Blood Volume Monitoring to Assess Dry Weight in Pediatric Chronic Hemodialysis Patients

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Objective: *Volume overload from an incorrect assessment of dry weight leads to cardiovascular diseases in chronic hemodialysis patients. Dry weight assessment in pediatric is difficult for a number of reasons including growth. Blood volume monitoring (BVM) has been proposed as an accurate method of estimating dry weight in adult. However, there is very scant data regarding BVM assessment in pediatric. Therefore, the authors conducted a study to compare dry weight, postdialytic body weight, predialytic blood pressure, intradialytic blood pressure, and intra dialytic symptoms between clinical adjustment and BVM method.*

Material and Method: *In pediatric chronic hemodialysis patient, BVM was performed to guide ultrafiltration to adjust dry weight compared with clinical adjustment. Data including dry weight, postdialytic body weight, predialytic blood pressure, intradialytic hypotension, and intradialytic symptoms were analyzed over each 1-month period of treatment course.*

Results: *Ten patients (5 males/5 females, age 16.55±2.49 years) were enrolled. Comparing clinical adjustment to assess dry weight with BVM, there were no differences in dry weight (38.38±7.43 vs. 38.12±7.58 kg) and postdialytic body weight (38.54±7.61 vs. 38.23±7.35) of both methods. Dry weight adjusted by clinical adjustment trends to higher than by BVM (0.14±0.46 vs. -0.26±0.57 kg). There is also no difference between predialytic blood pressure of both methods. There is no intradialytic hypotension during the study period. However, intradialytic symptoms in clinical adjustment dry weight is more frequent than BVM method, especially thirst.*

Conclusion: *The use of BVM tends to decrease dry weight in pediatric chronic hemodialysis patients. Even though, no difference in predialytic blood pressure and intradialytic hypotension. BVM to assess dry weight reduces abnormal intradialytic symptoms, especially thirst. So far, there is no gold standard to access the accurate dry weight in children.*

Keywords: *Blood volume monitoring, Dry weight, Hemodialysis*

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The balance of body fluids in pediatric patients with end stage renal disease who receive hemodialysis (HD) depend on appropriate fluid removal during dialysis. Proper fluid removal or ultrafiltration is targeted to the patient's dry weight. However, there is no current clear definition of dry weight[1]. Chavers et al[2] found a prevalence of hypertension is 75 to 85% in pediatric HD patients. One of the factors that cause hypertension is fluid overload[2]. Hypertension is a major risk factor for cardiovascular morbidity and mortality in pediatric HD patients[3-5]. In Phramongkutklao Hospital, more than 50% of pediatric HD patients have hypertension. In addition to controlling the fluid intake, the proper dry weight can prevent fluid overload in HD patient[6]. Chronic volume overload with poor control of blood pressure (BP) which are risk factors for left ventricular hypertrophy[7,8], and the control of fluid balance can reduce cardiovascular morbidities[7,9].

Pediatric dry weight depends on growth, illness, waxing, and waning of appetite. Dry weight estimated by history taking and physical examination (clinical adjustment) are imprecise. Agarwal[6] found that patients with fluid overload might not have signs or symptoms of it, which is called silent hypervolemia[6]. Currently, there are many kinds of method to assess dry weight such as biochemical markers (e.g., atrial natriuretic peptide (ANP), cyclic guanidine monophosphate (cGMP)), inferior vena cava (IVC) diameter, bio impedance analysis (BIA), and blood volume tracking during dialysis treatment. The limitation of biochemical marker is unable to assess dry weight in underweight HD patients and patients with cardiovascular disorders such as heart failure[10]. The interpretation of IVC diameter depends on

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investigator, and IVC measurement cannot be interpreted in patients with tricuspid regurgitation or right side heart failure[11]. BIA underestimates extracellular fluid component[1]. The result of blood volume tracking based on the changes of hematocrit (Hct), hemoglobin and plasma proteins are based on patient plasma refilling ability, which may be individual. Even in the same patient, the results may be different[12]. Because of the limitation, there is still no gold standard for dry weight assessment.

Blood volume monitoring (BVM) is one of the methods to assess dry weight in HD patients. It is a real time monitoring during HD treatment[13-16]. BVM helps to identify hypertensive HD that is caused by fluid overload when the result shows plasma fluid refilling from tissue to vessel at the end of dialysis after ultrafiltration for 10 to 30 minutes[6]. BVM is beneficial to pediatric HD patient to identify volume overload and to adjust appropriate ultrafiltration base on a new dry weight, which gives a better control of blood pressure[17-19].

