Case Report

A Case of Shear Wave Velocity Reflecting the Disease Activity in Glomerulonephritis

Sayaka Ono, Tomohiko Nishino*, Kazuhiro Takahashi, Masakazu Mimaki

Department of Pediatrics, Teikyo University School of Medicine, Tokyo, Japan

Abstract

Ultrasound elastography can measure tissue elasticity using the shear wave velocity (SWV). Evaluating disease activity with elastography instead of renal biopsy may be less invasive. However, to the best of our knowledge, although there are studies comparing different glomerular diseases using SWV, there are no reports that have measured glomerulonephritis longitudinally from the acute phase of the disease. This study aimed to assess whether SWV reflects disease activity in glomerulonephritis, and we continued to observe children with post-streptococcal acute glomerulonephritis (PSAGN) from the acute phase to over a year later. In this case, a 6-year-old boy diagnosed with PSAGN had impaired renal function, and was admitted and tested. He was placed in a prone resting position and measurements were taken from the back. SWV was measured ≥50 times at each examination, and the mean was calculated when the net amount of effective SWV was ≥50%. The tests were performed once in the acute phase and thrice during the recovery phase for 13 months. SWV was found to be significantly lower in the recovery period than during the disease onset, and continued to stay lower at each test during the recovery period ($P < 0.02$). In conclusion, this indicated that SWV fluctuated similarly to the disease activity of glomerulonephritis; therefore, we suggest using SWV measurement to estimate the disease activity in glomerulonephritis in children. Although more clinical cases are needed, SWV measurement is a noninvasive and reproducible imaging modality to estimate the disease activity in glomerulonephritis.

Keywords: Elasticity imaging techniques, glomerulonephritis, pediatrics, perfusion, ultrasonography

Introduction

In assessing disease activity in glomerulonephritis, reducing invasiveness remains a perennial problem. Although there are several ways to evaluate the kidneys, the usefulness of kidney biopsy in diagnosing glomerulonephritis and evaluation of the disease activity is unassailable. However, complications, such as bleeding and the development of arteriovenous fistulas, have been reported in children.[1] Therefore, repeated biopsies are not always advisable in daily practice, and an alternative method that is relatively less invasive and can evaluate the disease activity is needed. Imaging is essential for the early detection of renal diseases, monitoring renal function, and enhancing the assessment of disease progression and prognosis.[2] Ultrasound elastography is a noninvasive imaging modality that measures tissue elasticity, which is proportional to the shear wave velocity (SWV). The principle underlying SWV is that the propagation velocity of ultrasound is faster in hard tissue and slower in soft tissue.[3] Recently, it has been reported that children with glomerular diseases have higher elastography values than healthy children.[4] However, this finding is not necessarily generalizable as all the participants were on oral steroids and the glomerulonephritis group included focal segmental glomerulosclerosis and minimal change in disease. Furthermore, since renal elastography reflects not only fibrosis but also various confounding factors.[5] Longitudinal measurements in the same patient are required rather than only a comparison between different diseases. However, to our best knowledge, there are no reports on the use of shear wave elastography to longitudinally assess disease activity in glomerulonephritis from the acute phase. In the acute phase of glomerulonephritis, capillary and endothelial cell proliferation and inflammatory cell infiltration cause narrowing of the glomerular capillary wall. This is accompanied by blood stagnation due to the loss of function in some glomeruli, and

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Address for correspondence: Dr. Tomohiko Nishino, 2-11-1, Kaga, Itabashi-Ku, Tokyo 173-8605, Japan.
E-mail: sinonosino@yahoo.co.jp

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increased renal blood flow in others.[6] A reliable diagnosis made with repeatable and reproducible noninvasive measurements can enable the administration of the right treatment and improve prognosis. Herein, we present the case of a patient with post-streptococcal acute glomerulonephritis (PSAGN), in which SWV was measured longitudinally from the acute phase using renal elastography for over 1 year.

