Published in final edited form as:

J Orthop Trauma. 2004 July ; 18(6): 369–374.

The Effect of Perioperative Anemia on Clinical and Functional Outcomes in Patients With Hip Fracture

Ethan A. Halm, MD, MPH^{*,†}, Jason J. Wang, PhD^{*}, Kenneth Boockvar, MD, MS[‡], Joan Penrod, PhD[‡], Stacey B. Silberzweig, MS, RD[‡], Jay Magaziner, PhD[§], Kenneth J. Koval, MD[¶], and Albert L. Siu, MD, MSPH^{*,†,‡}

^{*} From the Department of Health Policy, Mount Sinai School of Medicine, New York, NY,

[†] Department of Medicine, Mount Sinai School of Medicine, New York, NY,

[‡] Department of Geriatrics and Adult Development, Mount Sinai School of Medicine, New York, NY,

[§] Department of Epidemiology and Preventive Medicine, University of Maryland School of Medicine, Baltimore, MD, and

[¶] Department of Orthopedics, Hospital for Joint Diseases, New York, NY.

Abstract

Objectives—To describe the epidemiology of perioperative anemia in patients with hip fracture and assess the relationship between the hemoglobin measurements and clinical outcomes.

Design—Prospective observational cohort study.

Setting—Four university and community teaching hospitals.

Patients—A consecutive cohort of 550 patients who underwent surgery for hip fracture and survived to discharge from August 1997 and August 1998 were evaluated and followed prospectively.

Main Outcome Measures—Deaths, readmissions and Functional Independence Motor mobility scores within 60 days of discharge.

Results—Anemia (defined as hemoglobin <12.0 g/dL) was present in 40.4% of patients on admission, 45.6% at the presurgery nadir, 93.0% at the postsurgery nadir, and 84.6% near discharge. The mean drop in hemoglobin after surgery was 2.8 ± 1.6 g/dL. In multivariate analyses, higher hemoglobin levels on admission were associated with shorter lengths of hospital stay and lower odds of death and readmission even after controlling for a broad range of prefracture patient characteristics, clinical status on discharge, and use of blood transfusion. Admission and preoperative anemia was not associated with risk-adjusted Functional Independence Motor mobility scores. In multivariable analyses, higher postoperative hemoglobin was associated with shorter length of stay and lower readmission rates, but did not effect rates of death or Functional Independence Motor mobility scores.

Conclusions—Substantial declines in hemoglobin were common in patients with hip fracture. Higher preoperative hemoglobin was associated with shorter length of stay and lower odds of death and readmission within 60 days of discharge. Postoperative hemoglobin was also related to length of stay and readmission rates.

Keywords

hip fracture; anemia; hemoglobin; outcomes; functional recovery

Anemia is common in the elderly and has been associated with increased mortality.^{1–3} Among patients with chronic disease or malignancy, hemoglobin levels are often robust predictors of long term survival.^{4–7} The degree of anemia among patients admitted to the hospital for medical and surgical conditions is associated with higher short term mortality in many,^{8–12} though not all, studies.^{13–15}

The relationship between hemoglobin levels and surgical outcomes is likely to be complex, and understanding it requires an ability to dissect out several interrelated issues. First, fluctuations in hemoglobin levels during a surgical patient's hospital course are common, so it is important to distinguish measurements on admission from subsequent ones both before and after surgery.^{8,9,12–17} Anemia at different points during the hospital course may also reflect different problems with varying implications. Anemia on admission may carry a poor prognosis because it is a physiologic indicator of underlying comorbid illness burden, illness severity (anemia of chronic disease), or prehospital bleeding. For this reason, proper adjustment for comorbidities and severity of illness on admission is imperative. In addition, many elderly patients may be dehydrated on admission, and the initial fluid hydration may decrease hemoglobin levels.¹⁸ Many surgical patients who are admitted for urgent or emergent conditions also can have bleeding and fluid shifts before their operation. Drops in hemoglobin levels during surgery can be caused by bleeding and hemodilution from intravenous fluids or fluid shifts.^{18–20} Finally, inpatients may lose blood through repeated phlebotomy ("hospital-acquired anemia"), though this may be largely a problem of patients requiring intensive care or repeated surgery.^{21,22}

Second, blood transfusions are common among surgical patients and need to be accounted for in studies of anemia.^{8,9,12–14,16} Indeed, most of the research in this area has predominantly focused on the impact of the blood transfusion itself on outcomes.

