MYTH OR REALITY: HEMATOCRIT AND HEMOGLOBIN DIFFER IN TRAUMA

Johanna M.M. Nijboer
Iwan C.C. van der Horst
Herman G.D. Hendriks
Hendrik-Jan ten Duis
Maarten W.N. Nijsten

ABSTRACT

Background
Estimating blood loss in trauma patients usually involves the determination of hematocrit (Ht) or hemoglobin (Hb). However, in trauma patients, a poorly substantiated habit exists to determine both Ht and Hb in assessing acute blood loss. This suggests that Ht and Hb provide different information. Moreover, a survey of the literature showed a significant association of the subject trauma with the use of Ht. We investigated whether Ht and Hb differ in trauma patients.

Methods
Trauma patients with an Injury Severity Score >15 admitted from 1996 to 2004 to the University Medical Center Groningen were analyzed. All blood samples obtained during the first 7 days post-injury in which both Ht and Hb were determined were studied. Ht and Hb were measured with a Coulter Counter. The relation between Ht and Hb was analyzed with linear regression. The potential effect of hemolysis was studied by analyzing lactate dehydrogenase levels.

Results
In 671 patients 2,461 paired Ht levels and Hb levels were obtained. The mean Ht was 30.9 ± 6.9% (interquartile range 25.8 – 35.8%). The mean concentration of Hb was 10.4 ± 2.3 g/dL (interquartile range 8.7 – 12.1 g/dL). Ht and Hb had a Pearson's R^2 of 0.99 and the following relations applied: Ht (%) = 2.953 x Hb (g/dL) or Hb (g/dL) = 0.334 x Ht (%). Lactate dehydrogenase was not related with Ht and Hb, indicating hemolysis was not relevant.

Conclusions
In a large series of trauma patients, Ht and Hb behaved as identical parameters. The idea that Ht is different from or even superior to Hb is a misconception. There is no reason for determining both Ht and Hb in trauma patients.

INTRODUCTION

Estimates of blood loss are often based on hematocrit (Ht) or hemoglobin (Hb) measurements. There is a longstanding custom to measure Ht and Hb together to determine blood loss in trauma patients, implying that they provide dissimilar information. However, Addison already published four decades ago that determination of both Ht and Hb is not necessary in most clinical situations[1]. Additionally, many physicians think Ht is more sensitive than Hb in detecting acute blood loss. This difference between Ht and Hb is alluded to by investigators who determined both values in studies on blood loss[2]. Exploration of PubMed-referenced articles for the keywords and text words "hematocrit", "hemoglobin", and "trauma" showed that in studies related to trauma there is a preference to use Ht in comparison with those not related to trauma (use of Ht 47% vs. 27%). In our hospital also, it is a common practice to request the measurement of both Ht and Hb in trauma patients. In this study, we tested the hypothesis that in trauma patients the determination of both Ht and Hb provides no additional information over the determination of only Ht or Hb.

PATIENTS AND METHODS

Trauma patients with an Injury Severity Score > 15 referred to the University Medical Center Groningen, a Level I trauma center, from 1996 to 2004, were studied retrospectively. Burn patients were not treated in our center. No age restrictions were set. Hemorrhagic shock was defined as systolic blood pressure < 90 mm Hg, heart rate > 110 beats per minute, and Hb level < 8 g/dL. All Ht and Hb values that were obtained simultaneously during the first 7 days post-injury, i.e., from the same blood sample, were included in the analysis. The drawn blood was anticoagulated with disodiumethylenediamine tetra-acetic acid and tested with a Coulter Counter (Beckman-Coulter, Fullerton, CA). This apparatus determined the Hb concentration by measuring the absorption spectrum of lysed blood. To determine (nonspun) Ht, the number of red blood cells was counted and multiplied by the mean corpuscular volume that was measured by the impedance method[3]. Lactate dehydrogenase (LDH; reference range 114 – 235 U/L) levels were also recorded when it was determined simultaneously with Ht and Hb.

Statistical Analysis
Data were expressed as means ± SD, or in case of strongly skewed distributions, as medians and interquartile ranges (IQRs). The paired determinations of Ht and Hb were analyzed with a scatter plot and by linear regression analysis with the least squares method, assuming a constant of 0. Pearson's R^2 was used as a measure of correlation between Ht and Hb. The potential relation of LDH with Ht and Hb was explored with

multivariate linear regression. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL) version 12.0.1 for Windows.

RESULTS

In 671 of the 730 trauma patients (92%), paired Ht levels and Hb levels had been determined. Seventy-two percent of these patients were male, with a mean age of 40 ± 22 years. One hundred and seven patients (16%) were < 18 years of age, with a median age of 13 years (IQR 7 – 16 years). No women were known to be pregnant. The vast majority (94%) suffered from a blunt injury, and 59% of the injuries were sustained in a traffic crash. The majority (73%) of patients suffered from a severe head and neck injury (Abbreviated Injury Scale Score ≥ 3). Thirty-seven patients (6%) suffered from hemorrhagic shock. The mean Injury Severity Score was 26 ± 10 with a 30-day mortality of 24%.

During the first 7 days post-injury, 2,461 paired Ht and Hb values were determined. For 1,481 of these paired values, LDH was also measured in the same sample. Mean Ht was 30.8 ± 6.9% (IQR 25.8 – 35.8%). Mean Hb was 10.4 ± 2.3 g/dL (IQR 8.7 – 12.1 g/dL). Ht and Hb had a Pearson's R^2 of 0.99 (Figure 1). The regression coefficient was 2.953. Therefore, the following equations apply: Ht (%) = 2.953 x Hb (g/dL) or Hb (g/dL) = 0.334 x Ht (%).