Jain et al[20] showed a good relationship between relative blood volume (RBV) and the incidence of intradialytic hypotension after BVM used. Ultrafiltration without causing intradialytic hypotension is estimated by the decrease of RBV not more than 8% in the first 90 minutes, 4% per hour, an hour later, and 12% during dialysis[20]. Hothi et al[21] found intradialytic hypotension developed when RBV decrease more than 88%, 84%, and 82% at first, second, and third hour respectively. The overall RBV should not lower more than 82% during dialysis[21]. Using BVM can prevent intradialytic hypotension and intradialytic symptoms such as yawning, cramping, nausea, vomiting, abdominal discomfort, and restlessness. It can also reduce rate of hospital admission[3,22].

In the past, with the limitations of technology by the old hemodialysis machine, there is no experience about BVM in pediatric HD patients in Thailand. The benefit from routine BVM using in Thai patient has not been definitely answered. Therefore, we decided to use BVM to adjust a dry weight for appropriate fluid removal, and help to decrease patient's blood pressure without intradialytic complication from excessive fluid removal.

Material and Method

Patients

Pediatric and adolescent chronic hemodialysis patients aged between 0 and 21 years from pediatric dialysis unit of Phramongkutklao Hospital, Thailand between June and November 2011 were recruited to participate in the present study. The exclusion criteria were 1) hemodynamically unstable patients (requiring inotropes or midodrine for blood pressure support), 2) active cardiovascular morbidity: congestive heart failure, ischemic heart disease, arrhythmia, 3) Total parenteral nutrition (TPN) or blood transfusion during HD, 4) severe acute illness e.g., major infections, malignancies, 5) serum albumin <3 g/dL, and 6) stay on HD less than 2 months. The subjects had not been on BVM before the study. The present study was approved by the Human Research Ethics Committee of Phramongkutklao Hospital, Thailand.

Study treatment

All patients will start HD treatment with dry weight by clinical assessment of four weeks period. Then BVM was performed to adjust a new dry weight during HD treatment for another four weeks. Data including dry weight, postdialytic body weight, predialytic blood pressure, intradialytic hypotension, and symptoms were collected during HD treatment of each period.

Standardized conventional hemodialysis procedure

Routine hemodialysis was performed according to the prescription of the pediatric nephrologist. All patients underwent HD for four hours of treatment three times a week on volumetric HD machines (Fresenius 5008) with high flux polysulphone membrane dialyzer based on patient body surface area. The dialysate temperature was between 36.5 to 37°C and concentration of Na 140, K 2, Ca 1.75, HCO_3 35 mmol/L were kept constant. Extracorporeal volume did not exceed 10% of total blood volume. Blood and dialysate flow rates were estimate with urea clearance 4 to 6 mL/kg per minute and 300 to 500 ml/minute, respectively. Regular heparin/low molecular weight heparin were used as anticoagulant. The patients were not allowed to eat or drink during the dialysis sessions. Ultrafiltration (UF) were adjusted according to dry weight by clinical adjustment in the first to fourth week and by BVM in the fifth to eighth week.

Clinical adjustment procedure

Clinical adjustment of dry weight was done by nephrologist and hemodialysis nurse. It depended on interdialytic weight gain (IDWG), previous dry weight, postdialytic body weight, pre and postdialytic blood pressure, signs of volume overload such as hypertension, periorbital edema, jugular vein

engorgement, ascites, extremity edema, and intradialytic complications. Estimated dry weight was reviewed and adjusted on all patients each time of HD.

BVM procedure

BVM is a biofeedback system that comes with Fresenius 5008 HD machine. RBV during HD was monitored by BVM, and kept monitoring until UF was stopped for 10 minutes to evaluate the plasma refilling. If plasma refilling was more than 0.5%, it indicated volume overload. Patient's dry weight would be adjusted to decrease for the next session. To prevent intradialytic hypotension, if RBV curve decreased rapidly, we would reduce UF to keep RBV curve to 88%, 84%, and 82% in first, second, and third hour[21]. Monitoring of RBV was performed by the same investigator during each HD session throughout the study period.

