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A Statistical Analysis on Association of Tissue Hormonic Imaging and Superior Image Quality

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Abstract

Introduction: Tissue harmonic imaging (THI) is recently introduced as a new imaging technology to improve the ultrasound image quality. Our study aims at to evaluate the statistical association of superior image quality with THI compare to conventional imaging in various types of abdominopelvic lesions.

Material and method: This is a prospective hospital based study done on Philips XD11 HE ultrasound scanner. Patients referred from various other department of our institute for abdominopelvic ultrasound having presence of lesion on ultrasound were included in our study. Ultrasound image of the lesion was archived in THI and conventional mode and comparative analysis was done by the expert radiologists. Then lesion were categorized as per echotexture of the lesion. Statistical analysis was done using Chi-square test.

Result: The statistically significant association was observed of superior image quality and cystic, echogenic lesion on THI compare to conventional imaging ($P<0.001$). No significant association of THI with superior image quality was found for solid, mixed, diffuse echotextural abnormal lesions. However THI had showed superior or equal image quality in higher proportion of these lesions compare to conventional imaging.

Conclusion: Our study supports the application of THI in abdominopelvic imaging.

Keywords: Tissue harmonic imaging, conventional imaging, ultrasound, abdominopelvic.

Introduction

Tissue harmonic imaging (THI) was accidently discovered by the scientists in USA when they were working on the development of microbubbles for contrast in echocardiography. They observed production of tissue image when the receiver was tuned to receive at twice the fundamental frequency. They documented the generation of harmonic frequencies from soft tissue even without the injection of microbubble contrast agents. They also found that harmonic image was superior to the conventional image (CI).[1]

Ultrasound is generally used as first imaging modality in evaluation of abdominal and pelvic diseases either in routine abdomino-pelvic screening or as initial diagnostic imaging in symptomatic patients. Widespread availability and inexpensiveness of this imaging modality has leads to earlier detection of the lesions. Image quality has been suboptimal in obese patients and poor image lead to

uncertainty in ultrasound diagnosis. Improvement in image quality is essential for proper diagnosis and to reduce costly repeat examinations.

Material and method

A prospective study was performed during the period from January 2012 to January 2015. Total 230 patients were studied of which 155 were male and 75 were female. Patients were in age range from 20 to 84 years. Patients referred from various other departments like gastroenterology, urology, nephrology, cardiology, cardiovascular thoracic surgery, chest medicine etc. for abdomino-pelvic ultrasound were included in the study. Patients without any lesion on ultrasound were excluded. Sonography was done on Philips XD 11 HE ultrasound scanner using C5-2 & L11-3 transducers. Images of lesion were obtained by using conventional and tissue harmonic imaging without changing any other parameter. Conventional and harmonic modes were choosen by toggle switch on the control panel. Images were acquired and analyse for image quality. Image quality was defined as overall assessment of contrast of lesion, sharpness in outline of the lesion, absence of artifact and noise. Lesions were classified into five categories (cystic, solid, echogenic, mixed, diffuse) and analysis of superior image quality on THI was done with Chi-square test. Analysis of superior image quality on THI was done with Chi-square test.

Result

Total 478 lesions were detected in 230 patients. Out of total 478 lesions studied 106 were cyst, 102 mixed lesions, 100 were solid, 108 were echogenic and 62 were diffuse abnormality. Presence or absence of the superior image quality in these lesions on THI is shown in Table 1. Organ-wise lesion distribution was 101 in liver, 39 in gallbladder, 68 in billiary tract, 110 in kidney, 37 in pancreas, 15 in spleen, 33 in GIT, 23 in urinary bladder, 17 in uterus, 35 in ovary.

Table 1: Showing different type of lesions and image quality on THI.

S.N.	Echotexture of the lesion	Superior Image Quality		Total
		Present	Absent	
1	Cyst	70	36	106
2	Echogenic	78	30	108
3	Solid	45	55	100
4	Mixed	56	46	102
5	Diffuse echotextural abnormality	25	37	62
Total		274	204	478

