MAVEN

REVIEW ARTICLE

DIVINE PALPATION EVALUATING TISSUE STRESS

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Abstract

Ultrasound elastography is a non-invasive method to assess the elasticity of soft tissues in response to applied force. This technique works on the principle of strain and shear wave imaging. Abnormal tissue deforms to a lesser extent than normal tissue after compression. Images can be obtained by measuring the amount of tissue distortion under an applied stress. Though it has limited sensitivity and specificity, it can reconstruct tissue elasticity over conventional sonography as well as is valuable in detecting disease process by produc- ing high contrast image. Sonographic elastography is used as a therapeutic tool to explore the causes of muscle pain, understanding of the state of a tissue area and to evaluate treat- ment outcomes. (2018, Vol. 02; Issue 01: Page 31 - 37)

Keywords: Elastography, Strain imaging, Shear wave imaging, Deformation, Force, High contrast.

Introduction

Palpation has been a very old criteria for measuring tissue stiffness and con- sistency. It has been a good clinical method to evaluate the elasticity of an area. As general criteria, malignant tis- sues are said to be stiffer than the normal tissues. Still palpation of very deeper tis- sues and areas was not possible until sci- entists discovered something which can. This article deals with a very new imaging modality technique based on the proper- ties of ultrasound which works mainly upon the properties of tissue stiffness. This modality is known as "ULTRASOUND ELASTOGRAPHY".

Definition and history

Ultrasound is defined by American Na- tional Standards Institute as; "sound at frequencies greater than 20KHz" (1). Sim- ilarly ultrasound elastography is defined as; "An imaging technique where elasticity of tissue is determined non- invasively to differentiate between normal and disesed tissue that helps to evaluate elasticity of soft tissues in response to applied force" (2).

The first recorded evidence for the use of sound in spatial orientation in bats dates back to 1794 by Lazzaro Spallanzani. Ian Donald introduced ultrasound in diagnos- tic medicine in 1956, when he used one- dimensional Amplitude mode (A-mode) to measure the foetal head (3). During 1970s Dr. Kit Hill of Royal Marsden College; Eng- land extracted tissue movement using ul- trasound echoes. Krouskop et al modified the ideas of Dr. Hill in 1987. Dr. J. Ophir and this team members from the Univer- sity Of Texas in 1991 finally explained the principles of elastography. Japanese elec- tronic giants Hitachi produced the first machine for elastography usage in 2003 and called it EUB-8500F (4).

Principle of elastography

The underlying principle explains that upon giving any external compression there is displacement of the underlying tissues which produces some amount of strain or stress. The resultant displace- ment is measured and is further depicted as an image which is called an ELASTO- GRAM. In general malignant tissues are harder than normal tissues so elas- tography is a way to use tissue stiffness for an early diagnosis in accordance with tissue palpation (5).

Elastogram

Elastogram is the image form of ultra- sound elastography. It is of two types – Grey scale elastogram and Colour elasto- gram (6, 7).

In gray scale elastogram the hard areas appear as dark and the soft areas appears as bright (5, 6). In colour elastogram the increasing tissue hardness appears in the ascending order as red>yellow>green>blue (6, 7) (Fig 1).

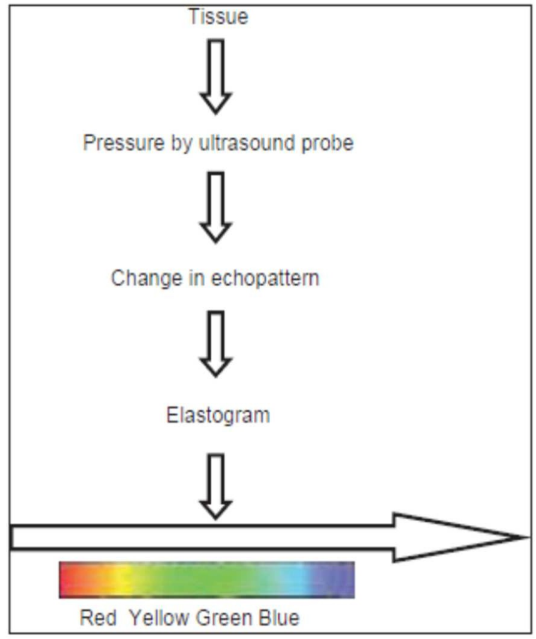

Fig 1: Image is depicting the Basic Princi- ple of working of elastography along with different colour modes that are found in elastograms

Types of elastography tech- niques

Elastography has been classified mainly as 3 types: (2)

Strain elastography/ Quasi- static elas- tography

Shear wave elastography

Acoustic Radiation Force Imaging(ARFI)/ Vibro Acoustography

Strain elastography

It visualizes the strain induced within the tissue using either an external or internal source. It is also called quasi-static elas- tography. The force is applied to 90 de- grees to the tissues (Fig 2). A small motion is induced within the tissue (approxi- mately 2% of axial dimension) with a quasi-static mechanical source. The axial component of the internal tissue displace- ment is measured by performing cross co- relation analysis on pre and post deformed radiofrequency echo frames and strain is estimated by spatially differentiating the axial displacements (8, 9).

