

Utility of ultrasound elastography in postoperative follow-up of children with unilateral ureteropelvic junction obstruction

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ABSTRACT

Introduction: We aimed to determine whether shear wave velocity (SWV) on ultrasound elastography is useful in follow-up of children with ureteropelvic junction obstruction (UPJO) following pyeloplasty.

Methods: Consecutive children with unilateral UPJO who were co-operative for elastography ($n = 31$) were included. SWV of normal kidney was used as control, and it was compared with that of the affected kidney (UPJO) in the same patient. They were followed up with elastography at 3 months and elastography + renogram at 6 months postoperatively. In patients with a static renogram at 6 months, the study was repeated at 1 year. Patient outcomes were classified as improved at 6 months, static at 6 months, and worsened at 1 year based on ultrasound and renogram findings. The SWV was compared between the different outcomes.

Results: Thirty-one children with a median age of 8.5 years were studied (m:f = 29:2; L:R = 22:9). The mean SWV was significantly higher (3.21 m/s) in UPJO kidney compared to the SWV (2.72 m/s) found in normal kidney ($P = 0.011$). The mean SWV was significantly less at 3 months (2.73 m/s) and 6 months (2.57 m/s) postoperative follow-up ($P = 0.018$ and $P = 0.001$). Among the patients who improved, the mean SWV was 2.65 m/s. This SWV was significantly raised (3.57 m/s) in patients whose condition remained static ($P = 0.006$) and even higher (4.36 m/s) in those who worsened ($P = 0.001$).


Conclusions: SWV was significantly higher in UPJO compared to normal kidneys in children. It is useful in assessing postoperative resolution, and a rising velocity can be useful as an early marker of recurrence in UPJO.

INTRODUCTION

Ureteropelvic junction obstruction (UPJO) is one of the common causes of hydronephrosis in children. The prolonged obstruction can lead to increased back pressure and subsequent loss of nephrons, ultimately resulting in parenchymal fibrosis and loss of its elasticity. This decrease in elasticity often leads to increased stiffness of the kidney. Ultrasound elastography measures the shear wave velocity (SWV) using acoustic radiation force impulse (ARFI) and estimates the stiffness of the kidney.^[1,2] Elastography is routinely used to measure the stiffness of various

tissues such as breast, liver,^[3] and thyroid but is not very popular for childhood renal pathologies.^[4,5] With the advent of newer ultrasound machines and the advancement of skills, SWV is being measured accurately in pediatric urological conditions of late.^[6-8]

Several authors have reported the usefulness of SWV measurement in children with vesicoureteric reflux (VUR),^[9] chronic kidney disease,^[10,11] and renal fibrosis^[12] and have compared it with normal.^[13] Although some authors^[1,2,14] have studied its role in UPJO, none of them have reported its usefulness in assessing postoperative resolution. In this

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pilot study, we measured SWV of normal kidney and compared it with that of the affected UPJO kidney in the same child. We have also measured SWV postoperatively and tried to establish its role in prognosis and follow-up after pyeloplasty.

METHODS

In this prospective cohort study, all consecutive children with unilateral UPJO admitted in the pediatric urology department for pyeloplasty (in whom ultrasound elastography was feasible), between November 2017 and October 2018, were included. Indications for surgery were worsening hydronephrosis with deteriorating split renal function (SRF) on renogram.^[15] Those with associated VUR, ureterocele, megaureter, distal ureteric obstruction, bladder outlet obstruction, and multicystic dysplastic kidneys were not included as renal fibrosis due to multiple pathologies may alter elasticity and confound the results. Infants who were uncooperative for elastography were also not included.

Ultrasound elastography was performed using Toshiba Aplio 500 Platinum ultrasound machine (Canon Medical Systems USA, Inc. 2441 Michelle Drive Tustin, CA 92780), using a convex probe (PVT-375BT) at a frequency range of 1.5 ~ 6.0 MHz. All the measurements were taken by the same radiologist (VS) to avoid any interobserver variations in the measurement. Adequate oral hydration was given and a full bladder was ensured before the study. Patients were not sedated as we performed the study in slightly older cooperative children. The children were placed in the prone position for the study, and ultrasound of the kidneys was performed in B-mode initially. They were included in the study if the cortical thickness was more than 8 mm. The SWVs (m/s) were calculated using two-dimensional shear wave elastography. Two measurements each were taken from the cortex of the upper, mid-, and lower poles of the normal kidney (control) and also from the UPJO kidney [Figure 1]. The region of interest (ROI) was kept at 8 mm, and a total of six readings were taken from the normal and UPJO kidney. The mean and median SWVs were thus calculated and compared.