Unfortunately, the literature examining the impact of transfusion on mortality is quite conflicted.^{23,24} The majority of studies have reported no effect of transfusion on mortality.^{13,16,25–34} However, several investigators have reported that transfusion was associated with lower risk of death,^{10,11} whereas others found it increased death rates.^{12,35,36} Finally, there has been little investigation of the impact of anemia on nonmortal outcomes.^{12,14}

We sought to characterize variations in hemoglobin levels during the course of hospitalization and examine the prognostic significance of hemoglobin levels measured at different time points during hospitalization using data from a prospective cohort study of patients undergoing surgery for hip fracture in 4 hospitals. The aims of this study were to: 1) describe the epidemiology of anemia during hospitalization; 2) assess the relationship between hemoglobin measurements and clinical and functional outcomes; and 3) determine whether hemoglobin measurements add independent prognostic information after adjusting for risk factors known to influence hip fracture outcomes.

MATERIALS AND METHODS

Study Patients and Sites

Consecutive patients hospitalized for hip fracture between August 1997 and August 1998 in 3 university teaching hospitals and 1 community teaching hospital were prospectively enrolled in an observational cohort study. Details of the study design and cohort characteristics were described previously.³⁷ All screening, enrollment, and data collection protocols were comparable across sites. Exclusion criteria were: age less than 50 years, fracture occurring as an inpatient, transfer from another hospital, sustained concurrent major internal injuries, pathologic fractures, fractures limited to the pelvis or acetabulum, fractures 2 cm or more below the trochanter, bilateral hip fractures, prior surgery on the same hip, or previous ipsilateral hip

fracture. Of the 804 patients who presented with hip fracture during the study period, 650 (81%) met eligibility criteria, and 571 (88%) of those agreed to participate. For the purposes of this report, we excluded an additional 17 patients who did not undergo hip fracture surgery and 4 patients for whom we lacked data on hemoglobin values during the index hospitalization. This report is based on 550 patients pooled across the 4 sites. The study was approved by the institutional review board of all participating institutions.

Data Collection and Measurements

Information on prefracture sociodemographic characteristics, living arrangements, functional mobility, and Do Not Resuscitate (DNR) status were collected from medical records and patient/proxy interviews during the index admission. Medical records were also used to ascertain comorbid conditions, vital signs, laboratory values, physical examination findings, and type of fracture on admission and clinical status on discharge. We used the modified the RAND comorbidity³⁸ score to measure the number of comorbidities and the Acute Physiology and Chronic Health Evaluation (APACHE) score³⁹ to assess acute physiologic illness on admission as previously described.³⁷ Information was also collected on active clinical issues and new impairments on discharge⁴⁰ and use of iron or erythropoietin on discharge.

We extracted information on all hemoglobin and hematocrit measurements performed during the index hospitalization from each hospitals' laboratory results computer system as well as the medical chart. Blood transfusion data were collected from blood bank registries and the hospital medical record. All transfusions were packed red blood cells.

Outcomes

Information about deaths, readmissions, and functional mobility 60 days after hospital discharge was obtained by telephone interview. For cognitively compromised patients, alternate respondents who were most familiar with the patient (usually a spouse or close relative) were interviewed. Prior studies indicate that proxies can provide reliable estimates for the domains of physical function measured in this study.^{41,42} The date of death was confirmed by checking public death registries. We also identified readmissions within 60 days of discharge by querying each hospitals' administrative databases as well as New York's Statewide Planning and Research Cooperative System (SPARCS) hospital discharge database (which contains data on all admissions in the state). When dates of first hospital readmission from multiple sources did not agree, we regarded same hospital administrative data as most reliable followed by SPARCS data and self-reported dates.

