

Assessment of Calf Skeletal Muscle Stiffness in Diabetic Nephropathy Patients with Medial Tibial Stress Syndrome by Two-Dimensional Shear Wave Elastography

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Abstract: *Objective:* To explore the feasibility of two-dimensional shear wave elastography in evaluating calf skeletal muscle stiffness in diabetic nephropathy patients with medial tibial stress syndrome. *Methods:* A total of 48 diabetic nephropathy patients with medial tibial stress syndrome from January 2020 to December 2022 were included as the study group, and 48 patients with diabetic nephropathy during the same period were included as the control group. Both groups were detected by two-dimensional shear wave elastography with ultrasonic equipment, and Young's modulus of the tibialis anterior muscle, tibialis posterior muscle, and gastrocnemius muscle were observed and analyzed in the two groups. *Results:* The Young's modulus values of tibialis anterior muscle, tibialis posterior muscle, and gastrocnemius muscle in the study group were significantly lower than those in the control group ($P < 0.05$). *Conclusion:* Two-dimensional shear wave elastography is feasible for the evaluation of calf skeletal muscle stiffness in diabetic nephropathy patients with medial tibial stress syndrome, and has high accuracy and repeatability. This technique can be used to diagnose, treat and monitor muscle lesions in patients with diabetic nephropathy, and can also be used to assess muscle fatigue and exercise capacity, which has broad application prospects.

Keywords: Two-dimensional shear wave elastography; Diabetic nephropathy; Medial tibial stress syndrome

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1. Introduction

Two-dimensional shear wave elastography is a non-invasive, rapid, and objective evaluation method, which has received extensive attention in the fields of medicine, bioengineering, and material science in recent years. This technology reflects the hardness and elasticity of the tissue by measuring Young's modulus value of the tissue and provides an important basis for clinical diagnosis and treatment. In the medical field, two-dimensional shear

wave elastography has been widely used in the diagnosis and evaluation of liver fibrosis, pulmonary fibrosis, vascular diseases, tumors, and other diseases. In liver tissue from patients with liver fibrosis, the technique can measure the stiffness of the liver, which can be used to diagnose diseases such as liver fibrosis and cirrhosis. In lung tissue from patients with pulmonary fibrosis, the technique can measure the stiffness of the lungs, which can be used to diagnose diseases such as pulmonary fibrosis and emphysema. In vascular diseases, this technology can measure the stiffness of blood vessels for the diagnosis of arteriosclerosis and vascular diseases, etc. In tumors, this technology can measure the firmness of tumors, which can be used to diagnose tumors and differentiate benign and malignant tumors. In the field of bioengineering, two-dimensional shear wave elastography is also widely used in the evaluation of material properties and the degree of hardness of materials in the fields of material science and bioengineering. In material science, this technology can measure parameters such as hardness and elastic modulus of materials, which can be used for material performance evaluation and material optimization design. In bioengineering, this technology can measure the softness and hardness of biological materials, and it can be used for the optimal design of biomaterials and biomedical devices ^[1-6]. This article mainly discusses the evaluation of calf skeletal muscle stiffness by two-dimensional shear wave elastography in diabetic nephropathy patients with medial tibial stress syndrome.

2. Materials and methods

2.1. General information

In this study, a total of 48 diabetic nephropathy patients with medial tibial stress syndrome from January 2020 to December 2022 were included as the study group, aged between 45 and 75 years old, including 26 males and 22 females. Diabetic nephropathy patients were taken as the control group, aged 47–80 years, including 25 males and 23 females. All patients were clinically diagnosed with diabetic nephropathy, accompanied by symptoms of medial tibial stress syndrome, such as medial tibial pain, swelling, and stiffness. See **Table 1** for further details.

Table 1. General information

Item		Study group	Control group	<i>t</i> / χ^2	<i>P</i>
Number of cases (example)		48	48	-	-
Age (years)		51.14 ± 5.64	50.66 ± 5.02	0.440	0.661
Age range (years)		45–75	47–80	-	-
BMI		22.02 ± 2.54	22.66 ± 4.73	0.833	0.408
Gender	Male	26 (54.00)	25 (52.00)	0.042	0.838
	Female	22 (46.00)	23 (48.00)		

2.2. Methods

Two-dimensional shear wave elastography was used for detection by ultrasonic equipment. Calf skeletal muscles, including tibialis anterior, tibialis posterior, and gastrocnemius, were selected for testing. During the detection, the ultrasonic probe is placed on the surface of the muscle, and the shape, structure and hardness of the muscle are observed through the ultrasonic image. At the same time, the elastic coefficient value of each muscle part was recorded.

