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PRACA POGLĄDOWA
REVIEW

Chronic and acute pancreatitis elastography – current knowledge

Elastografia w przewlekłym i ostrym zapaleniu trzustki – aktualna wiedza

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ABSTRACT

This paper is a review of available studies concerning the topic of ultrasound elastography as a modality for diagnosing chronic or acute pancreatitis. Twenty-eight articles published between 2004 and 2022 containing keywords related to elastography and acute and chronic pancreatitis were reviewed using databases and search engines such as PubMed, Scopus, Google Scholar and Web of Science. Acute and chronic pancreatitis increase the stiffness of the pancreatic parenchyma, which can be measured using strain or shear wave elastography. Numerous studies have shown promising results, and it seems that it is possible to use elastography as a routine technique in the diagnosis of chronic or acute pancreatitis. Nevertheless, certain limitations such as age or body weight, should be considered when performing elastography.

KEY WORDS

pancreatitis, elasticity imaging techniques, elastic modulus

STRESZCZENIE

Niniejsza praca stanowi przegląd dostępnych badań dotyczących elastografii ultrasonograficznej jako metody diagnostyki przewlekłego lub ostrego zapalenia trzustki. Dokonano przeglądu dwudziestu ośmiu artykułów opublikowanych w latach 2004–2022, zawierających słowa kluczowe związane z elastografią oraz ostrym i przewlekłym zapaleniem trzustki, z wykorzystaniem baz i wyszukiwarek takich jak PubMed, Scopus, Google Scholar i Web of Science. Ostre i przewlekłe zapalenie trzustki powoduje zwiększenie sztywności miąższu trzustki, co można zmierzyć za pomocą ela-

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stografii odkształceniowej lub fali poprzecznej. Liczne badania przyniosły obiecujące wyniki i wydaje się, że możliwe jest zastosowanie elastografii jako rutynowej techniki w diagnostyce przewlekłego lub ostrego zapalenia trzustki. Niemniej jednak podczas wykonywania elastografii należy wziąć pod uwagę pewne ograniczenia, takie jak wiek czy masa ciała.

SŁOWA KLUCZOWE

zapalenie trzustki, techniki obrazowania elastyczności, moduł sprężystości

INTRODUCTION

Elastography is an imaging technique used to measure stiffness in various organs, especially the liver [1]. In recent years, elastography has been tested for evaluating the pancreas. There are two main types of elastography: strain elastography (SE) and shear wave elastography (SWE). Both of them can be used with transabdominal ultrasonography [2]. SE measures the stiffness of the tissue based on the strain generated by external pressure, for example, from the pulsation of the aorta [3]. It has a negative correlation with the elasticity of the tissue – the larger the strain, the softer the tissue. The results are displayed on a B-mode image along with the reference images. The other technique, SWE, generates an acoustic radiation force impulse (ARFI). It uses the speed of sound waves, which depends on the viscoelastic properties of the tissue resulting in its resistance to the waves in order to estimate the stiffness of an organ. There is a positive correlation between the speed of the shear wave and the stiffness of the tissue – the higher the speed, the harder the tissue. The results are usually expressed in m/s or kPa [4]. SE provides semiquantitative or qualitative evaluation, whereas SWE allows qualitative or quantitative assessment [5]. Pancreatic diseases such as acute and chronic pancreatitis change the elasticity of the tissue, creating a diagnostical opportunity for elastography.

METHODOLOGY

Twenty-eight articles were found, all of which were from the last two decades. The databases and search engines PubMed, Scopus, Google Scholar, and Web of Science were used. Keywords specified in the appropriate section and concentrating on acute and chronic pancreatitis in elastography were employed. This paper mainly focuses on the ARFI technique due to the numerous recent studies.

Healthy pancreas

Although the Japanese Society of Medical Ultrasonics publishes elastography guidelines for the pancreas, defining a healthy pancreas elasticity value was problematic using elastography to measure the stiffness of the pancreas [5]. A study by Gallotti et al. [6] described the typical value of the shear wave speed for the pancreas to be about 1.40 m/s in young adults. Another study, by Ozturk et al. [7], also determined the normative values of pancreas stiffness in children and adolescents. Certain factors such as the body mass index (BMI), gender, alcohol, and smoking could influence the elastography results. A study by Stumpf et al. [8] showed that men have lower mean SWE values than women, and increasing age corresponds with higher mean values. However, a higher BMI corresponded with lower mean measurements. It can be attributed to more extensive fat deposits in the pancreatic tissue, which is softer than the pancreatic parenchyma. Moreover, another study also reported lower mean strain values in individuals with a higher BMI and increased pancreas echogenicity [9].

