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Original Contributions

USING SERIAL HEMOGLOBIN LEVELS TO DETECT OCCULT BLOOD LOSS IN THE EARLY EVALUATION OF BLUNT TRAUMA PATIENTS

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□ **Abstract—Background: Serial hemoglobin measurement (ΔHgb) is intended to aid in the early identification of blunt trauma patients who have significant blood loss requiring intervention. However, the utility of ΔHgb has yet to be rigorously studied. Objective: We sought to determine if ΔHgb is a reliable diagnostic tool in assessing blood loss in blunt trauma patients. Methods: We enrolled consecutive blunt trauma patients ≥18 years of age who presented to a level I trauma center. We measured 2 hemoglobin levels spaced 5 min apart and calculated the difference (ΔHgb) for each patient. We also recorded whether each patient required any of the following interventions to treat their injuries: 1) operation or procedure to control hemorrhage; 2) radiographic embolization; 3) administration of blood and blood products; 4) administration of ≥3 liters of intravenous fluids; and 5) exsanguination. Our primary outcome was the area under the receiver operating characteristic (ROC) curve. Results: We enrolled 251 patients, including 192 males and 59 females with a mean age of 40 years. Interventions occurred in 56 patients and were withheld in 195. The median ΔHgb was −0.1 gm/dL (interquartile range −0.5 to 0.1 gm/dL) for patients requiring intervention and 0.0 gm/dL (interquartile range −0.6 to 0.3 gm/dL) for patients not requiring intervention. We found the area under the ROC curve to be 0.53 (95% confidence interval 0.44–0.62). Conclusions: Our results indicated that ΔHgb does not reliably distinguish between blunt trauma patients who require intervention and those who do not.** © **2018 Elsevier Inc. All rights reserved.**

□ **Keywords—blunt trauma; hematocrit; hemoglobin; hemorrhage**

INTRODUCTION

Traumatic hemorrhage results in the loss of whole blood, including plasma and red blood cells. The resultant loss of intravascular volume triggers shifts of interstitial and intracellular fluid that act to restore overall intravascular volume but do not restore erythrocyte and hemoglobin (Hgb) losses and result in a dilution of the intravascular concentration of red blood cells and Hgb. This conceptual framework provides the rationale for using measurements of hematocrit and Hgb concentration to assess blood loss in blunt trauma patients. However, baseline hematocrit and Hgb levels are affected by many factors that are not associated with bleeding, such as age, gender, weight, volume of distribution, fluid status, and underlying conditions, such as anemia (1). As a result, single measurements have limited utility in the early assessment of blunt trauma patients (2,3).

Because the performance of single Hgb and hematocrit assessments is unreliable, serial measures have been suggested as a means of identifying patients who have

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decreasing values that might signify ongoing hemorrhage, and the use of serial hematocrit or serial Hgb measurements is now part of the routine evaluation of trauma patients at many institutions across the United States (4). However, recent studies on the utility of serial measurements have produced inconclusive results (1,4,5). These differing conclusions reflect differences in methodology, study populations, and the timeframe of the serial evaluations.

The goal of our study was to prospectively examine the performance of serial Hgb (ΔHgb) measurements in the early resuscitation of blunt trauma patients at 5-min intervals and assess the ability of ΔHgb to identify patients who require emergent intervention. The 5-min time interval was specifically chosen because of its relevance to typical trauma resuscitations and the ability of these measurements to identify patients and influence care in the early stages of trauma resuscitations where evaluations and decisions are made in relatively short time intervals. In addition, there is no current literature to illuminate the utility of serial Hgb measurements in this timeframe.

We specifically wanted to examine the receiver operating characteristic (ROC) curve to assess the discriminating capability of serial measurements.

METHODS

Study Design and Setting

We conducted an observational study that enrolled consecutive blunt trauma patients ≥18 years of age who presented to a level I trauma center. We excluded patients who were <18 years of age, pregnant, were primarily burn victims, sustained penetrating trauma, were transferred from another hospital, or received interventions before the second Hgb measurement. The study involved recording the first 2 Hgb levels that were routinely assessed at 5-min intervals on all patients presenting to our institution for blunt trauma evaluations. Nursing personnel provided Hgb measurements to treating clinicians as part of normal practice, but study personnel did not inform the treating clinicians of any measurements or changes in Hgb levels and the study did not interfere or otherwise alter the care of any patients. The study was reviewed by the University of California Los Angeles institutional review board and approval was granted under a waiver of informed consent.

Measurements and Outcomes

We calculated the difference (ΔHgb) for the 2 measured Hgb levels for each patient. We also recorded whether each patient required any of the following interventions to treat their injuries: 1) operation or procedure to control hemorrhage; 2) radiographic embolization; 3) administration of blood and blood products; 4) administration of ≥3 L of intravenous (IV) fluids; and 5) exsanguination. We counted only interventions that took place within the first 24 h of the patient's arrival to the resuscitation suite. We documented interventions that occurred in the resuscitation area using direct observation. We had 2 trained and independent observers review case records to ascertain whether interventions were performed outside of the resuscitations area. Disagreements were resolved by third-party assessments.

Analysis

We calculated the sensitivity and specificity of each level of ΔHgb in predicting the need for any of the index interventions and used these operator characteristics to construct a ROC curve for ΔHgb. Our primary outcome was the area under this ROC curve and its corresponding confidence interval (6). We also calculated the maximum Youden index associated with the ROC. In determining our sample size, we estimated that we would need 251 patients to estimate the optimal sensitivity of serial Hgb measurements to within 5% (± 2.5%). In the setting of acute hemorrhage, common practice is to withhold the administration of IV fluids and move straight to resuscitation with blood. Therefore, we calculated an additional area under the ROC curve where the administration of ≥3 L of IV fluids was not considered an intervention.

RESULTS

Our institution had 393 trauma activations between June 2016 and October 2016. We excluded 142 patients because they either underwent an index intervention before their second Hgb measurement or met 1 of the exclusion criteria. The remaining 251 patients, including 192 males and 59 females with a mean age of 40 years, form our cohort. We found that no interventions were performed in 195 patients, while a total of 93 interventions were administered to the remaining 56 patients. Figure 1 provides the flow diagram for patient enrollment, and Table 1 documents the distribution of interventions among our cohort. An operative procedure was the only intervention provided to 4 patients (1.6% of all enrolled patients, and 7.1% of the patients receiving some form of intervention). Of the 19 patients who received fluid support as their only intervention, 10 exhibited falling Hgb levels, 5 exhibited stable levels, and 4 exhibited rising levels.

The median ΔHgb was −0.1 gm/dL (interquartile range [IQR] −0.5 to 0.1 gm/dL) for patients requiring intervention and 0.0 gm/dL (IQR −0.6 to 0.3 gm/dL) for patients not requiring intervention. Figure 2 depicts