Does Hematocrit Reflect Red Cell Volume when Adjusted for Plasma Volume

Kurt Edwards, MD; Mihae Yu, MD; Fedro Lurie, MD; Danny Takanishi, MD; Andrew Tan, MD; Hao Chih Ho MD, Susan Apte, MD, Wega Koss MD
From University of Hawaii, Department of Surgery and Critical Care and the Queen's Medical Center

Introduction

Hematocrit (Hct), a term coined in 1903, is defined as the proportion of volume of a blood sample that is red blood cells(1)*Dorlands medical dictionary*. It is this inferred red blood cell volume from the Hct which clinicians utilize. We propose that in critically ill patients the hematocrit may not agree with red cell volume as determined by radionucleotide studies.

Methods

We performed a retrospective review comparing red cell volume to Hct values in critically ill surgical patients. These studies were performed within a university affiliated, single institution, surgical intensive care unit.

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Methods

The indication for performing the blood volume study was the treating physician's uncertainty of the patient's intravascular volume status. The Hct was obtained on a hematology analyzer (Coulter LH750, Beckman Coulter, Inc, Fullerton, CA, USA). Plasma volume (PV) was measured using radioisotope iodine-131 labeled albumin injected over 1 minute with serial blood draws over 12, 18, 24, 30 and 36 minutes extrapolated to time zero (BVA-100,Daxor,N.Y.). Simultaneous Hct value (Red cell vol./plasma volume) allowed calculation of Blood Volume (BV = PV + Red cell volume).

BV Values are expressed in mL as well as % deviation from ideal volumes. The predicted normal BV was determined from patient's height, weight and deviation from ideal body weight as described by Feldshuh and Enson. The range of normal values and degrees of deviation are presented below.

	Whole blood volume	Red Cell volume	Plasma Volume
Normal	+/- 8%	+/-10%	+/-8%
Mild deviation	9-16%	11-20%	9-16%
Moderated deviation	25-32%	31-40%	17-24%
sever	>32%	>41%	>32%

Methods

A "normalized" hematocrit or adjusted hematocrit is defined as the ratio of the patient's measured red cell volume (as determined by a radionucleotide study) to the predicted normal whole blood volume. Unlike the Hct, this measurement provides an accurate indication of the degree of red cell deviation without being distorted by variations in plasma volume.

Bland and Altman analysis compared bias and precision (error) between Hct and "normalized" hematocrit.

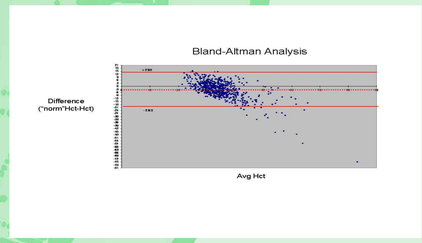
Results

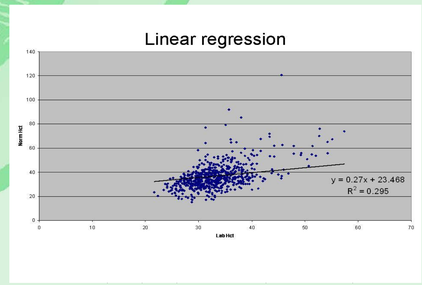
370 patients contributed 689 blood volume measurements. Demographics are presented below:
Age 67 13 years
Sex: 36% female, 64% male
Weight 78 25 kg
Height 167 11 cm
Severe sepsis/ septic shock -133 (36%)
Trauma-118 (31.2%)
Congestive heart failure -39(10%)
Acute renal failure -51(14%)

Results

Bland and Altman analysis showed a bias of -3.16 with limits of agreement of 14.17 to -20.15 between Hct and "normalized" hematocrit. A linear regression analysis demonstrated an R2 of 0.295.

In 28(5%) of the instances, there was greater than 40% deficit in red cell volume despite a Hct of 30% or greater. In 12 (1.7%) instances, there was a red cell volume deficit of less than 10% with a Hct of <30%





Discussion

It is the current practice to utilize Hct to guide red cell transfusion. Since Hct is the ratio of red cell volume to plasma volume, Hct may be misleading and not reflect red cell volume. This study shows poor agreement between Hct and "normalized" hematocrit, the latter being a better indicator of the degree of red cell deviation without being distorted by variations in plasma volume.

5% of the measurements had a severe red cell deficit (>40%) which was masked by a laboratory Hct of ≥30%. These patients may have poor oxygen delivery to the tissues from anemia as described by Valeri et al as the "missing blood syndrome".

Conclusions

There is very little agreement between the hematocrit and the "normalized" hematocrit. Measurement of Blood volume may provide a more specific guide to red cell transfusion although future studies are needed to confirm the clinical benefit of utilizing a "normalized" hematocrit.

Feldschuh J, Enson Y: Circulation 1977;56:605
Vlaeri CR et al, Transfusion 2006;46:365