Further research by Janssen and Papavassiliou [10] reported that the value of the strain histogram of a healthy pancreas was lower in people 60 years old or more, in contrast to younger people.

Acute pancreatitis

Due to the premature activation of pancreatic enzymes, there is damage to pancreatic tissue and initiation of the inflammatory response [11]. This leads to injury of the pancreatic cells and causes a transformation of fibroblasts into myofibroblasts, resulting in fibrosis of the pancreas [12]. Fibrotic changes generate elasticity alterations.

A study by Kaya et al. [13] evaluated the usage of ARFI in the diagnosis of acute pancreatitis (AP). ARFI was performed within 24 hours after admission. Nine shear wave velocity (SWV) measurements were taken; three for each part of the pancreas (tail, body, and head), then the results were averaged. The mean SWV was 2.43 ± 0.08 m/s in the patients with AP. It was determined that the SWV cut-off value of 1.63 m/s was associated with 100% sensitivity and 98% specificity for diagnosing AP. Nevertheless, there was no significant difference in the mean SWV between patients with edematous and necrotizing AP, and ARFI was found inadequate to predict the course of the disease.

Göya et al. [14] compared ARFI to B-mode sonography, finding that ARFI had a higher success rate in diagnosing AP. They also demonstrated that ARFI could detect AP in patients with a normal-appearing pancreas on CT imaging. Two techniques implementing ARFI – virtual touch tissue quantification (VTQ) and virtual touch imaging (VTI) – were evaluated. The main difference between them is that the former provides a quantitative evaluation of tissue stiffness and a qualitative elastography of tissue stiffness. With the cut-off value of 1.63 m/s, 100%

sensitivity and 98% specificity of the VTQ were achieved. The mean VTQ values were 1.17 ± 0.24 m/s in the healthy participants and 2.14 ± 0.74 m/s in the patients with AP. The VTI score is assigned based on the image's color scale. It was shown that the patients with AP had a color score between 3–6, while the control group achieved a score of 1 or 2.

Goertz et al. [15] showed that the ARFI values in the case of AP were lower compared to chronic pancreatitis (CP) but higher than in normal parenchyma. AP and CP were associated with ARFI SWV values of 1.79 ± 0.62 m/s and 2.13 ± 0.68, respectively. Normal tissue had the SWV of 1.3 ± 0.23. No correlation between the ARFI values and lipase levels was found. The mean percentage of failed measurements in the head was 8.0% and 14.0% for acute and chronic pancreatitis, respectively.

Mateen et al. [16] used ARFI-VTQ to differentiate inflammatory pancreatic diseases, and the mean values for a normal pancreas were 1.28 m/s, CP – 1.25 m/s, and AP – 3.28 m/s. The difference in elasticity is significant and may be successful in diagnosing AP.

One of the newest studies, conducted by Sezgin et al. [17], proved that pancreatic stiffness elevates during AP and normalizes with clinical improvement. However, even after one month, it is still higher than in healthy individuals.

In the study by Xie et al. [18], the SWV values of a healthy pancreas were 1.18 ± 0.23 m/s in the head and 1.21 ± 0.20 m/s in the body of the pancreas. There was no significant difference between these values and the SWV values in patients with AP. In these participants, the SWV values of the head and body were 1.18 ± 0.20 m/s and 1.25 ± 0.19 m/s, respectively.

Finally, a meta-analysis by Rifu et al. [19] that included eight case-control studies indicated 98.3% sensitivity and 95.5% specificity of ARFI elastography to diagnose AP.

Chronic pancreatitis

Chronic pancreatitis is a progressive inflammatory disease leading to endocrine and exocrine dysfunction. It involves calcification, parenchyma atrophy, and fibrotic changes [20]. Parenchymal hardness changes are vital for diagnosing CP and establishing its severity [21]. Several studies have been conducted to investigate the usefulness of elastography in this matter.

A study by Yashima et al. [22] reported that using ARFI to diagnose CP is feasible. The SWV measurements are higher in every part of the pancreas in CP than in healthy volunteers. This study did not include AP. Nonetheless, it also showed higher SWV values in individuals with a lower BMI.

Janssen and Papavassiliou [10] researched the effects of aging and chronic diffuse pancreatitis on pancreas elasticity using endosonographic elastography. It was proven that aging causes pancreatic tissue to harden, but it remains softer than with CP. There was also a cut--off value of 50 suggested for a diagnosis of CP.