Blood pressure measurements and numbers of intradialytic symptoms

Blood pressure was measured immediately before, during dialysis and at 30 minutes after each dialysis treatment by using a standard automatic blood pressure device with the patient in a sitting position. The numbers of intradialytic hypotension was collected. Intradialytic symptoms were recorded during each HD session by questionnaire. These symptoms included hypotension and/or other morbid symptoms. Patients answered to the questionnaire by rating the severity of symptoms that occurred. There were: no symptoms = 0 and the severity of symptoms 1 = 25%, 2 = 50%, 3 = 75%.

Definition

Dry weight is the lowest weight postdialysis that a patient can tolerate without the development of any signs or symptoms of low blood pressure during dialysis or after dialysis in the absence of volume overload and hypertension[1].

Hypertension is blood pressure that is the same as or higher than 95th percentile for normal values adjusted for age, gender, and height. From Kidney Disease Outcomes Quality Initiative (KDOQI) the target blood pressure in children should be lower than the 90th percentile for normal values adjusted for age, gender, and height or 130/80 mmHg, whichever is lower.

Intradialytic hypotension means the decrease of systolic blood pressure is more than 20 mmHg or the decrease of mean arterial pressure (MAP) is more than 10 mmHg, with symptoms needed treatment during HD such as yawning, cramping, nausea, vomiting, abdominal discomfort, restlessness, and syncope[23].

Silent hypervolemia means volume overload patient who does not have any sign and symptom of fluid excess such as edema or hypertension[6].

Plasma refilling means the shifting of fluid from interstitial space to intravascular space which shows the increasing in RBV more than 0.5% at the end of dialysis when stops ultrafiltration for 10 minutes[14].

Primary and secondary outcomes

1. The difference of dry weight and post dialysis body weight between clinical adjustment and BVM

2. Predialytic blood pressure, intradialytic hypotension, and intradialytic symptom, during period of study of both methods

Statistical analysis

The demographic data are presented as descriptive statistic such as mean, median, standard deviation and interquartile range (IQR). The values analyzed in body weight, dry weight, blood pressure before and after BVM assessing presented with mean and standard deviation. The data of intradialytic hypotension presented as median and IQR. The data between BVM and clinical adjustment were compared.

Results

Ten teenagers (5 male, 5 female) were enrolled in the present study. The average age was 16.55±2.49 years. The primary kidney disease which leaded to end stage renal disease were four cases of lupus nephritis, two cases of immune complex glomerulonephritis, two cases of obstructive uropathy, and two cases of unknown cause. The average duration of dialysis was 2.76±2.25 years. The average predialytic weight was 40.71±7.77 kg and the average height was 148.80±9.54 cm. The average dry weight before study was 38.24±7.46 kg. The average systolic blood pressure, diastolic blood pressure were 126.4±22.63 mmHg, and 73.4±20.82 mmHg respectively. Interdialytic weight gain was 2.47±0.50 kg. The dialysis adequacy (Kt/V) was 2.09±0.34, as shown in Table 1.

The average of dry weight after assessment by clinical adjustment for four weeks was 38.38±7.43 kg. The difference before and after was 0.14±0.46 kg. The

average of dry weight after assessment by BVM for four weeks was 38.12±7.58 kg. The difference before and after was 0.26±0.57 kg. Dry weight adjusted by clinical adjustment trends to increase and dry weight adjusted by BVM trends to decrease as Table 2. Four patients needed to decrease their dry weight (average 0.775 kg) during using BVM because of plasma refill over 0.5% after finishing HD and two patients needed to increase their dry weight due to RBV below keeping area. In the others, dry weights were not changed.

Similar to dry weight result, the average post dialysis weight with dry weight assessment by clinical adjustment for four weeks was 38.54±7.61 kg with increasing 0.29±0.54 kg. The average postdialytic weight with dry weight assessment by BVM for four weeks was 38.23±7.35 kg with decreasing 0.11±0.47 kg. The trend of the graph revealed postdialysis weight result from dry weight assessment by BVM trend to decrease but by trial and error trend to increase as Table 3.

The average systolic blood pressure resulting from dry weight assessment by clinical adjustment for 4 weeks was 126.50±21.91 mmHg with increasing 0.10±17.12 mmHg. The average systolic blood pressure resulting from dry weight assessment by BVM for four weeks was 131.10±21.28 mmHg with increasing 1.90±18.20 mmHg. The average diastolic blood pressure resulting from dry weight assessment by clinical adjustment for four weeks was 73.60±17.05 mmHg with increasing 0.20±17.11 mmHg. The average diastolic blood pressure resulting from dry weight assessment by BVM for four weeks was 79.30±19.01 mmHg with increasing 4.90±11.49 mmHg as Table 4.

