# Radioisotope Blood Volume Measurement in Hemodialysis Patients

Jun-Ki Park,MD; Sonika Puri,MD; Aditya Mattoo,MD; Frank Modersitzki,MPH; David S Goldfarb,MD,FASN

NYU School of Medicine & NY Harbor VA Healthcare System, New York

## OBJECTIVE

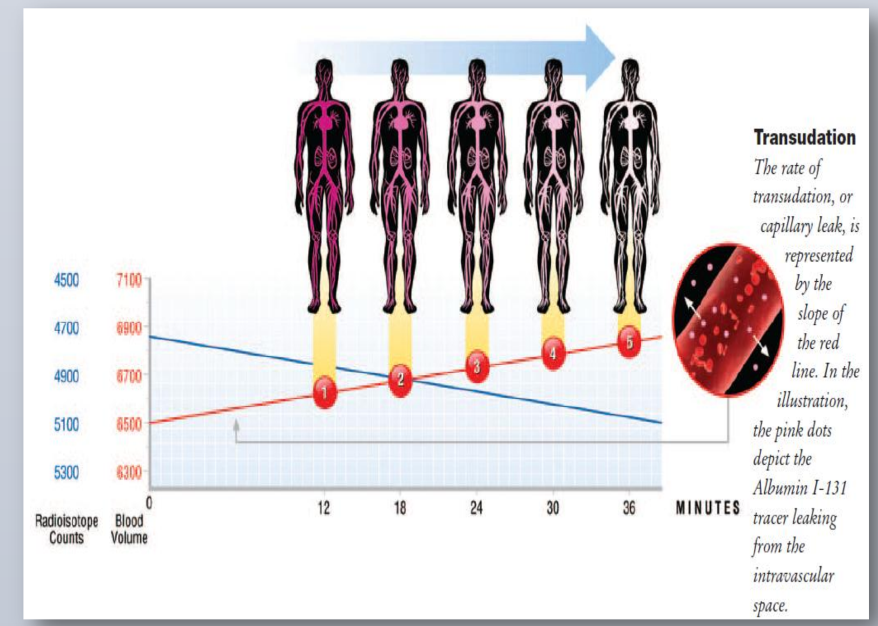
- To measure absolute blood volume (BV) changes during hemodialysis (HD) using injection of I-131 radio-labeled albumin.
- To compare direct measurement of BV using injection of I-131 radio-labeled albumin and indirect measurement of BV using changes in hematocrit (Hct) with Crit-Line Monitor (Hemametrics, CLM III).

## BACKGROUND

- HD removes excess intravascular and interstitial (IS), extravascular (EV) volume that accumulate during end stage renal disease (ESRD).
- Excess volume removal during HD is more likely to result in hypotension whereas ultrafiltration below target dry weight results in a state of chronic volume overload, which may lead to hypertension and congestive heart failure.
- Current practice of dry weigh assessment is based on a subjective, clinical assessment of volume status which can be erroneous in up to 50% cases.
- Indirect measures of volume assessment such as bioimpedance measurement, inferior vena caval diameter or Crit-Line Monitor have not been proven to be accurate measures of blood volume.
- Direct measurement of BV may lead to a more objective measurement of the true volume status in HD patients which can help guide changes to dry weight.
- Attempting to determine and achieve dry weight could contribute to the high rate of mortality in the first year after initiating hemodialysis.

## PRINCIPLE OF BV MEASUREMENT BY INDICATOR DILUTION METHOD

- Known amount of tracer (I-131, <25µCi) is administered.
- Time is allowed for complete mixing.
- Blood samples are drawn at serial intervals.
- Serial samples allow estimation of transudation from the intravascular space into the interstitial space.
- BV is then determined by the Blood Volume Analyzer (BVA-100, Daxor Corp, New York, NY)




$$PV = \frac{1000 \times (\text{Standard Count} - \text{Baseline Count})}{(\text{Sample Count} - \text{Baseline Count})}$$

$$BV = \frac{PV}{1-(Hct*f0.91*0.99)}$$

PV: Plasma Volume

f : F cell ratio $\frac{\text{Peripheral Hct}}{\text{Whole body Hct}}$

## METHODS

- 10 adult chronic HD patients were enrolled in this prospective IRB-approved observational study.
- BV was performed before and after HD using BVA-100. BVA-100 calculates BV with an accuracy of ±2.5%, by using radio-labeled albumin.
- It assumes normal BV for a given individual on the basis of patient's deviation from ideal body weight.
- Intradialytic relative BV changes were measured by CLM-III during the same HD session. Bland-Altman plot was used to compare relative BV change pre- and post-HD by BVA and CLM-III.

