PART VIII

Symposium  HOW TO PREVENT VASCULAR INSTABILITY DURING DIALYSIS

Chairman:  V Cambi
HOW TO PREVENT VASCULAR INSTABILITY:
HAEMOFILTRATION

E Quellhorst, B Schuenemann, U Hildebrand

Nephrological Centre Niedersachsen, Hann-Muenden, FRG

Summary

Most investigators agree that the remarkable tolerance of the vascular system to fluid withdrawal by haemofiltration is one of the most important advantages of this method. On the other hand it has been shown that blood pressure can be normalised in patients with dialysis-resistant hypertension by applying haemofiltration. The preservation of extracellular osmotic pressure during haemofiltration, obviously caused by the maintenance of a relatively high extracellular Na\(^+\) concentration, may induce a rapid and effective refilling of this compartment thus preventing vascular instability. A concept which may explain the apparently contradictory effect of haemofiltration on hypo- and hypertension, is proposed.

Introduction

During the past two decades the efficiency of haemodialysers concerning the elimination of different substances accumulated in uraemia has improved considerably thus offering the potential advantage of shortening dialysis time. The limited tolerance of the circulatory system to body fluid removal proves to be an obstacle to further reduction of treatment time rather than the capacity of dialysers. Collapse reactions, occurring in a high percentage of dialysis procedures [1] may have harmful effects especially in older patients with cerebro- or cardiovascular diseases, the number of whom is increasing in many dialysis centres. Haemofiltration may be looked upon as a mode of treatment applied in an attempt to reduce the frequency of collapse reactions during rapid fluid removal.

On the other hand, this new method has been reported to normalise severe hypertension resistant to dialysis and drug treatment without respect to its pathogenesis [2,3]. The following investigations were designed to give an interpretation of the entirely different reactions of the vascular system to haemofiltration: prevention of collapse reactions in some patients and normalisation of severe hypertension in others.
Patients and methods

At the start of dialysis treatment a minority of patients show normal blood pressure. Figure 1 demonstrates the frequency of normo- and hyperreninaemic hypertension as well as hypotensive reactions in a population of 300 dialysis patients, and the influence of haemodialysis and haemofiltration on these complications. As can be seen, normoreninaemic hypertension can be treated adequately by haemodialysis in most patients, whereas in hyperreninaemic hypertension, haemofiltration proves to be more effective. Finally, normotension could be achieved in 48 out of 56 patients with dialysis-resistant hypertension. Hypotensive reactions, frequent in 24 patients during haemodialysis treatment were observed in only three patients after transfer to haemofiltration.

Figure 2 shows the behaviour of plasma Na⁺, body weight, blood pressure and plasma renin activity in a patient with hyperreninaemic hypertension who was treated by haemodialysis and then by haemofiltration after having regained his initial body weight. In order to avoid misinterpretation from an overlapping of secretion and elimination by different types of dialysers or filters, blood for the determination of plasma renin activity was drawn from a venous catheter, the tip of which had been positioned in the vena cava caudalis at the orifice of the venae renales. Removal of body water provoked severe collapse reactions in haemodialysis inducing an increase in plasma renin activity and making saline infusions necessary. These extreme fluctuations of blood pressure and plasma renin activity could be avoided by haemofiltration in spite of more effective dehydration.
In Figure 2 the frequency of hypertensive and hypotensive episodes in 50 hypertensive patients during 10,000 treatment procedures each of haemodialysis and haemofiltration are correlated with the percentage of the initial body weight removed per hour. Hypo- and hypertensive episodes are defined as a deviation from the initial systolic blood pressure by 40mmHg or more, within 10 minutes. As can be seen, there is a strong correlation between the frequency of hypotensive episodes and the amount of fluid removed in haemodialysis whereas for haemofiltration such a relationship does not exist, also applying to hypertensive episodes in haemodialysis and haemofiltration.

In five patients with chronic renal insufficiency changes of inulin space, plasma osmotic pressure, plasma Na\(^+\) and urea concentration and the loss of body weight
were investigated during two procedures each of haemodialysis and haemofiltration (Figure 4). In both methods the urea clearance was adjusted to 120ml/min, Na⁺ concentration being 142mEq/L in substitution and dialysis fluids. Body weight for each patient was comparable at the start of each mode of treatment being reduced by the same amount in haemodialysis as in haemofiltration. Whereas the plasma urea concentration due to prior matching did not show differences between the two procedures, plasma Na⁺ concentration rose considerably with haemofiltration, but remained low with haemodialysis, thus inducing an increase in plasma osmotic pressure during haemofiltration. The inulin space, measured before and after treatment as well as three hours later showed a different behaviour: whereas it decreased significantly during dialysis it remained nearly stable in haemofiltration. The increase of the inulin space after treatment was more pronounced in haemofiltration than in haemodialysis, indicating more rapid refilling of the extracellular space after haemofiltration.

**Discussion**

It has been shown earlier that hypertension can be influenced favourably by haemofiltration, even in patients with severe dialysis-resistant high blood pressure.
Figure 4. Inulin space, plasma osmotic pressure, body weight and plasma concentration of Na⁺ and urea in five patients on haemodialysis and haemofiltration. Δ body weight = deviation of body weight from the initial value at the start of treatment. X ± SEM

[3] Collapse reactions occurring during dehydration in haemodialysis may be prevented even in hypotensive patients by linear fluid removal which can be achieved more easily by haemofiltration. The lack of collapse reactions not only limits the need for additional saline infusions as a means of stabilising the circulatory system, it may also prevent recurrent stimulation of the renin-angiotensin system. As simultaneous expansion of the extracellular space and hyperactivity of the renin-angiotensin system is assumed to be the main source of hypertension in advanced renal failure [4], the anti-hypertensive effect of haemofiltration may be explained by the lack of stimuli leading to this combination.
As has been stated earlier [5], the blood pressure response to fluid withdrawal by haemofiltration depends on the blood pressure at the start of the treatment procedure; in patients with severe hypertension a relatively small amount of ultrafiltrate removal is sufficient to induce a substantial decrease of blood pressure, whereas in patients with normo- or hypotension relatively large fluid removal is tolerated without further depression. This behaviour may be a strong point against the assumption that normalisation of blood pressure by haemofiltration is simply a function of dehydration. Other factors influencing the vascular tone have to be taken into consideration. One of these may be a more physiological adaptation of the circulatory system to intravascular fluid removal. We ourselves and other authors, could demonstrate that the peripheral resistance increases or at least remains stable in haemofiltration but decreases in haemodialysis [6–8].

Whereas plasma catecholamine levels showed a physiological response to body fluid removal in haemofiltration, no reaction or alternatively a decrease, was observed in haemodialysis [7,8]. Besides this, rapid ‘refilling’ of the extracellular space during and after haemofiltration, demonstrated here, may be an important factor in the prevention of vascular instability. Obviously the maintenance of a higher extracellular osmotic pressure, perhaps as a consequence of a higher extracellular Na⁺ concentration, may enhance this ‘refilling’ phenomenon [9].

The antagonistic effects of haemofiltration, normalisation of hypertension as well as prevention of hypotensive reactions, lead to a concept based on the present information about its effects on the determinants of blood pressure regulation (Figure 5). Contrary to haemodialysis, haemofiltration allows removal of sodium

Figure 5. Schematic concept of blood pressure regulation in haemofiltration. BP = blood pressure; ECS = extracellular space; IC = intracellular space

248