosis. In harmonic mode, the images were clearer, and the intensity of artifacts inside the gallbladder was reduced. In one case contracted, fibrotic gallbladder with multiple concretions was found, and the proper diagnosis was easily made based on the harmonic images (Fig. 2A, B). In one patient the posttraumatic

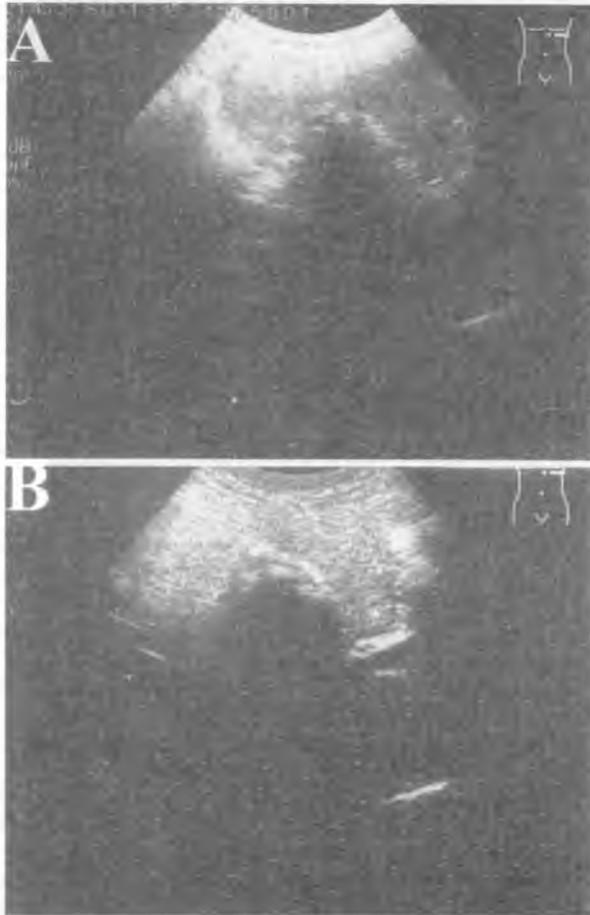


Fig. 2. Fibrotic gallbladder with multiple concretions (A – normal mode; B – THI)

hematoma was found. The images of THI were better, with margins of pathology easier to determine, so the evaluation of the lesion and its evolution over the time was easier in harmonic mode. In one case the cyst of the pancreas was found. It was better visualized in the harmonic mode, and the presence of the internal septa was easier in the THI. In 6 cases the hydronephrosis was found, and the images in the harmonic mode were better. The cysts of the kidney were found in 4 patients. They were better seen on the harmonic images (Fig.3). The prominent renal column was found in 1 case, and its assessment was more accurate in the



Fig. 3. The cysts of the kidney in harmonic mode

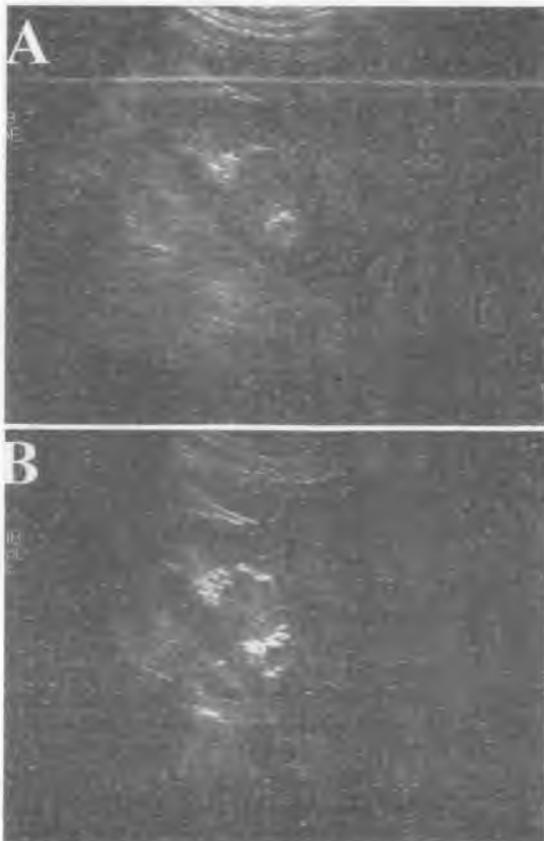


Fig. 4. The prominent renal column (A – normal mode; B – THI)

harmonic mode (Fig. 4A, B). In 3 patients the renal stones were found. They were seen in both harmonic and standard mode (Fig. 5). The hepatic angioma was found in one patient. The harmonic images were sharper, but did not provide additional diagnostic information (Fig. 6). In 1 patient the aneurysm of abdominal aorta was found. In the harmonic mode, the lumen of the dilatated aorta was darker. The walls with the plaques inside and the thrombus inside the lumen were clearer, so the measuring of the lumen and the diameter of the aorta is more precise.



Fig. 5. The renal stone in THI



Fig. 6. Hepatic angioma in harmonic imaging

In one case the complicated cyst of the ovary was found. In the harmonic mode the septa inside the cyst were easy visible, while in the normal mode, the cyst may be assessed as noncomplicated. The thickened intestine wall was found in one patient with the Crone's disease. This was seen on both, normal and harmonic mode. The normal gallbladder, urinary bladder and

big vessels were better seen in harmonic mode. Their images were clearer, the margins were sharper, and the level of artifacts inside them was reduced (Fig. 7).

