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● *Original Contribution*

FACTORS THAT INFLUENCE KIDNEY SHEAR WAVE SPEED ASSESSED BY ACOUSTIC RADIATION FORCE IMPULSE ELASTOGRAPHY IN PATIENTS WITHOUT KIDNEY PATHOLOGY

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Abstract—Our aim was to assess kidney shear wave speed by means of acoustic radiation force impulse (ARFI) elastography in patients without kidney pathology ("normal" patients) and to identify the factors that influence it. We analyzed 91 "normal" patients in whom kidney shear wave speed was assessed by means of ARFI elastography. Five valid ARFI elastographic measurements were obtained in all "normal" patients in both kidneys. In univariate analysis, age ($r = -0.370, p = 0.003$), gender (female vs. male, $r = -0.305, p = 0.003$) and measurement depth ($r = -0.285, p = 0.01$) were significantly correlated with kidney shear wave speed values assessed by ARFI elastography, whereas body mass index, kidney length and renal parenchyma thickness were not correlated. In multivariate analysis, only age ($p = 0.006$) and gender ($p = 0.03$) were significantly correlated with kidney shear wave speed values. In conclusion, kidney shear wave speed values assessed by ARFI elastography in "normal" patients are influenced mainly by age and gender and less by measurement depth. (E-mail: flaviu_bob@yahoo.com) © **2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Acoustic radiation force impulse, Acoustic radiation force impulse elastography, Kidney shear wave speed, "Normal" patients.**

INTRODUCTION

Acoustic radiation force impulse (ARFI) elastography is an ultrasound-based elastographic method used mainly in non-invasive assessment of liver fibrosis (Bota et al. 2013; Nierhoff et al. 2013), but also in evaluation of spleen stiffness, prediction of portal hypertension (Bota et al. 2012; Takuma et al. 2013) and assessment of thyroid nodules (Hou et al. 2013; Zhang et al. 2013), prostate lesions (Zhai et al. 2010) and focal liver lesions (Ying et al. 2012). Recently, this method was used also for assessment of kidney fibrosis, particularly in post-transplant patients (Grenier et al. 2013; Guo et al. 2013; He et al. 2014; Syversveen et al. 2012).

This method is based on the shear wave speed in the organ being examined. The ultrasound probe automatically produces an acoustic "push" pulse that generates shear waves, which propagate into the tissue. Their speed is quantified in a precise anatomic region, focused on a region of interest and displayed on the screen (Bamber et al. 2013).

Little information is available regarding kidney shear wave speed evaluated by ARFI elastography in patients who have not undergone kidney transplantation (Gallotti et al. 2010; Guo et al. 2013), and no detailed analysis of the factors that influence kidney shear wave speed has been performed in a significant cohort of patients.

The aims of our study were to assess kidney shear wave speed by means of ARFI elastography in "normal" patients and to identify the factors that influence it.

METHODS

Patients

Our prospective study included "normal" patients in whom kidney shear wave speed was evaluated by means of ARFI elastography between November 2012 and June 2013. The "normal" patients comprised healthy volunteers (medical students, nurses and medical doctors from our hospital) and patients hospitalized in various

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departments of our hospital. Healthy volunteers did not have a history of kidney disease, arterial hypertension or diabetes mellitus, but additional tests were not performed. All healthy volunteers had normal renal ultrasonograms, and the difference in length between the right and left kidney was less than 15 mm. The patients hospitalized in various departments of our hospital were defined as patients without kidney pathology as they had no history of kidney disease and had normal biological tests (serum creatinine and blood urea nitrogen) and normal urinary tests (without proteinuria and hematuria) and did not have diabetes mellitus. In all these patients, renal ultrasonography was performed and the same criteria used for healthy patients were applied.

All patients included in our study signed an informed consent; the study was approved by the local ethics committee and was in accordance with the Helsinki Declaration of 1975.

