Ultrasound elastography and its role in the research of diffuse liver diseases

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Abstract

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Background: Ultrasound elastography method takes an important place in the modern hepatology. Research is non-invasive, does not have complications and is quite cost-effective. In many cases, elastography research is presented as alternative way of liver biopsy. In this article we are going to review the technical features of various ultrasound elastography methods and describe diferrences between them. Current and future researches are basis of development and improvement of this method, which provide more credibility and perspective of accuracy of results.

Aim: Review of literature aims to briefly summarize existing knowledge about ultrasound elastography, to present its role and point out future research aspects.

Method: We looked for and considered 2006-2021 articles from PubMed and Google Scholar Medical Data bases, which include the following key words: liver fibrosis, liver cirrhosis, ultrasound, transient elastography, real-time elastography, acoustic radiation force impulse elastography, two-dimensional shear wave elastography.

Results: The results of research confirm great importance of ultrasound elastography in assessment of diffuse liver diseases.

Conclusion: Our literature review affirms, that described non-invasive research methods provide important information during chronic liver disease. There is not difficulty to produce it technically and is allowed to use them in freely in screening researches. Certainly, elastography study has some restrictions. There was pointed out that results at the early stages of fibrosis are less credible, that's why it is essential to carry out new studies that ultrasound elastography methods gain more credibility in this regard.

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Keywords: Liver fibrosis, liver cirrhosis, transient elastography, real-time elastography, acoustic radiation force impulse elastography, two-dimensional shear wave elastography.

Introduction

Every year, due to liver diseases about 2 million people die in the world. Among them approximately 1 million is caused by complications of cirrhosis, 1 million – by viral hepatitis and hepatocellular carcinoma. (1)

Duration and progression of chronic inflammatory in the liver tissue determine its fibrosis stage, which stipulates prognosis of the disease and influences patient's life. Suspending of fibrogenesis progression is considered as one of the main methods to prevent mortality caused by liver diseases.

Moreover, scientific discoveries for the last decade have changed comprehension of liver fibrosis mechanisms. Studies revealed, that liver fibrosis is reversible (2), but if it changes into cirrhosis, the reversal process becomes ineffective. (3)

Statistical and epidemiological data on liver diseases are very attantive. Subsequently, early detection of fibrosis stage during diffuse liver diseases gets more importance to suspend progression of the disease and to facilitate regression of fibrosis.

Modern methods of studying diffuse liver disease are impossible without ultrasound elastography.

Elastography is an imaging technique, which is based on tissue elasticity, non-invasive assesment of mechanical properties. This technique reveals changed soft tissue elasticity during various deseases, that is result of specific pathological and physiological processes. Analysis of ob-

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tained qualitative and quantitative information can be used for diagnostic purposes. (4)

Ultrasound elastography is a reliable and easily technique to conduct, therefore it is used widely to assess liver fibrosis. It is based on the hypothesis, according to which formation of fibrosis in the tissue provides decreasing of elasticity and increasing of density.(5)

During the study of diffuse liver diseases, there are used the following elastographic methods:

Transient elastography

The most common method of liver elastography is so-called Transient elastography TE, which determines tissue elasticity by measuring the velocity of elastic shear waves in parenchyma generated by a mechanical push. (6–8)

Transient elastography is carried out by FibroScan, a special elastometry device. An ultrasound probe that is mounted on the vibrator rod transmits to the liver oscillations with a low frequency (50 hertz) passing through the area between the right ribs. An elastic share wave is generated and spread in the liver. The propagation of share wave is followed by pulse-echo ultrasound. Velocity of it is measured and expressed in kilopascals. The velocity of the waves correlates directly with the elasticity of the tissue and increases proportionally together with stiffness of tissue. The more liver fibrosis is expressed, the higher velocity shear wave is propagated. It is possible to measured liver stiffness, which assessment ranges from 2.5 to 75 kPa.(5,6,9-11)

Due to its high informative, by using this method we can avoid liver biopsy in some patients. Transient elastography can also be used to monitor disease progression or to assume complications (12,13).Transient elastography is highly sensitive in the significant fibrosis and cirrhosis cases, but is not accurate enough to differentiate mild fibrosis stages, especially F0 - F2. (6,7,14,15)

Real-time elastography

Newly developed elastographic technologies are now widely applied in clinical practice and allow to determine tissue elasticity and perfusion features, as well as to differentiate better malignant and benign processes.(16,17)

RTE program loaded in ultrasound device is created to assess visually tissues elasticity. It calculates stiffness in accordance with tissue deformation degree and provides this information by colour images. Main point of real-time elastography is that compressive force or stress influences interest area and displacement-deformation or strain assessment is occured. The best method of applying stress is to compress the tissue with an ultrasound probe. To sum up, elastography provides imaging of tissue mechanical properties data and a real-time method of detecting abnormal tissue changes. Tissue deformation-displacement changes are recorded by a high-frequency ultrasound scanner and evaluated by correlation methods.(17–21)

RTE is distinguished from other ultrasound elastography techniques because it does not provide a quantitative assessment of liver stiffness.