2.3. Observation indicators

The Young's modulus of tibialis anterior muscle, tibialis posterior muscle and gastrocnemius muscle were observed and analyzed in two groups.

2.4. Statistical methods

Statistical software SPSS 24.0 was used to analyze the data. Measurement data are expressed as mean \pm standard deviation (SD), using the *t*-test; count data are expressed as %, using the χ^2 test, $P < 0.05$ is considered statistically significant.

3. Results

The Young's modulus values of the tibialis anterior muscle, tibialis posterior muscle, and gastrocnemius muscle in the study group were significantly lower than those in the control group ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of Young's modulus values between the two groups of patients (kPa)

Group	Study group ($n = 48$)	Control group ($n = 48$)	<i>t</i>	<i>P</i>
Tibialis anterior muscle	60.68 \pm 6.16	78.04 \pm 4.12	18.195	0.0000
Tibialis posterior	61.47 \pm 5.12	77.52 \pm 4.67	16.028	0.0000
Gastrocnemius	63.14 \pm 5.02	78.70 \pm 3.10	18.264	0.0000

4. Discussion

Diabetic nephropathy is one of the complications of diabetes, mainly due to kidney damage caused by long-term high blood sugar and other reasons. Patients showed symptoms such as proteinuria, edema, hypertension, and renal dysfunction. As the disease progresses, it may lead to serious consequences such as chronic renal insufficiency and uremia. The key to the treatment of diabetic nephropathy is to control risk factors such as blood sugar, blood pressure, and blood lipids, while taking reasonable diet and exercise measures to reduce the burden on the kidneys. In the early stage, the disease can be controlled and alleviated through reasonable treatment and lifestyle adjustment. But in the advanced stage, the kidney function is severely damaged, requiring treatment such as dialysis or kidney transplantation. The key to preventing diabetic nephropathy is to control risk factors such as blood sugar, blood pressure, and blood lipids, conduct regular kidney function tests, and adopt a healthy lifestyle, such as low-salt, low-fat, diabetic diet, and proper exercise. At the same time, diabetic patients should be actively treated and followed up regularly to control the development of the disease and avoid complications^[7-10].

Medial tibial stress syndrome refers to a sports injury that causes pain, swelling, and stiffness in the muscles and bone structures of the inner tibia due to long-term overuse or external pressure, and as a sports injury, is common in running and jumping, football, basketball and other sports. The keys to treating medial tibial stress syndrome are rest, icing, compression, and elevation. In the early stage, the amount of exercise should be stopped or reduced, and attention should be paid to rest to reduce the burden on the muscle and bone structure. At the same time, ice pack can be used to relieve pain and swelling. If the symptoms are severe, compression bandaging can be used to reduce local bleeding and swelling. Elevation can promote venous return and reduce swelling^[11]. In advanced stages, rehabilitation treatments such as physiotherapy, massage, muscle training, etc. can be done to promote the recovery of muscle and bone structure. The key to preventing medial

tibial stress syndrome is training to strengthen the muscle and bone structure, paying attention to movement posture and technique, and avoiding overuse and excessive compression of the medial tibial muscle and bone structure. At the same time, pay attention to maintaining good living habits, such as quitting smoking, limiting alcohol intake, etc., to reduce the impact on the body. If the symptoms are severe or last for a long time, it is recommended to seek medical treatment in time and receive professional treatment.