Ultrasound examination

The ultrasound examination was performed in each subject in the same session as the ARFI elastography measurements, using a Siemens Acuson S2000 ultrasound system (Siemens AG, Erlangen, Germany), with a 4- to 9-MHz convex array probe. Renal ultrasound was performed by one nephrologist (F.B.) with more than 10 y of experience in ultrasonography. All patients had normal kidney structure, which was defined as homogenous grainy gray renal parenchyma and bright renal sinus, without hydronephrosis, renal cysts, renal stones, tumors or pseudo-tumors. We also reported kidney length and renal parenchymal thickness. Kidney length was measured in a longitudinal section from the upper to the lower pole, whereas renal parenchymal thickness was measured in the midportion of the kidney opposite the renal hilum.

ARFI elastography

ARFI elastography was performed in all patients using Siemens Acuson S2000 ultrasound system software, Version 2.0, with a 4- to 9-MHz convex array probe using the Virtual Touch tissue quantification application.

Scanning was performed with the patient in lateral decubitus. A region of interest cursor of pre-defined size (5 mm in width and 10 mm in length) was positioned by the operator in the midportion of the kidney, in the renal cortex, with minimal scanning pressure, while the patients were asked to stop breathing for a moment to minimize breathing motion (Fig. 1). We aimed for five valid measurements in each subject; from these, a median value was calculated, and the result expressed in meters per second (m/s). If the measurement was not valid, "x.xx" was displayed on the screen. Measurement depth is also displayed on the screen; the maximum depth at which ARFI elastography measurements can be performed is 8 cm.

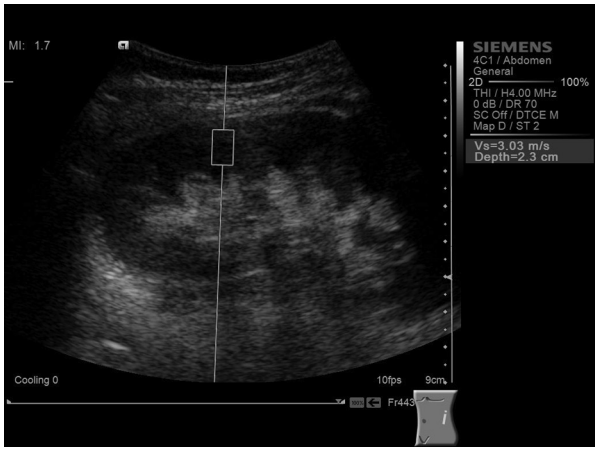

Fig. 1. Measurement of kidney shear wave speed with acoustic radiation force impulse elastography.

Statistical analysis

Statistical analysis was performed using MedCalc Software, Version 12.4.0. (MedCalc Software, Ostend, Belgium). The distribution of the numerical variables was first tested with the Kolmogrov–Smirnov test. Either the mean value and standard deviation (normal distribution) or median value and range (non-normal distribution) are presented. Student's *t*-test was used for group comparison of continuous variables with a normal distribution; otherwise, the Mann–Whitney *U*-test was applied. To compare qualitative variables, Pearson's χ^2-test was used. Spearman's rank correlation coefficient (r) was used to assess correlations between the results of kidney shear wave speed measurements made with ARFI elastography and such parameters as age, gender and kidney length. Backward stepwise multiple regression was used for multivariate analysis, which included only variables that reached statistical significance in univariate analysis. In this study, p-values <0.05 were considered to indicate statistical significance.

RESULTS

Kidney shear wave speed was assessed by means of ARFI elastography in 91 "normal" patients. The main characteristics of these patients are summarized in Table 1.

Five valid ARFI elastographic measurements were obtained in both kidneys of each "normal" patient. The mean kidney shear wave speed values obtained in the right and left kidneys were similar: 2.49 ± 0.81 m/s versus 2.36 ± 0.75, $p = 0.25$. Because kidney shear wave speed values were similar for both kidneys, further