

# Peripheral Blood Hematocrit Is a Poor Surrogate for Red Blood Cell Volume in Patients with Volume Excess or Depletion

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## BACKGROUND

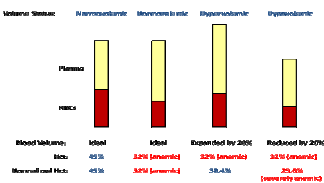
- > Anemia ( Hg <11) is associated with poor prognosis in acutely and chronically ill patients – particularly in those with volume excess or depletion. Conversely Hg above 13 portends greater morbidity and mortality. (Choi and Crete studies)
- > While peripheral hematocrit (pHct) may provide a good estimate of red blood cell volume (RBCV) in euvoletic patients, discordance between pHct and RBCV has been reported in critical care, hematology and congestive heart failure (CHF) settings.
- > Dialysis often produces large variations in pHct; 4 hours of ultrafiltration may increase pHct by >5% points.
- > We considered whether volume status may be important in assessments of RBCV in clinical situations in which achievement of adequate perfusion and tissue oxygenation dictate management.
- > To examine whether pHct is a suitable proxy for RBCV, we performed a retrospective analysis on a large population of patients with a wide variety of medical conditions.

## DEFINITIONS

- >  $TBV = PV + RBCV$  (where PV= plasma volume)
- >  $pHct (\% \text{ packed red cell volume}) = [RBCV / (RBCV + PV)] \times 100$
- >  $\text{Normalized Hct (nHct)} = pHct (TBV / \text{Ideal TBV})$
- > Blood Volume Analysis (BVA): FDA approved, radioisotopic method of determining PV, RBCV and TBV. Observed results are compared with ideal volumes which are predicted based on patient gender, height, and weight.

## CENTRAL QUESTION

Figure 1. Is pHct a good surrogate for RBCV?



## OBJECTIVE

To examine whether the peripheral blood Hct is a suitable proxy for RBCV in patients with a variety of volume states.

## METHODS

- > **Design:** Blood volume analyses (BVA) of inpatients and outpatients at two large tertiary care hospitals were retrospectively reviewed.
- > **Inclusion criteria:** 940 consecutive patients with a wide variety of illnesses were referred to nuclear medicine for radioisotopic blood volume analysis. Patient characteristics are described in Table 1.
- > **Exclusion criteria:** Pregnant or nursing; allergic to iodine
- > **Blood Volume Analysis:** Peripheral Hct was assessed from baseline blood sample. BVAs were performed using the BVA-100 (Daxor Corporation, New York, NY). 1 mL of <sup>131</sup>I-labeled albumin (<25 uCi) was injected IV. 5mL blood samples, collected at 12, 18, 24, 30, and 36 min post-injection, were assayed for radioactivity in duplicate and the results plotted (minimum three sample points, standard deviation SD <2.9%). Plasma volume (PV) was derived by extrapolating to time zero. BVA presents RBCV, PV, TBV and nHct as absolute values and as deviation (mL and %) from ideals, based on patient gender, height and weight.
- > **Interpretation of Results:** Blood volume status is classified based on the severity of blood volume derangements as follows:
  - Hypovolemic: Measured BV shows >8% deficit relative to ideal BV
  - Normovolemic: Measured BV shows ≤8% deviation relative to ideal BV
  - Hypervolemic: Measured BV shows >8% excess relative to ideal BV
- > **Data Analysis:** Regression analysis was used in correlation studies. Bland-Altman analysis examined the mean difference between normalized and peripheral Hct methods.

## SUBJECTS

Table 1: Patient Characteristics (n=940)		Table 2: Volume Status of Patients (n=940)	
Gender	459 F, 481 M	Hypovolemic (TBV>8% Below Ideal TBV)	208 (22.1%)
Mean Age, years (range)	65.2 (17-95)	Normovolemic (TBV=Ideal TBV +/- 8%)	372 (39.6%)
Mean BMI kg/m <sup>2</sup> (range)	30.6 (14.3-80.3)	Hypervolemic (TBVs>8% Above Ideal TBV)	360 (38.3%)

## RESULTS

Table 3: Sample Patient Data						
Patient #	Age (yr) / Gender	Volume Status (BVA)	pHct	nHct	% Dev from ITBV	% Dev from IRBCV
1	80/M	Hypovolemic	31.5	46.1	46.3	2.5
2	86/F	Hypervolemic	32.9	42.0	27.7	5.0
3	77/F	Normovolemic	33.3	33.8	1.7	-15.5
4	82/M	Hypovolemic	31.8	25.3	-20.5	-43.9
5	77/F	Hypovolemic	32.0	22.5	-29.5	-43.7

ITBV: Ideal Total Blood Volume (Normal ±8%); IRBCV: Ideal Red Blood Cell Volume (Normal ±10%); IPV: Ideal Plasma Volume (Normal ±8%)

## RESULTS

Fig. 2. Normalized Hct – Available Only from Blood Volume Analysis – Correlates Better with True RBCV than does Peripheral Hct

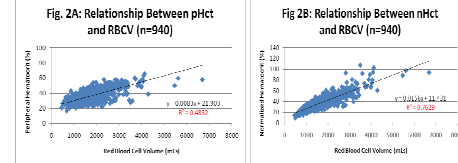


Fig. 4. Peripheral Hct Both Underestimates (Fig. 4A) and Overestimates (Fig. 4B) True Anemia

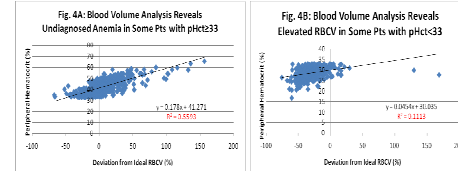


Fig. 5. Normalized Hct is a Better Proxy than pHct for Reductions in RBCV

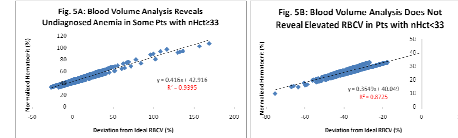


Fig. 3. Bland-Altman Analysis Examines Difference Between Peripheral and Normalized Hct Methods as a Function of Volume Status

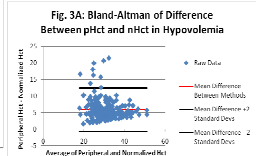


Fig. 3B: Bland-Altman of Difference Between pHct and nHct in Normovolemia

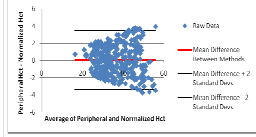
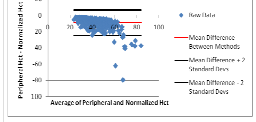


Fig. 3C: Bland-Altman of Difference Between pHct and nHct in Hypervolemia



## CONCLUSIONS

- > Evaluation of anemia is inextricably linked to volume status
- > Peripheral blood Hct (pHct) provides a good estimate of RBCV in normovolemic patients, but not in hypo- or hypervolemic patients.
  - pHct underestimates RBCV in states of fluid excess (dilutional anemia) and overestimates RBCV when PV is low (hemococoncentration).
- > The normalized Hct (nHct) provided by blood volume analysis offers dramatically improved correlation with true RBCV in hyper- and hypovolemic patients because it corrects for abnormal volume status.
- > Blood volume analysis may greatly improve anemia and volume management in a wide variety of patient types.

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