

## Measurement of Relative Change in Blood Volume and Plasma Refilling Rate during Hemodialysis by Noninvasive Continuous Hemoglobin Monitoring using Pulse Oximetry

Yamada H., Saeki M., Sakamoto S., Ito J., Saitoh M., Minoguchi, K., Kawada K., M Higurashi A., Takahash S., Takeda K. *Proceedings of the American Society of Anesthesiologists*, October 13, 2012. Washington DC: A811

### Background

Extravascular fluid accumulation is observed in perioperative period. Ultrafiltration during hemodialysis is thus required to remove accumulated fluid after surgical procedures for patients with end stage renal failure on hemodialysis. Although intra-hemodialysis hypotension is multifactorial issue, one of the most common factors of the hypotension is acute reduction of circulating plasma volume. As decrease in plasma volume is calculated as ultrafiltration rate (UFR) - plasma refilling rate (PRR) during hemodialysis, evaluating decrease in plasma volume and adjusting UFR to PRR is significant for hemodynamically stable hemodialysis. Noninvasive spectrophotometry-based technology that provides continuous hemoglobin measurements (SpHb) has been introduced. As saturation monitoring by pulse oximeter is routine care in intensive care unit, it would be of great clinical significance if relative change in blood volume and PRR could be estimated by SpHb using pulse oximetry. In this study, we measured SpHb during hemodialysis and calculated relative change in blood volume and PRR. We then compared them with those calculated by hematocrit measured by Crit-Line, online monitoring device which optically measure hematocrit of hemodialysis circuit.

### Methods

Patients who performed hemodialysis in general ICU of city hospital were enrolled for the study. Pulse oximeter (Masimo Rainbow SET CO-Oximetry Radical-7, Masimo Corp., Irvine, CA) were equipped and hemoglobin concentration was monitored continuously during hemodialysis. Crit-Line (In Line Diagnostics, Kaysville, UT) was set in hemodialysis circuit for in line monitoring of hematocrit. Relative change in blood volume ( $\Delta BV$ ) was calculated as  $(\text{starting Hb or Hct} / \text{current Hb or Hct}) - 1$ . Plasma refilling rate (PRR) (ml/h) was calculated as  $UFR \text{ (ml/h)} - \text{change of plasma volume (ml/h)}$ . Hemodialysis was planned by nephrologists independent on this study. The correlation and agreement between two methods were evaluated by linear regression and Bland Altman analysis.

### Results

Thirty two runs of hemodialysis in 11 patients (5 male and 6 female) which provided 115 pairs of values were analyzed. Two cases in which red blood cell was transfused were excluded for the study. Linear regression showed a good correlation between relative change of blood volume calculated by SpHb ( $\Delta BV[\text{SpHb}]$ ) and relative change of blood volume calculated by hematocrit measured using Crit-Line ( $\Delta BV[\text{Crit}]$ ) (coefficient of correlation:  $R=0.97$ ,  $p<0.001$ .  $\Delta BV[\text{SpHb}] = 0.88 \times \Delta BV[\text{Crit}] + 0.02$ ). Good agreement of  $\Delta BV[\text{SpHb}]$  and  $\Delta BV[\text{Crit}]$  was shown by Bland and Altman comparison (bias 0.92%, precision 3.21%). Plasma refilling rate calculated by SpHb ( $\text{PRR}[\text{SpHb}]$ ) was  $652 \pm 261$  ml/h (mean  $\pm$  SD) (range 210-1302). While PRR calculated by Crit-Line ( $\text{PRR}[\text{Crit}]$ ) was  $678 \pm 259$  ml/h (mean  $\pm$  SD) (range 191-1352). Linear regression showed good correlation between  $\text{PRR}[\text{SpHb}]$  and  $\text{PRR}[\text{Crit}]$ . (coefficient of correlation:  $R=0.96$ ,  $p<0.001$ .  $\text{PRR}[\text{SpHb}] = 0.992 \times \text{PRR}[\text{Crit-Line}] + 2.18$ ). Bland and Altman analysis showed good agreement of  $\text{PRR}[\text{SpHb}]$  with  $\text{PRR}[\text{Crit}]$  (bias 3.23 ml/h, precision of 55.0 ml/h).

### Conclusion

Relative change in blood volume and plasma refilling rate measured by SpHb showed good concordance with those measured by Crit-Line. Continuous monitoring of SpHb by pulse oximetry enabled us to evaluate relative change in blood volume and adjust ultrafiltration rate to plasma refilling rate. The results of this study indicate that SpHb monitoring contributes to effective ultrafiltration and stable blood purification.