The Association between Post-Dialysis Hematocrit Levels and Ultrafiltration Volume in Maintenance Hemodialysis Patients

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Abstract

BACKGROUND: It is well known hematocrit will increase after hemodialysis, and this phenomenon is called the hemoconcentration effect. However, the question if a greater ultrafiltration volume will cause higher hematocrit levels remains controversial. Therefore, further examination of the association between the ultrafiltration volume and the changes in hematocrit levels during hemodialysis is needed.

METHODS: A prospective study examining 71 stable hemodialysis patients at the mid-week treatment (Wednesday or Thursday) and at the first dialysis treatment of the next week (Monday or Tuesday) was conducted. The association between the ultrafiltration volumes and the changes in hematocrit or hemoglobin levels at the mid-week treatment and the beginning of the next week treatment was measured.

RESULTS: The results revealed a post-dialysis hemoconcentration effect. However, the ultrafiltration volume and the changes in intradialytic hematocrit levels revealed no significant correlations (r = 0.065, P > 0.05 at the mid-week treatment; r = 0.162, P > 0.05 at the beginning of the next week treatment).

CONCLUSION: Our results demonstrated no correlations between the ultrafiltration volume and the changes in intradialytic hematocrit levels whether at the mid-week treatment or the beginning of the next week treatment. Many factors such as gender, age, body habitus, and underlying cardiac disease will determine the intradialytic refilling effect. (Acta Nephrologica 2011; 25: 182-185)

KEY WORDS: hematocrit, hemodialysis, ultrafiltration

Introduction

The optimal hemoglobin level for end-stage renal disease (ESRD) patients on dialysis is still open to debate (1). The KDOQI guidelines do not state the best time to obtain blood sampling of hemoglobin (Hgb) or hematocrit (Hct) (2). For convenience, Hgb or Hct are taken before hemodialysis in the mid-week (Wednesday or Thursday) of dialysis in Taiwan. Movilli et al. demonstrated post-hemodialysis Hgb concentration increases 5% after hemodialysis (3). Asher et al. also showed similar results (4). In hemodialysis patients, lack of blood volume regulation is common, and the ultrafiltration volume (Uf) between each dialysis session may influence the Hgb concentration or Hct. We hoped to find if greater ultrafiltration volume would cause higher hematocrit levels.

This study examined changes in Hgb and Hct...
concentration before and after standard hemodialysis. The relationships between the ultrafiltration volume and the changes in intradialytic Hgb or Hct levels at separate dialysis sessions were also evaluated.

Materials and Methods

In a local hemodialysis center in Taichung, Taiwan, all patients who received hemodialysis were evaluated. Those who experienced dialysis hypotension, dialyzer clotting during the dialysis session or had bleeding history in the most recent month were excluded. Seventy-one outpatients undergoing regular hemodialysis 3 times per week with a stable condition during dialysis were enrolled in this study. The underlying renal disease caused ESRD, including chronic glomerulonephritis (n = 42), diabetic nephropathy (n = 24), lupus nephritis (n = 2), nephrolithiasis related (n = 2) and gouty nephropathy (n = 1). Recombinant human erythropoietin (rhEPO) was given to keep Hct within an optimal range of 33-36% according to the KDOQI guideline. No institutional review board approval was obtained since all the data were collected from the monthly routine test following the guidelines of the bureau of national health insurance. All participants agreed to blood sampling and gave oral informed consent. Pre- and post-dialysis blood samples for measurement were drawn at the mid-week treatment (Wednesday or Thursday) and the first dialysis treatment of the next week (Monday or Tuesday). All patients lay supine on the bed during blood sampling. Blood samplings were taken directly from an arterial site with sterile techniques without saline or heparin contamination before and after dialysis treatment. Hgb, Hct, serum levels of albumin, as well as ΔHgb, ΔHct, Uf, and RUf were collected. ΔHgb, ΔHct, Uf, and RUf are defined as:

\[ \Delta Hgb \text{ (g/dL)} = (\text{post-dialysis Hgb concentration}) - (\text{pre-dialysis Hgb}) \]

\[ \Delta Hct \% = (\text{post-dialysis Hct concentration}) - (\text{pre-dialysis Hct concentration}) \]

\[ Uf = (\text{post-dialysis body weight}) - (\text{pre-dialysis body weight}) \]

\[ \text{Relative Uf} \% \text{ (RUf} \%) = 100 \times \left( \frac{Uf}{\text{divided by the pre-dialysis body weight}} \right) \]

All values are reported as means ± SD. A paired Student t-test was used for intra-group and inter-group comparisons. Correlations between changes in hemoglobin (ΔHgb) or hematocrit (ΔHct) versus ultrafiltration volume (Uf) or relative ultrafiltration volume (RUf) were tested by the Pearson correlation coefficient test. A two-tailed P value < 0.05 was considered significant. Statistical analyses were performed with SPSS (version 14.0, SPSS, Inc., Chicago, Ill.).

Results

There were 25 males and 46 females enrolled, with a mean age of 62.2 ± 13.8 years, and a mean hemodialysis treatment period of 84.5 ± 60.6 months. The mean ferritin levels were 543.7 ± 372.5 ng/mL. The mean dosages of rhEPO were 3862.7 ± 2612.1 U/week (Table 1).