Out of 106 cystic lesions 70 (66.03%) showed superior image quality on THI compare to conventional imaging (Figure 1[I]). In 10 (9.43%) cystic lesions conventional image quality was superior compare to THI. Rest 26 (24.52%) cystic lesion showed equal image quality on both imaging techniques. THI showed superior image quality in 78 (72.22%) echogenic lesions compare to conventional imaging (Figure 1[II]). 24 (22.22%) lesions showed no difference between both imaging technique. In 6 (5.55%) lesion conventional imaging showed superior image quality compare to THI. Out of total 100 solid lesions 45 (45%) appeared superior on THI compare to conventional imaging (Figure 1[III]). 35 (35%) lesions showed equal image quality on both imaging. Rest 20 (20%) lesions were had superior image quality on conventional compare to tissue harmonic imaging. Of 102 mixed type of lesions, 56 (54.90%) showed superior image quality on THI (Figure 1[IV]). 26 (25.49%) showed no difference while 20 (19.60%) showed superior image on conventional imaging. Total 62 lesions of diffuse abnormality were detected out of which 25 (40.32%) showed superior image quality on THI, 26 (41.93%) showed superior image quality on

conventional imaging. Remaining 11 (17.74%) lesions did not showed any difference on both imaging (Figure 1[V]).

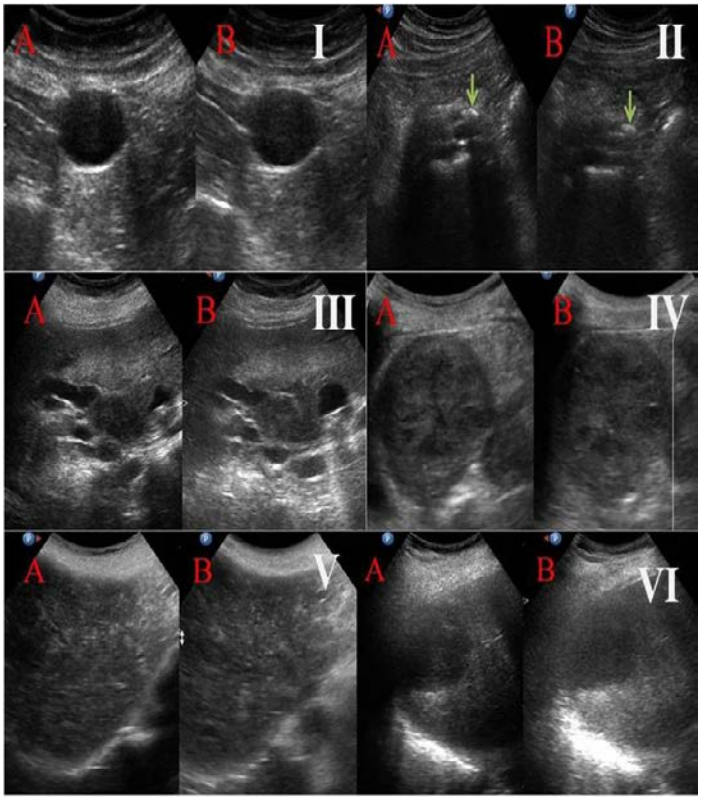

Figure 1 (I-VI): I to VI ultrasound images are showing simple ovarian cyst, calculus, cholangiocarcinoma, mixed neoplastic mass , diffuse echotextural abnormality and abscess in obese patient respectively. A images are showing tissue harmonic image of the lesion while B images are showing the corresponding conventional images of the lesion. Superior image quality is noted in the all tissue harmonic images except in case of V (diffuse ecotextural abnormality) where no difference in the image quality was observed. Image VI is showing superior lesion demarcation and content details on THI in case of abscess in the obese patient.

After applying chi-square test $p<0.001$ was noted for cyst and echogenic tissue, hence difference between THI & CI for these lesions is highly statistically significant for image quality. Other lesions showed $P<0.50$.

Discussion

Sonography is generally used as a preliminary investigation in the patients with symptomatology suggestive of abdomino-pelvic disease. It is noninvasive, safe, cheap and easily available imaging modality important in the lesion characterisation.

Tissue harmonic imaging is a recent innovation in gray scale imaging that has become available in most ultrasound machines over past decades. Harmonic frequencies are integral multiples of the fundamental frequencies. Second harmonic refer to a frequency twice of the fundamental.[2] When ultrasound waves travels through the body, region of high pressure moves slightly faster than region of lower pressure which result in progressive distortion of the transmitted ultrasound waves.[3] Original wave is distorted from a perfect sinusoid shape to a sharper, more peaked, sawtooth shape. These distorted waves contain higher harmonics of the transmitted waves including second harmonic waves. Tissue harmonic image is generated from the echoes returning at second harmonics.[4] The current technology uses second harmonic waves for imaging.[2] Harmonic signals are generated by two different types of processes. One by using filter to screen out fundamental signals from the harmonics and other by using two simultaneous pulses with 180^0 phase difference.[5]

