Original Article

ISSN (0): 2347-338X; ISSN (P): 2347-3371

Role of Tissue Harmonic Imaging in Evaluation of Focal Liver Lesions

Yarramsetti Madhusudana[1], Uma Maheswara Reddy V[2], Pulagam Sindhura[3], K S Vedaraju[4]

[1]Postgraduate, Department of Radiodiagnosis, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: ymadhusudana25@gmail.com, ORCID ID: 0000-0002-4640-9616

[2]Professor, Department of Radiodiagnosis, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: mahesh.rd2112@gmail.com, ORCID ID: 0000-0002-5481-5518

[3]Assistant professor, Department of Radiodiagnosis, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: sindhupulagam@gmail.com, ORCID ID: 0000-0001-9797-5987

[4]Professor and HOD, Department of Radiodiagnosis, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: vedarajuks@yahoo.in, ORCID ID: 000-0002-6995-5919

Abstract

Background: Tissue Harmonic Imaging is based on phenomenon of non-linear distortion of an acoustic signal as it travels through the body. Tissue harmonic imaging has a higher signal-to-noise ratio and fewer side lobe artefacts, allowing for better scanning of obese patients and those with weak acoustic windows, as well as solid and cystic distinction. **Subjects and Methods:** Over the course of six months, we studied 140 patients with liver lesions who were referred to the department of radiodiagnosis at Narayana Medical College in Nellore. Study was performed on GE Voluson expert 730 ultrasound machine using conventional gray- scale and Tissue harmonic imaging (THI) for assessing role of sonography. Two observers used both conventional sonography and tissue harmonic imaging to study 140 patients. **Results:** The study comprised 140 liver lesions, with the first observer ranking THI as better than conventional sonography in 108 lesions (77.1%) for overall image quality and the second observer ranking THI as better than conventional sonography in 100 lesions (71.4%). There was good agreement between two observers for the same (Kappa value 0.64). **Conclusion:** Harmonic imaging improves image quality and improves visualization of internal detail of the lesions. Routine use of harmonic imaging in evaluating all focal liver lesions is recommended.

Keywords: Tissue Harmonic Imaging, Focal Liver Lesions, THI.

Corresponding Author: Dr. Pulagam Sindhura, Assistant Professor, Department of Radiodiagnosis, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: sindhupulagam@gmail.com

Received: 20 March 2022 **Revised: 24 May 2022** **Accepted: 03 June 2022** **Published: 30 June 2022**

Introduction

THI was developed in 1997 after researchers discovered that native tissue can also produce diagnostically helpful harmonic waves while examining the harmonic frequencies produced by insonating microbubbles.[1]
THI is a sort of native harmonic imaging that does not employ microbubbles and instead uses harmonic vibrations that occur naturally in tissue.[2,3]
Tissue harmonic imaging (THI) is a widely used ultrasound diagnostic method. This method generates images with less artefacts than typical fundamental wave US tissue imaging by using higher-frequency harmonic waves generated by nonlinear fundamental US wave propagation. Harmonic frequencies are integer multiples of the fundamental frequency. The amplitudes of harmonic waves are almost always less than the amplitudes of fundamental waves.[4,5,6]
The majority of modern clinical US systems use second harmonic echoes to create THI images. Image processing techniques (such as bandwidth receive filtering, pulse inversion, side-by-side phase cancellation, and pulse-coded harmonics) are employed to remove the fundamental frequency echoes, and the remaining harmonic frequency data is used to generate the diagnostic image.[7,8]
Improved signal-to-noise ratio and less artefacts caused by side lobes, grating lobes, and reverberation are among THI's benefits. THI is commonly utilized in ultrasound and is available on practically all radiology diagnostic imaging equipment.
The goal of this study is to see how effective Harmonic imaging is at detecting focal liver lesions.

