Quantitative evaluation of kidney damage in spontaneously hypertensive rats by ultrasound localization microscopy

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Background, Motivation and Objective

As a typical chronic kidney disease (CKD), hypertensive nephropathy is one of the common syndromes of hypertension. Currently, renal resistive index (RRI), derived from color Doppler ultrasound imaging, is often used as a critical marker of the stage of hypertensive nephropathy in the clinic. However, its sensitivity and specificity are limited for early diagnosis. Ultrasound localization microscopy (ULM) has been developed to obtain microvascular hemodynamics, which is beneficial for early diagnosis of diseases. In our previous work, the *in-vivo* feasibility of ULM in evaluation of CKD was validated using ischemic-reperfused rat kidney model (Yang et al, IUS 2018). The objective of this study was to investigate the value of ULM in the diagnosis of hypertensive nephropathy.

Statement of Contribution/Methods

Spontaneous hypertensive rats were examined. 8 rats were at the age of 10 weeks (group A: early stage) and 17 rats were at the age of 50 weeks (group B: late stage). After injecting diluted microbubble (SonoVue, Italy) solution, a Vantage system with an L20-10 probe was used to acquire the data of the kidney. 4,000 frames of 7-angle coherent compounding plane-wave images were acquired at PRF of 5000 Hz. Using ULM technique, the localization density map, and blood flow direction and speed maps can be obtained (Figs. a-c). Thereafter, the blood flow speeds of arteries and veins along profile lines parallel to the edges of the kidney with different offsets were obtained (Fig. c). The mean speeds along profile lines with different offsets were calculated and fitted with straight lines, and the speed gradient was calculated as the slopes of fitting lines (Fig. d). The speed gradient ratio of artery and vein were finally obtained (Figs. e and f).

Results/Discussion

As shown in Fig. e, both the mean blood speed of the artery and the vein increase nearly linearly with the depth (offset: -0.5~-1.5mm). Significant difference of the speed gradients between artery and vein is found in both groups. The speed gradient ratio in group B is lower than that in group A (Fig. f). Similar to RRI, the speed gradient ratio may reflect the distal resistance of renal capillaries, which indicates the renal damage on microvessels caused by hypertension. More experiments will be performed to investigate the feasibility of microvascular hemodynamics obtained by ULM for early diagnosis of hypertensive nephropathy.

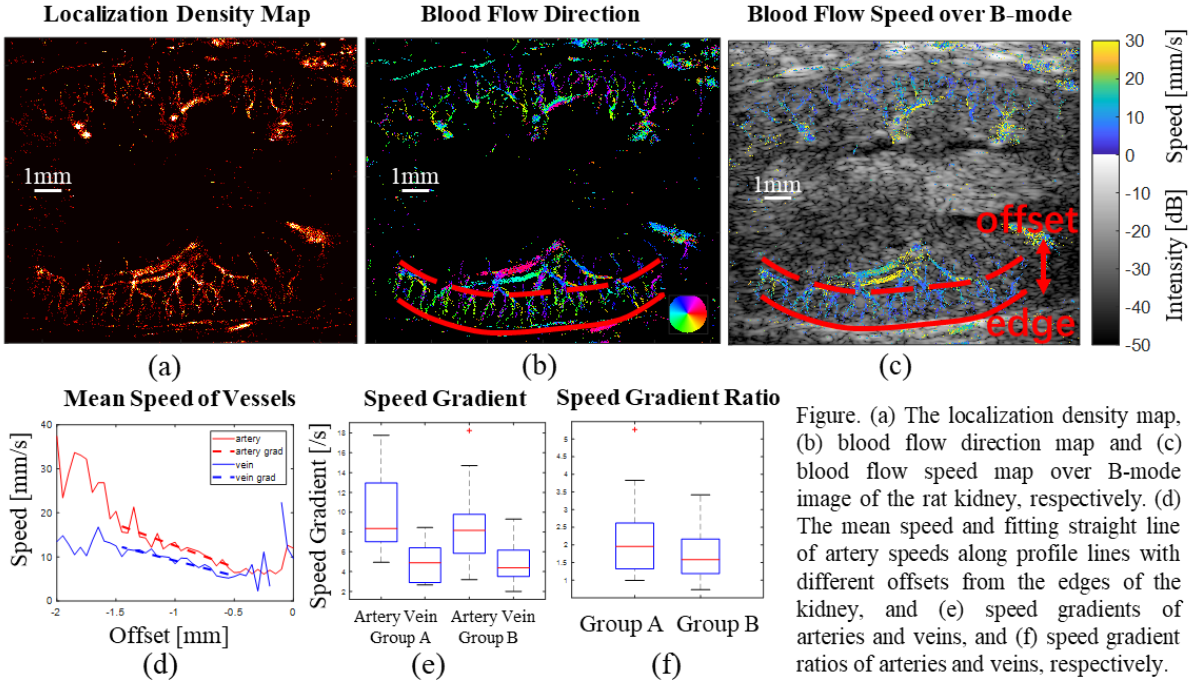

Figure. (a) The localization density map, (b) blood flow direction map and (c) blood flow speed map over B-mode image of the rat kidney, respectively. (d) The mean speed and fitting straight line of artery speeds along profile lines with different offsets from the edges of the kidney, and (e) speed gradients of arteries and veins, and (f) speed gradient ratios of arteries and veins, respectively.