Functional mobility (ability to walk and climb stairs) was measured using a modified version of the previously validated, locomotion subscale of the Functional Independence Measure (FIM), which rates the patient's independence in walking 150 feet and going up and down 12 to 14 stairs (each rated from 1 to 7, where 1 = requires total assistance and 7 = complete independence).^{43,44} The total FIM locomotion score ranges from 2 to 14, with higher scores indicating better mobility.

Statistical Analyses

We calculated means with standard deviations and medians with interquartile ranges as appropriate. We used logistic regression to examine the association between hemoglobin measurements and the risk of death and readmission and linear regression to assess associations between hemoglobin measurements and functional mobility (FIM scores) or hospital length of stay. Because we were interested in examining effects of both maximal and minimal hemoglobin levels, our primary analyses used hemoglobin as a continuous variable. Secondary analyses that categorized hemoglobin values into various strata (eg, <9.0, 9.0 to 9.9, ≥10.0, <9.0 vs. ≥9.0, or <10.0 vs. ≥10.0, <12.0 vs. ≥12.0) yielded results similar to those presented.

Because most of participants were female, we used the World Health Organization hemoglobin classification criterion of less than 12.0 to indicate a clinical diagnosis of anemia.^{1,45} Though length of stay data were skewed, linear regression models of length of stay produced results that were similar to models examining log (length of stay). For ease of interpretation, we present the results for the length of stay untransformed.

Because this was an observational study of usual care, the timing of hemoglobin measurements was not standardized. Although all patients had a measurement of hemoglobin before and shortly after surgery, there was no uniform assessment of hemoglobin on or near discharge. Therefore, we were unable to develop reliable multivariable models for discharge hemoglobin.

Our multivariable analyses adjusted for a previously validated hip fracture risk factor model (age, gender, prefracture functional status, dementia, admission from a nursing home, paid help at home, RAND comorbidity score, and APACHE score),³⁷ and other covariates known to influence clinical and functional hip fracture outcomes such as active clinical issues and new impairments on discharge,⁴⁰ and DNR status. In addition, the final multivariate models assessing the impact of preoperative hemoglobin measurements adjust for blood transfusion during hospitalization, and the models of postoperative values adjust for admission hemoglobin and transfusion, processes of care known to influence hip fracture outcomes.⁴⁰ All analyses used two-tailed significance levels of $P < 0.05$ and were conducted with SAS statistical software 6.12 (SAS Institute, Cary, NC).

RESULTS

Patient Characteristics

Characteristics of the hip fracture patients in the study are displayed in Table 1. The average patient was 81.9 years old with 2.3 comorbid illnesses prior to their fracture. The overall mean hospital length of stay was 8.6 ± 6.3 days (median 7.0 days) and varied from 8.3 to 10.0 days among the 4 sites ($P < 0.007$).

Outcomes

In the 60 days after discharge, 3.8% (21) of patients died. The median time to death was 31 days (interquartile range [IQR] 21–41). Ninety-three patients (16.9%) were readmitted to the same or a different acute care hospital within 60 days. The median time to readmission was 20 days (IQR 7–34). We had data on functional mobility for 461 of the 530 patients (86.9%) who survived 60 days. Among these patients, the average FIM locomotion score was 6.6 ± 3.8 (range 2–14). Overall, 39.3% were completely dependent ($\text{FIM} \leq 4$), and 15.8% were functionally independent ($\text{FIM} \geq 12$).

Just over half of all patients (55.5%) received a red blood cell transfusion during their hospital stay. Transfusions were given to 4.7% of patients prior to surgery and 54.4% after surgery. The average number of units of blood received was 2.3 ± 2.1 (median, 2; IQR 1–3).