Strain imaging has the advantage of being easy to use and providing elasticity images with a high spatial resolution (10). In order to obtain reproducible elastogram com- pression has to be performed at least twice

(11). Strain images basically depict the dif- ference in elasticity of a lesion and the sur- rounding tissue (10).

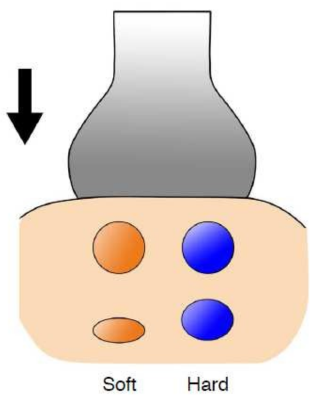

Fig 2: Pictorial representation of force ap- plication which is 90 degree to the source in strain elastography

Shear wave elastography

This method uses acoustic radiation force applied tangentially to generate shear waves in the body (Fig 3). SONIC TOUCH (Ultrasound Transducer) which produces high intensity short duration acoustic pulse is used for this method (11). Fre- quencies used are in range of 50-500 Hz. The shear waves propagate in tissues at a speed of 1-10m/s; consequently they cross an ultrasound image plane of 3-6 cm width in 10-20 miliseconds (12). Elasticity is displayed using a colour coded super- imposed on a B-mode image. Images in the range of 5000-20000 frames per second are obtained.

In case of malignant tumours there is change in velocity of acoustic waves be- cause the tumour area is stiffer than sur- rounding tissues.

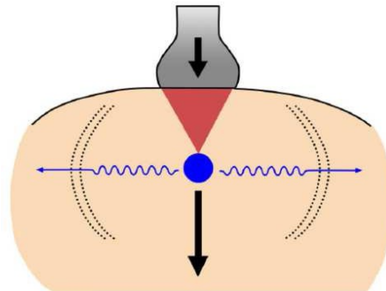

Fig 3: Pictorial representation of force ap- plication which is tangential to the source in shear wave elastography

Acoustic radiation force imag- ing (ARFI)

Acoustic radiation force imaging is also known as vibro –acoustography. Two beams of frequencies in range of 2-5 MHz are used to generate acoustic emission; the difference between the frequencies should be 10-70 KHz. No external com- pression is needed. This technique pro- vides estimation of viscoelastic parameter

(2). Imaging is based on acoustic response of diseased and normal tissue.

Clinical applications in head and neck region

(1) Differentiating Benign From Malignant Cervical Lymph Nodes:

Elastography for assessment of lymph nodes was first used by Janssen et al. Lyshchik et al published one of the first clinical studies to evaluate the diagnostic strength of strain elastography by investi- gating 141 lymph nodes of which 98 were confirmed to be benign and 43 to be ma- lignant by the help of histopathology;

strain elastography demonstrated sensi- tivity of 85% and a high degree of accuracy (13).

The 4-point elastography scale is most fre- quently used for detecting malignant lymph nodes. Out of which scores of 1-2 indicate benign lymph nodes, and scores of 3-4 indicate malignant lymph nodes, which appears as blue area on elastogram (14) (Fig 4, 5)

