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The Low Diagnostic Utility of Rechecking Hemoglobins within 24 Hours in Hospitalized Patients

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Abstract

Purpose—Clinicians often repeat hemoglobin tests within a 24 hour period to detect or monitor anemia. We sought to determine the percentage of hemoglobin tests repeated within a single hospital day that were at least 1.0 g/dL lower than the first test.

Methods—We performed a retrospective cross-sectional analysis of hospitalized adults on medical or surgical services over a year at a single academic hospital. Using patient and laboratory data in the electronic health record, we analyzed the proportion of repeated hemoglobin tests that was at least 1 g/dL less than the initial hemoglobin value of that day, excluding days when transfusions were administered.

Results—A total of 88,722 hemoglobin tests were obtained from 12,877 unique patients, who contributed a total of 86,859 hospitalization days. In 12,230 (14.1%) of those days, two or more hemoglobin tests were obtained within a single day. In the 6,969 patients who had two hemoglobin tests obtained on the same day and no transfusions given, 949 (13.5%) were ≥ 1 g/dL lower than the initial hemoglobin value of that day and 260 (3.7%) were ≥ 2 g/dL lower. Repeated tests did not often reach transfusion thresholds: 482(6.9%) of repeat hemoglobin values were < 8 g/dL and 64 (0.9%) were < 7 g/dL.

Conclusions—Hemoglobin tests were repeated in 14% of hospital days. For patients who had two hemoglobin tests obtained on the same day, 13.5% demonstrated a clinically significant drop. This information may be helpful to clinicians when considering whether repeat testing is appropriate.

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Keywords

High-value care; anemia; lab testing; overuse

Introduction

Clinicians often check a patient's hemoglobin level multiple times throughout a hospitalization and sometimes multiple times in a single day in order to detect and monitor for anemia. Multiple stable hemoglobin values within a single day may help document the absence of significant blood loss and provide reassurance to clinicians and patients. Although repetitive testing may uncover true drops in hemoglobin level, it may also lead to falsely positive or spurious readings that trigger further unnecessary testing or intervention. In addition, repeat phlebotomy can contribute to hospital-acquired anemia, increased costs, and patient discomfort.[1,2,3]

The diagnostic yield of repetitive hemoglobin testing is unclear.[4,5] There are few guidelines that address the appropriateness of blood testing practices in hospitalized patients, and there have been concerns that tests are often over-ordered.[6,7,8,9,10] The objective of this study was to describe the proportion of repeat hemoglobin tests that demonstrated a clinically significant drop of at least 1 g/dL when obtained on the same calendar day.

Methods

We collected data from all adult medical or surgical patients (age ≥ 18 years) who were hospitalized for at least 24 hours at the University of California, San Francisco Medical Center (San Francisco, CA) and discharged between September 1, 2012 and September 1, 2013. We used the electronic health record (EHR) system (Epic, Madison WI) to collect information on patient demographics (age, sex, race, ethnicity), hospitalization characteristics (including admission date, discharge date, and discharging hospital service), and whether there was a diagnosis of bleeding (identified by searching primary and secondary discharge diagnoses for specific ICD-9 codes for hemorrhage).[11]

We obtained all hemoglobin results from these hospitalizations, including the date and time when the results were visible in the EHR, whether the hemoglobin test was obtained from an intensive care unit setting or a general medical/surgical ward, and whether or not a transfusion of packed red blood cells was given on that day. Hemoglobin results obtained from the same patient on the same calendar day (12:00 AM to 11:59 PM) were the focus of this analysis.

Statistical Methods

Our primary analysis was restricted to hospital days in which exactly two hemoglobin values were obtained on a given patient because we felt patients who had three or more tests were likely to have strong indications for repeat testing. We described the proportion of repeated tests that demonstrated a clinically significant drop from the first hemoglobin result; clinically significant was defined as ≥ 1 g/dL. We also described the percentage of repeat

tests when the drop was ≥ 2 g/dL. Finally, we described how frequently the second hemoglobin test fell below commonly used transfusion thresholds of 7 g/dL and 8 g/dL. Because we could not determine the exact time blood transfusions were administered, our primary analysis excluded days in which a packed red blood cell transfusion was administered as transfusion would directly alter the hemoglobin result. However, we also conducted an analysis that included transfusion days.

We used a logistic regression model to test the association of individual patient factors with a hemoglobin drop of ≥ 1 g/dL in a single day. We accounted for potential clustering of hemoglobin values when there were multiple tests obtained in the same individual by using generalized estimating equations with exchangeable working correlation and robust standard errors. After the initial unadjusted analyses, covariates were included in the adjusted analysis if they were associated with the primary outcome at a significance level of <0.05, or for reasons of face validity.