Hemoglobin Measurements During Hospitalization

The distributions of hemoglobin measurements throughout hospitalization are shown in Figure 1. The average hemoglobin on admission was 12.3 ± 1.7 g/dL. The mean of the lowest value prior to surgery was 11.9 ± 1.8 g/dL. The mean of the lowest hemoglobin levels after surgery was 9.5 ± 1.5 g/dL; the last measured postoperative hemoglobin averaged 10.8 ± 1.2 g/dL. Anemia (defined as hemoglobin < 12.0 g/dL) was present in 40.4% of patients on admission, 45.6% at the presurgery nadir, 93.0% at the postsurgery nadir, and 84.6% near discharge.

The mean drop in hemoglobin from admission to the preoperative nadir was 0.3 ± 0.9 g/dL. The average drop following surgery (from admission to lowest postoperative level) was 2.8 ± 1.6 g/dL. Over the course of the entire hospitalization, the average decline in hemoglobin was 1.5 ± 1.8 g/dL. Patients who were not transfused experienced the largest net drop in hemoglobin during hospitalization compared with those who were transfused, though both groups experienced net losses (2.2 vs. 0.9; $P < 0.0001$).

Associations Between Hemoglobin Values and Outcomes

In univariate analyses, higher hemoglobin levels on admission were associated with lower odds of death and readmission, better functional mobility, and shorter lengths of hospital stay (Tables 2 and 3). Admission hemoglobin remained a robust predictor of mortality, readmissions, and length of stay in multivariable analyses that controlled for a broad range of prefracture patient characteristics, clinical status on discharge, and blood transfusion (Table 3). However, admission hemoglobin was not associated with functional mobility scores in the risk-adjusted, multivariate analyses. We found similar associations between the lowest hemoglobin value prior to surgery and rates of death, readmission, and length of stay. This was due, in large part, because the hemoglobin on admission and the lowest value before surgery were highly correlated ($r = 0.87$; $P < 0.0001$).

The lowest postoperative hemoglobin measurement was a univariate predictor of readmissions, functional mobility score, and length of stay, but not deaths. After adjusting for other important prognostic factors (including the receipt of a postoperative transfusion), higher hemoglobin values after surgery were associated with lower risk-adjusted odds of readmission and shorter length of stay, but did not influence rates of death or mobility scores in the multivariate analyses.

Additional analyses that examined dichotomized hemoglobin levels using clinical thresholds or controlled for other potential confounders such as discharge destination, hospital site, number of units of blood transfused, and discharge prescriptions for iron or erythropoietin produced results that were similar to those reported above.

DISCUSSION

In this multisite, prospective cohort study of patients undergoing surgery for hip fracture, patients experienced a small drop in their hemoglobin level between admission and surgery (mean 0.3 g/dL). In contrast, the average drop in hemoglobin after surgery was considerable (mean 2.8 g/dL), roughly equivalent to a loss of 2 to 3 units of blood. Thus, 40% of patients were anemic on admission (hemoglobin <12.0 g/dL), but nearly all had anemia following surgery.

The small drop in hemoglobin we observed prior to surgery likely reflects the fact that many patients who are admitted with hip fracture are somewhat dehydrated, and the initial fluid hydration may decrease hemoglobin. The large decline in hemoglobin that was seen following surgery is probably a function of both considerable bleeding during the surgical repair and hemodilution from intravenous fluids. Of note, although half of the patients received a blood transfusion, those who were transfused still ended up losing the equivalent of 1 unit of blood over the course of their hospitalization (compared with a 2-unit drop for those who were not transfused).

Overall, the degree of anemia before surgery was a strong, independent predictor of death and readmission within 60 days of the surgical repair, as well as hospital length of stay. Higher hemoglobin measurements after surgery were also associated with shorter length of stay and lower risk-adjusted odds of readmission. In contrast, none of the hemoglobin measurements

was associated with functional mobility outcomes in multivariate analyses. The degree of anemia is probably a strong, independent prognostic factor because it is a marker of underlying comorbid illness burden and physiologic reserve. This is consistent with our previously reported finding that the majority of readmissions following hip fracture surgery are for comorbid conditions (such as infectious or cardiovascular diseases), not surgical complications.⁴⁶ As such, the hemoglobin value appears to capture risk information not accounted for by many standard comorbidity or disease classification systems.

