IJDIAS International Journal of Discoveries and Innovations in Applied Sciences
| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 1 Issue: 5

Comparison of Features of Liver and Spleen Elastometry

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Summary

Liver elastometry is indicated if fibrosis is suspected. The latter can lead to several systemic complications: splenomegaly, varicose veins of the gastrointestinal tract, ascites. Speaking about splenomegaly, it should be noted that in alcoholic liver disease splenomegaly is not pronounced, but in its parenchyma, pathoanatomical examination reveals venous congestion with expansion of venous vessels and sinusoids, pulp fibrosis, histiocyte proliferation, areas of siderosis and fibrosis The review presents data on the comparison of the features of measuring the stiffness of the liver and spleen, the effect on the measurement results of various conditions (type of sensor used, food intake, number of measurements, patient position, breathing phase, etc.). A literature search was carried out in the PubMed and eLibrary databases. In particular, the stiffness values of the liver and spleen vary differently at the heights of inspiration and expiration. This is due to the blood filling of organs with changes in intrathoracic and intra-abdominal pressure, as well as a decrease in arterial flow to the spleen during exhalation.Published data on liver and spleen stiffness values in healthy volunteers are presented. The spleen is a tougher organ than the liver. The different stiffness of the liver and spleen is explained by the peculiarities of the blood supply (the spleen receives most of the blood flow from an artery with an intensive flow, the liver from the portal vein). The reasons for the increase in the stiffness of these organs are described, both in norm and in pathology.The study of liver stiffness can be used to diagnose liver cirrhosis and portal hypertension, the study of spleen stiffness - to diagnose portal hypertension, as well as for indirect diagnosis of the presence of varicose veins of the esophagus and the nature of the lesion of the spleen.

Key words: stiffness of the spleen; stiffness of the liver; elastography; comparison of stiffness; overview.

Introduction

Elastometry is now considered the third ultrasound technology after echography and Doppler imaging Elastometry is a group of instrumental diagnostic methods used to visualize and assess the stiffness of organs and tissues. The principle of elastography is based on the idea that pathological changes make tissues harder, harder and less elastic.Thanks to her, there has been a significant qualitative leap in the differential diagnosis of focal pathology of the liver and superficially located organs. This method opened up new and very promising possibilities of visualization - determination and comparison of the elasticity of body tissues.These methods expand the capabilities of the ultrasound system and increase the reliability of ultrasound diagnostics, including when examining patients with chronic liver diseases. The choice of a place for measuring tissue elasticity indicators is made using a test volume on a two-dimensional ultrasound image, and the numerical values of the elasticity indicator are given in kilopascals, therefore the method is called quantitative ultrasound elastography or elastometry.These methods expand the capabilities of the ultrasound system and increase the reliability of ultrasound diagnostics, including when examining patients with chronic liver diseases. The choice of a place for measuring tissue elasticity indicators is made using a test volume on a two-dimensional ultrasound image, and the numerical values of the elasticity indicator are given in kilopascals, therefore the method is called quantitative ultrasound elastography or elastometry.Previously, no studies have been conducted that summarize and compare the features of liver and spleen elastometry, comparing pathologies that can be diagnosed by these studies. This review was carried out with the aim of comparing the available data on the methods of carrying out and the results of measuring the stiffness of the liver and spleen. Tasks:

- to compare the features of methods for studying stiffness of the liver and spleen;
- to determine the ranges of stiffness of the liver and spleen in healthy volunteers;
- to analyze diseases and their complications, in which the stiffness of the liver and spleen increases.

The search for scientific and medical literature in abstract and scientometric databases from the PubMed and eLibrary platforms was carried out. Search depth - 2010 to 2020.The search terms were used: spleen, spleen elastography, spleen stiffness, liver, liver stiffness, liver elastography, spleen, spleenelastography, spleenstiffness, liver, liverstiffness "," Liverelastography ". A critical analysis of the selected literature was carried out in accordance with the sections indicated in the research objectives.

Reproducibility of hardness measurement results

ISSN 2792-3983 (online), Published under Volume: 1 Issue: 5 in October-2021

Y.S. Choetal. report that the method of two-dimensional shear wave elastography (2D ESW) was able to carry out IZH in 52.9% of patients, while IZH - in 94.2% of patients [1].