All the patients underwent standard open dismembered pyeloplasty by the same surgeon (RB). They were followed up with elastography at 3 months and 6 months postoperatively. Renogram was performed at 6 months in all patients. Those with an improved grade of hydronephrosis on ultrasound and improved drainage on renogram at 6 months were considered success and did not undergo further renogram. Those with poor drainage at 6 months were considered static, and renogram was repeated at 1 year. Those with persistent Grade 4 hydronephrosis or decreased SRF and poor drainage on renogram at 1-year follow-up were considered as failures.^[15] The mean/median SWV was compared between the different outcomes. Statistical analysis was

performed using paired *t*-test using the Statistical Package for the Social Sciences, version 12.0 (SPSS, Chicago, IL, USA), and $P < 0.05$ was considered statistically significant. Informed consent was obtained from all participants, and the study was approved by the institutional ethics committee (CSP-MED/17/NOV/40/146).

RESULTS

Among the 31 children studied, there was a male preponderance (m:f = 29:2), and the left side was more commonly affected (L:R = 22:9) [Table 1]. The median age of the study population was 8.5 years (10 children aged between 0 and 5 years, 14 between 6 and 10 years, and 7 between 11 and 15 years). The mean SWV was significantly higher ($P = 0.011$) in UPJO kidney (3.21 m/s) compared to the SWV found in normal kidney (2.72 m/s) [Figure 2].

Postpyeloplasty, in 26 patients, both ultrasound and renogram showed an improvement at 6-month follow-up. They were considered success and did not undergo a repeat renogram at 1 year. In three patients, renogram drainage was static at 6 months, but the drainage improved at 1 year. In two patients, the hydronephrosis was persistent at Grade 4 on ultrasound at 1-year follow-up, along with worsening of drainage/SRF. These were considered as failure and underwent a repeat pyeloplasty.

The mean SWV was significantly less at 3 months (2.73 m/s) and 6 months (2.57 m/s) postoperative follow-up ($P = 0.018$ and $P = 0.001$) compared to preoperative SWV [Figure 2]. The 6-month SWV was further analyzed among subgroups based on outcome. Among the patients who improved ($n = 26$), it was 2.65 m/s [Figure 3]. This was significantly raised (3.57 m/s) in patients ($n = 3$) whose condition remained static ($P = 0.006$) and even higher (4.36 m/s) in those ($n = 2$) who worsened ($P = 0.001$).

Figure 4 shows the scatter plot of individual patients. There was an early trend of increase in SWV in the two patients who worsened, indicating the usefulness of elastography as an early marker of deterioration. Both patients eventually underwent redo pyeloplasty. The three patients who remained static showed no signs of worsening and are being followed up.

Table 1: Demographic data (n=31)

Demographic data	Age group	n	Outcome summary
Age distribution (years)	0-5	10	Median age: 8.5 years
	6-10	14	
	11-15	7	
Sex distribution	Male	29	Male:female=29:2
	Female	2	
Side distribution	Left side	22	Left:right=22:9
	Right side	2	

