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Diagnostic accuracy of sonoelastography in different diseases

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Keywords

sonoelastography, sensitivity, specificity, accuracy, different diseases

Abstract

The objective of this study was to evaluate the diagnostic accuracy of sonoelastography in patients of primary and secondary health care settings. Google scholar, PubMed, Medline, Medscape, Wikipedia and NCBI were searched in October 2017 for all original studies and review articles to identify the relevant material. Two reviewers independently selected articles for evaluation of the diagnostic accuracy of sonoelastography in different diseases based on titles and abstracts retrieved by the literature search. The accuracy of sonoelastography in different diseases was used as the index text, while B-mode sonography, micro pure imaging, surgery and histological findings were used as reference texts. Superficial lymph nodes, neck nodules, malignancy in thyroid nodules, benign and malignant cervical lymph nodes, thyroid nodules, prostate carcinoma, benign and malignant breast abnormalities, liver diseases, parotid and salivary gland masses, pancreatic masses, musculoskeletal diseases and renal disorders were target conditions. The data extracted by the two reviewers concerning selected study characteristics and results were presented in tables and figures. In total, 46 studies were found for breast masses, lymph nodes, prostate carcinoma, liver diseases, salivary and parotid gland diseases, pancreatic masses, musculoskeletal diseases and renal diseases, and the overall sensitivity of sonoelastography in diagnosing all these diseases was 83.14% while specificity was 81.41%. This literature review demonstrates that sonoelastography is characterized by high sensitivity and specificity in diagnosing different disorders of the body.

Introduction

Elastography is a non-invasive technique used to differentiate the elasticity of the diseased and normal tissue. Elastography is used in different modalities of radiology, including ultrasound and magnetic resonance imaging, while sonoelastography is most commonly used of all modalities. Since the mid-1990s, elastography has been in use for evaluation of stiffness and elasticity of soft tissues by giving external pressure[1]. It is an alternative technique for biopsy as it is safe and non-invasive. It can detect stiffness and elasticity of muscles as well as other tissues of the body. When a disease develops in the body, the tissues of that particular area become stiff as compared with adjacent normal tissues. When compression is applied to abnormal tissue, it deforms less as compared with normal tissue. Malignant tumors, in which tissue becomes stiffer in comparison with normal tissues, may serve as an example. The standard method used for detection of lesions is palpation, but if a lesion is too small or if it is located too deep, palpation is not useful, and sonoelastography can help clinicians make an accurate diagnosis. Elastography is based on the principle of tissue deformity upon application of external pressure. During elastography, internal or external pressure is applied to tissues, which results in their displacement. If the examined tissue is malignant, it displaces to a lesser degree as malignant tissues become hard. On the other hand, if the tissue is benign, displacement is high because the tissue is

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soft[1,2]. The variation in the soft tissue elasticity helps characterize focal and diffuse pathologies[1,3]. During sonoelastography, images are obtained before and after compression and then deformation is evaluated. Tissue hardness or softness appears in the ultrasound monitor in a color box. On an elastogram, soft areas appear as red or yellow, the green color represents firm areas with intermittent stiff areas while hard areas appear as blue. Tissue hardness and elasticity increases due to increased fibrosis and desmoplastic reaction[2,4,5]. There are generally 3 techniques of sonoelastography. The first of them is based on mechanical stress where tissue is stressed by internal or external forces. The technique in which the sonologist applies manual compression with the help of the transducer is known as quasi-static elastography (also known as strain imaging); it is a very common technique. The right angle and appropriate compression are necessary and, when not done properly, the image will contain many artifacts. Moreover, in order to obtain an appropriate elastogram, compression has to be applied at least twice[5–8]. The third technique is supersonic elasticity imaging (SSI), or shear wave elasticity imaging (SWEI), in which acquisition time is <30 s. The speed of shear waves in soft tissues is a thousand to hundred times slower than longitudinal waves, but high in hard tissues. The propagation speed of shear waves is then directly related to tissue stiffness. Shear wave elastography is similar to acoustic radiation force impulse imaging (ARFI)[5,9]. It can be applied clinically for the diagnosis of breast masses, lymph nodes, prostate carcinoma, liver diseases, salivary and parotid gland diseases, pancreatic masses, musculoskeletal diseases and renal diseases. The aim of our study is to evaluate the accuracy of sonoelastography in diagnosing different disorders with the help of previously published studies.