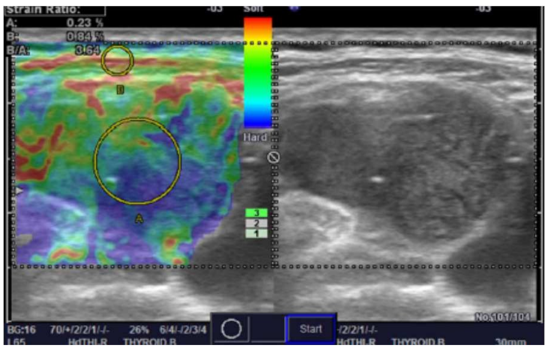

Fig 4: Strain elastogram of Metastatic cer- vical Lymph node

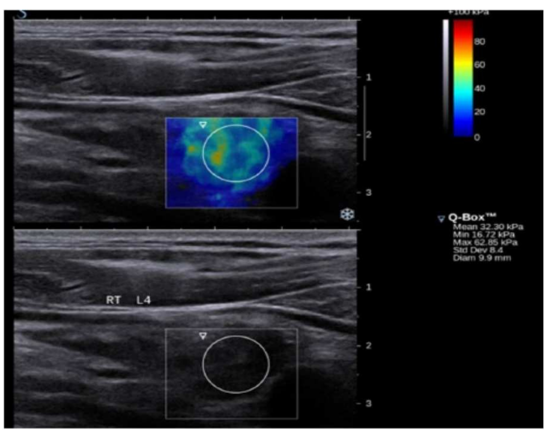

Fig 5: Shear elastogram of Metastatic Cer- vical Lymph Node

(2) Evaluation of Salivary Gland Lesions:

Dumitriu et al evaluated 74 salivary tu- mours (out of these 18 were malignant) using strain elastography and concluded that there was higher strain indices in case of malignant neoplasms than in be- nign ones (15). Anotherstudy by Wierzbicka et al. found Warthin tumours to be elastic(in the colour coding region of blue, green, small parts shaded yellow) and Pleomorphic Adenomas to be predom- inantly elastic(in the colour coding region of green, yellow; less than half shaded) (16) (Fig 6, 7, 8, 9).

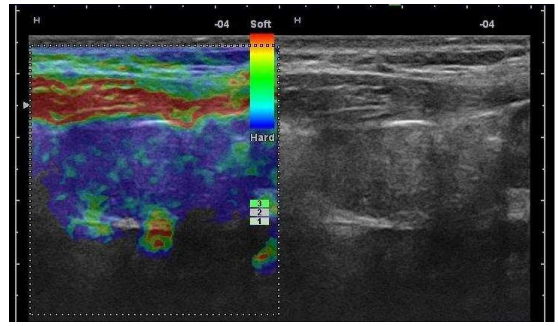

Fig 6: Pleomorphic adenoma

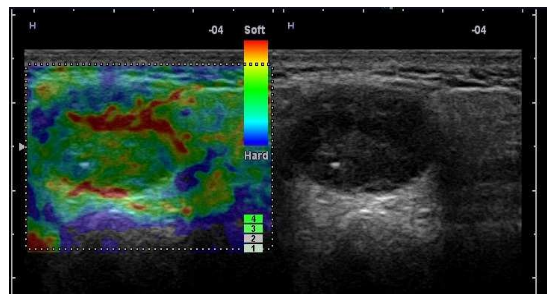

Fig 7: Basal Cell Adenoma

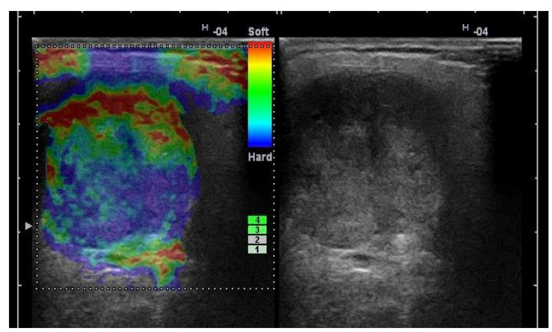

Fig 8: Acinic Cell Carcinoma

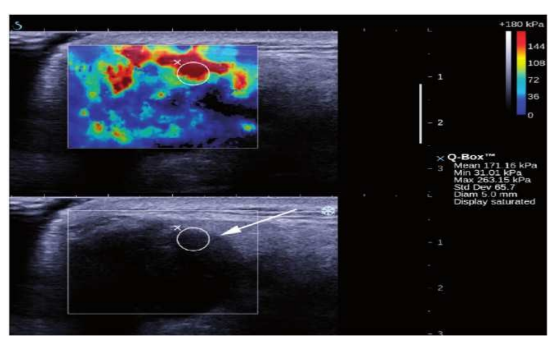

Fig 9: Parotid Gland (hypoechoic mass)

(3) Evaluation of Thyroid Nodules: Clinical application of elastography in thy- roid region was first reported by Rago et al in 2007 (17). Rago et al used a five point scale based on Ueno and Itoh's study us- ing strain elastography (18). Score of 1 de- fined elasticity that is soft in nodule, 2- mostly soft in nodule, 3-peripherally soft, 4-entirely hard, 5-hard in the area under consideration as well as entire nodule. There was another criteria of scoring the elasticity of nodules and it was given by Asteria et al in 2008 (19). This study used 4-point scales based on study of Itoh et al (20).

