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EDITORIAL

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# Doppler monitoring of renal hemodynamics: why the best is yet to come

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Sir: In this issue of "Intensive Care Medicine," Wan et al. [1] report that Doppler ultrasound-derived estimates of renal blood flow (RBF) are weakly correlated with implanted flow probe measurements of RBF and RBF changes in merino ewes. It is widely admitted that it is impossible to accurately estimate RBF and RBF changes by using Doppler ultrasound for two main reasons: firstly, as mentioned by the authors, there are limits to the accuracy of measurement of vessel diameter and the subsequent estimation of cross-sectional area with Doppler ultrasound. Unfortunately, the authors did not report the diameter values (mean and confidence intervals), and reproducibility of their measurements. Secondly, small changes in the angle of insonation may induce major changes in Doppler shift and blood flow velocity. The study by Wan et al. [1] recalls this evidence by presenting a comprehensible evaluation of the limits of the Doppler ultrasound technology.

The other limitations of the study are clearly discussed by the authors. The fact that RBF was measured with Doppler ultrasound in the right renal artery while RBF was monitored with a transit-time flow probe in the left renal artery is acknowledged. Significant differences in RBF may be physiologically observed between the right and left kidney, and thus may hamper comparison of RBF obtained at opposite sides using two different techniques. In some clinical studies, pathological thresholds are even defined according to differences in resistive index (RI) between the left and right sides. Furthermore, in practice, disease-related differences in vasoreactivity between right and left sides may well contribute to differences in the drug-induced changes in RBF. Even if one admits the main conclusion of the authors, namely that Doppler RBF does not reflect baseline RBF nor could track $> 20\%$ RBF changes, we feel that the paper must not encourage one to "throw the baby out with bath water." It is not necessary to say that clinicians have to be careful when interpreting data obtained with renal Doppler ultrasound; however, it must be pointed out that Doppler sonography remains a useful clinical tool to assess renal dysfunction.

The Doppler indices of perfusion generally used are the resistive index {RI = [peak (systolic) flow velocity – minimum (diastolic) flow velocity] / peak (systolic) flow velocity} and the pulsatility index {PI = [peak (systolic) flow velocity – minimum (diastolic) flow velocity] / mean flow velocity}. They are independent of the angle of insonation and of the diameter. These indices are advanced as useful parameters for quantifying the alterations in renal resistances. Most recent studies did not even mention any theoretical reason upon which to predict an unequivocal link between RI and RBF. Importantly, the formalism of Ohm's law relating mean flow, mean pressure gradient, and resistance implies that changes in flow must not be interpreted as reflecting changes in resistance (and vice versa) in cases where the changes in the pressure gradient are not monitored. This basic observation also applies to left-sided cardiac output/systemic vascular resistance and right-sided cardiac output/pulmonary vascular resistance.

For clarity purposes, the main correlates of RI must be briefly recalled. It has been suggested that RI is related to resistance and compliance of the renal circulation, to central hemodynamics (especially arterial stiffness and pulse pressure), and to other factors including age and the underlying renal disease [2]. The RI has been studied in ureteral obstruction [3], evaluation of solitary kidney function [4], renal transplant dysfunction [5], and several diseases such as diabetic nephropathy and atherosclerosis [6]. The RI is also correlated with the progression of renal disease [7, 8]. Lerolle et al. [9] reported the first application of RI in the field of sepsis and intensive care showing that RI has a predictive value for acute renal failure apparition. Recently, in patients with septic shock, we have reported that a significant decrease in renal RI is observed when increasing mean arterial pressure (MAP) by norepinephrine from 65 to 75 mmHg [10]; thus, Doppler ultrasonography with RI calculation may be of interest in the management of these patients to determine the optimal MAP level for renal perfusion as early as possible [10].

The RI and the PI are not only dependent on the vascular resistance, but they have also been shown to correlate with the severity of renal damage under various clinical settings including primary renal diseases [11, 12] and primary hypertension [13]; therefore, in intensive care RI and PI could be useful clinical tools for assessing both acute variations in renal vascular resistance or compliance and renal damage in multiple-organ dysfunction syndrome.

Finally, Doppler of renal arteries is a rapid, noninvasive, painless, repeatable technique. This latter point is a key point because physicians can follow the time course of changes in intrarenal arterial waveforms and evaluate the resulting effects of their treatment strategy. Keeping in mind that RBF cannot be reliably monitored by using Doppler ultrasound, further studies monitoring intrarenal arterial waveforms in the critically ill are strongly encouraged.

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