We evaluated all tests as two sided at a 0.05 level of significance. Statistical analyses were conducted using STATA version 13 (STATA Inc.) and R (R Foundation for Statistical Computing, http://R-project.org). This study was approved by the local institutional review board, and waiver of informed consent was obtained due to the nature of the study

Results

Over the time period of the study, a total of 88,722 hemoglobin tests were obtained from 12,877 unique patients who contributed a total of 86,859 hospitalization days. At least one hemoglobin test was obtained on 69,524 (80.0%) of hospital days. For 57,294 (66.0%) of hospital days, one hemoglobin test was obtained. Exactly two hemoglobin tests were obtained on 8,143 (9.4%) of hospital days, and three or more tests were obtained on 4,087 (4.7%). The mean number of hemoglobin tests per hospital day was 1.3. Characteristics of the days in which one or more hemoglobin tests were obtained are shown in Table 1.

The primary analytic cohort comprised 4,106 patients who had 6,969 hospital days where exactly two hemoglobin tests were obtained and no transfusions were given. The mean value and standard deviation of the first hemoglobin test was 10.5 ± 2.1 g/dL and the mean value of the second was 10.4 ± 1.9 g/dL. The second test was on average 0.07 g/dL lower than the first [95% confidence interval (CI) 0.04-0.09].

Out of 6969 repeated tests, 949 (13.5%) were ≥ 1 g/dL lower than the initial hemoglobin value of that day and 260 (3.7%) were ≥ 2 g/dL lower. Repeated tests did not often reach transfusion thresholds: 482(6.9%) of repeat hemoglobin values were < 8 g/dL and 64 (0.9%) were < 7 g/dL.

The mean drop in the hemoglobin value was greatest on the date of admission. On admission, the mean initial hemoglobin value was 11.7 ± 2.3 and the mean of the second value was 11.1 ± 2.1, for a drop of 0.55 g/dL [95% CI 0.50-0.61]. Overall, 30.0% (562/1871) of hemoglobin tests that were repeated on the admission day were ≥ 1 g/dL lower than the initial value. On subsequent hospitalization days, the second hemoglobin was

on average 0.11 [95% CI 0.09-0.13] higher than the first, and only 7.6% (387/5125) of repeated tests were ≥ 1 g/dL lower than the first.

The drop was also related to the initial hemoglobin value. For days on which the initial hemoglobin value was ≥10 g/dL, the mean drop was 0.37 g/dL [95% CI 0.33-0.40], from 12.0±1.6 to 11.6 ±1.6, and 21.2% (820/3860) of repeated tests were ≥ 1 g/dL lower than the first. For days in which hemoglobin was < 10 g/dL, the second hemoglobin was on average 0.30 g/dL [95% CI 0.27-0.33] higher than the first, and 4.1% (129/3136) of repeated tests were ≥ 1 g/dL lower than the first.

In a multivariable model that adjusted for age, sex, race, ethnicity, hours between tests, and hospital service, several variables were associated with a hemoglobin drop of ≥ 1 g/dL in single day. These included the initial hemoglobin value (adjusted odds ratio [AOR] 1.46, 95% CI 1.40 - 1.52), whether the test was performed on the date of admission (AOR 3.47 [95% CI 2.84 -4.24]), a discharge diagnosis of bleeding (AOR 1.29 [95% CI 0.99 - 1.66]), whether either test was performed while the patient was in an intensive care unit (AOR 1.41 [95% CI 1.20-1.66]), and whether the first hemoglobin value of the day was ≥ 1 g/dL lower than the most proximate hemoglobin result from that hospitalization (AOR 0.68 [95% CI 0.52-0.90]).

We repeated the analysis including the 1,147 days in which at least one blood transfusion was administered. In this analysis, the mean change from the first to the second hemoglobin was 0.05 g/dL [95% CI 0.03-0.08], from a hemoglobin of 10.2 ± 2.1 g/dL to 10.3 ± 1.9 g/dL. The second hemoglobin test was < 8 g/dL in 693(8.5%) of cases and < 7 g/dL in 123 (1.5%).

Discussion

Hemoglobin tests were drawn from patients on 80% of hospital days. For 14% of hospital days, two or more hemoglobin tests were drawn on the same day. Only 13.5% of repeated hemoglobin tests demonstrated a clinically significant drop of at least 1 g/dL. Hemoglobin levels were more likely to reveal a significant drop if they were obtained on the day of admission or if the patient's initial hemoglobin level was greater than 10 g/dL. Several additional predictors of a clinically significant hemoglobin drop within a day include a diagnosis of bleeding and whether the patient was located in the intensive care unit. This study provides information that can be useful to clinicians in estimating the likelihood of detecting a significant drop in hemoglobin.[12]

A significant drop in hemoglobin values was most commonly observed on the first hospital day. Although we lacked data on the exact reasons for this, we speculate that this may be related to factors common in newly hospitalized patients: admission phlebotomy and blood work, hemoconcentration/volume depletion in acutely ill people, and the initiation of intravenous hydration.

