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Application value of ultrasound elasticity technique in the evaluation of renal impairment in chronic diseases in the elderly

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Abstract: The study explores the diagnostic value of ultrasonic elastography (UE) in early kidney damage in elderly patients with chronic diseases (hypertension, diabetes). A total of 100 elderly patients with chronic diseases who visited our hospital from January 2022 to December 2024 were selected as the observation group, while 50 healthy elderly individuals were chosen as the control group during the same period. The elastic modulus values of the kidneys in both groups were measured using ultrasound elastography, and the differences between the two groups were compared. The results showed that the elastic modulus values of the kidneys in the observation group were significantly higher than those in the control group ($P<0.05$); there was a significant correlation between the elastic modulus values of the kidneys and the patients' renal function indicators (serum creatinine, blood urea nitrogen, glomerular filtration rate) ($P<0.05$). This study demonstrates that ultrasound elastography can quantitatively assess the degree of kidney damage in elderly patients with chronic diseases, providing valuable information for clinical diagnosis and treatment, and has high application value.

1. Introduction

With the aging of the global population, the incidence of chronic diseases in the elderly is on the rise. Common chronic diseases of the elderly, such as diabetes, hypertension, cardiovascular disease, etc., not only seriously affect the quality of life of the elderly, but also often cause various complications, among which renal damage is a more common and serious one. According to statistics, the incidence of renal damage is as high as 30% -5,0% in elderly patients with chronic diseases[1]. Renal impairment not only leads to a gradual decline in renal function, but may also progress to end-stage renal disease, requiring alternative therapy such as dialysis or kidney transplantation, placing a heavy physical and financial burden on the patient. Therefore, an early and accurate assessment of the degree of renal damage in elderly patients with chronic diseases is important for developing reasonable treatment plans and delaying disease progression.

Traditional methods of renal damage assessment mainly include laboratory indicators such as serum creatinine, blood urea nitrogen and glomerular filtration rate, as well as imaging tests such as renal ultrasound and CT[2]. However, these methods have some limitations. Serum creatinine and BUN levels are susceptible to various factors, such as muscle mass, diet, medication, etc., which do not accurately reflect early renal damage. Estimation of the glomerular filtration rate, although relatively accurate, requires 24-hour urine collection, which is cumbersome and has poor compliance for the elderly. Imaging examinations such as renal ultrasound and CT mainly observe the morphological and structural changes of the kidney, and have low sensitivity to early renal parenchymal damage. Therefore, finding an accurate, non-invasive and convenient method for assessing renal damage has important clinical needs.

As an emerging imaging technique, ultrasound elasticity technology has been widely used in clinical diagnosis in recent years. It evaluates the pathological state of the tissue by measuring the modulus value of elasticity, reflecting the hardness and elasticity of the tissue. The elastic changes in renal tissue are closely correlated with the degree of renal impairment, therefore, ultrasound elasticity technique is expected to be an effective method for assessing renal impairment in geriatric chronic diseases. This paper aims to explore the application value of ultrasound elasticity technology in the evaluation of renal damage in elderly chronic diseases, and to provide new ideas and methods for clinical diagnosis and treatment.

2. Research design and methods

2.1 Research objects

100 elderly patients with chronic diseases who visited our hospital from January 2022 to December 2024 were selected as the observation group. Among these, 60 were male and 40 were female; the age range was 60-85 years with mean age (68.5 ± 5.5). The distribution of disease types was: 40 patients with diabetes, 30 patients with hypertension, 20 patients with cardiovascular disease, and 10 patients with other chronic diseases (such as chronic obstructive pulmonary disease, chronic kidney disease, etc.). During the same period, 50 healthy elderly people were selected as the control group, 28 males and 22 females; age 60-80 years, mean age (66.8 ±4.8). In terms of age, gender and other aspects, there was no statistical significance ($P > 0.05$), which was comparable.

2.2 Inclusion and exclusion criteria

Inclusion criteria: All the patients in the observation group met the diagnostic criteria for the relevant chronic diseases of the elderly, such as diabetes according to the World Health Organization (WHO), and hypertension according to the Chinese Guidelines for the Prevention and Treatment of Hypertension; and the duration of the disease was more than 1 year. The patient is conscious and able to cooperate with the ultrasound test and related laboratory tests.

Exclusion criteria: excluding other diseases seriously affecting renal function, such as acute glomerulonephritis, systemic lupus erythematosus nephritis, etc.; excluding ultrasound contraindications, such as severe obesity and abdominal skin infection; excluding patients with drugs affecting renal function in recent (within 3 months).

2.3 Methods

A Aixplorer color Doppler diagnostic instrument was equipped with XC6-1 convex array probe with frequency set to 3.5-5.5MHz. The patient was taken in the supine position and placed the upper limbs on both sides of the head to fully expose the abdomen. First, a routine renal ultrasound examination was performed to observe the basic conditions such as the size, morphology and structure of the kidney. The ultrasound elastography mode was then initiated and the sampling box was adjusted to an appropriate size so that it contained most of the renal parenchyma while avoiding the renal sinus and perirenal adipose tissue as much as possible. Ask the patient to hold his breath for 3-5 seconds and freeze the image after the image stabilizes. Three different regions of interest (ROI) were selected on the image, and each ROI was 1.0cm * 1.0cm. The elastic modulus value (in kPa) of each ROI was measured and recorded, and the average of the three ROI measurements was taken as the elastic modulus value of the kidney.