M. Balakrishnanetal. compared intra- and interobserver reproducibility of liver and spleen elastometry results using shear wave point elastography (TESW).ВнутриисследовательскаявоспроизводимостьрезультатовИЖПwas 0.89 (95% confidence interval (CI) 0.85-0.92), IZhS - 0.72 (95% CI 0.61-0.8). Interobserver reproducibility: 0.85 (95% CI 0.76–0.9) for LPI and 0.73 (95% CI 0.6–0.83) for LPI [2]. A.V. Kovalev and A.V. Borsukov made conclusions about an increase in the reproducibility of results when using the improved technique of spleen elastometry by the 2D ESV method using several patient positions and a larger number of measurements (sensitivity 92.1%, specificity 88.5%, accuracy 90.5%) versus the standard technique (69, 1%, 93.7%, 80.3%, respectively) [3].

According to different authors, the reproducibility of IHP is positively influenced by the presence of liver cirrhosis and the thickness of the abdominal wall less than 17.2 mm [1], negatively - obesity, waist circumference more than 105 cm and the distance from the skin to the liver capsule more than 2 cm [2]. The reproducibility of IZhS is positively influenced by splenomegaly (the length of the spleen is more than 9.4 cm), negatively - by its small size [2, 4]. Narrow intercostal spaces impede both IZhP and IZhS [5].

Patient position

With IVI, most researchers used the position of the patient supine [5–12] or on the left side [8, 9, 13]. The experimental use of the patient's position on the left side showed a significant excess of the average results over the results obtained in the same patients in the supine position [8].

In the case of IZhS, the studies were carried out with the patient lying on his back with the left hand retracted behind the head or with both hands [4, 14–23]. The position of the patient on the right side was also used [13].

Breathing phase

When examining the liver, M.H. Yunetal. found that its rigidity after deep exhalation was significantly greater than after deep inhalation (8.7 and 7.9 kPa, respectively). According to the authors' assumption, this is due to the fact that during exhalation, intrathoracic pressure and venous return to the heart from the hepatic veins decrease; thus, the blood supply to the liver increases, and the effect of “stagnant liver” arises [24]. The same results were shown by W. Lingetal's study: the stiffness of the liver on expiration is significantly greater than the stiffness at the height of inspiration (4.2 versus 3.4 kPa)[25].Other researchers have noted that the breathing phase does not affect the results of the LPI [26]. Holding the breath for a few seconds with calm breathing leads to the optimal results of the IVP [27, 28].

When examining the spleen, patients are asked to hold their breath for the duration of the measurement [21]. A. Pawlućetal. measurements were taken after a deep breath - this technique improves visualization of the spleen and reduces the number of artifacts [16]. In a study by M. Giuffrèetal.patients inhaled deeply and held their breath for 5 s [22].However, there is evidence that hardness values increase with deep breaths. T. Karlasetal. compared two breathing methods during elastometry - holding the breath after a deep exhalation and after a deep inhalation. After deep exhalation the results were 2.46 ± 0.36 m / s, after deep inhalation - 2.66 ± 0.36 m / s [20].

Eating

Researchers avoid measuring hardness immediately after a meal. In different studies, the interval between refusal of food and the beginning of the study ranged from 4 to 8 hours [4, 15, 17, 18].According to M. Kjærgaardetal., The increase in liver stiffness depends on the calorie content of the food taken. After consuming 625 kcal, liver stiffness increased by 22% (2D ESV) and by 28% (transient elastometry (TE)); after consumption of 1250 kcal, the increase in hardness was 31% (3D ESV) and 37% (TE). The stiffness of the spleen increases after eating by 17-19%. The authors recommended performing IZH and IZhS at least 3 hours after a meal [29].

Number of measurements. In the case of LPI, from 5 to 15 measurements were carried out [5, 7–12, 25]. J.H. Yoonetal. it was shown on 86 patients that after 6 measurements, no significant change in the result and interquartile range (IQR) was observed [5].

In the study of the spleen in different works, a different number of measurements were carried out - 3, 5, 10, 20 [4, 14–20, 29]. According to the results of T. Karlasetal., 7 measurements in healthy patients and 8 measurements in patients with cirrhosis are sufficient to obtain stiffness values with an IQR of less than 5% [20]. The authors recommend to carry out 10 measurements, since this figure corresponds to the traditional number of LPIs when performing TE [20].