## RESULTS

**TABLE 1. DEMOGRAPHICS: N = 10; MEAN AGE 69 ± 9.9yrs**

| Male (%) | Hypertension (%) | Diabetes (%) | Coronary artery disease (%) |
|---|---|---|---|
| 100 | 100 | 50 | 50 |

**TABLE 2. BVA-100 SAMPLE DATA (N = 2 examples)**

| | | BV PREDICTED IDEAL (mL) | BV MEASURED (mL) | BV DIFFERENCE BETWEEN MEASURED AND IDEAL BV (mL) | CHANGE FROM IDEAL BV (%) |
|---|---|---|---|---|---|
| Case 1 | PRE-HD | 5610 | 8052 | 2442 | + 43.5 |
| | POST-HD | | 7703 | 2093 | + 37.3 |
| | | UF: 3800ml | BV loss: 349ml | IS loss: 3451mL | IS/UF loss: 91% |
| Case 2 | PRE-HD | 4901 | 6940 | 2039 | + 41.6 |
| | POST-HD | | 5655 | 754 | + 15.4 |
| | | UF: 2800ml | BV loss: 1285ml | IS loss: 1515ml | IS/UF loss: 54% |

UF = weight change; IS loss = UF – BV loss

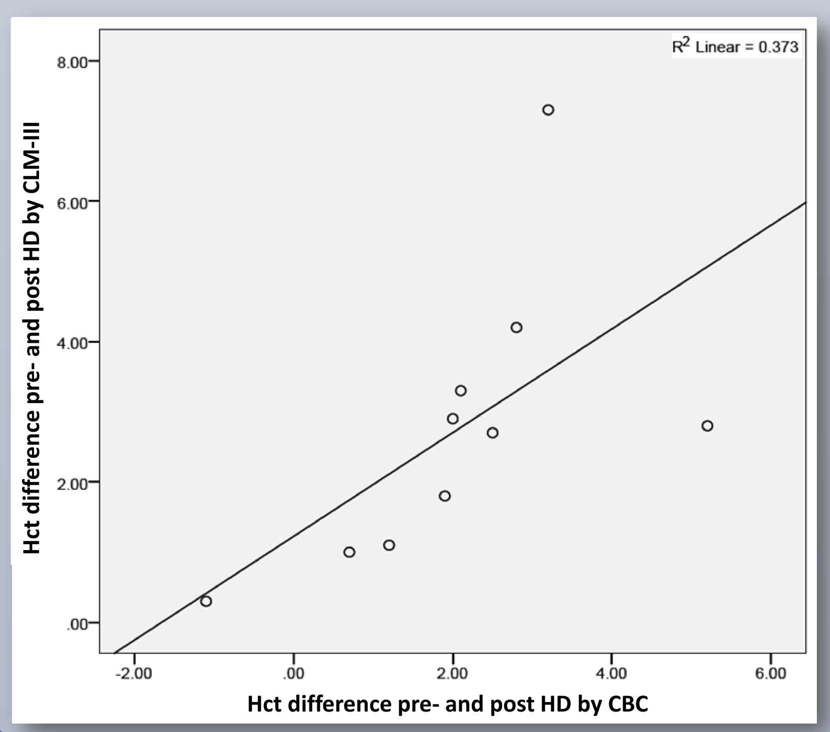
**Interpretation, Case 1:** Most of the UF occurred from the IS component of the extracellular space, indicating a high degree of refilling.

**Interpretation, Case 2:** A little more than half the UF came from the IS space indicating a lower degree of refilling.

- 8 of 10 cases had significant hypervolemia, 2 cases were normovolemic.
- The range of PRE-HD BV variation from predicted ideal was 156ml-2442ml.
- Significant inter-individual differences in IS fluid loss ranged from 54% to 99% of total weight loss.

**TABLE 3. MEAN HEMATOCRIT: Peripheral Blood vs. CLMIII (± SD), N=10**

| Pre–HD Peripheral | Post-HD Peripheral | Pre-HD CLM-III | Post-HD CLM-III |
|---|---|---|---|
| 31.6 (3.6) | 34.0 (4.5) | 29.9 (3.2) | 32.0 (4.2) |