Subjects and Methods

The study was conducted using a GE Voluson expert 730 ultrasound machine utilizing standard gray-scale and Tissue harmonic imaging (THI).
Two observers used conventional sonography and tissue

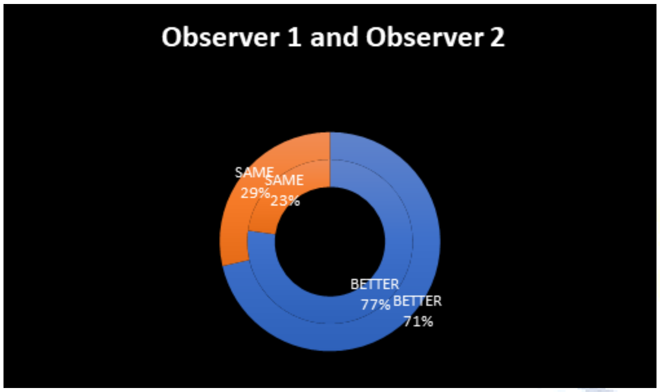
harmonic imaging to examine 140 patients.

Inclusion criteria:
- All the patients referred to our department for the imaging evaluation of suspected focal liver lesions.

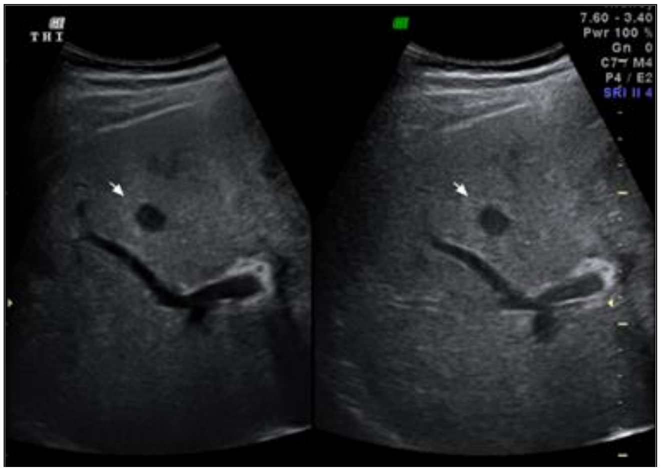
Exclusion criteria:
- Incidentally detected simple cysts
- Follow up not available.

Statistical analysis was performed using IBM SPSS 19 software to obtain statistical Correlation. Kappa values for interobserver variation in tissue harmonic imaging were calculated on the same.

Results



The research comprised 140 liver lesions. For overall image quality, the first observer ranked THI better than conventional sonography in 108 lesions (77.1%), while the second observer ranked THI better than conventional sonography in 100 lesions (71.4%). For the same, there was a lot of consensus between two observers (Kappa value 0.64). In 117 lesions (83.6%), the first observer ranked THI as being better than conventional sonography in judging internal architecture, whereas the second observer rated THI as being better in 114 lesions (81.4%). There was extremely strong agreement between both observers (Kappa value 0.925).



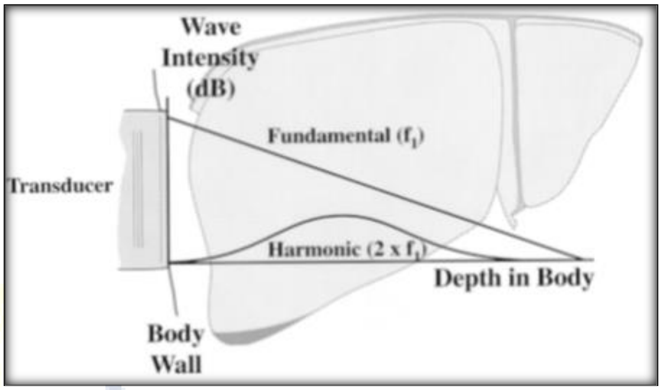
Tissue harmonic image (left) of patient with metastasis showing better SNR and artifact reduction.

Discussion

Tissue harmonic imaging

Tissue harmonic imaging (THI) is a grayscale ultrasound mode that uses harmonic information to provide images of higher quality than standard sonography. As an ultrasonic wave insonates tissues in the body, nonlinear distortion of an acoustic signal produces harmonic waves.[9,10,11]

Integer multiples of a fundamental transmission frequency make up harmonics. Ultrasonic waves created at the transducer's surface, on the other hand, steadily decrease in intensity as they travel within the body.