Intradialytic hypotension was not identified during this experiment but questionnaires demonstrated intradialytic symptoms. Despite statistically insignificance, intradialytic symptoms in group of dry weight adjusted by clinical adjustment trends to be more than by BVM especially thirst as Table 5.

Table 1. Patient demographics

Demographic data	Mean ± SD
Age (years)	16.55±2.49
Duration of hemodialysis (years)	2.76±2.25
Body weight (kg)	40.71±7.77
Height (cm)	148.80±9.54
Dry weight (kg)	38.24±7.46
Systolic blood pressure (mmHg)	126.40±22.63
Diastolic blood pressure (mmHg)	73.40±20.82
Interdialytic weight gain (kg)	2.47±0.50
Kt/V	2.09±0.34

Table 2. The comparison of dry weight (kg) between clinical adjustment and BVM

Data	Time	Dry weight assessment	
		Clinical adjustment	Blood volume monitoring
Dry weight (kg)	Pre assessment of dry weight	38.24±7.46	38.38±7.43
	Post assessment of dry weight	38.38±7.43	38.12±7.58
	The difference between pre and post assessment of dry weight	0.14±0.46	-0.26±0.57

BVM = blood volume monitoring

Table 3. The comparison of postdialysis weight (kg) between clinical adjustment and BVM adjustment dry weight

Data	Time	Dry weight assessment	
		Clinical adjustment	Blood volume monitoring
Post dialysis weight (kg)	Pre assessment of dry weight	38.25±7.45	38.34±7.35
	Post assessment of dry weight	38.54±7.61	38.23±7.35
	The difference between pre and post assessment of dry weight	0.29±0.54	-0.11±0.47
Interdialytic weight gain (kg)	Pre assessment of dry weight	2.47±0.50	1.67±0.52
	Post assessment of dry weight	1.98±0.61	2.10±0.62
	The difference between pre and post assessment of dry weight	-0.49±0.64	0.43±0.92

Table 4. The comparison of blood pressure between clinical adjustment and BVM adjustment dry weight

Data	Time	Dry weight assessment	
		Clinical adjustment	Blood volume monitoring
Systolic blood pressure (mmHg)	Pre assessment of dry weight	126.40±22.64	129.20±18.77
	Post assessment of dry weight	126.50±21.91	131.10±21.28
	The difference between pre and post assessment of dry weight	0.10±17.12	1.90±18.20
Diastolic blood pressure (mmHg)	Pre assessment of dry weight	73.40±20.82	74.40±17.03
	Post assessment of dry weight	73.60±17.05	79.30±19.01
	The difference between pre and post assessment of dry weight	0.20±17.11	4.90±11.49

Table 5. Abnormal intradialytic symptoms

Symptoms of intradialytic hypotension (median)	Dry weight assessment	
	Clinical adjustment	Blood volume monitoring
Malaise	3.13	1.04
Thirst	2.08	0.00
Numbness	0.00	0.00
Tetany	1.04	0.00
Headache	1.04	0.00
Nausea and vomiting	1.04	0.00
Faint	1.04	0.00
Insomnia	0.00	0.00

Discussion

The present study suggested BVM might be helpful for dry weight assessment in pediatric chronic HD patients. Despite statistical insignificance of the differences dry weight of both method, dry weight adjusted by BVM was decreased especially in patients who had plasma refilling effect. Rodriguez et al[14] had studied in 28 adult HD patients using BVM. The average of dry weight decreased 1.25±2.97 kg (p = 0.03). Especially in whom RBV decreased less than 3% per hour during dialysis and had plasma refilling, average dry weight decreased 5.38±2.18 kg (p = 0.002)[14]. Candan et al[3] had studied nine hypertensive pediatric HD patients using BVM for four weeks. Predialytic and postdialytic weight decreased 0.5, 0.6 kg, significantly after using BVM[3].

Four patients needed to decrease their dry weight (average 0.775 kg) during using BVM because of plasma refilling over 0.5% after finishing HD. Their RBV curve did not show flat line indicating fluid overload. Two patients needed to increase their dry weight 0.25 kg due to RBV below keeping area. Other patients did not have to change their dry weight. According to results of the present study, dry weight might not reduce to the target or actual values in a short period of time. There should be a long period study monitored continuously to determine the actual dry weight of the patient.