Depending on the specific clinical circumstance, the detection of a significant hemoglobin drop in 13.5% of repeat tests could be considered high or low. If clinicians strongly suspect a patient is bleeding, then this proportion could justify a repeat test given that more than one out of 10 such tests will show a drop. Conversely, if clinicians think it unlikely that a patient

is truly bleeding, they could consider approximately 9 out of 10 times a drop will not be detected. Our study does not answer the normative question of when a repeat blood test is indicated, but it can help clinicians better consider the pre-test probability of drop. To this end, we specifically included both patients with and without bleeding diagnoses to demonstrate the probability in diagnostically uncertain situations where the clinician has not yet determined if a patient is bleeding. Moreover, our adjusted model shows that even a diagnosis of bleeding only moderately increases the chance of detecting a drop, although the effect was not statistically significant.

There are several limitations of our study. Because this was an observational study of clinical care and the number of hemoglobin tests per day was not randomly determined, the expected change in hemoglobin values observed in patients with repeated testing cannot be extrapolated to days where only a single hemoglobin test was obtained. Clinicians may have ordered a repeat hemoglobin as part of a panel that was ordered to monitor leukocyte or platelet counts, so the percentage of significant hemoglobin drops may have been higher if there were a way to exclude tests done for those other purposes. There may also have been strong clinical indications for repeat testing that we were unable to account for. It is reassuring, however, that even in patients with a discharge diagnosis of hemorrhage, the proportion of hemoglobin levels that fell below common transfusion thresholds was low.

In conclusion, repeated hemoglobin testing in a single day only uncommonly reveals clinically actionable drops. This information may be helpful to clinicians when considering whether repeat testing is appropriate.

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Clinical Significance

1. Clinicians routinely re-check the hemoglobin level within a single hospital day
2. Repeating a hemoglobin level in a hospital day only infrequently demonstrates a drop of greater than 1 gm/dL
3. A repeat hemoglobin level is more likely to demonstrate a drop on the first hospital day, in patients in the intensive care unit, or in patients with high initial hemoglobin levels

Table 1

Number of Hemoglobin (Hgb) Tests Obtained in a Single Hospital Day and Patient Characteristics

	Hospital Days			
	1 Hgb test obtained N=57,294 N(%)	**2 Hgb tests obtained N=8,143 N(%)**	**3 or more Hgb tests obtained N=4,087 N(%)**	
Patient age, median years (IQR[a])	61 (49-72)	62(51-73)	64(53-74)	p<0.001
Female Sex	28,796(50.3)	3,966(48.7)	1,887(46.2)	p<0.001
Race				
White	33,426(58.3)	4509(55.4)	2182(53.4)	p<0.001
Non-white	22899(40.0)	3485(42.8)	1793(43.9)	
Unknown	969(1.69)	149(1.8)	112(2.7)	
Ethnicity				
Hispanic or Latino	6767(11.8)	1061(13.0)	477(11.7)	p=0.006
Initial Hemoglobin value of day, median g/dL (IQR)	10.7(9.4-12.1)	9.9(8.6-11.5)	9.5(8.4-10.8)	p<0.001
Drop of >1 g/dL from prior known value	6714(11.7)	1462(18.0)	736(18.0)	p<0.001
Hemoglobin test on day of admission	10179(17.82)	1549(19.0)	663(16.2)	p<0.001
Patient location in ICU[b]	9344(16.3)	2834(34.8)	2507(61.3)	p<0.001
Service type[c]				
Medical Service	25545(44.6)	3676(45.1)	1860(45.5)	p=0.362
Surgical service	31749(55.4)	4467(54.9)	2227(54.5)	
Primary or secondary discharge diagnosis of bleeding	2934(5.1)	869(10.7)	877(21.5)	p<0.001
Transfusion of packed red blood cell during hospitalization day	1101(1.9)	1147(14.1)	1463(35.8)	p<0.001

[a] Interquartile Range

[b] Intensive Care Unit

[c] "Medical services" included hospital medicine, cardiology, neurology, and neurovascular services. "Surgical services" included cardiac surgery, colorectal surgery, cardiothoracic surgery, general surgery, gynecologic oncology, gynecology, neurosurgery, orthopedics, otolaryngology, head & neck surgery, plastic surgery, thoracic surgery, urology, and vascular surgery