This picture shows how the relative intensities and frequency changes of harmonic ultrasound beams and fundamental transmission waves change when they penetrate deeper into tissues

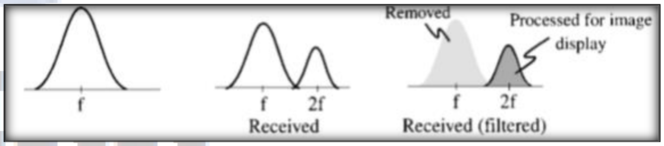
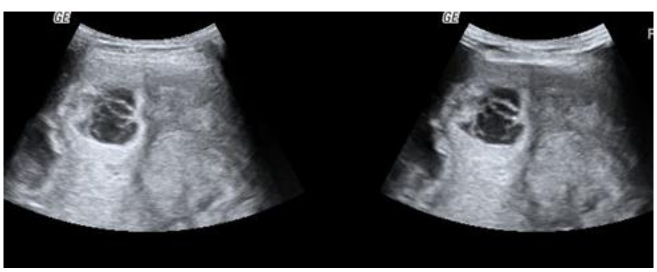


Image showing transmitted and received waves frequency spectrum. The fundamental wave (f) starts at the surface of the transducer and is linearly attenuated as it passes through the body. The harmonic wave (2f) is created as the fundamental wave moves through the body. The harmonic wave increases in intensity exponentially inside the deeper tissues before attenuating. Harmonic imaging uses only the harmonic frequency in the received echosignal by filtering off the transmitted frequency spectrum in the signal.

As the fundamental ultrasonic pulse passes through body tissues, the harmonics intensify. Weak waves, such as side lobes, grating lobes, scattered echoes, and the edges of the main ultrasound pulse, create little or no harmonics. As a result, tissue harmonic images exhibit less side artefacts and better contrast resolution. Harmonics are formed far away from the body wall, and because they are produced in tissues, they only travel through the body wall once, resulting in fewer artefacts.[12,13,14]

Improved axial resolution due to higher frequencies and better lateral resolution due to narrower beams are two potential benefits of harmonic imaging.[8,15,16] Cystic lesions and those containing echogenic tissues such as fat, calcium, or air were particularly well-represented using harmonic

imaging.[16] In patients with a BMI of 30 or higher, harmonic imaging was clearly superior in terms of lesion visibility and diagnosis confidence. Reduced side lobe noise increases signal-to-noise ratios and lowers artefacts.[17,18,19]
Because of the reduced negative effects of the body wall, harmonic imaging is especially beneficial in obese patients. The strength of harmonic waves created is determined by the nonlinearity coefficient (B/A coefficient) of the tissue insonated, which is a measure of a tissue's ability to support a nonlinear wave. When all other variables were identical, nonlinearity coefficients were highest in bodily tissues with a lot of fat, which increased the intensity of harmonic waves created. One of the factors that enhanced lesion appearance in obese patients, whose body walls generally include a substantial proportion of fat, was greater intensity.
The generation of harmonic waves within the body's tissues gave ultrasonic beams a higher effective frequency, allowing imaging without major attenuation or distortion of these waves in the body wall thus allowing for greater depth penetration. Harmonic imaging increased lesion visibility and diagnostic confidence in obese patients. The improvement in lesion visibility was closely linked with an increase in BMI, demonstrating that harmonic imaging is an effective tool for imaging these patients.[20,21,22]
In focal hepatic lesions, Kushaljit Singh Sodhi compared tissue harmonic imaging (THI) with conventional sonography.[23] In fifty patients with localised hepatic lesions, THI and conventional grayscale imaging were used, and two sets of images of the lesions were recorded (one for THI and one for conventional) and analysed for fluid-solid distinction, detail, and overall image quality. These images were compared with the conventional sonographic images and assigned a grade of better, same, or worse. Fine-needle aspiration cytology (FNAC)/surgery/other modalities such as computed tomography (CT) or magnetic resonance imaging (MRI) were used to confirm lesions.