Kuwahara et al. [23] proved that pancreatic parenchyma elasticity was elevated in patients with CP, especially with endoscopic ultrasonography features of CP such as hyperechoic foci with shadowing and lobularity with honeycombing. They were also able to calculate the pancreatic elastic modulus in kilopascals with SWE. The mean measurement success rate was 91.2 ± 13.7%.

Llamoza-Torres et al. [24] tried to determine the accuracy of ARFI for diagnosing CP. In this study, a significant difference was reported between the mean SWV in the pancreases of healthy individuals (1.27 m/s) and those with CP (1.57 m/s), $p = 0.037$. The accuracy of ARFI for the diagnosis of CP was 69.7% for the SWV value of 1.4 m/s in the pancreatic body.

Pozzi et al. [25] used point shear wave elastography (pSWE) to measure pancreatic stiffness. The results of this study proved pSWE to be suitable for diagnosing CP in all the patients except for one. Pancreatic parenchyma hardness was significantly ($p = 0.001$) higher in the CP patients than in the healthy individuals. What is more, higher values were also observed in the patients with a longer course of illness ($p = 0.01$), chronically taking analgesic medications ($p < 0.05$), and with a lower body weight ($p < 0.05$). An overall intraclass correlation coefficient of 0.77 was reported.

In 2019 Yamashita et al. [26] published a study that showed a positive correlation between the SWE values and endoscopic ultrasound (EUS) features of CP and the Rosemont classification, which is generally used to diagnose CP with EUS. However, the Rosemont classification is based on subjective observations, and SWE is an objective tool.

In one of the most recent studies published by the end of 2021, Nakaoka et al. [21] examined the possibility of diagnosing CP using elastography. Diagnosing early CP via SWV elastography had a sensitivity of 76%, a specificity of 88%, and a correct diagnosis rate of 81%. The authors also noted that pancreas hardness increases with age, which needs to be considered in CP diagnosis.

Acute pancreatitis, chronic pancreatitis, or a neoplasm

Differentiating between acute and chronic pancreatitis or a neoplasm can appear challenging, but Goertz et al. [15] measured the ARFI values in acute and chronic pancreatitis and adenocarcinoma. The results were significantly lower in AP than in CP ($p = 0.02$) and in adenocarcinoma ($p < 0.001$), but there was no significant difference between CP and adenocarcinoma ($p = 0.43$). Nevertheless, the latter's values were the highest of all.

A study by Park et al. [27] also focused on differentiating benign pancreatic lesions from

malignant ones. They concluded that it is possible to distinguish those two pancreatic abnormalities with ARFI-VTI and VTQ.

Mayerle et al. [28] created a study whose aim was to determine whether semiquantitative EUS-elastography is superior to EUS-guided fine-needle aspiration (EUS-FNA) and B-mode EUS in the diagnosis of solid pancreatic lesions. The results demonstrated that the sensitivity of EUS-elastography (96%) was comparable to B-mode EUS (94%), but the specificity for EUS--elastography was much lower (34%) than for B-mode EUS (64%). Nonetheless, the total accuracy of those two modalities was alike (84% vs. 87%). The examination of EUS-FNA proved it to be less sensitive than EUS-elastography (82% vs. 96%), but the specificity reached 100% for the diagnosis of a malignant neoplasm. Also, the total accuracy of EUS-FNA was 85%. The authors of this study agreed that using EUS-elastography only in the differential diagnosis of pancreatic masses is not a better modality compared to B-mode EUS and EUS-FNA.

CONCLUSIONS

In diagnosing acute and chronic pancreatitis, elastography of the pancreas seems to be a promising modality. It may be done via transabdominal ultrasound performed during a routine check-up. The limitations of the method are the same as those of ordinary ultrasound, and they mainly consist of gas or fluid obscuration of the pancreas, severe obesity and low tissue translucency. Both SE and SWE provide reliable results. However, nowadays, the ARFI technique is gaining more attention. It is a real-time and radiation--free technique that can help objectively diagnose acute or chronic pancreatitis. Both AP and CP are characterized by high stiffness of the pancreatic parenchyma, and this fact has a positive correlation with the ARFI results.

Nonetheless, this modality has limitations such as advanced age, gender, high or low body weight, analgesic drug intake, and longer illness duration affecting pancreatic parenchyma hardness, which can provide false results. Also, the differentiation between CP, AP, and neoplasms can be challenging, but studies are currently being conducted to examine this matter. To conclude, it can be highly beneficial to use elastography for CP or AP diagnosis, especially by combining it with the patient's medical history, signs and symptoms.

Conflict of interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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