The images of the parenchyma organs such as pancreas, spleen, liver were better in harmonic mode. Their evaluation was improved in the THI.

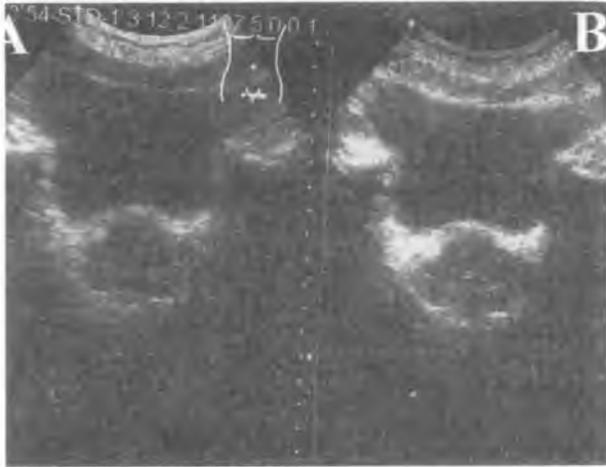


Fig. 7. Urinary bladder (A – normal mode; B – THI)

DISCUSSION

Harmonic images are clearer with higher contrast: this is especially useful in abdominal scanning (5). The minimum noise and clutter in harmonic mode reduces artifacts in liquid cavities, which appear much clearer and darker on images. The tissue harmonic imaging is especially useful in the assessment of urinary bladder, gallbladder, large vessels and their pathologies. The assessment of cysts and differentiation true cysts and cystic tumors may be improved by the harmonic mode.

In evaluation of urinary bladder most of the artifacts degrading bladder images are reduced, and its walls are much better outlined in the harmonic mode (3).

Evaluation of gallbladder wall, its contents and the biliary tree can be improved in harmonic mode, with clearer differentiation of gallbladder sludge from artifacts, and detection of stones (9). This takes place especially in the case of cervical gallbladder stones.

Images of the lumen of vessels also appear with fewer reverberations artifacts and with a darker lumen on harmonic images. So vessel can often be easier to identify and clearer (1,9). The increase in contrast resolution can lead to more confident assessment of abdominal and pelvic masses, particularly in obese patients, differentiating hypogenic solid masses and cystic lesion (9).

The harmonic imaging can lead to a better analysis of tissue parenchyma and a better detection of lesion. The assessment of prominent renal columns may be easier in harmonic mode, so THI may be helpful in differentiation with tumors.

The pancreatic area is sometimes difficult to assess, with a poor contrast between fat and gland and, within the gland, between healthy parenchyma and tumors. Some recent study showed that, for pancreas, harmonic imaging was significantly better than conventional sonography. Visualization of the pancreatic duct and the common bile duct was also improved (9).

The detection of focal liver lesion is often better in harmonic mode, which can increase the liver-lesion contrast, leading to improved detection of hepatic lesions, particularly in patients with viral liver cirrhosis (7,9,10).

CONCLUSION

1. In harmonic mode the level of artifacts generated by the body wall is reduced and contrast resolution is increased due to reduction in noise level.
2. Visualization of liquid structures, such as gallbladder, urinary bladder or large vessels and their pathologies is often improved in harmonic mode.
3. The assessment of gallbladder stones, especially localized in the gallbladder cervix is improved in harmonic mode.
4. The deeper structures are often better seen because of the deeper penetration in harmonic mode.
5. Reduction of artifacts leads to better visualization of low contrast lesions. The US examination of obese patients may be easier in harmonic mode. In some cases, the THI may allow differentiation of hypoechogenic from cystic lesions.

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SUMMARY

The tissue harmonic imaging (THI) is a new modality of ultrasonograph examination. The harmonic mode is characterized by a lower level of artifacts, due to reduction of side lobes energy and narrowed beam. The penetration in harmonic mode is also improved, so the

visualization of deeper structures is often better. The assessment of liquid structures such as gallbladder, urinary bladder or large vessels and their pathologies is usually improved in the harmonic mode. The evaluation of cystic lesions, and differentiation cystic lesions and the hypoechogenic pathologies is easier in THI. Gallbladder stones localized in the gallbladder cervix are better evaluated in the harmonic mode. So the tissue harmonic imaging should be a part of standard ultrasonographic examination.

Wartość harmonicznego obrazowania tkanek w diagnostyce ultrasonograficznej jamy brzusznej

Harmoniczne obrazowanie tkanek jest nową metodą diagnostyki ultrasonograficznej. Obrazowanie w trybie harmonicznym charakteryzuje się zmniejszeniem poziomu artefaktów, poprzez redukcję energii płatów bocznych i węższą wiązkę ultradźwięków. Penetracja ultradźwięków w trybie harmonicznym jest również zwiększona, dzięki temu uzyskiwane są lepsze obrazy struktur głębokich. Ocena struktur zawierających płyn (tj. pęcherzyk żółciowy, pęcherz moczowy, duże naczynia) oraz ich patologii jest zwykle łatwiejsza w trybie harmonicznym. Ocena zmian torbielowatych oraz różnicowanie torbieli od zmian hipoechogenicznych są łatwiejsze w trybie harmonicznym. Złogi pęcherzyka żółciowego zlokalizowane w jego szyi są lepiej widoczne w THI.