Study year	Country	Type of article	Technique	Disease	Sensitivity %	Specificity %	Sample size	Journal
2012[10]	China	Meta-analysis	Sonoelastography	Superficial malignant lymph nodes	74	90	9 articles	*European Journal of Radiology*
			Sonoelastography	Superficial Benign lymph nodes	90	88		
2009[11]	Italy	Original research	Sonoelastography	Thyroid nodules	82	88	25	*Journal of Ultrasound*
			Sonoelastography	Deep lymph nodes in mediastinum or abdomen	85	92		
			Sonoelastography	Cervical lymph nodes	75	80		
2015[12]	USA	Original research	Sonoelastography	Malignancy in thyroid nodules	79	77	not reported	*Abdominal Imaging*
2009[13]	Different centers of Europe	Original research	Sonoelastography	Superficial lymph nodes	92	83	101	*World Journal of Gastroenterology*
2012[14]	Romania	Original research	Sonoelastography	Benign cervical lymph nodes	67	97	69	*Medical Ultrasonography*
			Sonoelastography	Malignant cervical lymph nodes	71	97		
2013[15]	Romania	Review article	Sonoelastography	Superficial lymphadenopathy	42	100	not reported	*Medical Ultrasonography*
2008[16]	Japan	Original research	Sonoelastography	Cervical lymph nodes	83	100	85	*American Journal of Roentgenology*
2009[17]	Republic of Korea	Original research	Sonoelastography	Thyroid nodules	70	100	45	*American Journal of Roentgenology*
2012[18]	Turkey	Original research	Sonoelastography	Thyroid nodules	86	82	74	*American Journal of Roentgenology*
			Sonoelastography	Thyroid nodules	89	82		
2013[19]	USA	Review article	Sonoelastography	Lymph nodes	86	66	24 articles	*American Journal of Roentgenology*
2012[20]	China	Original research	Sonoelastography	Enlarged cervical lymph nodes	98	64	93	*Asian Pacific Journal for Cancer Prevention*
2010[21]		Original research	Sonoelastography	Prostate carcinoma	90	79		*Journal of Urology*
2009[22]	Japan	Original research	Sonoelastography	Prostate carcinoma	73	90	311	*Japanese Journal of Clinical Oncology*
2010[23]	Japan	Original research	Sonoelastography	Prostate carcinoma	72	86	87	*Journal of Urology*

