Assessment and Management of Optimal Fluid Status

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Significance of assessment of fluid status

Body mass can be divided into components on the basis of differing physical properties, which reflect hydration, nutrition and body fat. The recognition of these abnormalities is very important in peritoneal dialysis (PD). Fluid retention induces the development of cardiovascular disease and dehydration may promote loss of residual renal function[1]. International guidelines (KDOQI, ISPD (international society for PD) and EBPG (European best practice guideline) recommend management of optimal fluid status[2-4]. For this, ISPD is recommending maintenance of euvolemia, K/DOQI achieve euvolemia and optimal blood pressure, EBPG the minimum peritoneal target for net ultrafiltration in anuric patients 1.0 L per day.

Body can be divided into two compartments, fat mass and fat free mass (FFM). FFM is composed of total body water (TBW), visceral protein and bone mineral. TBW can be divided into extracellular water (ECW) and intracellular water (ICW). ECW reflects hydration status. ICW reflects BCM and thus nutrition. FFM can be estimated by assuming it has a fixed hydration of 73%. BCM has a fixed hydration of 72 % in BIA.

Body composition analysis

Gold standard reference methods provide the most accurate data for body composition analysis (BCA). TBW is measured by administration of water-containing isotopes of hydrogen, Deuterium, tritium, heavy oxygen isotope. Densitometry determines TBW with underwater weighing. ECW can be measured by bromide dilution and ICW with total body potassium (TBK). Fat can be accurately measured by air displacement plethysmography. These methods have limitations: cost, limited availability, travel to facilities. Dilution methods have their own errors (>2L for TBW) and yield different results (e.g. 4% difference between the deuterium-TBW method and the 18O-TBW method).

The most common BCA methods used with dialysis are anthropometric method (Watson eq, etc), Bioelectrical impedance (BIA), dual energy X-ray absorptiometry (DEXA), and total body water measurement (D2O). For gold dilution technique with D2O and bromide, the patients have fast for 10 hour and blood sample is taken. The patients drink the mixture of D2O and bromide. D2O goes to ICW and ECW. Bromide stays in ECW. And patients should fast again for next 4 hour. This is troublesome for patients. DEXA is a clinically applicable but not bedside. It is between gold standard and bedside. DEXA has many advantages: short measurement time, minimal radiation, high precision, detailed information. However, DEXA has its limitations: 1) results produced by different scanners show some variations because differences among manufacturer in technology, models and soft ware 2) inherent assumptions regarding levels of hydration, tissue density vary by manufacturers because lean tissue by DEXA contains body water as its dominant

component, and changes in hydration will be reflected as change in lean tissue, confounding nutritional interpretation. Limb/trunk lean mass ratio (LTLM) measured by DEXA is associated with 5 year survival in hemodialysis (HD). High limb/trunk lean mass has better survival than low LTLM in both male and female patients on HD. LTLM ratio is a marker of regional distribution of lean mass volume[5].

BIA as the method of BCA

BIA has simple, portable, repetitive, not invasive, relative inexpensive, moderate accurate and high precision with serial measurement. Multifrequency-BIA can differentiate ECW from ICW, which is most interest and seems to be of greatest promise among the methods of BCA. Bioimpedance measure the ability to oppose (impede) electric current flow. At low frequency, cell behaves as insulator. At the highest frequency, tissue properties become more and more equal to that of water. Therefore, electric conductive properties of various tissues are different. Depending on these differences, we can analyze body composition. BIA with physiologic tissue model is well validated in HD patients with gold standard methods[6]. Segmental BIA (SBIA) has potential to be a gold standard. In this technique, voltage is measured at the hip and shoulder in addition to the ankle and wrist. Segmental BIA measures accurately fluid volume and body composition in each segment independent of posture. At present, segmental BIA is not suitable for routine use because it needs additional equipment and more complex data analysis[7, 8].

BCA by BIA and clinical relevance in PD patients

ECW normalized by height (nECW) was measured in 100 stable PD patients. Uncontrolled hypertension group had significantly higher nECW than controlled hypertension or normotension groups[9]. ECW/ICW (E/I) ratio was measured in 227 incident PD patients and patients survival was followed-up. For every increase of 0.1 in the E/I ratio, the relative risk of death was 1.368[10]. ECW was measured in 269 prevalent HD patients and patients were followed-up for 3.5 years. Patients who have ECW excess more than 2.5 L had higher mortality rate. The relative risk was 2.1. The relative risk (RR) for diabetes was 2.766[11]. In prospective study with 28 PD patients, ECW/TBW % was negatively correlated with albumin levels, handgrip strength and DPI[12]. Volume overload measured by BIA is associated with loss of circadian BP variation. In multiple regression analysis, ECW/TBW ratio was independent determinants of the ratio of night SBP to day BP (loss of dipping at night)[13]. Volume overload measured by BIA is associated with endothelial dysfunction. In multiple regression model, ECW normalized by height was independent determinants of flow-mediated dilatation index[14]. Lee et al. from Korea studied the correlation between ECW% and NT-pro-BNP. proBNP levels were well correlated with LV mass index measured by echocardiography. TBW, ECW% and ECF/ICW ratio were not correlated with NT-pro-BNP[15]. Several hydration indicators are using in BIA. ECV/TBW is commonly used. However, ECV/height has higher sensitivity in detecting hypervolemia in PD than ECV/TBW or ECC/BW[16].

Limitations of BIA

SF and MF-BIA estimate BCA with regression equation, not direct measuring. Therefore, results are only expressed in probability terms and affected by extremes in BMI and nutrition. Head, neck, hands and feet

are ignored and trunk is mostly ignored as far greater cross-sectional area & less length. Several studies have shown that TBW or ECW measured by BIA is not identical to that measured by gold standard method. Davies from UK studied fluid status in icodextrin and 2.27% glucose groups. Changes in TBW estimated from D2O dilution and BIA had similar pattern but not identical. The estimate of TBW estimated by D2O dilution is independent of BW. However, TBW estimated from BIA is not. The correlation between two methods was significant[17]. In another study by Davies, TBW measured by BIA (Tanita) was different from that measured by D2O[18]. The study performed by Konings from Netherlands showed the body composition analysis with different methods in 40 PD patients. There was a good correlation among the different methods such as BIA, anthropometry, DEXA, NaBr and D2O. However, there was a gap between the methods [19]. One study performed by Zhu from US analyzed BIA and intraperitoneal (IP) volume. They measured intraperitoneal volume continuously during peritoneal dialysis in both whole body BIA (WBIA) and SBIA. Mean true drain volume was 2.19 L. There was a good agreement between measured and calculated data by SBIA. However, WBIA could not detect the drain volume and it was just 0.84L by WBIA[20]. One study performed by Zhu from US analyzed BIA and IP volume. They measured intraperitoneal volume continuously during peritoneal dialysis in both WBIA and SBIA. Mean true drain volume was 2.19 L. There was a good agreement between measured and calculated data by SBIA. However, WBIA could not detect the drain volume and it was just 0.84L by WBIA[20]. Another study by Zhu measured intraperitoneal volume continuously during tidal peritoneal dialysis by SBIA. Bland Altman analysis between measured and calculated UFV yield limits of agreement of 0.12 L. Therefore, this study shows the potential of SBIA to be a continuous monitor of changes in IP volume[21].

In summary, for clinical application of BIA, it needs understanding in clinical practice about nature and interpretation of the measurement technique and possible limitations in terms of accuracy and precision. In addition to clinical assessment, serial measurements of BIA may be helpful for determining hydration and nutrition status. It may identify changes in hydration or nutrition earlier than would occur with routine monitoring.

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