Shear wave elastography was first used in thyroid malignancy in 2010 by Sebag et al. Sebag and his team found that sensitivity was 81.5% and specificity was 97% (21). Even meta analysis of 8 ultrasound elas- tography studies from 2005-2009(a total of 639 thyroid nodules with 24% being malignant) showed a pooled sensitivity of 92% and specificity of 90% (22). Figure 10 and 11 shows thyroid nodule.

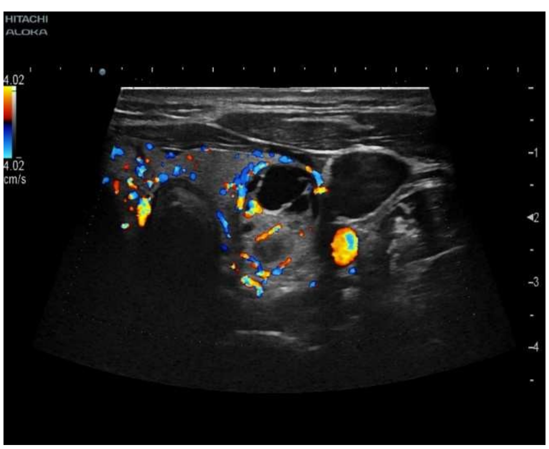

Fig 10: Complex Thyroid Nodule

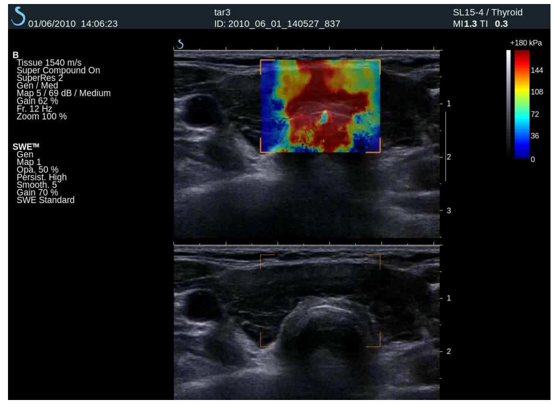

Fig 11: Thyroid Nodule

(4) Assessing Masseter Stiffness: Ultrasonic elastography can help to evalu- ate elasticity of muscles, internal appear- ance and thickness. Therefore it can as- sess the masseter muscle in patients with myofacial pain and temporomandibular joint disorders (TMD). A study by Akihiko and Ariji et al found that there is some po- tential relationship between hardness of masseter muscle and oedematous change in muscle (23). It was seen that hardness may increase in presence of oedematous change (Fig 12).

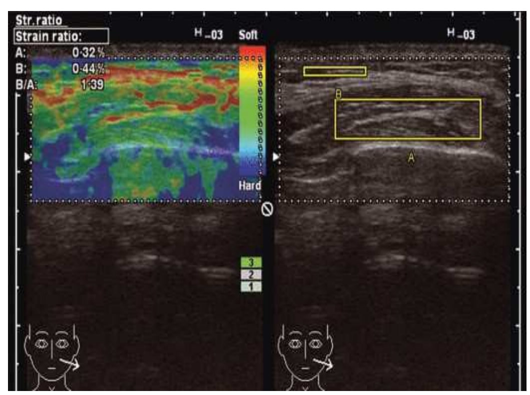

Fig 12: Elastography of Masseter Muscle

Limitations of usage of ultra- sound elastography

Elastography now-a-days is becoming an early and better way of diagnosing poten- tially malignant and benign lesions. How- ever it being a new concept there are still many loop holes in its usage.

Most common of the limitations are:- Inability to control the extent of tissue compression via ultrasound. This problem has been overcome by the usage of ARFI (21).

Its usage has seen to be of little value in cases of superficial protuberant masses and in areas adjacent to prominent bony structures; where it is difficult to apply uniform compression over the entire re- gion of interest (24).

Usage of this technique is also difficult in areas adjacent to blood vessels as pulsa- tions from blood vessels interferes with the ultrasound waves leading to difficulty in image formation.

Little is known of its usage in relapsing or chronic lymphadenitis (7).

Conclusion

Ultrasound elastography is a novel, non- invasive imaging modality that is now a days helping in early diagnosis of wide va- riety of oral malignant and benign lesions. Besides oral region its usage has proven fruitful in liver tumours and breast adeno- mas. Since it is giving us early diagnosis in a non-invasive way therefore in future it can replace the invasive techniques like biopsy which we are using in recent times for diagnosing malignancy. However it is still a very new and fresh concept so more and more studies and clinical trials are needed for its full proof usage.

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