There was no difference in pre dialytic blood pressure in our study. It might be explained by "lag phenomenon" (extracellular volume return to normal but blood pressure takes time about a few weeks to months more)[24]. It is found mostly in chronic volume overload patients[25]. Patel et al[26] showed that a BVM-guided UF algorithm resulted in improved blood pressure control in pediatric HD patients after six months. Patients could reduce antihypertensive drug usage. The incidence of intradialytic hypotension decreased significantly (p<0.05), even though there are no different in dry weight and the thickness of left ventricular myocardium[26]. Another study found changing of MAP from 111.3±2.5 to 94.4±1.7 mmHg in patient with actual dry weight needed times more than six months[27]. From time limitation, the present study did not find the statistically different change of blood pressure. Another reason, more than 60% of primary kidney disease resulted in ESRD in our patients was glomerulonephritis, therefore, the cause of hypertension in these patients might not be related to chronic hypervolemia.

Intradialytic hypotension was not identified during this experiment but questionnaires demonstrated abnormal intradialytic symptoms. Despite statistical insignificance, intradialytic symptoms in group of dry weight adjusted by clinical adjustment trended to be more than by BVM especially thirst. The results were consistent with previous research, which showed BVM reduced intradialytic symptoms such as nausea, vomiting, yawning, cramps, discomfort in the

abdomen, restlessness, dizziness, and reduce the rate of admission to hospital[22,23]. The main reason was monitoring RBV with BVM could control ultrafiltration by keeping RBV value not lower than 88%, 84%, and 82% in first, second, and third hour, and not below 82% during HD to avoid these complications[21]. BVM can present a real time monitoring for RBV during HD. Therefore, physician and HD nurse could use RBV data to help adjust ultrafiltration during HD or use automatic ultrafiltration controlled by BVM[13-16].

Moreover, the reason why no significant difference from the present study might be a limitation of BVM itself. Dasselaar et al[12] found the BVM depended on the change of body fluid such as blood transfusion, the posture of patient during measurement, splanchnic vasoconstriction, and the ability of plasma refilling, which was individualized to each person. In the same person, the result varied. The results could not be set to the same standard[12]. Then the use of the RBV curve and plasma filling in indicating volume overload might not be standard in all patients[14]. Thus, assessment of dry weight in HD patients should rely on various information and tools due to no gold standard of dry weight measurement. The limitations of the present study were small sample size and short period of the study. Therefore, dry weight in our study might not have reached nadir point. A follow-up study with longer period of study is required.

Conclusion

The use of BVM guided ultrafiltration tends to decrease dry weight in chronic dialytic patients, and reduces abnormal intradialytic symptoms, especially thirst. Up to the present time, there is no gold standard method to achieve ideal dry weight in children. Therefore, clinical adjustment dry weight with other helping methods such as BVM is very useful to access the accurate dry weight in dialytic pediatric patients.

What is already known on this topic?

There is currently no clear definition of dry weight. There is still no gold standard for dry weight assessment. BVM is beneficial to pediatric HD patient to identify volume overload and to adjust appropriate ultrafiltration. Base on a new dry weight, it gives a better control of blood pressure and reduces intradialytic hypotension.

What this study adds?

Even though there is no statistical difference in dry weight between clinical adjustment and BVM, the incidence of intradialytic hypotensive symptoms tend to decreased in BVM group. BVM can present a real time monitoring for RBV during HD. This findings support BVM using for ultrafiltration adjustment during HD.

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Potential conflicts of interest

None.

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การประเมินน้ำหนักตัวแห้งด้วยวิธี blood volume monitoring ในผู้ป่วยเด็กโรคไตเรื้อรังที่ได้รับการฟอกเลือดอย่างต่อเนื่อง