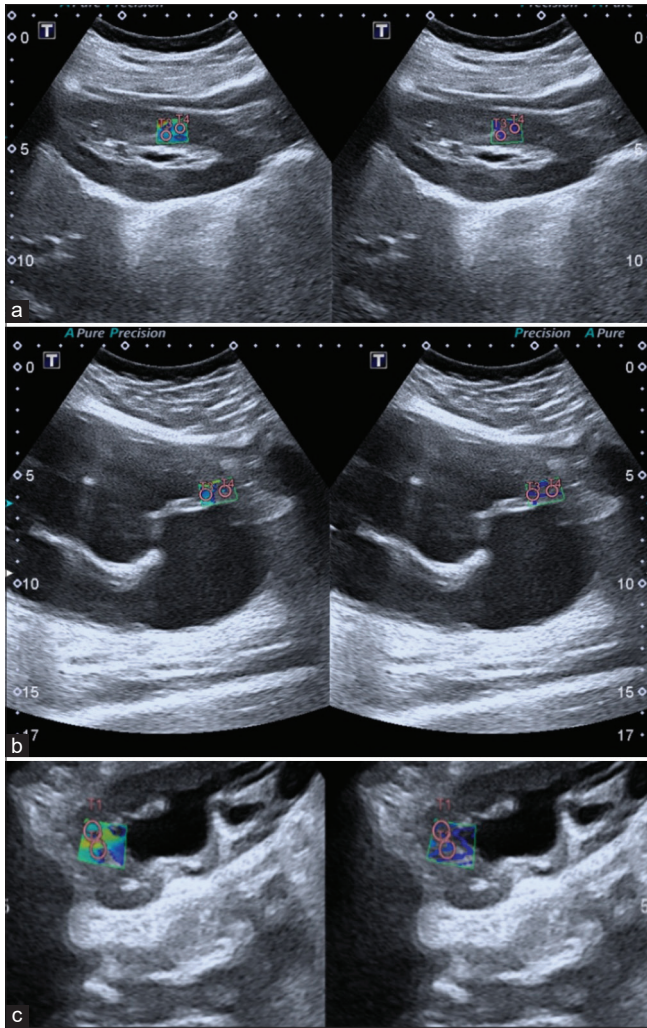


Figure 1: Ultrasound elastography to measure shear wave velocity (m/s); images depict measurements in the same patient. (a) Shear wave velocity in normal kidney was 2.38 m/s; (b) that of affected ureteropelvic junction obstruction kidney showing increased shear wave velocity at 3.11 m/s; (c) shear wave velocity at 6 months postpyeloplasty reduced to 2.56 m/s

DISCUSSION

Ultrasonogram and radionuclide renogram are widely used investigations to assess the severity of UPJO preoperatively and its resolution postoperatively. While several sonographic parameters have been reported to assess the severity of hydronephrosis,^[16-18] the usefulness of ARFI and SWV on elastography has not been well studied or reported. While some authors have studied the role of elastography in UPJO^[1,2,14] to our knowledge, this is the first prospective study to assess SWV values in affected hydronephrotic units both preoperatively and postoperatively following pyeloplasty.

Sohn *et al.*^[2] measured SWV in 51 children and found that the median SWV was higher (2.02 m/s) in hydronephrotic kidneys compared to that in normal kidney (1.75 m/s; $P = 0.027$). They concluded that ARFI measurement

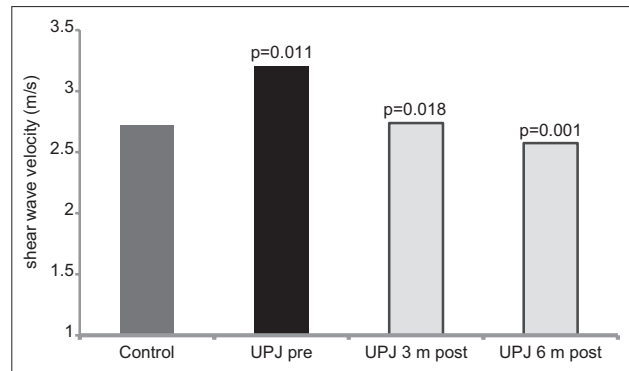


Figure 2: Bars represent mean shear wave velocity of all patients ($n = 31$); it was significantly higher ($P = 0.011$) in ureteropelvic junction obstruction kidney (black bar; 3.21 m/s) compared to that (dark gray bar; 2.72 m/s) found in normal. There was a significant reduction at 3 months and 6 months postoperative period (light gray bars) after pyeloplasty

of the kidney is feasible in young children although they were not able to differentiate between UPJO and nonobstructive hydronephrosis. Habibi *et al.*,^[1] on the other hand, showed significantly higher SWV values in control kidneys compared to UPJO kidneys. The median SWV was 2.82 m/s for the control kidneys and 2.36 m/s for the kidneys in the UPJO group. SWV being a new parameter with no standardization across centers, it is possible that two studies had contradicting values. Our findings are more in line with that reported by Sohn *et al.*^[2] Until we establish uniform reference values, it may be possible to compare patient outcomes only within centers by the same sonographer/machine.

Dillman *et al.*^[14] attempted to determine whether SWV measurements before or after intravenous diuretic could be useful in discriminating obstructive hydronephrosis from unobstructive hydronephrosis in children. They did not find SWV useful in the diagnosis of UPJO. In the present study, we did not attempt to look at the role of SWV in the diagnosis of UPJO, as we used ultrasound grading and renogram parameters in defining obstructed hydronephrosis. We rather focused on the dynamic changes of SWV following pyeloplasty to see whether it can be used as an early marker of recurrence.