Conventional ultrasound waves are produced at the tissue surface and progressively decreased in intensity as they traverse within the body tissue. In comparision harmonic waves are not produced in superficial part of the tissue. They reached to the point of maximum intensity in the central portion of transmitted wave before they decreased in attenuation.[6-9] Therefore image suffer less from reverberation artifacts which are generated in overlying muscle and fat. Side lobe like low level components of the ultrasound beam are suppressed in THI which result in

clear demonstration of fluid filled structure like gallbladder, urinary bladder, biliary tract and cystic lesion.[4],[10]

Ultrasound beam is not sharp, but has low intensity "skirt". THI reduces these low intensities resulting in a narrow beam. Narrower beam in higher frequency result in better focusing with improve lateral resolution.[4] Higher frequency improves axial resolution which result in improve visualization of smaller objects along beam axis. [2]

We found improvement in total image quality of THI compare to conventional imaging. We attribute this advantage to the improved contrast resolution on THI between the black cystic lesion and the gray or white surrounding soft tissue and reduced reverberation artifact from overlying fat and muscle.[4] On the other hand conventional imaging showed shadows of gray different from surrounding tissue which was obliterated on THI. Cystic lesion appears virtually echo-free, making it easier in assessment. Difference is more easily and quickly appreciated. In our study total image of the cystic lesion was superior in 66.03% on THI. Demonstration of content of the cystic lesion was better with THI compare to conventional imaging. Sometimes in conventional imaging the artifacts occurring within the cyst can confused with true echogenic structure like debries, septations, hemorrhage. With conventional imaging sometimes it becomes very difficult to differentiate hypoechoic lesion from cyst.[2] THI is very useful technique in such conditions. Small cystic lesions did not showed significant difference between THI and conventional imaging because artifactual echoes were not significant even on conventional imaging.

Visualization of highly echoreflective tissue like fat, calculus, calcification and air were demonstrated superiorly with THI with better detection of posterior acoustic shadow. Reduction in side lobe and reverberation artifacts resulted in filling of anechoic region of biliary/urinary tract and acoustic shadow of calculi giving better lesion demonstration.[10] Tissue containing higher proportion of fat have high nonlinearity coefficient. Nonlinearity coefficient is a measure of tissue capability to support a nonlinear wave. Harmonic wave intensity is dependent on this nonlinearity coefficient. Harmonic wave intensity is increase with increase in nonlinearity coefficient. Hence in tissues containing fat increase intensity by harmonic wave improve the lesion image quality.[2] Ortega et al has found the clarity of acoustic shadowing was more on THI in seven out of 17 cases compare to conventional imaging ($P<0.02$, Wilcoxon's signed rank test). They also found that improved visualization of intraductal stone/mass in average 8 out of 17 cases ($P<0.01$, Wilcoxon's signed rank test).[4] In our study we found improved total image quality in 72.22% of highly echogenic tissue on THI.

Our study showed statistically significant association of THI and superior image quality in cystic and echogenic lesions but we could not found statistically significant results for the mixed, solid and diffuse abnormality. The superior image quality had reported in higher percentage of the mixed masse (54.90%) compare to solid mass (45%) and diffuse abnormality (40.32%). In solid lesion we found improvement in demonstration of margin, echotexture, contrast difference between lesion and surrounding tissue. Our study showed that the lesions with superior and equal image quality on THI is higher compare to conventional imaging [96 (90.56%) for cyst, 102 (94.44%) for echogenic, 80 (80%) for solid, 82 (80.39%) for mixed lesion and 36 (58.06%) for diffuse echtextural abnormality].

Sabina choudary et al had found that lesion visibility and diagnostic confidence is clearly better in THI compare to conventional imaging even in obese patients. They also found that the THI is particularly useful in depicting cystic

& echogenic lesions.[2] Artifactual echoes in the obese patient frequently fill the cystic lesion and tissue attenuation makes it difficult to visualize the lesion. Sonographic signals of conventional imaging passess twice through body wall between the lesion and transducer. Thick and attenuating body wall in large patient result in greater beam distortion and artifact production on conventional imaging compare to THI.[4] In THI there is single transmission of sonographic signal through body wall and decreases the effect of body wall.

Conclusion

Our study had showed that the tissue harmonic imaging provides statistically significant superior image quality in cystic, echogenic lesions compare to conventional fundamental imaging. Moreover in other types of lesion it gives superior or equal image quality in higher percentage of lesions. Hence we support the use of THI for abdominopelvic imaging.

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