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Application of Shear Wave Elastography of Biceps Humerus in Normal Subjects

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Abstract

Objective: To explore the feasibility and method of real-time shear wave elastography (SWE) to evaluate the elasticity of the biceps brachii under different tension states. Methods: 100 healthy young people were enrolled, including 48 males and 52 females. SWE technology was used to measure the Young's modulus of the right biceps brachii muscle at different flexion angles of the elbow joint (0 °, 45 °, 90 °, 135 °). Compare the Young's modulus of the biceps brachii with different bending angles and different weight holding conditions. Results: Under the same flexion angle, the difference in the Young's modulus of the biceps brachii muscle under different weight-bearing conditions was statistically significant (P <0.001). The elasticity values of each group increased with the increase in weight; The difference in Young's modulus of the biceps brachii muscle at different flexion angles was statistically significant (P <0.001). The elbow flexion was highest at 45 ° and the elbow flexion was lowest at 135 °. Conclusion: Real-time shear wave elastography can quantitatively reflect the elasticity of the biceps brachii in different states. The Young's modulus value increases with increasing muscle tension. The elbow bending angle is one of the factors affecting its elasticity.

Keywords

Real-time shear wave elastography; Biceps; Young's modulus.

1. Introduction

In recent years, the incidence of stroke has been increasing year by year. The standard incidence of first stroke among residents aged 40 to 74 in my country has increased by an average of 8.3% per year [1]. Data from the "2018 China Health Statistics Summary" shows that stroke is currently the leading cause of death and disability in the Chinese population. The severity of limb spasm after stroke and the treatment effect are one of the important factors affecting the disability rate of the disease. The correct evaluation of the limb muscle spasm of stroke patients has an important guiding role in scientifically formulating treatment plans. In the past, clinical judgments were mostly made by direct contact diagnosis of muscle elasticity. There were deficiencies such as inability to quantify, poor reproducibility, and inconsistent standards.

Real-time shear wave elastography technology has been widely used in the study of pathological changes in thyroid, breast, liver and other parts. Muscle spasm after stroke is an increase in passive muscle tone caused by stretched hyperreflexia in spinal cord segments after brain tissue injury. Shear wave elastography technology can quantitatively detect the Young's modulus value of the tissue and evaluate the elastic hardness of the tissue. The higher the Young's modulus value, the greater the hardness of the tissue. Therefore, the muscle tension can be quantified by measuring the Young's modulus value. This study uses this technology to measure the elasticity of the biceps brachii under different tension states, and provides a

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method and data basis for evaluating the elasticity of the biceps brachii under normal and pathological conditions.

2. Research Objects and Methods

2.1. Research Objects

A total of 100 volunteers who came to our hospital for health checkups and engaged in non-physical work from September to November 2019, right-handed. Age 18-31 years old, average age 24.08±2.47 years old; height 155-182cm, average 168.07±7.32 cm; weight 44-95kg, average 61.93±10.80kg. Exclusion criteria: history of upper limb deformity or trauma, history of various muscle diseases such as myasthenia gravis, progressive muscular dystrophy, periodic paralysis, and history of hypertension, diabetes, hyperthyroidism, hypothyroidism, etc. All participants signed an informed consent form and cooperated with the training.

2.2. Apparatus and Method

The Aixplorer real-time shear wave elastography ultrasonic diagnostic instrument produced by Supersonic Imagine (Supersonic Imagine, Aixen Provence, France), L10-2 linear array probe is used. All volunteers were in a supine position, routine ultrasound examination to rule out biceps lesions, and then the transverse section was scanned along the vertical muscle bundle from top to bottom to scan the biceps muscle belly, and then the probe was rotated 90° along the parallel muscle bundle direction from inward Scan the lateral longitudinal section, and use the "cross method" to locate and mark the thickest position of the biceps muscle belly. After that, keep your right forearm flat on the bed, hold dumbbells with weights of 0kg, 1kg, and 3kg in your right hand, and flexion of the elbow joint at 0°, 45°, 90°, 135° (starting position: supine position: arm on torso) Both sides and the elbow joints straight. The palm is up and fist-like. Measurement method: Sagittal plane. Protractor: The axis is located on the side of the joint and passes through the epicondyle of the humerus. The fixed arm is parallel to the midline of the humerus. The movable arm is parallel to the midline of the forearm.) Continue 1 minute. At the same time, select the elasticity imaging mode (SWE), and set the area of interest to a size of (10×10) mm, and the area of interest is about 1 to 1.5 cm deep from the skin surface to ensure that the non-mosaic color fills the sampling frame and then the image is frozen. Start the Q-BOX function to measure the Young's modulus of muscle tissue in the region of interest. The Q-BOX measurement area is uniformly set to a diameter of 3mm (the diameter varies depending on the size of the area of interest), the system automatically calculates the average Young's modulus value of the muscle tissue in the Q-BOX area, and the measurement is taken 3 times. Average.