2008[24]	Japan	Original research	Sonoelastography	Prostate carcinoma	68	81	107	*Ultrasound in Medicine and Biology*
2008[25]	Germany	Original research	Sonoelastography	Prostate carcinoma	75	77	109	*European Urology*
2008[26]	Austria	Original research	Sonoelastography	Prostate carcinoma	88	72	not reported	*Abdominal Imaging*
2007[27]	Austria	Original research	Sonoelastography	Prostate carcinoma	80	79	15	*British Journal of Urology International*
2010[28]	NR	Original research	Sonoelastography	Prostate carcinoma	88	79	not reported	*Journal of Radiotherapy and Oncology*
2015[29]	USA	Pictorial Essay	Sonoelastography	Prostate carcinoma	72	76	not reported	*Abdominal Imaging*
2011[30]	Republic of Korea	Original research	Sonoelastography	Axillary lymph nodes in breast cancer	81	67	62	*Journal of Ultrasound in Medicine*
2009[31]	China	Original research	Sonoelastography	Breast lesions	98	44	104	*Journal of Ultrasound in Medicine*
2008[32]	Italy	Original research	Sonoelastography	Non-palpable breast lesions	80	81	278	*European Radiology*
2012[33]	USA	Review article	Sonoelastography	Malignant breast abnormalities	88	98	9 articles	*Breast Cancer Research and Treatment*
			Sonoelastography	Benign breast abnormalities	83	72		
2010[34]	Italy	Original research	Sonoelastography	Breast nodules	89	93	110	*La Radiologia Medica*
2009[35]	Italy	Original research	Sonoelastography	Fibrosis staging of chronic liver disease F2-F4	91	80	74	*World Journal of Gastroenterology*
			Sonoelastography	F3-F4	96	79		
			Sonoelastography	F4	94	87		
2003[36]	France	Original research	Sonoelastography	Hepatic fibrosis	93	94	106	*Ultrasound in Medicine and Biology*
2010[37]	Japan	Original research	Sonoelastography	Non-alcoholic fatty liver disease	100	91	54	*RSNA Radiology*
2013[38]	Turkey	Original research	Sonoelastography	Parotid gland masses	61	59	75	*Acta Radiologica*
2010[39]	Romania	Original research	Sonoelastography	Pleomorphic adenoma of salivary glands	69	46	70	*Medical Ultrasonography*
2012[40]	India	Original research	Sonoelastography	Inflammatory pancreatic disease	97	93	166	*Journal of the Pancreas*
2015[29]	USA	Pictorial Essay	Sonoelastography	Pancreatic masses	95	69		*Abdominal Imaging*
2009[13]	Different centers of Europe	Original research	Sonoelastography	Pancreatic masses	92	69	101	*World Journal of Gastroenterology*
2013[41]	Tokyo	Original research	Sonoelastography	Achilles tendon	100	86	10	*RSNA Radiology*
2009[42]	Austria	Original research	Sonoelastography	Lateral epicondylitis	100	89	38	*American Journal of Roentgenology*
2011[43]	Republic of Korea	Original research	Sonoelastography	Lateral epicondylitis	77	76	48	*American Journal of Roentgenology*
2015[44]	USA	Pictorial Essay	Sonoelastography	Fibrosis in kidney disease	86	95	not reported	*BMC Nephrology*
2012[45]	USA	Original research	Sonoelastography	Chronic kidney disease	80	75	25	*Journal of Ultrasound in Medicine*

Tab. 1. *Characteristics of the included studies*

Methods

Search strategy

Two reviewers (I.M and R.B) searched the Google scholar, PubMed, NCBI, Medline and Medscape databases from 2007 up to 2015 with the following key terms: diagnostic accuracy, sonoelastography, sensitivity, specificity, superficial lymph nodes, neck nodules, malignancy in thyroid nodules, benign and malignant cervical lymph nodes, thyroid nodules, prostate carcinoma, benign and malignant breast abnormalities, liver diseases, parotid and salivary gland masses, pancreatic masses, musculoskeletal diseases and renal disorders.

Selection criteria

Two reviewers (I.M and R.B) independently screened the titles and abstracts of the relevant articles and full articles for inclusion and extraction of data. Any disagreement between the reviewers was resolved by means of a consensus. Studies were eligible if they included information about superficial lymph nodes, neck nodules, malignancy in thyroid nodules, benign and malignant cervical lymph nodes, thyroid nodules, prostate carcinoma, benign and malignant breast abnormalities, liver diseases, parotid and salivary gland masses, pancreatic masses, musculoskeletal diseases, renal disorders and diagnostic accuracy of sonoelastography in these diseases.

Data synthesis

The eligible studies were first categorized, and the analysis of the data was performed according to the target conditions. We retrieved the sensitivity and specificity relating to the selected diseases for each individual study and made forest plots. A table was also made for predefined subgroups of types of articles, country, sample sizes as well as sensitivity and specificity values (Tab. 1). Data analysis was performed with the help of Microsoft excel 2017 and Statistical Package for the Social Sciences version 24 (SPSS 24, IBM, Armonk, NY, United States of America).