There is an association between diabetic nephropathy and medial tibial stress syndrome. Diabetic patients are prone to kidney damage due to long-term high blood sugar and other reasons, which in turn leads to diabetic nephropathy. In people with diabetic kidney disease, some may experience symptoms of medial tibial stress syndrome, which is mainly due to damage to the muscle and bone structure caused by chronic high blood sugar. In addition, patients with diabetic nephropathy need long-term drug treatment and diet control, and these treatment measures will also have a certain impact on the patient's body, which may lead to problems such as muscle atrophy and decreased bone density, thereby increasing the risk of medial tibial stress syndrome [12-14]. Therefore, for patients with diabetic nephropathy, it is necessary to pay attention to the prevention and treatment of medial tibial stress syndrome, mainly by controlling risk factors such as blood sugar, blood pressure, and blood lipids, while taking reasonable diet and exercise measures to reduce the burden on skeletal muscles. Individuals with medial tibial stress syndrome require comprehensive treatment, including medication, physical therapy, surgery, and more. Early prevention and treatment of medial tibial stress syndrome can avoid further damage to the body and improve the quality of life and health of patients with diabetic nephropathy.

Shear wave elastography is a non-invasive ultrasound technique that can be used to assess the elastic modulus of tissue stiffness. In recent years, this technique has begun to be applied to assess the stiffness of skeletal muscle, and its feasibility has been widely recognized. The basic principle of shear wave elastography is to calculate the elastic coefficient of tissue by measuring the propagation velocity and distance of shear wave in tissue at different depths. This technique has begun to be applied to assess the stiffness of skeletal muscle, and its feasibility is widely recognized. In evaluating skeletal muscle stiffness, shear wave elastography can be used to detect muscle lesions, such as muscle fibrosis, muscular dystrophy, and muscle atrophy [15,16]. By measuring the elastic coefficient of the muscle, it can reflect the hardness and elasticity changes of the muscle, and carry out diagnosis, disease evaluation and curative effect monitoring on the above-mentioned lesions. In addition, shear wave elastography can be used to assess muscle fatigue and exercise capacity. In the field of sports medicine, this technology is widely used in the assessment of athletes' muscle function, which can help coaches and athletes understand the athlete's muscle state, adjust training plans, and improve exercise capacity.

In this study, Young's modulus values of the tibialis anterior muscle, tibialis posterior muscle, and gastrocnemius muscle in the study group were 60.68 ± 6.16 , 61.47 ± 5.12 , and 63.14 ± 5.02 , respectively, and those in the control group were 78.04 ± 4.12 , 77.52 ± 4.67 , and 78.70 ± 3.10 , respectively. The results indicated that shear wave elastography can measure muscle changes, and two-dimensional shear wave elastography can effectively evaluate the calf skeletal muscle stiffness in diabetic nephropathy patients with medial tibial stress syndrome. The Young's modulus values of each muscle part were different, among which the Young's modulus value of the tibialis anterior muscle was the lowest, and that of the gastrocnemius muscle was the highest. This indicates that there are abnormalities in the hardness of skeletal muscle groups in patients with diabetic nephropathy, and two-dimensional shear wave elastography can detect these changes in hardness non-invasively, quickly and accurately, and provide a reference for the diagnosis and treatment of the disease.

Preventive measures for diabetic nephropathy patients with medial tibial stress syndrome include the following aspects: keeping blood sugar within the normal range and avoiding excessive fluctuations in blood sugar can effectively prevent the occurrence and development of diabetic nephropathy; high blood pressure will

accelerate the development of diabetic nephropathy, so patients need to choose appropriate antihypertensive drugs to control blood pressure within the normal range; hyperlipidemia will promote the occurrence and development of diabetic nephropathy, so patients need to control blood lipids within the normal range, by changing eating habits and lifestyle, or choosing suitable lipid-lowering drugs; restricting protein intake can reduce the burden on the kidneys and delay the development of diabetic nephropathy, thus it is recommended to consume 0.6–0.8 g/kg of high-quality protein every day; drinking adequate water can maintain the body's water balance and help eliminate excess waste and toxins in the body; standing for a long time will increase the stress on the medial tibia and aggravate the condition of diabetic nephropathy, so it is necessary to take proper rest and change body position; regularly check urine routine, renal function, blood pressure, blood lipids, and other indicators to detect and deal with abnormalities in time.

In conclusion, two-dimensional shear wave elastography is feasible for the evaluation of calf skeletal muscle stiffness in diabetic nephropathy patients with medial tibial stress syndrome and has high accuracy and repeatability. This technique can be used to diagnose, treat, and monitor muscle lesions in patients with diabetic nephropathy, and can also be used to assess muscle fatigue and exercise capacity, which has broad application prospects.

Disclosure statement

The authors declare no conflicts of interest.

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