2.3. Statistical Processing

SPSS 26.0 statistical software was used for statistical analysis. Measurement data were expressed as (x±s). One-way analysis of variance was used for comparison between multiple groups, and t-test was used for pairwise comparison between groups. $P<0.05$ indicated that the difference was statistically significant.

3. Results

All participants successfully completed the biceps imaging scan and the Young's modulus measurement. The Young's modulus value increased with the increase of muscle tension. The real-time shear wave elastography performance of the biceps brachii was as follows: The stable non-mosaic color filling in the sampling frame changes from blue to red as the Young's modulus value changes. The larger the Young's modulus value, the more red the color, and vice versa, the bluer the color. (Figure 1)

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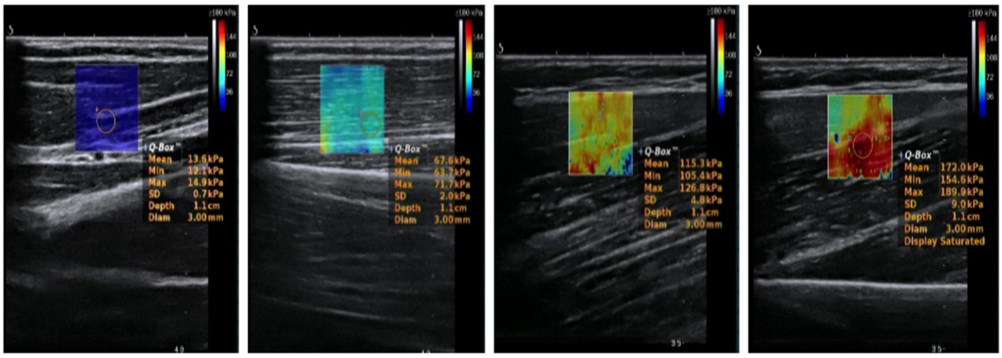

Figure 1. Shear wave elastography and Young's modulus value of biceps brachii under different muscle tension (a. Young's modulus value is 13.6kPa, the elasticity graph is dark blue; b. Young's modulus value is 67.6kPa, The elastic graph is light blue; c. Young's modulus value is 115.3kPa, elastic graph is yellow; d. Young's modulus value is 172.0kPa, elastic graph is red;)

3.1. Comparison of Young's Modulus of Biceps When the Elbow Joint Is Bent at Different Angles under the Same Weight-bearing State

When the elbow joint is flexed at 0°, 45°, 90°, 135° in the zero-weight state, the Young's modulus values of the biceps are: 56.74±13.60kPa, 89.24±25.24 kPa, 46.83±10.11 kPa, 15.11±2.87 kPa. When the elbow joint is flexed at 0°, 45°, 90°, 135° under the load of 1Kg, the Young's modulus of the biceps muscle is 70.68±10.37 kPa, 124.04±27.04 kPa, 56.00±11.37 kPa, 15.59±3.09, respectively. kPa. When the elbow joint is bent at 0°, 45°, 90°, 135° under a weight of 3Kg, the Young's modulus values of the biceps are 76.06±18.28 kPa, 153.76±38.50 kPa, 63.48±14.10 kPa, 15.72±3.50 kPa. Comparison of differences between groups, P value <0.05. (See Table 1)

3.2. Comparison of Young's Modulus Values of Biceps Brachii under Different Weight-bearing Conditions with the Same Elbow Joint Bending Angle

When the elbow flexion is 0°, the Young's modulus of the biceps brachii under the load of 0kg, 1kg and 3kg are 56.73±10.37 kPa, 70.68±10.36 kPa, 76.06±18.28 kPa, respectively. When the elbow joint is flexed at 45°, the Young's modulus of the biceps brachii under the load of 0kg, 1kg and 3kg are respectively: 89.24±25.24 kPa, 124.04±27.04 kPa, and 153.76±38.50 kPa. When the elbow joint is flexed at 90°, the Young's modulus of the biceps under the load of 0kg, 1kg, and 3kg are: 46.93±10.11 kPa, 56.00±11.37 kPa, 63.48±14.11 kPa; the difference between groups, P value< 0.05, which is statistically significant. When the elbow is flexed at 135°, the Young's modulus of the biceps under the load of 0kg, 1kg, and 3kg are: 15.11±2.87 kPa, 15.59±3.09 kPa, 15.72±3.50 kPa, respectively. Comparison of differences between groups, P value>0.05, is not statistically significant. (See Table 1)