Compare mode to assess conventional gray scale (right) vs Tissue harmonic imaging (left), images were acquired simultaneously in single breath hold.

Tissue harmonic imaging	Our study n=140	Kushaljit singh sodhi et al n=50
Image quality observer 1	108 (77.1 %)	39 (78%)
Image quality observer 2	103 (73.6%)	42(84%)
Internal detail observer 1	109 (77.9%)	38 (76%)
Internal detail observer 2	114 (81.4%)	40(80%)
Kappa for – Image quality	0.65	-
Kappa for – internal detail	0.92	-

THI to be better than conventional sonography in 108 lesions (77.1 %) for overall image quality, second observer ranked 109 lesions (77.9%) to be better than conventional sonography. There was good agreement between two observers for the same (Kappa value 0.65). THI outperformed traditional sonography in determining internal architecture in 117 (83.6 percent) lesions, according to the first observer and in 114 (81.4 percent) lesions, according to second observer. Both observers had a high level of agreement (Kappa value 0.925).
Our study was correlating with study done by Kushaljit singh sodhi etal in first observer ranked THI to be better in 78% patients for image quality and 76 % for internal detail. Second observer ranked THI to better in 80% of cases for internal detail and 84% for image quality.

Conclusion

All the lesions assessed by the observers showed THI to be either superior or same to conventional gray scale imaging in assessing the focal liver lesions, none of the lesions conventional gray scale image were superior to THI.
Few lesions in obese patients which were barely seen on conventional sonography were visualized very well on THI significantly improved the lesion conspicuity. Artifacts were significantly reduced in most cases improving fluid-solid differentiation. We recommend using tissue harmonic imaging routinely as an adjunct for conventional gray scale images in all patients with focal liver lesions.
Harmonic imaging improves visualization, image quality and improves internal detail of the lesions. Routine use of harmonic imaging in evaluating all focal liver lesions is recommended.

References

1. Averkiou MA, Roundhill DR, Powers JE. A new imaging technique based on the nonlinear properties of tissues. Proc IEEE Ultrason Symp 1997;2:1561–1566.
2. Desser TS, Jeffrey RB Jr, Lane MJ, Ralls PW. Tissue harmonic imaging: utility in abdominal and pelvic sonography. J Clin Ultrasound. 1999;27(3):135-42. doi: 10.1002/(sici)1097-0096(199903/04)27:3<135::aid-jcu6>3.0.co;2-p.
3. Ryu JA, Kim B, Kim S, Yang SH, Choi MH, Ahn HS. Ultrasound evaluation of normal and abnormal fetuses: comparison of conventional, tissue harmonic, and pulse-inversion harmonic imaging techniques. Korean J Radiol. 2003;4(3):184-90. doi: 10.3348/kjr.2003.4.3.184.
4. Anvari A, Forsberg F, Samir AE. A Primer on the Physical Principles of Tissue Harmonic Imaging. Radiographics. 2015;35(7):1955-64. doi: 10.1148/rg.2015140338.
5. Forsberg F, Shi WT, Goldberg BB. Subharmonic imaging of contrast agents. Ultrasonics. 2000;38(1-8):93-8. doi: 10.1016/s0041-624x(99)00148-1.
6. Kollmann C. New sonographic techniques for harmonic imaging--underlying physical principles. Eur J Radiol. 2007;64(2):164-72. doi: 10.1016/j.ejrad.2007.07.024.
7. Jensen JA. Medical ultrasound imaging. Prog Biophys Mol Biol. 2007;93(1-3):153-65. doi: 10.1016/j.pbiomolbio.2006.07.025.
8. Turner SP, Monaghan MJ. Tissue harmonic imaging for standard left ventricular measurements: fundamentally flawed?