The proportion of patients in our cohort who had preoperative anemia was similar to that reported in other cohorts of hip fracture patients^{13,14} and those undergoing noncardiac surgery.¹² Our results are consistent with other investigators who have found a relationship between preoperative hemoglobin and mortality.^{9,13,14} In contrast to our findings, the National Veterans Administration Surgical Quality Improvement Program reported that postoperative anemia (defined as hematocrit <36.0) was associated with higher 30-day death rates among patients undergoing noncardiac surgery.¹² Another single-institution study of hip fracture patients who were 65 years or older also failed to find an association between anemia and risk-adjusted functional outcomes.¹⁴

Some limitations of the present study are worth noting. First, because this was an observational study, we are cautious about inferring cause and effect relationships. However, we are confident that our use of a validated, robust, hip-fracture specific risk model³⁷ and control of other important prognostic factors such clinical status on discharge⁴⁰ and postoperative blood transfusion¹⁶ makes it unlikely that major unmeasured confounding explain our results. We are confident that the lack of a multivariate association between hemoglobin measurements and postdischarge mobility scores is a true result, not a type II error. The FIM measure that we used is a well-validated, reliable, sensitive indicator of mobility.^{43,44} In addition, we had 99% power to detect modest differences in mobility scores (1.5 points or 39% of a standard deviation) between patients who were anemic or not anemic on admission and 91% power to ascertain a similar impact of anemia after surgery.

In conclusion, surgeons, geriatricians, and medical consultants should be aware that the average patient with hip fracture experiences a large drop in their hemoglobin following surgery, and hemoglobin on admission is a potent, independent risk factor for poor outcomes. Future efforts to understand the various medical and surgical determinants of outcomes following hip fracture surgery should control for the degree of anemia on admission. These data suggest that strategies to raise hemoglobin levels, especially among vulnerable anemic patients, through transfusion or recombinant human erythropoietin may be promising, though prospective testing will be required.

References

1. Izaks GJ, Westendorp RG, Knook DL. The definition of anemia in older persons. *JAMA* 1999;281:1714–1717. [PubMed: 10328071]
2. Salive ME, Cornoni-Huntley J, Guralnik JM, et al. Anemia and hemoglobin levels in older persons: relationship with age, gender, and health status. *J Am Geriatr Soc* 1992;40:489–496. [PubMed: 1634703]
3. Ania BJ, Suman VJ, Fairbanks VF, et al. Incidence of anemia in older people: an epidemiologic study in a well-defined population. *J Am Geriatr Soc* 1997;45:825–831. [PubMed: 9215333]
4. The TIFDED Study Group. Thromboprophylaxis in hip fracture surgery: a pilot study comparing danaparoid, enoxaparin and dalteparin. *Haemostasis* 1999;29:310–317. [PubMed: 10844404]
5. Horwich TB, Fonarow GC, Hamilton MA, et al. Anemia is associated with worse symptoms, greater impairment in functional capacity and a significant increase in mortality in patients with advanced heart failure. *J Am Coll Cardiol* 2002;39:1780–1786. [PubMed: 12039491]