The mean SWV was significantly raised in UPJO kidney (3.21 m/s) compared to SWV found in normal kidney (2.72 m/s). Among the patients who improved, the mean SWV was 2.65 m/s. This SWV was significantly raised (3.57 m/s) in patients whose condition remained static and even higher (4.36 m/s) in those who worsened. There was an early trend of increase in SWV in the two patients who worsened indicating the usefulness of elastography as an early marker of deterioration.

An experienced radiologist and a good ultrasound machine are required for a proper SWV measurement and non-availability of these may be a limitation to this modality

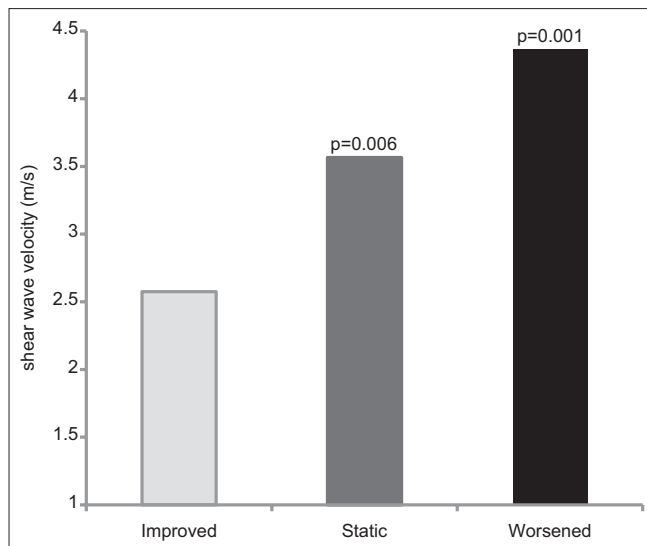


Figure 3: Bars represent 6-month shear wave velocity in relation to outcome subgroups. Among the patients who improved ($n = 26$), the mean shear wave velocity was 2.65 m/s (light gray bar). This was significantly ($P = 0.006$) higher at 3.57 m/s in those who remained static (dark gray bar; $n = 3$) and even higher at 4.36 m/s in those who worsened (black bar; $n = 2$)

becoming widely acceptable. This technique becomes impossible in those with severe cortical thinning, as the ROI cannot be placed accurately. We have tried to remove the operator bias by having a single radiologist perform all the ultrasounds. However, we do not know about the influence of age and hydration on the outcomes. We have studied only older children, and SWV measurements can be difficult in infants who may not keep still. Another limitation of this study is the small cohort. Further larger studies are required to support or negate the findings of this pilot study.

CONCLUSIONS

SWV was significantly higher in UPJO compared to normal kidneys in children. It is useful in assessing postoperative resolution, and a raising velocity can be useful as an early marker of recurrence in UPJO.

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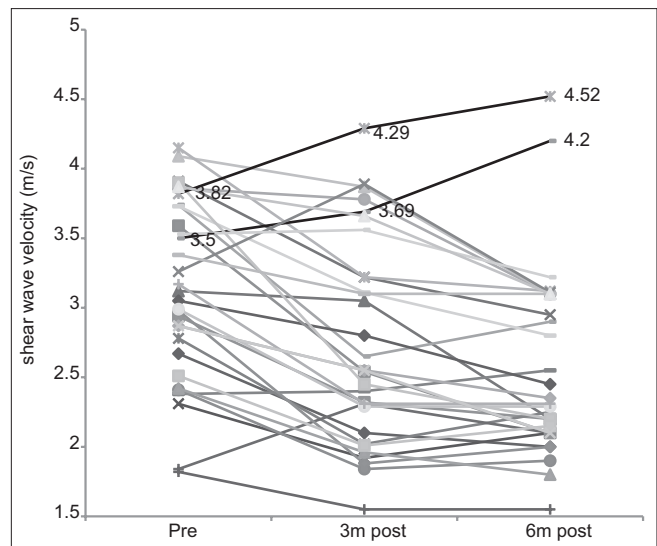


Figure 4: Scatter plot representing dynamic changes in shear wave velocity. There was an early trend of increase in shear wave velocity in the two patients (black lines) who worsened

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