Results

Study selection and characteristics

In total, 69 studies were found after the search. Four were excluded due to duplication, 10 did not include sufficient data for our research, and 9 were rejected on the basis of the title and abstract. The flow chart summarizes the flow records through review in Figure 1. Ultimately, 46 studies were included in the analysis, 16 of which were devoted to lymph nodes, 9 to prostate

Fig. 1. *Flowchart of the search and selection process*

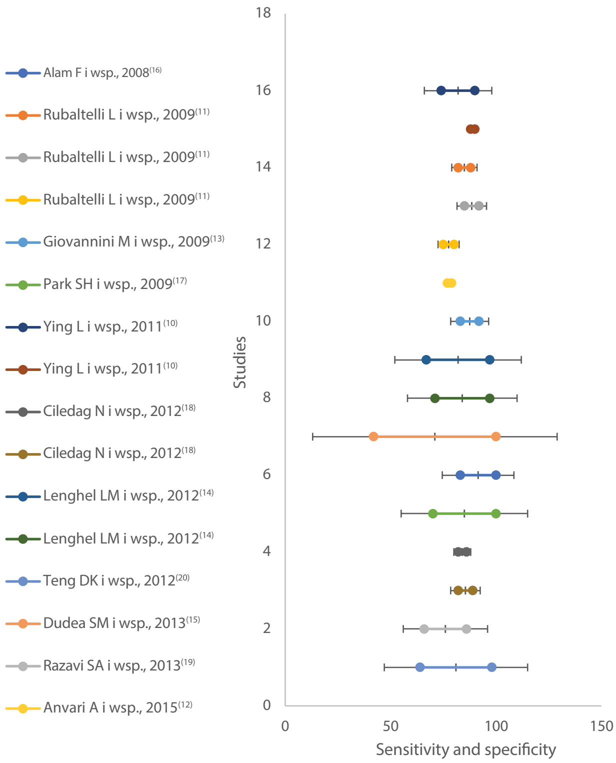

Fig. 2. *Forest plot for lymph nodes*

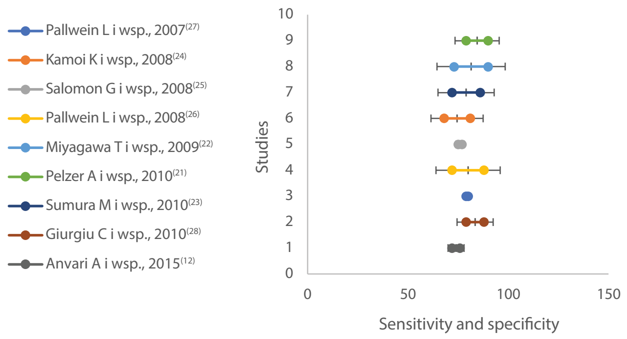

Fig. 3. *Forest plot for prostate carcinoma*

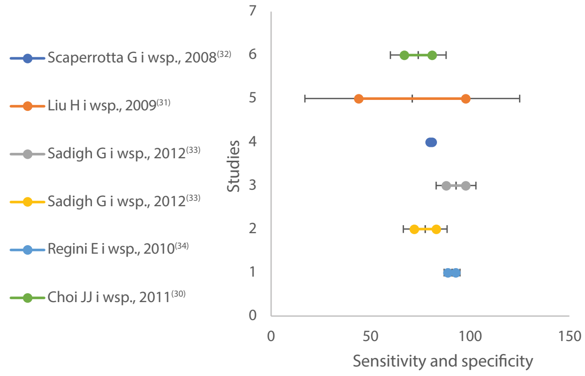

Fig. 4. *Forest plot for breast masses*

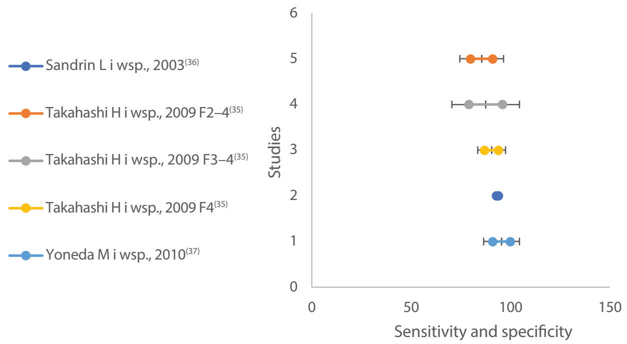

Fig. 5. *Forest plot for liver diseases*

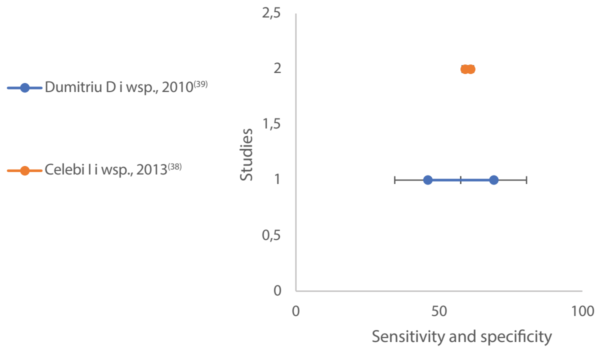

Fig. 6. *Forest plot for salivary and parotid gland*

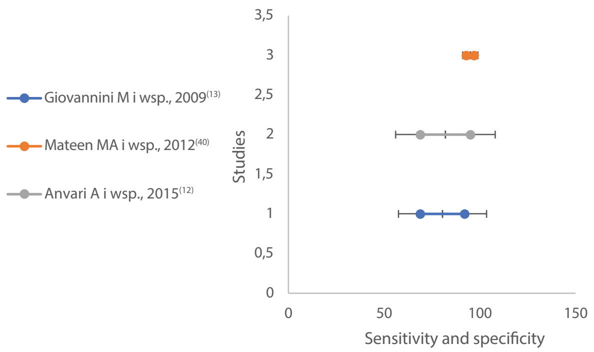

Fig. 7. *Forest plot for pancreatic masses*

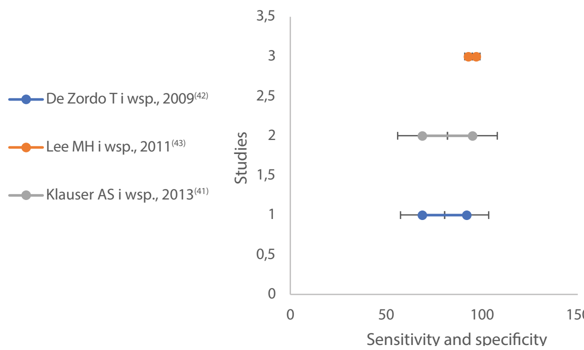

Fig. 8. *Forest plot for musculoskeletal diseases*

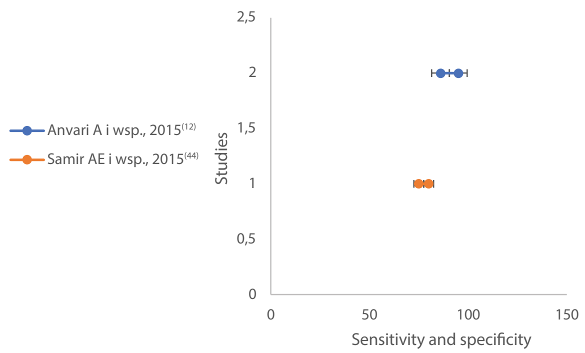

Fig. 9. *Forest plot for renal diseases*

carcinoma, 6 to breast masses, 5 to liver diseases, 3 to pancreatic masses, 3 to musculoskeletal diseases, 2 to renal diseases and 2 to salivary and parotid gland diseases. Thirteen authors were contacted to supplement the data, but sufficient information was not obtained. All the analyses were performed in the clinical and radiology departments of hospitals.

Data analysis

