Dynamics of oxygen saturation, fluid and blood pressure during hemodialysis and their associations with clinical outcomes

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The investigations presented in this thesis aim to provide deeper insights into the pathophysiological effects of the hemodialysis (HD) treatment, using novel information measured by the Crit-Line monitor™ (CLM). These data include continuous measurements of blood oxygen saturation and relative blood volume (RBV) at very high frequency during HD. Regarding measurements of blood oxygen saturation it is of note that - depending on the type of vascular access - the CLM can determine either central-venous or arterial oxygen saturation. Deployment of the CLM in a large population of U.S. HD patients allowed for conduction of research into the potential clinical relevance of intradialytic blood oxygen saturation and RBV. The studies presented in this thesis focused on the associations between intradialytic measurements reflecting arterial and venous oxygen saturation, systolic blood pressure (SBP), and RBV with clinical outcomes.

In Chapter 2 and Chapter 3, the associations of intradialytic arterial oxygen saturation with clinical outcomes such as intradialytic hypertension, hospitalization and mortality were studied. We found that in a large cohort of chronic HD 10% of the studied patients experience prolonged intradialytic hypoxemia, a condition defined by an arterial oxygen saturation below 90% lasting for more than 1/3 of the dialysis treatment. A significant association between prolonged intradialytic hypoxemia and the clinical outcomes all-cause hospitalization and mortality was observed. We also showed for the first time a lower risk with higher intradialytic arterial oxygen saturation and intradialytic hypertension (defined as a peri-dialytic SBP increase ≥10 mmHg), and persistent intradialytic hypertension (defined as average peri-dialytic SBP increase ≥10 mmHg throughout the entire 6-months observation period).

The relationship between central venous oxygen saturation and mortality and ultrafiltration volume are discussed in Chapter 4 and Chapter 5. We found that in chronic HD patients lower central venous oxygen saturation levels are associated with poorer survival. Also inverse relationship between intradialytic central venous oxygen saturation change and ultrafiltration volume corrected for body weight, meaning that most patients at high ultrafiltration volume weight experienced a more pronounced intradialytic central venous oxygen saturation decline.

Intradialytic RBV was also associated with patient survival, which was studied in Chapter 6. Our study found that hazard ratios for all-cause mortality were significantly below 1 in patients whose RBV levels were 93-96% at the first hour, 89-94% at the second hour, and 86-92% at the third hour, respectively, indicate a significantly better survival in patients with RBVs within these favourable ranges compared to those with RBVs outside.

Lastly, the relation between peri-dialytic SBP and outcome was investigated in Chapter 7. The main finding of this study is the interaction of peridialytic SBP changes in relation to pre-dialysis SBP level with mortality, depicting baseline clinical differences

among patients. In patients whose pre-dialysis SBP is low an increase in SBP during HD is associated with improved outcomes as compared to patients experiencing a further decline; whereas, contrastingly, a further increase of SBP in patients who already begin HD with a high SBP level is associated with adverse outcomes.