In Table 2, the post-dialysis Hgb (10.4 ± 1.5 g/dL) and Hct (32.8 ± 4.2%) at mid-week were significantly higher than the pre-dialysis Hgb (10.1 ± 1.4 g/dL) and Hct (31.9 ± 4.0%) at mid-week (P < 0.001, respectively). Another result showed the post-dialysis Hgb (10.1 ± 1.4 g/dL) and Hct (31.5 ± 3.8%) at the beginning of the next week were also significantly higher than the pre-dialysis Hgb (9.8 ± 1.3 g/dL) and Hct (30.4 ± 3.6%) at the beginning of the next week (P < 0.001, respectively). The above results confirmed the long known hemoconcentration effect following hemodialysis.

Table 3 shows comparisons of parameters between the separated dialysis sessions. The mean Uf at the beginning of the next week was significantly higher than that at mid-week (2.9 ± 1.0 kg vs. 2.6 ± 1.0 kg, P < 0.001). The mean RUf at the beginning of the next week was also significantly higher than that at
mid-week (4.8 ± 1.5% vs. 4.3 ± 1.4%, \( P < 0.001 \)). The mean \( \Delta \)Hgb at the beginning of the next week was significantly higher than that at mid-week (0.4 ± 1.3 g/dL vs. 0.3 ± 1.1 g/dL, \( P < 0.001 \)). The mean \( \Delta \)Hct at the beginning of the next week was significantly higher than that at mid-week (1.1 ± 3.7% vs. 0.9 ± 3.4%, \( P < 0.001 \)).

In Table 4, at the mid-week treatment, \( \Delta \)Hct does not show any correlation with \( Uf \) (\( R = 0.065 \), \( P > 0.05 \)) or \( RUf \) (\( R = 0.181 \), \( P > 0.05 \)). No correlations were found between \( \Delta \)Hgb and \( Uf \) (\( R = 0.087 \), \( P > 0.05 \)) or \( RUf \) (\( R = 0.207 \), \( P > 0.05 \)). In the beginning of the next week treatment, the \( \Delta \)Hct is not correlated with \( Uf \) (\( R = 0.162 \), \( P > 0.05 \)) or \( RUf \) (\( R = 0.199 \), \( P > 0.05 \)). In addition, the \( \Delta \)Hgb is not correlated with \( Uf \) (\( R = 0.179 \), \( P > 0.05 \)) or \( RUf \) (\( R = 0.22 \), \( P > 0.05 \)).

### Discussion

Dialysis patient’s Hgb levels were kept according to the K/DOQI guideline (2). Most studies that evaluated anemia in hemodialysis patients measured pre-dialysis Hgb levels. However, several studies have discussed post-hemodialysis hemoconcentration (3-5). Post-dialysis Hgb has been known to increase in comparison with pre-dialysis Hgb as a result of ultrafiltration of plasma volume during dialysis. Our results also demonstrate this post-dialysis hemoconcentration effect.

Movilli et al. demonstrated both Hgb and Hct increased by 5% after dialysis and they also demonstrated a linear relationship between changes in Hgb and ultrafiltration volume (3). However, in contrast
to this strong correlation between Hgb changes and ultrafiltration volume found by Movilli, our results showed no correlation between ΔHgb/ΔHct and Uf/RUf. Therefore, we inferred additional factors might have influenced ΔHgb/ΔHct in our hemodialysis patients.

Geller et al. measured pre- and post-dialysis Hgb and body weight in 133 hemodialysis patients. Absolute and percentage change in Hgb (%ΔHgb) and percent change in body weight (%ΔBW) were determined for that treatment. He found patients with post-dialysis Hgb > 13 g/dL had a greater increase in %ΔHgb that was out of proportion to %ΔBW. Such disproportion of %ΔHgb to %ΔBW that might have been due to the variation in volume compartments was also considered a factor rather than ultrafiltration alone (6). Agarwal et al. reported differences in interstitial fluid volume reserve and movement of this fluid might affect the intravascular space (7). The difference in blood volume is highly variable, specifically in congestive heart failure, which may affect Hgb levels. This variability is due to multiple factors including gender, age, body habitus, and underlying cardiac disease (8).

Minutolo reported plasma refilling persists after the end of dialysis, with restoration of pre-dialysis Hgb levels within the initial 2 hours, and this refilling effect is greater in non-anemic patients (Hgb > 13 g/dL) than in anemic patients (Hgb < 13 g/dL). He concluded the extent of the intradialytic increment of Hgb is limited by greater intradialytic plasma refilling, and the force driving this phenomenon resides mainly in the larger changes in total protein concentration (9). In addition, consequent hemodilution caused by redistribution of water from the extra- to the intravascular space might reduce the extent of Hgb elevation that had been reported (10).

Limitations exist in our study. First, we didn’t evaluate the volume compartments and serum viscosity in our patients, which might influence the interpretation of Hgb changes due to the intradialytic interstitial fluid refilling effect. Second, most of our enrolling patients were females. A different body habitus may affect the relationship between the ultrafiltration volume and the hemoconcentration effect, which may prevent our study result from being applied to the general dialysis population.

In conclusion, our study results demonstrated the changes in intradialytic Hgb or Hct levels at mid-week and at the beginning of the next week treatment had no correlations to the respective ultrafiltration volume or relative ultrafiltration volume in these two groups. Differences in the interstitial fluid volume reserve and the subsequent refilling effect might explain the result. The refilling effect might be influenced by many factors such as age, gender, body habitus, and underlying cardiac disease. For avoiding hyperviscosity caused morbidity and mortality (11), whether pre-dialysis hematocrit or post-dialysis hematocrit should be chosen as an optimal Hct target is currently unclear, and further studies are needed to clarify the complex relationship between Hct changes and ultrafiltration volume.

References