The data analysis is presented in Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9. Characteristics (study year, country, disease, sensitivity, specificity, sample size and journal name) of the included studies are presented in Table 1. Pooled results of overall sensitivity and specificity of sonoelastography in diagnosing different diseases are shown in Table 2. The overall pooled sensitivity and specificity values of sonoelastography in 16 studies concerning the lymph nodes were 79.31% and 86.52%, respectively. As for the 9 studies on prostate carcinoma, the overall pooled sensitivity and specificity of sonoelastography were 78.43% and 79.71%, respectively. The pooled sensitivity and specificity of sonoelastography in diagnosing breast masses in 6 studies addressing this problem were 86.40% and 75.73%, respectively. In 5 studies on liver diseases, the pooled sensitivity of sonoelastography was 94.94% and specificity was 86.22%. In 2 studies addressing the salivary and parotid gland diseases, the pooled sensitivity and specificity of sonoelastography were 64.95% and 52.75%, respectively. As for the 3 studies on pancreatic masses, the overall pooled sensitivity and specificity of sonoelastography were 94.80% is 76.95%, respectively. The overall pooled sensitivity and specificity in diagnosing musculoskeletal diseases in the 3 selected studies were 92.17% and 83.73%, respectively. In the 2 studies addressing renal diseases, the overall pooled sensitivity of sonoelastography was 82.85% and specificity was 85.00% (Tab. 2). None of the analyses found significant heterogeneity between the studies.