2.4 Observing indicators

Kidney tissue hardness related parameters: the elastic modulus value is mainly observed, which reflects the hardness of the kidney tissue. The larger the value is, the harder the kidney tissue is.

Renal function index: Fasting venous blood was collected in the morning for blood creatinine (Scr),blood urea nitrogen (BUN), and glomerular filtration rate (eGFR). Among them, blood creatinine was measured by the picric acid method, urea nitrogen by the urease-wave method, and the glomerular filtration rate was calculated according to the simplified MDRD formula.

2.5 Statistical methods

The data were analyzed using the SPSS22.0 statistical software. Measurement data are expressed as mean ± standard deviation ($x \pm s$), using independent sample t-test for comparisons between two groups; analysis of variance for comparison between multiple groups and LSD-t-test for pairwise comparisons. Count data were expressed as number of cases and percentage using χ^2 test. A $P < 0.05$ was considered as a statistically significant difference.

3. Results

3.1 Comparison of the two groups of basic parameters

The results of renal elasticity parameters and renal function indexes between the observation and control groups are shown in Table 1. The renal elastic modulus value of the observed group was significantly higher than the control group, and the difference was statistically significant ($t=15.42$, $P < 0.05$). In terms of renal function index, blood creatinine and blood urea nitrogen in the observation group were significantly higher than the control group, statistically significant ($t = 16.78, 10.23$, $P < 0.05$), while the glomerular filtration rate was significantly lower than the control group ($t = -14.56$, $P < 0.05$). This indicates increased kidney tissue stiffness in elderly patients with chronic disease.

Table 1: Comparison of renal elasticity parameters and renal function indexes between the two groups ($x \pm s$)

group	n	Elastic modulus value (kPa)	serum creatinine (μmol/L)	usea nitrogen (mmol/L)	Glomerular filtration rate (ml/min/1.73m²)
observation group	*100*	30.56±5.23	135.26±25.14	8.56±2.13	65.32±10.56
control group	*50*	18.25±3.12	82.45±15.32	5.23±1.25	95.45±12.34
t	-	15.42	16.78	10.23	-14.56
P	-	*<0.05*	*<0.05*	*<0.05*	*<0.05*

3.2 Correlation analysis results

The Pearson correlation analysis of the renal elastic modulus and disease severity of patients in the observation group showed that there was a significant positive correlation with blood creatinine ($r=0.65$, $P<0.05$), significant positive correlation with BUN ($r = 0.58$, $P<0.05$) and significant negative correlation with glomerular filtration rate ($r = -0.72$, $P<0.05$). This indicates that as the renal elastic modulus value increases, the blood creatinine and BUN levels increase, the glomerular filtration rate decreases, and the more severe the renal function impairment becomes. At the same time, the patients in the observation group were stratified according to the severity of disease, and the analysis found that the value of renal elastic modulus was also significantly positively correlated with the severity of disease ($r = 0.55$, $P<0.05$), that is, the more serious the disease, the greater the hardness of the kidney tissue and the higher the value of elastic modulus. (Table 2)

Table 2. Correlation analysis of renal elasticity modulus value and renal function index and disease severity in the observation group

metric	correlation coefficient (r price)	P price
Blood creatinine (μmol/L)	0.65	*<0.05*
Urea nitrogen (mmol/L)	0.58	*<0.05*
Glomerular filtration rate (mL/min/1.73m ²)	-0.72	*<0.05*
Disease severity	0.55	*<0.05*

4. Conclusion

The results of this study show that ultrasound elastic technology has important value in the assessment of renal damage in elderly chronic diseases. By measuring the elastic modulus value of the kidney, it can accurately distinguish the elderly patients with chronic diseases and healthy elderly, and the elastic modulus value and renal function index (blood creatinine, urea nitrogen, glomerular filtration rate) and the severity of the disease, which can effectively reflect the degree of renal damage in the elderly patients with chronic diseases[3]. Compared with the traditional renal damage assessment method, ultrasonic elasticity technology has the advantages of non-invasive, convenient and reproducible, and can be examined at the bedside, especially for elderly patients[4].Through the analysis of correlation, it was found that the increase of renal elastic modulus value, the increase of serum creatinine and urea nitrogen level, and the decrease of glomerular filtration rate were more serious with the more severe renal function damage.[5]

However, this study also has some limitations. First, the relatively small sample size may affect the generalizability and representativeness of the findings. Future studies could further expand the sample size to include more elderly patients with chronic diseases of different types and severity to improve the reliability of the findings. Secondly, the measurement results of ultrasound elasticity technology may be affected by many factors, such as the model of ultrasound equipment, the technical level of the operator, the respiratory movement of the patient, etc. Therefore, in clinical application, operating procedures are needed to strictly regulate to improve the accuracy and repeatability of measurements. Moreover, this study only explored the application value of ultrasound elasticity technology in the evaluation of renal damage in chronic diseases in the elderly, and further research is needed for its role in guiding clinical treatment and evaluating prognosis.

In conclusion, ultrasound elasticity technology, as an emerging imaging technique, provides a new method and means for the assessment of renal damage in elderly chronic diseases. Although there are still some shortcomings, with the continuous development and improvement of technology, it is believed that ultrasonic elasticity technology will play a more important role in the diagnosis, treatment and prognosis evaluation of renal damage in chronic diseases in the elderly.

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