6. Caro JJ, Salas M, Ward A, et al. Anemia as an independent prognostic factor for survival in patients with cancer: a systematic, quantitative review. *Cancer* 2001;91:2214–2221. [PubMed: 11413508]
7. Sullivan P. Associations of anemia, treatments for anemia, and survival in patients with human immunodeficiency virus infection. *J Infect Dis* 2002;185(suppl 2):S138–S142. [PubMed: 12001035]
8. Carson JL, Poses RM, Spence RK, et al. Severity of anaemia and operative mortality and morbidity. *Lancet* 1988;1:727–729. [PubMed: 2895260]
9. Carson JL, Duff A, Poses RM, et al. Effect of anaemia and cardiovascular disease on surgical mortality and morbidity. *Lancet* 1996;348:1055–1060. [PubMed: 8874456]
10. Hebert PC, Wells G, Tweeddale M, et al. Does transfusion practice affect mortality in critically ill patients? Transfusion Requirements in Critical Care (TRICC) Investigators and the Canadian Critical Care Trials Group. *Am J Respir Crit Care Med* 1997;155:1618–1623. [PubMed: 9154866]
11. Wu WC, Rathore SS, Wang Y, et al. Blood transfusion in elderly patients with acute myocardial infarction. *N Engl J Med* 2001;345:1230–1236. [PubMed: 11680442]
12. Dunne JR, Malone D, Tracy JK, et al. Perioperative anemia: an independent risk factor for infection, mortality, and resource utilization in surgery. *J Surg Res* 2002;102:237–244. [PubMed: 11796024]
13. Carson JL, Duff A, Berlin JA, et al. Perioperative blood transfusion and postoperative mortality. *JAMA* 1998;279:199–205. [PubMed: 9438739]
14. Gruson KI, Aharonoff GB, Egol KA, et al. The relationship between admission hemoglobin level and outcome after hip fracture. *J Orthop Trauma* 2002;16:39–44. [PubMed: 11782632]
15. Khuri SF, Daley J, Henderson W, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *J Am Coll Surg* 1997;185:315–327. [PubMed: 9328380]
16. Halm EA, Wang JJ, Boockvar K, et al. Effects of blood transfusion on clinical and functional outcomes in patients with hip fracture. *Transfusion* 2003;43:1358–1365. [PubMed: 14507265]
17. Feagan BG, Wong CJ, Lau CY, et al. Transfusion practice in elective orthopaedic surgery. *Transfus Med* 2001;11:87–95. [PubMed: 11299025]
18. Odumala AO, Ayekoloye CI, Packer G. Predictors of excessive blood loss during operative treatment of hip fractures. *J R Coll Surg Edinb* 2002;47:552–556. [PubMed: 12109609]
19. Borders JC, Eisele DW, Lyles CA. Diagnostic blood loss in the patient undergoing head and neck surgery. *Arch Otolaryngol Head Neck Surg* 1994;120:707–710. [PubMed: 8018321]
20. Howe C, Paschall C, Panwalker A, et al. A model for clinical estimation of perioperative hemorrhage. *Clin Appl Thromb Hemost* 2003;9:131–135. [PubMed: 12812382]
21. Smoller BR, Kruskall MS. Phlebotomy for diagnostic laboratory tests in adults. Patterns of use and effect on transfusion requirements. *N Engl J Med* 1986;314:1233–1235. [PubMed: 3702919]
22. Wisser D, Van Ackern K, Knoll E, et al. Blood loss from laboratory tests. *Clin Chem* 2003;49:1651–1655. [PubMed: 14500590]
23. Carson JL, Hill S, Carless P, et al. Transfusion triggers: a systematic review of the literature. *Transfus Med Rev* 2002;16:187–199. [PubMed: 12075558]
24. Calder L, Hebert PC, Carter AO, et al. Review of published recommendations and guidelines for the transfusion of allogenic red blood cells and plasma. *Can Med Assoc J* 1997;156:S1–S8. [PubMed: 9347786]
25. Morrison RS, Magaziner J, Gilbert M, et al. Pain and delirium in elderly hip fracture patients. *J Gen Intern Med* 2000;15(suppl):84. [PubMed: 10672110]
26. Topley E, Fisher M. The illness of trauma. *Br J Clin Practice* 1956;1:770–776.
27. Fortune JB, Feustel PJ, Saifi J, et al. Influence of hematocrit on cardiopulmonary function after acute hemorrhage. *J Trauma* 1987;27:243–249. [PubMed: 3560265]
28. Johnson RG, Thurer RL, Kruskall MS, et al. Comparison of two transfusion strategies after elective operations for myocardial revascularization. *J Thorac Cardiovasc Surg* 1992;104:307–314. [PubMed: 1495291]
29. Weisel RD, Charlesworth DC, Mickleborough LL, et al. Limitations of blood conservation. *J Thorac Cardiovasc Surg* 1984;88:26–38. [PubMed: 6376959]
30. Hebert PC, Wells G, Marshall J, et al. Transfusion requirements in critical care. A pilot study. Canadian Critical Care Trials Group. *JAMA* 1995;273:1439–1444. [PubMed: 7723158]

