Admission Hematocrit and Transfusion Requirements after Trauma

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BACKGROUND: The decision to transfuse packed RBCs (PRBC) during initial resuscitation of trauma patients is based on physiologic state, evidence for blood loss, and potential for ongoing hemorrhage. Initial hematocrit (Hct) is not considered an accurate marker of blood loss. This study tests the hypothesis that admission Hct is associated with transfusion requirements after trauma.

METHODS: From June to December 2008, data from 1,492 consecutive admissions at a Level I trauma center were retrospectively reviewed to determine whether initial Hct was associated with PRBC transfusions. From October 2009 through October 2011, data from 463 consecutive transfused patients were retrospectively reviewed to determine whether Hct correlated with number of PRBC units received.

RESULTS: Packed RBC transfusion was not correlated with heart rate and was more highly correlated with Hct ($r = -0.45$) than with systolic blood pressure or base deficit ($r = -0.32$ or $r = -0.26$). Hematocrit was a better overall predictor than systolic blood pressure (sensitivity 45% vs 29%, specificity 94% vs 98%, area under receiver operator characteristic curve 0.71 vs 0.64). Lower Hct was associated with hypotension, more advanced shock, higher blood loss, and increased transfusion of PRBC, plasma, platelets, or cryoprecipitate (all, $p < 0.01$).

CONCLUSION: Admission Hct is more strongly associated with the PRBC transfusion than either tachycardia, hypotension, or acidosis. Admission Hct is also correlated with 24-hour blood product requirements in those receiving early transfusions. These findings challenge current thinking and suggest that fluid shifts are rapid after trauma and that Hct can be important in initial trauma assessment. (J Am Coll Surg 2013;216:65–73. © 2013 by the American College of Surgeons)

Traditionally, hematocrit (Hct) is not considered a reliable index of blood loss after trauma. Classic teaching is that Hct remains stable after a bleeding episode because compensatory mechanisms for fluid shifts are relatively slow.[1] The axiom that "patients bleed whole blood" has emerged because plasma and red cells are lost in equal amounts.[2] In fact, most believe that Hct remains within the normal range immediately after hemorrhage, and that blood loss is not reflected until several hours after a traumatic event.[3] However, most physiologists can probably quote references in animal and human research, as well as Starling's Law of the Capillary, that fluid shifts are rapid due to transcapillary refill after blood loss.

We recently reported that admission Hct correlated with hypotension, acidosis, and hemorrhage in patients who required emergency trauma surgery.[4] These provocative data challenged conventional wisdom, but the practical application was limited for 2 reasons. First, only those patients who received emergent operations within 4 hours of admission were included. Second, all patients receiving nonoperative management were excluded (eg, angioembolization and those with neurologic and orthopaedic injuries).

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Abbreviations and Acronyms

BD = base deficit
Hb = hemoglobin
Hct = hematocrit
HR = heart rate
OR = odds ratio
PRBC = packed RBCs
SBP = systolic blood pressure

This retrospective study examined 2 consecutive samples of trauma patients and was designed to test whether Hct, hypotension, tachycardia, or acidosis correlated with receipt of transfusions and/or the amount transfused during resuscitation. We hypothesized that initial Hct correlates with early transfusion in all trauma patients.

METHODS

This was a retrospective review of consecutive patients admitted to a single Level I trauma center within 2 time periods. It was approved by the Institutional Review Board of the University of Miami and the Clinical Trials Office of Jackson Memorial Hospital/Ryder Trauma Center with waiver of informed consent.

Who received transfusions?

Adult patients during a 6-month period (June to December 2008) were retrospectively reviewed to identify whether Hct was associated with receipt of blood transfusions. Medical records were examined for those with arrival hemodynamic data and laboratory values. Patients were divided into 2 groups based on transfusion of at least 1 U packed RBCs (PRBC) or no transfusion.

How much was transfused?

Adults who received PRBCs during the immediate resuscitation period (in the trauma bay and/or operating room) during a 2-year period (October 2009 through October 2011) were retrospectively reviewed to determine whether Hct correlates with transfusion amount. Exclusion criteria were dead on arrival, death during initial resuscitation, pregnant, younger than 18 years old, transferred from outside hospitals, or missing Hct. The patients were divided into the following quartiles: initial Hct <30%, Hct 30% to 34.9%, Hct 35% to 39.9%, and Hct ≥40%.

Demographics and injury information (ie, age, sex, mechanism, Injury Severity Score), vital signs in the resuscitation unit (ie, arrival, minimum/maximum values), 24-hour fluid data (ie, intravenous fluids, blood products, urine output), and laboratory values (ie, blood gas pH, base deficit [BD], Hct) were collected. Blood samples were drawn either from the upper extremities or the femoral vein at admission. To ensure standardization of laboratory values, only those run on a blood gas analyzer (Siemens RAPIDLab 1265) in the main laboratory were included. Blood products administered in the first 24 hours were cross checked with blood bank records, and estimated blood loss was obtained from combining blood loss recorded in the operative report with chest tube output. Mortalities were identified from the trauma registry, operative records, and medical examiner reports, when available. Causes of death were assigned by examiners who were unaware if the patient received a transfusion.

Statistical analysis

PASW software version 19.0 (PASW) was used for statistical analyses. Normally distributed data are reported as mean ± standard deviation or number (percentage), as appropriate. Data that are not normally distributed (as determined by skewness/kurtosis, Shapiro-Wilk, and Q-Q plots) are expressed as median (interquartile range). Significance was assessed at $p < 0.05$.

Categorical data (ie, sex, mechanism, transfusion status) in Hct subgroups were compared using chi-square test or Fisher's exact test. Normally distributed data were compared using the Student's *t*-test or ANOVA, and nonparametric data were compared with a Mann-Whitney U test or Kruskal Wallis test. Post-hoc comparisons between Hct groups were done with a Bonferroni correction. Hemodynamic and laboratory variables were used to calculate the sensitivity, specificity, positive predictive value, and negative predictive value for the receipt of a transfusion. To identify ability of vital signs to predict transfusion, receiver operating characteristic curves were generated and areas under the curve were calculated. Variables with a $p < 0.20$ on univariate analysis were entered into a forward stepwise logistic regression to identify those associated with transfusion. Pearson's *r* was used to express the correlation between 2 continuous variables with normal distribution and Spearman's *r* was used if the variables were not normally distributed.

RESULTS

From June to December 2008, there were 1,492 consecutive admissions with arrival hemodynamic and Hct data. There were 224 (15%) patients who received a transfusion during immediate resuscitation and 1,268 (85%) who did not. Arrival (87 ± 23 beats/min vs 85 ± 22 beats/min) and maximum (118 ± 25 beats/min vs 116 ± 26 beats/min)