Discussion

Real-time elastography is an innovation in the field of radiology. It is non-invasive and complimentary to conventional B-mode ultrasound. Elastography reduces the number of unwanted biopsies by differentiating between benign and malignant masses. Sonoelastography has been in use for many years for diagnosing many diseases. In a study published in 2008, conducted to investigate the differentiation between malignant and benign breast masses before biopsy, 278 women were included with 293 lesions classified in the BIRADS system (Breast Imaging Reporting and Data System). Sonoelastography was performed for all the lesions and 110 of them were found to be malignant and 183 were benign, which also was histologically proven [32]. In another study conducted in 2008, the authors wished to learn about the accuracy of B-mode ultrasonography and sonoelastography in the diagnosis of enlarged cervical lymph nodes. For that purpose, 37 patients were enrolled and scanned with B-mode ultrasonography and sonoelastography. The results showed that the accuracy of B-mode ultrasonography was 84%, while the accuracy of sonoelastography was 93%[16]. Moreover, sonoelastography is an effective and useful technique for detection of the intratendinous and peritendinous alterations of lateral epicondylitis. It also plays the fundamental role in differentiating between control and diseased extensor tendon origins with high sensitivity and strong correlation with ultrasound findings[42]. A prospective study conducted in 2009 aimed to evaluate the accuracy of acoustic radiation force impulse (ARFI) elastography in assessing liver fibrosis in patients with chronic HCV (hepatitis C). For that purpose, 74 patients were enrolled in the study and underwent tests for aspartate aminotransferase (AST)-to-platelet ratio index (APRI) as well as fibro-max and ARFI elastography. The results show that ARFI elastography has a strong correlation with the results of liver biopsy and that it is accurate and reliable for predicting liver fibrosis[35]. Sonoelastography is one of the useful qualitative scoring methods in the diagnosis of salivary gland masses, including parotid and sub-mandibular lesions, in terms of detecting benign and malignant masses[45]. During sonoelastography of parotid gland tumors, different signs can be frequently seen, such as: garland sign more for malignant tumors than for benign ones, dense core sign for Pleomorphic adenomas, half-half sign for Warthin's tumor and bull's eye sign for parotid cysts[46]. The results of the previous studies match with our review article that sonoelastography is highly accurate in diagnosing different clinical disorders.

Conclusion

It is concluded that sonoelastography is an easy, rapid and non-invasive technique for detection of many diseases and has high sensitivity and specificity. Tissue elasticity not only varies across different tissues, but also

Disease	No of studies	Mean sensitivity	Mean specificity	Std. deviation
Lymph nodes	16	79.31	86.52	13.196
Prostate carcinoma	9	78.43	79.71	8.327
Breast masses	6	86.40	75.73	6.800
Liver diseases	5	94.94	86.22	3.324
Salivary and Parotid Gland	2	64.95	52.75	5.303
Pancreatic masses	3	94.80	76.95	2.406
Musculoskeletal diseases	3	92.17	83.73	13.568
Renal diseases	2	82.85	85.00	4.031
Pooled sensitivity and specificity	**46**	**83.14**	**81.41**	**11.902**

Tab. 2. *Pooled sensitivity and specificity*

seems to reflect disease-induced alternations in tissue properties. Real-time sonoelastography has been recently applied to the normal and pathologic tissues in muscle and tendon disorders, and it showed promising results and new potential. Therefore, it is expected to be a useful modality for providing novel diagnostic information in musculoskeletal diseases because tissue elasticity is closely related to musculoskeletal pathology. It can also be used as a research tool to provide insight into the biomechanics and pathophysiology of tissue abnormality.

Conflict of interest

No conflict of interest.

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