The elastogram is only a qualitative representation of the elasticity of anatomical structures, therefore different methods of elastogram analysis are developed for semi-quantitative estimation.(9)

Real-time elastography is considered to be an informative method to detect significant fibrosis and cirrhosis diagnosis in patients with chronic liver disease.(22,23)

Real-time elastography results is slightly inferior than Transient elastography, but it even shows a significant correlation in respect to it.

In that way, real-time elastography can be used for patients to whom use of FibroScan is limited. Certainly, their combination can provide to get better results. It is considered, that both these methods are applied to diagnose significant fibrosis and cirrhosis. (24)

Acoustic radiation force impulse elastography

Not long time ago, elastography new method has been established - Acoustic radiation force impulse (ARFI) elastography, which applies radiation force pulses to measure liver stiffness by using B-mode of ultrasound. (18,25)

Acoustic radiation force impulse elastography method provides to determine quantity of tissue mechanical properties by propagating shear wave induced by acoustic radiation into the tissue and measuring the velocity.(5,26,27)

To condut this study it is essential to region of interest be selected, high-intensity acoustic pulse is transmitted to that region of interest. Shear waves propagate and generate localized tissue movement. Shear wave velocity is expressed in m/sec and measured in quantities in a small region. (8,9,14,28–31)

Ultrasound transmitter automatically generates an acoustic impulse, which forms shear waves and propagates into the tissue. The system measures the shear wave velocity in the anatomical, precisely oriented region of interest and obtained velocity is displayed on the screen. The velocity of propagation increases in proportion to the increase of fibrosis severity.(32)

In 2008, a new modality quantitative determination of acoustic radiation force impulse became available. A powerful ultrasound impulse pressure force, which reaches maximum at one point, is applied to generate the shear wave. It is a source of generating the shear wave, which propagate perpendicular to its (longitudinal axis). Due to this feature, this method is called as point shear wave elastography (pSWE). It is considered as ARFI-based technique, which allows us to measure the shear wave velocity. (9,29,31,33,34)

here are studies according to which ARFI and TE have ability to diagnose severe fibrosis (F≥3) or cirrhosis (F4) with higher accuracy, and while applying their credibility is reduced in unclear fibrosis cases.(5)

Diagnostic provison of FibroScan has been found out more affective than acoustic radiation force impulse for some authors. Some authors states the opposite, but there is not sufficient data and evidence for the high reliability of the latter one yet.(27)

Two-dimensional shear wave elastography

Two-dimensional shear wave elastography (2D SWE) applies acoustic radiation force like point shear wave elas-

tography to provide propagation shear waves in the liver tissue, but has got different transmitting and measurement methods than it. During point shear wave elastography one impulse of ARFI radiates to focal point, 2D SWE induces the shear waves at many points and generates entire front of the cone-shaped shear waves that propagates from ARFI axis to side direction. The propagation of the shear waves is reflected and expressed on a colored elasticity map called an elastogram. The operator can place a circular region within the elastogram. According to result of multiple measurements, an average shear wave velocity reflected in m/sec is obtained in ROI and it is transmitted into Young's modulus (kPa) by algebraic calculations, so through this mechanism provides quantitative assessment of tissue stiffness. (6,7,35)

2D SWE techniques can accurately assess liver fibrosis stage in kilopascals by estimating the quantitative density in real time. According to data, by assessment of Fibrosis staging its accuracy is similar to ARFI but it is more accurate than RTE and TE. (8)

According to Leung et al. 2013 data, SWE can identify F2 fibrosis stage by revealing 7.1 kPa and 92.1 % specificity. Therefore, 2D-SWE can be applied freely as screening tool for the early diagnosis of important fibrosis, which is a significant starting point for treatment of chronic viral hepatitis. (36)

According to existing studies Shear Wave Elastography is more effective than FibroScan to diagnose important fibrosis, though final conclusions need new studies. (27) In spite of that 2D SWE diagnostic rate is higher than other non-invasive methods, effectiveness depends on the fibrosis stages. It can not cross a significant dependence on the fibrosis stages. (37–39)

2D SWE technique provides more accurate and reliable information during significant liver fibrosis like other methods, than mild liver fibrosis case.(7)

So, reviewed literature gives us possibility to conclude that the non-invasive elastography method is a highly effective way for routine clinical practice in the detection and assessment of liver fibrosis.

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