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Correlation study of geriatric frailty syndrome with ultrasound elastography parameters

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Abstract: This study examines the changes in renal and carotid artery elasticity parameters in patients with geriatric frailty syndrome, analyzing the clinical value of ultrasound elastography (UE) in frailty assessment. A total of 120 elderly frail patients (frailty group) and 60 healthy elderly individuals (control group) were selected from January 2023 to December 2024. The Fried frailty phenotype criteria were used for frailty staging, and shear wave elastography (SWE) was applied to measure the elastic modulus values of renal cortex and carotid arteries. Traditional biochemical indicators (blood creatinine, eGFR) and atherosclerosis parameters (pulse wave velocity, PWV) were also recorded simultaneously. Pearson correlation analysis and ROC curve evaluation were used to assess the relationship between elasticity parameters and frailty severity. The results showed that the renal cortex elasticity value (28.5±5.2 kPa) and carotid artery elasticity value (35.6±6.8 kPa) in the frailty group were significantly higher than those in the control group (12.8±2.1 kPa, 18.3±3.4 kPa). Elasticity values were positively correlated with the frailty index (FI) (p<0.01) and negatively correlated with eGFR (p<0.01). ROC curve analysis revealed that the combined use of renal cortex elasticity value and carotid artery elasticity value had an AUC of 0.93 for diagnosing moderate to severe frailty (sensitivity 88%, specificity 85%). The study found that ultrasound elastography parameters are significantly associated with the severity of geriatric frailty syndrome and can serve as a non-invasive, objective assessment tool to assist in early identification and intervention of frailty status.

1. Introduction

With the increasing aging of the global population, geriatric frailty syndrome has become a research hotspot in the field of geriatric medicine. Frailty syndrome is a multi-dimensional clinical state, manifested by decreased physiological reserve and increased body vulnerability, which makes the elderly more prone to adverse health events, such as fall, disability, hospitalization and death, facing various stress factors. Accurately assessing the degree of geriatric frailty syndrome is important for developing personalized interventions and preventing the occurrence of adverse events.

Traditionally, the assessment of geriatric frailty syndrome mainly relies on clinical scales and questionnaires, such as the Fried Frailty phenotype, the FRAIL scale, etc. However, these methods have some subjectivity and lack objective biological indicators. In recent years, with the continuous development of imaging technology, ultrasound elastography (UE) technology is gradually applied in clinical practice. The UE technique is able to measure the hardness and elasticity changes of the elasticity of the tissue, providing a new perspective for the diagnosis and evaluation of diseases.

In the study of senile frailty syndrome, the kidney and carotid artery are important target organs, and their elasticity changes may be closely related to the degree of frailty. Kidney is an important organ to maintain the stability of the internal environment, and the decline of renal function plays an important role in the development of senile frailty syndrome. The carotid artery, as a window reflecting the degree of systemic arterial stiffness, its altered elasticity is also closely related with the risk of cardiovascular disease, which is one of the common complications in elderly patients with frailty syndrome. Therefore, the purpose of this study is to investigate the changing characteristics of renal and carotid elasticity parameters in patients with senile frailty syndrome, analyze the clinical value of UE technique in frailty assessment, and provide a new basis for early diagnosis and intervention of geriatric frailty syndrome.

2. Research design and methods

2.1 Research objects

A total of 120 elderly frailty patients attending our hospital between January, 2023 and December 2,2024 were selected as the frailty group, and all patients met the diagnostic criteria for Fried frailty phenotype[1]. At the same time, 60 cases of healthy elderly people who underwent physical examination in our hospital during the same period were selected as the control group. In comparison with the general data of gender, age and other aspects, the difference was not significant (P> 0.05), which was comparable.

Frailty group: a total of 120 patients, including 65 males, 55 females; age 65-85 years, mean (75.3±6.8) years. All patients showed varying degrees of debilitating symptoms, such as weight loss,loss of appetite, delayed mobility, and prone to falls. Patients were divided into three subgroups of mild, moderate and severe frailty phenotype criteria.

Control group: a total of 60 healthy elderly patients were included, including 32 males and 28 females; age was 65-80 years, mean (73.9±5.6) years. All the control group members were confirmed by full physical examination, with no history of major disease and no debilitating symptoms.

2.2 Inclusion and exclusion criteria

Inclusion criteria: aged 65 years; frail group met Fried criteria for Frailty phenotype; members of the control group confirmed by full physical examination; signed informed consent to undergo ultrasound elastography and related assessments;

Exclusion criteria: patients with severe heart, lung, liver and kidney; patients with serious diseases such as malignancy; patients with mental or cognitive impairment unable to cooperate with examination; patients with contraindications for ultrasound elastography.

2.3 Methods

Ultrasonic elastography examination: Sound science Aixplorer color Doppler ultrasound diagnostic instrument, equipped with XC6-1 convex array probe, frequency set to 3.5-5.5MHz.

Check with a color Doppler ultrasound diagnostic instrument equipped with shear wave elastography (SWE) technique. The patient was placed in the supine position with adequate exposure of the examination site. First, a routine ultrasound examination was performed to observe the morphology and structure of the kidneys and carotid arteries. Then switch to SWE mode for elastography of the kidney cortex and carotid arteries. In the stable images, the region of interest (ROI) was selected, and the elastic modulus value of the renal cortex and the carotid artery was measured and recorded. Each sites were measured three times and the average was taken as the final result.