Table 1. Young's modulus values of biceps brachii under different weight-bearing conditions and different elbow joint flexion angles

	0°	45°	90°	135°
Load 0kg Young's modulus value	56.74±13.60kPa	89.24±25.24 kPa	46.83±10.11 kPa	15.11±2.87 kPa
Load 1kg Young's modulus value	70.68±10.37 kPa	124.04±27.04 kPa	56.00±11.37 kPa	15.59±3.09 kPa
3kg Young's modulus value	76.06±18.28 kPa	153.76±38.50 kPa	63.48±14.10 kPa	15.72±3.50 kPa

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4. Discussion

Limb spasm after stroke is an important cause of disability after stroke. Reasonable evaluation of the degree of limb muscle spasm after stroke is the basis of treatment. In the past, doctors used to feel the tension and elasticity of the muscles to subjectively judge the degree of spasm. Modified Ashworsh scale (MAS method), clinical spasm index, muscle Methods such as electrograms to assess the muscle state of spastic limbs. Among them, the MAS method is a commonly used clinical evaluation method for spasticity due to its simplicity, ease of use, non-invasiveness, and low cost. However, it is easily affected by the examiner's experience. The evaluation results of physicians with different levels of understanding of the scale differ greatly. It is not easy to find subtle changes in muscle anatomy. The past evaluation methods of muscle spasm, including MAS method, clinical spasticity index, and electromyography, all have shortcomings such as strong subjectivity and insufficient evaluation content [2]. Choosing a scientific, objective, and comprehensive evaluation method for spasticity is of great significance for guiding the clinical development of a reasonable treatment plan and evaluating the prognosis.

In recent years, with the popularization and application of resolution ultrasound probes, ultrasound examination has played an increasingly important role in the diagnosis of muscle, bone and nerve diseases [5-8]. In particular, ultrasound real-time shear wave elastography (SWE), as a new technology that can reflect the mechanical characteristics of tissues, can be used to evaluate the properties and hardness of the lesion or tissue by measuring the Young's modulus value. It has been widely used at present It is used to measure liver stiffness and identify benign and malignant lesions such as thyroid, breast, and prostate [3-4].This technology can reflect the stiffness of the spastic muscle by measuring the Young's modulus of the muscle, so that the spasticity of the muscle can be detected and recorded in a quantitative way. Combined with conventional ultrasound imaging technology, it can not only clearly show the anatomical changes of the diseased muscle, but also quantitatively evaluate the degree of muscle spasm in real time. The degree of pathological changes can be assessed by comparing the Young's modulus of the biceps brachii under normal and spastic conditions.

In this study, passive weight-bearing was used to simulate limb spasticity, and real-time shear wave elastography was used to measure the Young's modulus of the biceps muscle belly under different weight-bearing conditions to obtain the relationship between the skeletal muscle Young's modulus and the degree of limb spasticity . At the same time, the influence of different bending angles of the elbow joint on the Young's modulus of the biceps brachii under the same weight-bearing condition was analyzed, so as to provide a method basis for the ultrasonic shear wave elastography to assess the degree of biceps lesions in normal and spastic states. The results show that: 1) Under the same weight-bearing state, with the different elbow joint flexion angle, the Young's modulus of the biceps brachii muscle changes accordingly. When the biceps brachii muscle is in the stretched position (flexion 45°), Yang The value of Young's modulus is the largest; when the biceps brachii is in a relaxed position (flexion 135°), the value of Young's modulus is the smallest. 2) Except when the elbow joint is flexed at 135°, when the elbow joint is bent at the same angle, the Young's modulus value of the biceps brachii muscle increases with the increase in the weight-bearing muscle tension; when the elbow joint is flexed at 135°, the Young's modulus value is There is a slight difference but the change is not obvious, which may be related to the fact that the biceps brachii is in an unstressed state at this angle, but may be squeezed by surrounding muscles. The above results suggest that the Young's modulus value of the biceps brachii muscle is not only related to its muscle tension, but also the bending angle of the elbow joint is also an important influencing factor. A unified examination method should be established to ensure the clinical evaluation of limb spasticity, prognosis and efficacy. The objectivity and repeatability of the evaluation.

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The results of this study show that real-time shear wave elastography technology can conveniently and quantitatively measure the Young's modulus of the biceps brachii muscle, thereby reliably assessing its elastic hardness and degree of spasm. When measuring, all Young's modulus values should be obtained from the longitudinal section of the muscle belly, and the probe angle and pressing force should be strictly controlled to minimize the error as much as possible [9]. Limited by the sample size, the specific measurement values in the conclusions of this study still need to be further measured and counted with large samples, so as to obtain the normal reference value of the normal biceps brachii of Chinese people.

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