"Normalized Hematocrit" from Blood Volume Analysis Offers Enhanced Accuracy over Peripheral Hematocrit in Assessment of Red Blood Cell Volume

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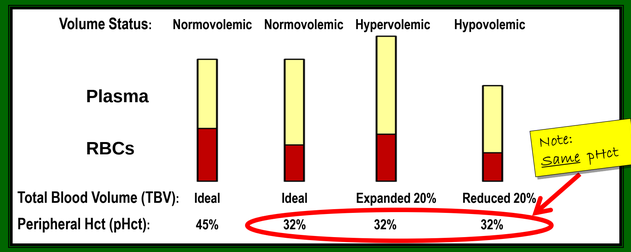
BACKGROUND / OBJECTIVES

➢Assessment of red blood cell volume (RBCV) is fundamental in clinical medicine, and is particularly important in the evaluation of anemia.

➢Peripheral hematocrit (pHct) (% packed red cell volume) is commonly used as an indicator of RBCV. pHct is a good indicator of RBCV in normovolemic patients, but pHct may be unreliable when volume status is abnormal and pHct is confounded by dilutional anemia or hemoconcentration (Fig. 1). Abnormal volume status is common in critical illness, kidney disease, and heart failure.

Fig. 1 The problem with peripheral hematocrit (pHct)



➢Blood Volume Analysis (BVA) is an FDA-approved, radiotracer indicator dilution method of determining RBCV, Plasma Volume (PV), and Total Blood Volume (TBV). Patient BVA results are automatically compared with ideal values calculated based on patient gender, height, and weight and categorized based on the severity of abnormality.

➢In addition to standard blood volume parameters, modern BVA provides "normalized hematocrit " (nHct), a calculated hematocrit value which is corrected for volume status derangement.

➢We retrospectively reviewed a large number of BVA studies to assess:

- ➢Prevalence of abnormal volume status in the inpatient population
- ➢Relation between pHct and nHct
- ➢How well pHct and nHct reflect RBCV status

DEFINITIONS

➢ Total Blood Volume (TBV) = PV + RBCV (where PV = plasma volume)

➢ Peripheral Hct (pHct) = (% packed red cell volume) = [RBCV/(RBCV + PV)] x 100

➢Normalized Hct (nHct) = pHct (TBV/Ideal TBV)

METHODS

➢Study Design: Retrospective review of inpatient BVA studies at a large tertiary care hospital.

➢Peripheral Hematocrit (pHct) was assessed by Coulter counter in the hospital clinical lab. pHct used was the mean of multiple (2-3) samples obtained at the time of BVA.

➢Blood Volume Analysis: BVAs were performed using the BVA-100 (Daxor Corporation, New York, NY). 1 mL of ^{131}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 (semi-log, minimum 3 sample points, standard deviation SD <3.9%). Plasma volume (PV) was determined by extrapolating to time zero. RBCV and TBV were calculated using patient pHct. BVA provides RBCV, PV, and TBV as absolute values and as deviation (mL and %) from ideal values and also provides nHct. Patient volume status was classified as follows:

-Hypovolemic: Measured TBV is >8% below ideal TBV
-Normovolemic (Euvolemic): Measured TBV is within 8% of ideal TBV
-Hypervolemic: Measured TBV is >8% above ideal TBV

➢Data Reviewed: 627 consecutive inpatients with a wide variety of illnesses were referred for initial BVA studies between 12/1/04 and 4/30/08. These studies were retrieved from the BVA-100 database for analysis.

➢Data Analysis: Bland-Altman analysis was used to examine the relationship between pHct and nHct. Regression analysis was used to examine the correlation between pHct, nHct and true red cell volume status.

RESULTS

Table 1 Patient Characteristics

Total # of patients	627
Gender	322 F, 305 M
Mean Age, years (range)	69.6 (17-95)

Fig. 2 Patient Volume Status

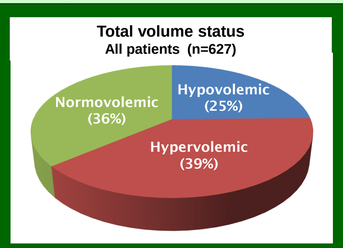


Fig. 2 Abnormal volume status is common in inpatients. Of 627 patients, only 237 (36%) had normal blood volume. Of the remainder, 245 (39%) were hypervolemic and 155 (25%) were hypovolemic.

