Variability of relative blood volume during haemodialysis

Sir,
In ‘Variability of relative blood volume during haemodialysis’ [1] Krepel and co-authors conclude that relative blood volume (RBV) monitoring during haemodialysis is of limited use in the prevention of dialysis associated hypotension. They base this conclusion upon the large coefficient of variation (CV) of RBV for standardized ultrafiltration volume, both interpatient and intrainpatient, and the absence of a significant correlation between changes in RBV and blood pressure. Their data and conclusions raise the question of what might reasonably be expected of the monitoring of RBV when one considers the complexity of the physiology of the cardiovascular dynamics in response to ultrafiltration (UF) and haemodialysis.

In simplest terms, the net change in RBV in response to UF is the result of the equation

$$\Delta BV = UF \text{ rate} - \text{vascular refilling rate}$$

The vascular refilling rate (VPR) is, in the main, a function of the degree of hydration of the interstitial fluid space, although other factors such as peripheral vascular perfusion and response to vasoactive drugs might be expected to influence passive and active fluid exchange across the endothelial interface between vascular and interstitial fluid.

The blood pressure response to UF, on the other hand, cannot be described by a simple equation such as that for change in RBV in response to UF. Krepel et al. describe the significant correlation between heart rate response (tachycardia) and change in RBV, but an increase in heart rate is only one of many possible responses to reduction in effective blood volume. For example, the team from Maastricht led by Leunissen, have provided data that thermal energy balance during haemodialysis and ultrafiltration has a significant and overarching effect on blood pressure response through changes in peripheral vascular resistance and venous compliance [2,3].

We should, therefore, be cautious in expecting changes in blood pressure response to RBV to be exactly predictable even when RBV responses to UF are highly correlated. The value of RBV monitoring in predicting hypotension might well be greatest in those patients most prone to inadequate vascular refilling. Hypotension occurred in Krepel’s patients in only 7 of 100 dialysis sessions in two patients, and in 6 of these the Bezold-Jarish reflex (withdrawal of sympathetic activity related to compromised venous return) seems to have been operative. This is hardly typical of the experience of most dialysis clinicians.

It is interesting, therefore, to analyze the CV for RBV reported by Krepel et al. for RBV response. This analysis seeks to define whether the CV is dependent upon the RBV response to UF. As Figure 1 shows, there is a highly significant correlation between the CV for RBV and the RBV value.

The CV of RBV is clearly inversely correlated with RBV. It is reasonable to assume that the patients with lowest RBV (and highest CV of RBV) have well hydrated interstitial volume facilitating ready vascular refilling. These patients would be least prone to intradialytic hypotension. By contrast, the CV of RBV for patients with larger RBV change is low. These patients would be most prone to hypotension since vascular refilling is impaired either because the interstitial space is ‘dry’ or because of other causes of impaired vascular refilling. RBV change would, then, be least subject to variance and most useful for patients most at risk of hypotension. On the other hand, low RBV in response to UF (and its high CV) may indicate overhydration (so-called ‘flat-liners’) and, as such, provide a useful diagnostic adjunct in the determination of hypervolaemia.
The high CV of RBV reported by Krepel et al. suggest both a limitation and a potential for RBV monitoring during haemodialysis and ultrafiltration. Interpatient and intrapatient variability in RBV response to UF make it unlikely that a single value of change in RBV will reliably predict hypotension (the so-called 'crash-crit' principle). The use of RBV monitoring as a predictor of hypotension will require that individual patient sensitivity of blood pressure change in response to RBV and UF be determined on an individual patient basis. Having established a profile of patient sensitivity (and variance) in response to change in RBV, the inclusion of such variance within constants in an algorithm determining UF rate in response to change in RBV would sensitize RBV monitoring to the individual patient's haemodynamic response and make RBV monitoring a useful tool. Such biofeedback use of RBV to control UF rate has been suggested as a progressive step in haemodialysis technology [4,5].

Kreple et al. are, I believe, premature in dismissing a potential value for RBV monitoring in predicting haemodynamic response to UF and haemodialysis. The technology of RBV monitoring, whether by optical or ultrasonic technique, does provide an additional tool in the assessment of patient hydration status and, where change in RBV is incorporated in feedback control of UF, a limited but useful means to reduce intradialytic hypotension.

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Reply

Sir,

We are glad and grateful that Dr Woods has commented on our paper in such detail. The seemingly interesting finding of a negative correlation between relative blood volume and the coefficient of variation appeared to surprise Dr Woods. This correlation however is a logical one. CV and RBV are not independent variables, as the coefficient of variation is equal to the standard deviation divided by the mean, multiplied by 100 (to produce a percentage). However, we share Dr Woods’ conviction that monitoring of RBV can be of value in treating patients with dialysis related hypotension, a group of patients not particularly targeted in our study. The main point we wanted to stress was that due to the large variability of blood volume changes, other physiological defence mechanisms should be taken into account.

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