Eur J Echocardiogr. 2006;7(1):9-15. doi: 10.1016/j.euje.2005.08.006.
9. Shapiro RS, Wagreich J, Parsons RB, Stancato-Pasik A, Yeh HC, Lao R. Tissue harmonic imaging sonography: evaluation of image quality compared with conventional sonography. AJR Am J Roentgenol. 1998;171(5):1203-6. doi: 10.2214/ajr.171.5.9798848.
10. Yücel C, Ozdemir H, Aşik E, Oner Y, Işik S. Benefits of tissue harmonic imaging in the evaluation of abdominal and pelvic lesions. Abdom Imaging. 2003;28(1):103-9. doi: 10.1007/s00261-001-0157-x.
11. Ward B, Baker AC, Humphrey VF. Nonlinear propagation applied to the improvement of resolution in diagnostic medical ultrasound. J Acoust Soc Am. 1997; 101: 143–54.
12. Hann LE, Bach AM, Cramer LD, Siegel D, Yoo HH, Garcia R. Hepatic sonography: comparison of tissue harmonic and standard sonography techniques. AJR Am J Roentgenol. 1999;173(1):201-6. doi: 10.2214/ajr.173.1.10397127.
13. Desser TS, Jeffrey RB. Tissue harmonic imaging techniques: physical principles and clinical applications. Semin Ultrasound CT MR. 2001;22(1):1-10. doi: 10.1016/s0887-2171(01)90014-9.
14. Lencioni R, Cioni D, Bartolozzi C. Tissue harmonic and contrast-specific imaging: back to gray scale in ultrasound. Eur Radiol. 2002;12(1):151-65. doi: 10.1007/s003300101022.
15. Burns PN, Hope Simpson D, Averkiou MA. Nonlinear imaging. Ultrasound Med Biol. 2000;26 Suppl 1:S19-22. doi: 10.1016/s0301-5629(00)00155-1.
16. Choudhry S, Gorman B, Charboneau JW, Tradup DJ, Beck RJ, Kofler JM, et al. Comparison of tissue harmonic imaging with conventional US in abdominal disease. Radiographics. 2000;20(4):1127-35. doi: 10.1148/radiographics.20.4.g00jl371127.
17. Crouse LJ, Kramer PH. Second harmonic imaging: good reverberations. Am Heart J. 1999;138(1 Pt 1):19-20. doi: 10.1016/s0002-8703(99)70240-1.
18. Choi CS, Ku YJ, Yoon DY, Yun EJ, Seo YL, Lim KJ, Baek S, Bae SH, Nam ES. Harmonic ultrasonography for the detection of microlithiasis in the gallbladder. Ultrasonography. 2014;33(4):275-82. doi: 10.14366/usg.14024.
19. Feldman MK, Katyal S, Blackwood MS. US artifacts. Radiographics. 2009;29(4):1179-89. doi: 10.1148/rg.294085199.
20. Harvey CJ, Pilcher JM, Eckersley RJ, Blomley MJ, Cosgrove DO. Advances in ultrasound. Clin Radiol. 2002;57(3):157-77. doi: 10.1053/crad.2001.0918.
21. Powers J, Kremkau F. Medical ultrasound systems. Interface Focus. 2011;1(4):477-89. doi: 10.1098/rsfs.2011.0027.
22. Whittingham TA. Tissue harmonic imaging. Eur Radiol. 1999;9 Suppl 3:S323-6. doi: 10.1007/pl00014065.
23. Sodhi KS, Sidhu R, Gulati M, Saxena A, Suri S, Chawla Y. Role of tissue harmonic imaging in focal hepatic lesions: comparison with conventional sonography. J Gastroenterol Hepatol. 2005;20(10):1488-93. doi: 10.1111/j.1440-1746.2005.03780.x.

How to cite this article: Madhusudana Y, Reddy VUM, Sindhura P, Vedaraju KS. Role of Tissue Harmonic Imaging in Evaluation of Focal Liver Lesions. Asian J. Med. Radiol. Res. 2022;10(1):23-26.

DOI: dx.doi.org/10.47009/ajmrr.2022.10.1.5

Source of Support: Nil, **Conflict of Interest:** None declared.