Influence of gender, age, height, body weight In most studies, liver stiffness was higher in men than in women

[6, 10, 13, 25]. Some other authors did not find significant differences in the indicators of liver stiffness in men and women [26, 30].

ISSN 2792-3983 (online), Published under Volume: 1 Issue: 5 in October-2021

In children under 1 year of age, when examining with a convex probe, lower values of spleen stiffness were revealed than in other age groups; when investigating with a linear sensor, such a difference was not found [21].M.J. Leeetal., Studying the stiffness of the internal organs in children, found that the stiffness of the liver does not depend on age, and the stiffness of the spleen undergoes changes - in the group of children under 5 years old it is slightly lower (2.02 ± 0.037 m / s) than in the groups older 5 years (2.30–2.37 m / s) [14]. Among adult volunteers, there was no difference in the stiffness of the spleen among different age groups [18, 22, 23].

Most of the IHS results indicate that there is no significant difference between men and women [4, 18, 19, 22, 23, 31–33].Also, no difference was found among patients of different heights, with different body weight and body mass index [18, 19, 22, 23].

Sensor type

In a study of liver stiffness S. Changetal. showed that the shear wave velocity when using the TESV method with a convex probe was significantly higher than when using a linear probe at the same depth both on the phantom and in healthy volunteers. It is possible that these differences are related to the different frequency and spatial resolution of the convex and linear transducers.According to the results of the phantom study, the linear transducer provided a reliable coefficient of variation at a distance of 5–40 mm between the transducer and the ROI, and the convex transducer at a distance of 25–60 mm.

T. Cañasetal. studied the difference between the values of the stiffness of the spleen, obtained by the convex and linear transducers, and did not reveal a statistically significant difference (convex transducer - 2.17 m / s, 95% CI 2.08-2.26; linear transducer - 2.15 m / s , 95% CI 2.09–2.21), but found a lower variability in results when studying with a linear probe than with a convex probe [21].

Causes of increased stiffness of the liver and spleen

Thus, the tissue of the organ can react to an acute inflammatory process, trying to isolate the focus of inflammation from neighboring, while healthy tissues. LPI is used to assess the presence of liver cirrhosis. With cirrhosis of the liver, its stiffness increases to 15–100 kPa. Attention is drawn to a significant increase in the transition from normal tissue to pathological: the stiffness of the liver at a shear wave propagation speed of 1 m / s is 3 kPa, while at a speed of 3 m / s Young's modulus reaches 27 kPa, which corresponds to the presence of liver cirrhosis [26].

In patients with decompensated cirrhosis, liver stiffness more than 24.6 kPa indicates the presence of clinically significant portal hypertension (sensitivity 81%, specificity 88%) [4].

Diseases that are accompanied by an increase in the stiffness of the spleen can be divided into three groups: infectious, myeloproliferative, liver and portal vein diseases; in addition, accumulation diseases are isolated. A. Baturetal. thetESV method was used to study how the stiffness of the spleen changes in these groups of diseases.In diseases of the liver and the portal vein system, the stiffness was 3.27 ± 0.36 m / s, in myeloproliferative diseases - 2.98 ± 0.33 m / s, in infectious diseases - 2.44 ± 0.21 m / s. Obviously, in various diseases that cause splenomegaly, the spleen parenchyma is filled with different cells and, accordingly, the mechanical properties of the spleen itself change in different ways. Thus, spleen elastography can serve as a method for differential diagnosis between the above three groups of diseases [31].Liver and spleen stiffness values do not differ in patients with varicose veins of the esophagus (EVV) with and without a high risk of rupture - i.e. it is not possible to predict the presence of EVEP by organ stiffness [4]. One can only exclude with a probability of 88.9% the presence of EVEP with a high risk of rupture in adult patients with spleen stiffness less than 35.8 kPa.

In children, there is a correlation with the presence of portal hypertension with a liver stiffness value of more than 2.09 m / s (sensitivity 77%, specificity 80%) and with a spleen stiffness value of more than 3.14 m / s (sensitivity 68%, specificity 99%) [19].There is also evidence that the stiffness of the spleen significantly increases with extrahepatic obstruction of the portal vein: the mean value of stiffness is 44.92 ± 12.35 kPa.