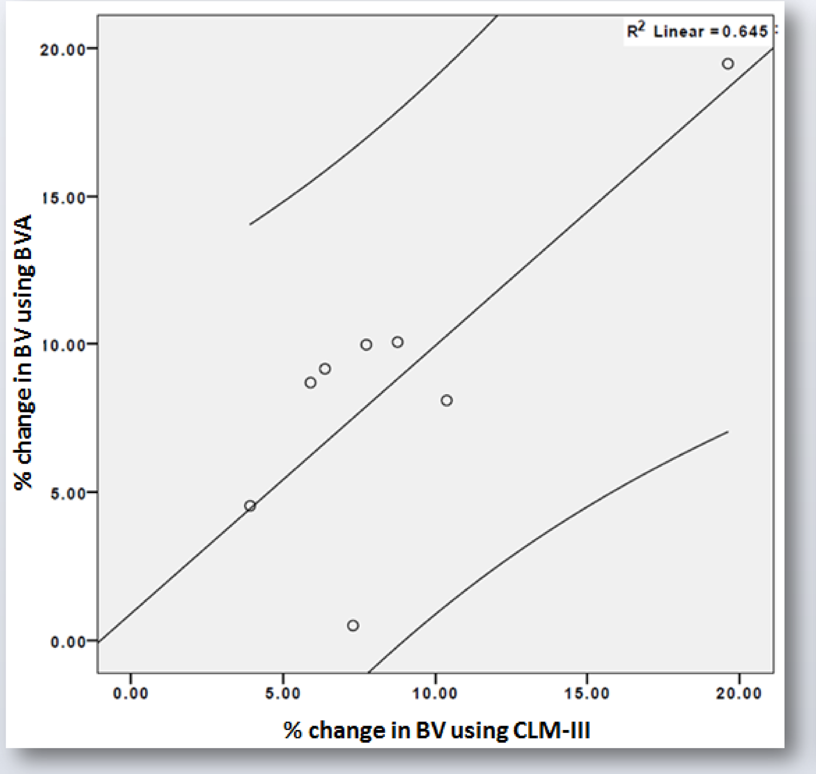

**Graph 1:**

Spearman Rho correlation graph

- X axis represents the difference between pre- and post-HD Hct obtained from peripheral blood
- Y axis represents the difference between pre- and post-HD Hct and measured by CLM-III, for each patient (°).
- Correlation is significant at level of P < 0.01

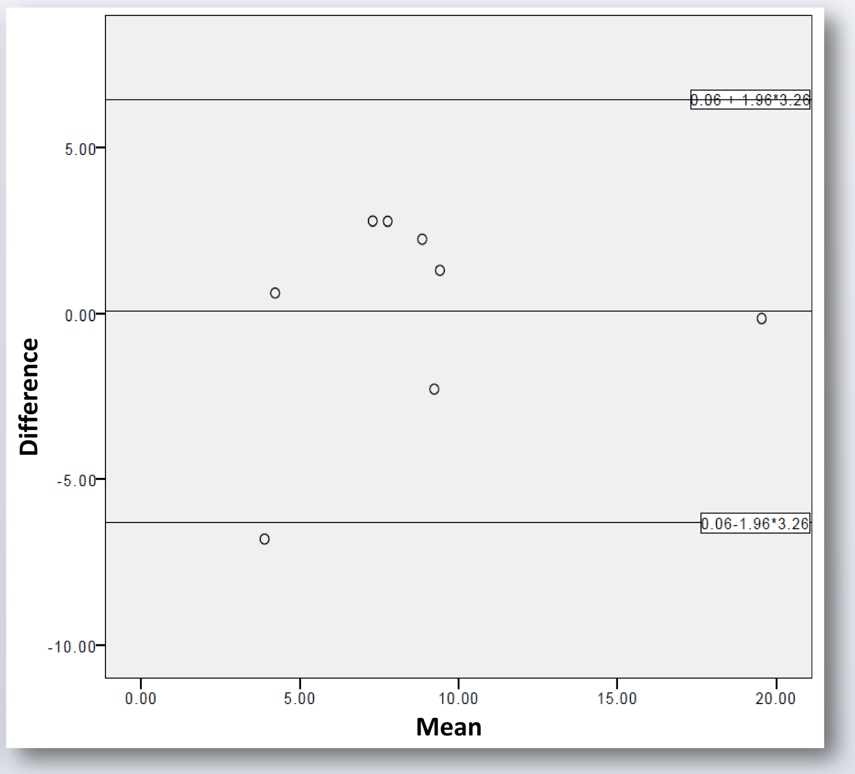
## RESULTS

**Graph 2:** Spearman Correlation graph




Strong correlation Is seen between the relative blood volume change obtained using BVA and CLM-III, N= 8 ( 2 outliers excluded). Peripheral lines are 2 SD.

**Graph 3:** Bland Altman Plot




Difference = % change in BV by BVA - % change in BV by CLM-III

Mean = $\frac{\text{\% change in BV by BVA + \% change in BV by CLM-III}}{2}$

When the 2 outliers are taken out, the plot shows that the measurements of relative BV by BVA and CLM-III have a good agreement with small bias (mean difference of 0.06) and 7 out of 8 measurements within 2 SDs.

## SUMMARY

- Pre- and Post-HD BV analysis using BVA in 10 HD patients showed that 8 of 10 patients had significant hypervolemia at the beginning of HD, while 5 of 10 continued to remain hypervolemic at the end of HD.
- BV measurements using BVA correlated well with CLM-III measurements.

## CONCLUSIONS

- BVA is useful to determine absolute BV and changes in BV.
- Although CLM-III results correlated well, the device did not yield absolute values and did not indicate the degree of hypervolemia present.
- Fluid removal from EV and IS spaces can be calculated based on absolute BV changes to describe individual refilling ability.
- The BVA technique, providing absolute values for, and variation from, ideal volumes may prove useful in prescribing and monitoring UF rates and establishment of optimal BV and dry weight in HD patients.
- More accurate prescription of UF and dry weight has the potential to reduce the morbidity and mortality associated with chronic HD.

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