Fig. 3 Concordance of pHct & nHct

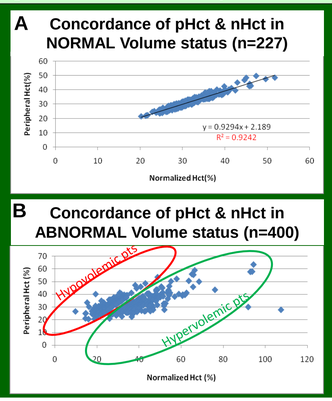


Fig. 3 Concordance of pHct and nHct depends on volume status. The measures agree only when volume status is normal (Fig. 3A). In hypervolemia, pHct is decreased relative to nHct (hemodilution); in hypovolemia pHct is increased (hemoconcentration) compared to nHct (Fig. 3B).

RESULTS (cont'd)

Fig. 4 Bland-Altman analysis of pHct & nHct

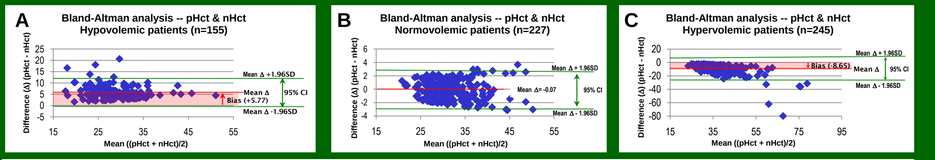


Fig. 4. Bland-Altman analysis examines the difference between pHct and nHct methods as a function of volume status in our patient population. Compared with nHct, pHct shows no bias in normovolemic patients (Fig. 4B), an average positive bias of 5.8 percentage points in hypovolemic patients (Fig. 4A), and an average negative bias of 8.6 percentage points in hypervolemic patients (Fig. 4C). The 95% Limits of Agreement between the nHct and pHct methods are (-2.96 to +2.81) in normovolemic patients, (-0.15 to +11.6) in hypovolemic patients, and (-24.6 to +7.3) in hypervolemic patients.

Fig. 5 pHct and nHct as indicators of red blood cell volume status

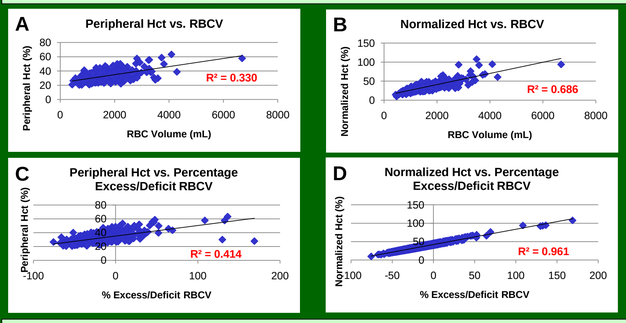


Fig. 5A-B Correlation with RBC Volume--Normalized Hct from BVA correlates better with actual RBCV (Fig. 5B; R^2= 0.686) than does peripheral Hct (Fig. 5A; R^2 = 0.330)

Fig. 5C-D Correlation with % Deviation from Ideal RBC Volume--Normalized Hct from BVA also correlates much better with % deviation from ideal RBCV (Fig. 5D; R^2 = 0.961) than does peripheral Hct (Fig. 5C; R^2 = 0.414)

CONCLUSIONS

➢Abnormal volume status (hypervolemia or hypovolemia) is very common in the inpatient population.

➢Peripheral Hct (pHct) may not be a reliable indicator of RBCV in hypovolemic or hypervolemic patients.

- **pHct underestimates RBCV in states of fluid excess (dilutional anemia) and overestimates RBCV when PV is low (hemoconcentration).**

➢Reliable assessment of RBCV status requires knowledge of volume status; blood volume analysis provides this information.

➢Normalized Hct (nHct) from blood volume analysis offers improved assessment of true RBCV in hyper- and hypovolemic patients because it corrects for abnormal volume status.

➢Blood volume analysis may greatly improve anemia assessment and volume management in many patients.

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