Case Report

This case report describes a 6-year-old boy with no history of renal disease. He had no specific family history and was not on any regular medications before the course of the disease. Five days before admission, macrohematuria was observed. The patient was admitted based on the following findings: abnormal urinalysis, low levels of complement C3, positive results on a rapid streptococcus antigen detection test, antistreptolysin O levels of 398 IU/mL, and impaired renal function [Table 1]. Blood tests revealed no pancytopenia or hypoproteinemia and no antibodies, including anti-double stranded deoxyribonucleic acid antibodies; moreover, the patient did not experience edema, weight gain, or hypertension. Thus, only supportive therapy was provided. Proteinuria disappeared after 8 days, and the serum complement titer increased and normalized (C3, 85 mg/dL) after approximately 1 week. Hematuria disappeared after approximately 2 months, and no abnormal urine findings or serum complement titers have been observed to date. SWV was measured four times: once in the acute phase on admission and three times during the recovery period (5, 10, and 13 months later) [Table 1]. For the measurement, the patient was placed in a prone position, and the kidneys were measured bilaterally at the upper, middle, and lower poles from the back using an ultrasound system (ARIETTA 70, Hitachi Aloka Medical, Japan) and convex probe (1–5 MHz). SWV was measured ≥50 times at each examination, and the mean was calculated when the net effective SWV was ≥50% [Figure 1]. SWV was significantly lower during the recovery period than in the acute phase, and the values showed reproducibility [Figure 2, $P < 0.02$].

Discussion

SWV is a noninvasive modality that can reflect disease activity in glomerulonephritis. Notably, in this case, SWV fluctuated according to disease activity. This patient's disease course was similar to that of most PSAGN cases, where remission is spontaneous, and relapse is rare. To the best of our knowledge, no study has performed temporal measurement of SWV in acute glomerulonephritis yet; however, this method may be useful for assessing glomerulonephritis activity.

Ultrasound elastography can be a useful and reproducible assessment in children. Several reports have examined vesicoureteral reflux (VUR), common pediatric diseases, and all demonstrated high reproducibility. VUR kidneys with scarring had higher SWV than contralateral kidneys without scarring in the same individuals.[7,8] Furthermore, patients' kidneys without scarring have higher SWV than that of normal children, suggesting an effect of hyperfiltration.[8] In this case of glomerulonephritis without left–right differences, the high SWV in the acute phase may be related to hyperfiltration. In contrast, it has been reported that kidneys with scars have lower SWV by a previous study which included many younger children.[9] However, because SWV increases with artifacts due to low age and with aging,[9,10] results should be interpreted cautiously. Although direct comparison of measurement values with other studies is impossible, the decrease in SWV was shown repeatedly over time in this study and so considered a significant finding.

SWV may be a sensitive measure of renal perfusion in glomerulonephritis. In the kidney, SWV is known to reflect hemodynamics more strongly than fibrosis because of the organ's

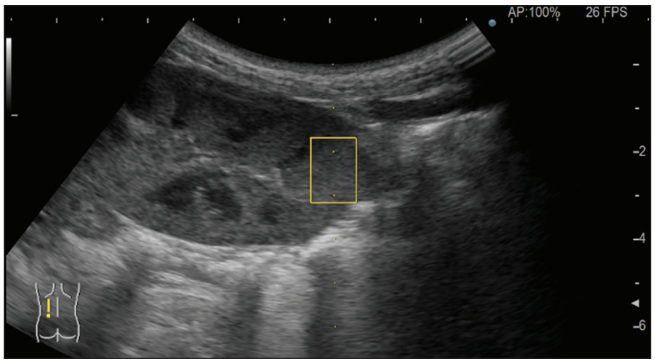

Figure 1: ROI setting and measurement of SWV. The measurement is obtained by lightly applying the probe on the back of the reclining child with as little manual pressure as possible. The region of interest enclosed by the yellow line (10 mm × 15 mm) was determined, while maximally excluding the vasculature and renal pelvis, vertically below the probe. ROI: Region of interest, SWV: Shear wave velocity

Table 1: Urinalysis, renal function, and shear wave velocity from the onset of post-streptococcal acute glomerulonephritis to 13 months after onset