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วัตถุประสงค์: ภาวะน้ำเกินจากการประเมินน้ำหนักตัวแห้งที่คลาดเคลื่อนเป็นปัจจัยเสี่ยงสำคัญนำไปสู่โรคหัวใจและหลอดเลือดในผู้ป่วยเด็กโรคไตเรื้อรังที่ได้รับการรักษาด้วยการฟอกเลือด การประเมินน้ำหนักตัวแห้ง (dry weight) ในเด็กทำได้ยาก สาเหตุหนึ่งเกิดจากการที่เด็กมีการเจริญเติบโตตามวัย การประเมินน้ำหนักตัวแห้งด้วยวิธี blood volume monitoring (BVM) เป็นวิธีประเมินน้ำหนักตัวแห้งที่แม่นยำวิธีหนึ่งในผู้ใหญ่ แต่ยังมีข้อมูลน้อยในเด็ก ผู้นิพนธ์จึงได้ศึกษาเปรียบเทียบน้ำหนักตัวแห้ง น้ำหนักตัวหลังฟอกเลือด ความดันเลือดก่อนการฟอกเลือด และภาวะแทรกซ้อนระหว่างการฟอกเลือด เช่น ความดันเลือดต่ำ และอาการผิดปกติต่างๆ ระหว่างการประเมินน้ำหนักตัวแห้งด้วยวิธีตรวจร่างกายโดยแพทย์และพยาบาลไตเทียมกับวิธี BVM ในผู้ป่วยเด็กโรคไตเรื้อรังที่ได้รับการฟอกเลือดอย่างต่อเนื่อง

วัสดุและวิธีการ: ผู้นิพนธ์ทำการศึกษาในผู้ป่วยเด็กโรคไตเรื้อรังที่ได้รับการฟอกเลือดอย่างต่อเนื่อง โดยกำหนดน้ำหนักตัวแห้งของผู้ป่วยด้วยวิธีตรวจร่างกายเป็นระยะเวลา 1 เดือน ที่มารับการฟอกเลือด หลังจากนั้นเปลี่ยนมาใช้วิธี BVM กำหนดน้ำหนักตัวแห้งเป็นระยะเวลาอีก 1 เดือน แล้วนำข้อมูลน้ำหนักตัวแห้ง น้ำหนักตัวหลังการฟอกเลือด ความดันเลือดก่อนการฟอกเลือด ภาวะแทรกซ้อนที่เกิดขึ้นระหว่างฟอกเลือดของทั้ง 2 วิธี มาเปรียบเทียบกัน

ผลการศึกษา: มีผู้เข้าร่วมการศึกษาทั้งหมด 10 คน แบ่งเป็นชาย 5 คน หญิง 5 คน อายุโดยเฉลี่ย 16.55±2.49 ปี หลังการประเมินน้ำหนักตัวแห้งด้วยวิธีตรวจร่างกายเปรียบเทียบกับวิธี BVM ไม่พบความแตกต่างของน้ำหนักตัวแห้งทั้ง 2 วิธี (38.38±7.43 และ 38.12±7.58 กิโลกรัม) รวมถึงน้ำหนักตัวหลังฟอกเลือด (38.54±7.61 และ 38.23±7.35 กิโลกรัม) และความดันเลือดก่อนฟอกเลือด แต่น้ำหนักตัวแห้งจากวิธีตรวจร่างกายจะเพิ่มขึ้นเมื่อครบระยะเวลา 1 เดือน ในขณะที่น้ำหนักตัวแห้งจากการวัดด้วยวิธี BVM มีค่าลดลง (0.14±0.46 และ -0.26±0.57 กิโลกรัม) ในการศึกษานี้ไม่พบความดันเลือดต่ำระหว่างฟอกเลือด แต่พบอาการกระหายน้ำหลังฟอกเลือดเสร็จจากการกำหนดน้ำหนักตัวแห้งด้วยวิธีตรวจร่างกายมากกว่าวิธี BVM

สรุป: การประเมินน้ำหนักตัวแห้งด้วยวิธี BVM จะได้น้ำหนักตัวแห้งที่น้อยกว่าวิธีตรวจร่างกาย ซึ่งจะช่วยเพิ่มการกำจัดน้ำออกจากร่างกายขณะฟอกเลือดได้มากขึ้น แม้ว่าการศึกษานี้จะยังไม่เห็นความแตกต่างของความดันเลือดก่อนฟอกเลือดของทั้ง 2 วิธี อาจเนื่องจากเป็นการศึกษาระยะสั้น แต่พบว่าการกำหนดน้ำหนักตัวแห้งด้วยวิธี BVM ช่วยลดอาการผิดปกติระหว่างที่รับการฟอกเลือดได้ โดยเฉพาะอาการกระหายน้ำ อย่างไรก็ดี ณ ปัจจุบันยังไม่มีวิธีมาตรฐานในการประเมินน้ำหนักตัวแห้ง จึงควรพิจารณาใช้วิธี BVM ควบคู่ไปกับการการตรวจร่างกายในการกำหนดน้ำหนักตัวแห้งของผู้ป่วย