Two hundred and thirty-one patients (33%) received one or more units of red blood cell (RBC) transfusion during the first 7 days post-injury. We administered 1,363 units of RBCs, with a mean of 6 units per transfused patient. In these patients, Ht and Hb displayed the same relation as in nontransfused patients. A large fraction of LDH values were above the upper reference range, with a mean level of 503 ± 419 U/L (IQR 281 – 575 U/L). However, LDH showed no relation with Ht and Hb in linear regression analysis (coefficient of $1.7x10^{-5}$, p = 0.123) suggesting that hemolysis did not lead to a disparity in Ht and Hb was not a relevant factor in our series.

DISCUSSION

This study showed that Ht and Hb behaved as identical parameters in trauma patients. Figure 1 demonstrates that Ht and Hb correlate in all ranges, demonstrating that the idea that Ht is different from Hb is a misconception. This observation was seen in all subgroups of patients. With one-sixth of the population being younger than 18 years of age, and 18% being older than 65 years age, we think that the results are applicable for patients of all ages. The set of Ht–Hb values we analyzed represented a mix of transfused patients (with values obtained pretransfusion, during transfusion, and post-transfusion)

and nontransfused patients. Previous publications show, per unit of transfused RBC, an increase of 1 to 1.5 g/dL of Hb and 3% of Ht[4]. The equilibration of Hb concentration takes approximately 15 minutes in normovolemic patients[5]. Apparently, in this study, RBC transfusions did not alter the nearly total correlation between Ht and Hb.

The equivalence of Ht and Hb is not surprising, since both parameters, albeit indirectly, represent the Hb concentration in blood. Virtually, all Hb in blood is contained within erythrocytes, and so the plasma Hb concentration is close to zero. Therefore, whether the amount of Hb per liter of blood is determined or the blood's volume occupied by the Hb filled erythrocytes is determined, similar information is gained. Rare exceptions are macrocytic and polycytemic anemia in which the Ht is defined by erythrocytes not containing a normal mean corpuscular Hb concentration[3]. In our study population, the patients apparently had very similar mean corpuscular Hb concentrations (Figure 1). Another exception that may theoretically cause a disparity between Ht and Hb is hemolysis, because the determination of Hb includes free plasma Hb in contrast to the determination of Ht. In this large series, the LDH was increased in more than 75% of the samples, but no relation was found between LDH and Ht and Hb, suggesting hemolysis was not a relevant factor.
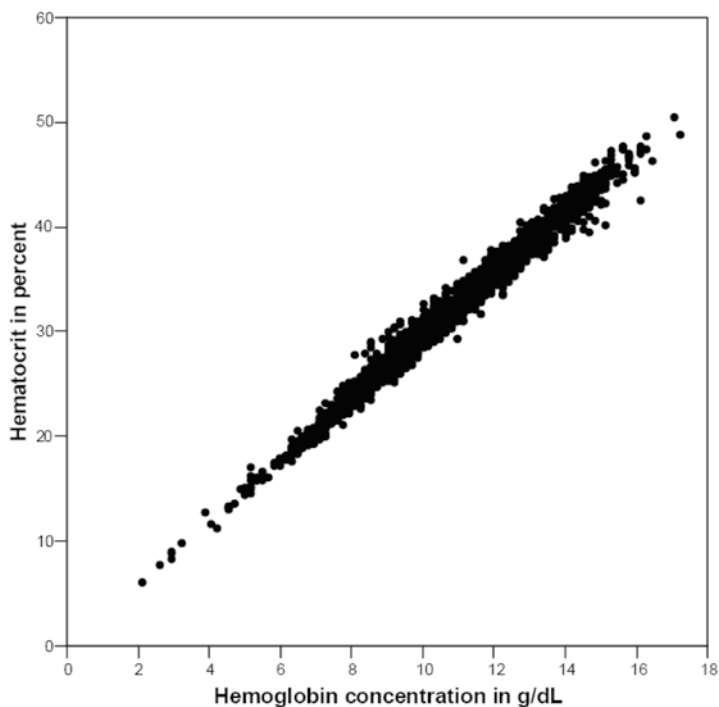
Figure 1. The relation between 2,461 paired hematocrit and hemoglobin values. Pearson's R^2 = 0.99 (p < 0.001).

CONCLUSION

In our series of trauma patients, Ht and Hb provided identical information. Ht is not different from Hb and determining both Ht and Hb in trauma patients has no rationale. Physicians should use either Ht or Hb according to personal preference or hospital practice

REFERENCES

1. Addison DJ. Is routine ordering of both hemoglobin and hematocrit justifiable? Canad Med Ass J. 1966;95:974–975.
2. Davidovic L, Markovich M, Kostic C, et al. Ruptured abdominal aortic aneurysms: factors influencing early survival. Ann Vasc Surg. 2005;19:29–34.
3. Perkins SL. Examination of the blood and bone marrow. In: Greer JP, Foerster J, Lukens JN, eds. Wintrobe's Clinical Hematology. Philadelphia, PA: Lippincott, Williams and Wilkins; 2004:3–25.
4. Simon TL. Red cell transfusion. In: Rossi EC, Simon TL, Moss GS, eds. Principles of Transfusion Medicine. Baltimore, MD: Williams & Wilkins; 1991:97–140.
5. Elizalde JI, Clemente J, Marin JL, et al. Early changes in hemoglobin and hematocrit levels after packed cell transfusion in patients with acute anemia. Transfusion. 1997;37:573–576.