Discussion

The lower intra- and interobserver reproducibility of measurements of the spleen compared to the liver is explained when comparing organ syntopy. The liver is a fairly voluminous organ (weight about 1500 g), with its vast diaphragmatic surface directly adjacent to the abdominal wall, which facilitates visualization.The spleen is a much smaller organ (100–300 g), syntopically next to it are the stomach, loops of the small intestine, and the colon [38]. These structures are often filled with heterogeneous content, which makes visualization difficult [24-31].

Attention is drawn to the fact that the results of IZH and IZhS change differently during inhalation and exhalation: at the height of inhalation, the stiffness of the liver decreases, and the stiffness of the spleen increases; after a deep exhalation, the stiffness of the liver becomes greater and the stiffness of the spleen is less.As previously assumed [23],

ISSN 2792-3983 (online), Published under Volume: 1 Issue: 5 in October-2021

after exhalation, the blood supply to the liver increases, which increases its stiffness, and after inhalation, its blood supply decreases, and accordingly the liver stiffness decreases. As for the spleen, the decrease in its stiffness on expiration can be explained by the fact that during deep exhalation the celiac trunk is compressed by the legs of the diaphragm, thus reducing the arterial flow to the spleen, which makes a significant contribution to the formation of its stiffness. When inhaling, the compression of the celiac trunk stops, and the arterial flow to the spleen is restored.After eating, the stiffness of both the liver and spleen increases. This is probably due to the intensification of blood flow in the organs of the gastrointestinal tract.

When choosing the location of the zone of interest for measuring the stiffness of both the liver and the spleen, it is important that it is located at a distance of up to 6 cm from the sensor and at a depth of at least 1 cm from the organ capsule. This is due to the fact that connective tissue trabeculae extend deep into the capsule of the parenchymal organs.When choosing the zone of interest for the IZhS, it is important that at the time of measurement on the line between the sensor and the zone of interest in the spleen there are no "air" structures (left lung, stomach, intestines), which will increase the accuracy and reproducibility of the measurement.

According to research data, the stiffness of the liver is normally in the range of 4.0–6.5 kPa, and the stiffness of the spleen is in the range of 12–21 kPa.There is an assumption that the stiffness of the spleen is greater than the stiffness of the liver because the spleen perceives high blood pressure from the splenic artery extending from the celiac trunk, and the liver receives most of the blood from the portal vein, where such pressure is not applied [41]. This assumption is indirectly confirmed by the data of M.J. Leeetal. [fourteen]. It is known that the kidneys, like the spleen, receive blood from an artery, which creates high blood pressure. Indeed, in children, the stiffness of the liver was 1.12 m / s, spleen - 2.25 m / s, right kidney - 2.19 m / s, left kidney - 2.33 m / s.The values of the stiffness of the kidneys and spleen are comparable, the values of the stiffness of the liver are comparatively lower [14]. From this it follows that the results of IZhS may depend on blood pressure - in patients with high blood pressure, the stiffness of the spleen is greater. In addition, in the literature it was not possible to find works on the effect of physical activity on the stiffness of the spleen. These assumptions require additional research.

Conclusion

Based on the results of the literature review, the following conclusions can be drawn.

1. For a long time, biopsy was the only accurate method for determining the degree of liver fibrosis. Methods for measuring liver and spleen stiffness do not differ in terms of patient position, food intake, depth and location of the zone of interest, the number of measurements, and the type of transducer. The reproducibility of the IZhP is higher than the reproducibility of the IZhS.
2. The obtained values of liver stiffness are significantly less than the values of the stiffness of the spleen, the spleen is a more rigid organ. This can be attributed to differences in the cellular composition of the spleen and liver and to the pressure exerted on the spleen by blood from the artery of the same name.
3. Measuring the stiffness of both the liver and spleen can be used as a diagnostic criterion for portal hypertension. In addition, IZhL can be used to diagnose liver cirrhosis, IZhS - as a marker for excluding the development of EVVP and for indirect diagnosis of the nature of the spleen lesion.

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ISSN 2792-3983 (online), Published under Volume: 1 Issue: 5 in October-2021