Detection of biochemical indexes and arteriosclerosis parameters: All patients collected fasting venous blood before ultrasound elastography for the detection of traditional biochemical indexes such as blood creatinine. At the same time, pulse wave velocity (PWV) and other arterial stiffness parameters. All tests were performed by professionals to ensure the accuracy and reliability of the results.

Frailty assessment: Frailty was assessed in the frailty group using the Fried frailty phenotype criteria. The criteria included five indicators: weight loss, reduced handgrip strength, slow movement, perceived fatigue, and decreased physical activity. Patients with three or more items can be defined as frailty. Based on the evaluation results, patients were divided into three subgroups: mild, moderate and severe frailty.

2.4 Observing indicators

Ultrasonic elastic imaging parameters: including renal cortex elastic modulus value, carotid elasticity modulus value, etc. These parameters are used to reflect the elastic characteristics of the kidney and carotid arteries.

Biochemical indicators and arteriosclerosis parameters: including blood creatinine, estimated glomerular filtration rate (eGFR), pulse wave conduction velocity (PWV), etc. These parameters were used to assess renal function and degree of arteriosclerosis in patients.

Degree of frailty: Frailty was assessed using Fried Frailty phenotype criteria and divided into three subgroups: mild, moderate and severe frailty based on the evaluation results.

2.5 Statistical methods

Data analysis was performed using the SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($x \pm s$), and comparisons between groups were performed by t-test or ANOVA. Count data are expressed as rate (%) and compared between groups using χ^2 test. A Pearson correlation analysis was used to investigate the relationship between ultrasound elastography parameters and weakness, biochemical parameters and arterial stiffness parameters. ROC curves were used to assess the efficacy of ultrasound elastography parameters in diagnosing geriatric frailty syndrome, and the optimal cutoff value, sensitivity, and specificity were calculated. A $P < 0.05$ was considered as a statistically significant difference.

3. Results

3.1 Comparison of ultrasound elastographic parameters between the two groups

Comparison of ultrasound elastography parameters between the two groups showed that the renal cortical elastic modulus values (28.5 ±5.2 kPa) and carotid elastic modulus values (35.6 ±6.8 kPa) were significantly higher than the control group (12.8 ±2.1 kPa and 18.3 ±3.4 kPa, respectively), with statistically significant differences ($P < 0.01$). The specific results are shown in Table 1.

Table 1 Comparison of ultrasonic elastic imaging parameters between two groups (x ±s, kPa)

group	Example number	The elastic modulus value of the renal cortex	Carotid artery elastic modulus value
Frailty group	120	28.5 ±5.2	35.6 ±6.8
control group	60	12.8 ±2.1	18.3 ±3.4
t price	-	18.672	15.789
P price	-	<0.01	<0.01

3.2 Correlation between ultrasound elastographic parameters and the degree of frailty

A Pearson correlation analysis was used to investigate the relationship between ultrasound elastography parameters and the degree of weakness. The results showed that the values of the frailty index (FI) (r=0.72, P <0.01), and the carotid elastic modulus was also positively correlated with FI (r=0.65, P <0.01). This indicates that the elastic modulus values of the kidney and carotid arteries increased with the aggravation of the weakness. At the same time, the elastic modulus value of renal cortex and carotid artery was negatively correlated with eGFR (r= -0.68, P <0.01), that is, with the decline of renal function, the elastic modulus value also increased accordingly.

3.3 ROC curve analysis

The ROC curves were used to assess the efficacy of ultrasound elastography parameters in the diagnosis of geriatric frailty syndrome. The results showed that the elastic modulus value of AUC for severe weakness was 0.86(95%CI:0.80-0.92), with a sensitivity of 80% and a specificity of 82%.Carotid elastic modulus value alone for the moderate and severe weak AUC of 0.82(95%CI:0.75-0.89), sensitivity of 75% and specificity of 78%. However, when the renal cortex elastic modulus value combined with carotid elastic modulus value was diagnosed, AUC increased to 0.93(95%CI:0.88-0.97), sensitivity was 88% and specificity was 85%. This indicates that the combined application of the two elastic parameters was able to significantly improve the diagnostic efficacy. (Table 2)

Table 2. Results of the ROC curve analysis

Parameters / combinations	AUC	95%CI	sensitivity
cortex renis	0.86	0.80-0.92	80%
arteria carotis	0.82	0.75-0.89	75%
Kidney cortex + of the carotid artery	0.93	0.88-0.97	88%

4. Conclusion

This study analyzed the clinical value of ultrasound elastography in the assessment of frailty by exploring the changes of renal and carotid elastic parameters in elderly patients with a frailty syndrome. The results showed that the renal cortex and carotid elastic modulus values of all patients in the frailty group were significantly higher than those in the control group, and these elastic parameters were closely associated with the degree of frailty[2]. With the aggravation of weakness, the elastic modulus value of kidney and carotid arteries showed an increase trend, while it was negatively correlated with eGFR. The ROC curve analysis further demonstrated that the combination of renal cortex and carotid elastic modulus values could significantly improve the efficacy to diagnose moderate to severe frailty.

The results of this study suggest that the ultrasound elastography technique has significant

clinical value as a noninvasive, objective assessment tool in the early identification and intervention of geriatric frailty syndrome[3]. By measuring the elasticity parameters of the kidney and the carotid artery, it can indirectly reflect the frailty state and the organ function changes of the patients, and provide a scientific basis for clinical decision-making. However, some limitations of this study remain, such as limited sample size and failure to consider other factors that may influence elasticity parameters. Therefore, in future studies, further expanding the sample size and comprehensively considering multiple factors are needed to more accurately evaluate the utility of ultrasound elastography in senile frailty syndrome.

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