	Onset	After 5 months	After 10 months	After 13 months
U-PCR (g/gCre)	1.60	0.03	0.02	0.03
U-RBC (/HPF)	>100	1-4	0-1	0-1
eGFR (mL/min/1.73 m^2)	63.2	84.9		87.9
C3 (mg/dL)	27	103		87
C4 (mg/dL)	23	21		15
CH50 (U/mL)	28	49		44
SWV (m/s)	2.33±0.28	2.05±0.35	1.95±0.28	2.02±0.40

U-PCR: Urine protein/creatinine ratio, U-RBC: Red blood cells in urine, HPF: High power field, eGFR: Estimated glomerular filtration rate, SWV: Shear wave velocity

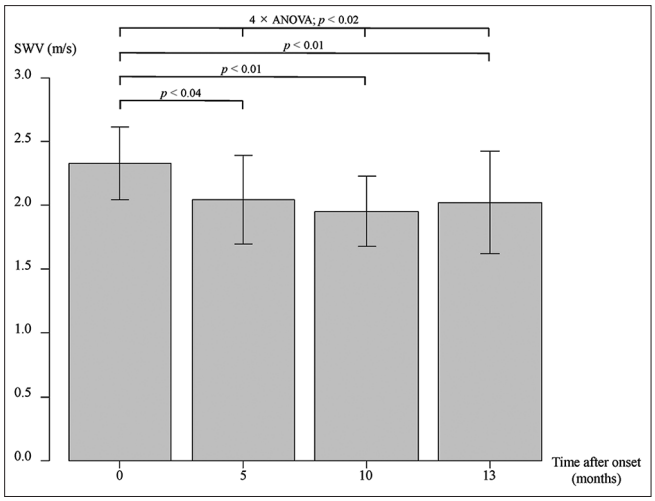

Figure 2: SWV trajectory. The vertical axis: SWV (m/s), and the horizontal axis: Time point from onset. A one-way analysis of variance by Dunnett test revealed that the result indicated that SWV was significantly lower at recovery period (5, 10, and 13 months later) than at the onset ($P < 0.02$). SWV: Shear wave velocity

complex compartmentalization and hemodynamics.[3] In animal models, a significant increase in the SWV of the kidneys due to blood stagnation by renal vein ligation was reported.[11] In this case, high SWV was observed because of blood stagnation caused by capillary and endothelial cell proliferation and inflammatory cell infiltration because of acute glomerulonephritis. In addition, increased renal blood flow significantly increased the renal cortex stiffness by hydration detected using magnetic resonance elastography.[12] Increased renal blood flow to the remaining glomeruli resulting from glomerulonephritis may have contributed to the high SWV at disease onset in this case. The low SWV measured repeatedly during the recovery period indirectly supports our inference that it is a disease activity of glomerulonephritis.

Inflammation caused by glomerulonephritis can be observed using SWV. The high liver stiffness in the acute phase may reflect inflammation, edema, and swelling of hepatocytes; as the biomarker values reflecting disease activity improved in the recovery period, the liver stiffness decreased on elastography.[13] This case showed a decrease in SWV along with the degree of inflammation in glomerulonephritis. The fact that this was shown in a child without weight gain or edema is striking and warrants further investigation.

Despite the interesting findings, this study has several limitations. First, there is a possibility that the high SWV may have been due to fibrosis as no pathological evaluation was performed. However, since the SWV decreased with improvement in the disease, this change is unlikely to indicate irreversible changes, such as fibrosis. It is noteworthy that PSAGN, which has a clear onset time without renal disease history, showed such a transition. Second, currently, there is no consensus on the optimal method for renal elastography, which may have led to assessor bias. However, we maintained the reliability of the measurements by setting the cutoff value for the net amount of effective SWV, as was done for the liver.[14]

To summarize, SWV fluctuated along with the disease activity in the patient with PSAGN; therefore, we suggest using SWV measurement as a noninvasive and reproducible imaging modality to estimate disease activity in children with glomerulonephritis. However, because of some existing challenges, such as histological evaluation and choice of measurement methods, further studies are needed.

Declaration of patient consent

The authors certify that they have obtained appropriate patient's guardian consent form. In the form, the guardian has given the consent for the child's images and other clinical information to be reported in the journal. The guardian understands that the child's name and initial will not be published and due efforts will be made to conceal the identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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