31. Bush RL, Pevec WC, Holcroft JW. A prospective, randomized trial limiting perioperative red blood cell transfusions in vascular patients. *Am J Surg* 1997;174:143–148. [PubMed: 9293831]
32. Carson JL, Terrin ML, Barton FB, et al. A pilot randomized trial comparing symptomatic vs. hemoglobin-level-driven red blood cell transfusions following hip fracture. *Transfusion* 1998;38:522–529. [PubMed: 9661685]
33. Lotke PA, Barth P, Garino JP, et al. Predonated autologous blood transfusions after total knee arthroplasty: immediate versus delayed administration. *J Arthroplasty* 1999;14:647–650.
34. Bracey AW, Radovancevic R, Riggs SA, et al. Lowering the hemoglobin threshold for transfusion in coronary artery bypass procedures: effect on patient outcome. *Transfusion* 1999;39:1070–1077. [PubMed: 10532600]
35. Hebert PC, Wells G, Blajchman MA, et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators. Canadian Critical Care Trials Group. *N Engl J Med* 1999;340:409–417. [PubMed: 9971864]
36. Vincent JL, Baron JF, Reinhart K, et al. Anemia and blood transfusion in critically ill patients. *JAMA* 2002;288:1499–1507. [PubMed: 12243637]
37. Hannan EL, Magaziner J, Wang JJ, et al. Mortality and locomotion 6 months after hospitalization for hip fracture: risk factors and risk-adjusted hospital outcomes. *JAMA* 2001;285:2736–2742. [PubMed: 11386929]
38. Keeler EB, Kahn KL, Draper D, et al. Changes in sickness at admission following the introduction of the prospective payment system. *JAMA* 1990;264:1962–1968. [PubMed: 2120475]
39. Knaus WA, Draper EA, Wagner DP, et al. APACHE II: a severity of disease classification system. *Crit Care Med* 1985;13:818–829. [PubMed: 3928249]
40. Halm EA, Magaziner J, Hannan EL, et al. Frequency and impact of active clinical issues and new impairments on hospital discharge in patients with hip fracture. *Arch Intern Med* 2003;163:108–113. [PubMed: 12523924]
41. Magaziner J, Zimmerman SI, Gruber-Baldini AL, et al. Proxy reporting in five areas of functional status. Comparison with self-reports and observations of performance. *Am J Epidemiol* 1997;146:418–428. [PubMed: 9290502]
42. Magaziner J, Simonsick EM, Kashner TM, et al. Patient-proxy response comparability on measures of patient health and functional status. *J Clin Epidemiol* 1988;41:1065–1074. [PubMed: 3204417]
43. Granger C. *Guide for the Use of the Uniform Data Set for Medical Rehabilitation* Buffalo, NY: Research Foundation, State University of New York; 1987.
44. Heinemann AW, Linacre JM, Wright BD, et al. Relationships between impairment and physical disability as measured by the functional independence measure. *Arch Phys Med Rehabil* 1993;74:566–573. [PubMed: 8503745]
45. Stoltzfus RJ, Dreyfuss ML. *Guidelines for the Use of Iron Supplementation to Prevent and Treat Iron Deficiency Anemia* Geneva, Switzerland: World Health Organization; 1998.
46. Boockvar K, Halm EA, Litke A, et al. Hospital readmission after hospital discharge for hip fracture: surgical and non-surgical causes of effect on outcomes. *J Am Geriatric Soc* 2003;51:399–403.

FIGURE 1.
Hemoglobin values during hip fracture hospitalization (g/dL).

TABLE 1
 Characteristics of 550 Patients Hospitalized With Hip Fracture

Patient Characteristics	N (%)
Age, yrs	81.9 ± 8.8 (range 52–105)
<75	104 (18.9)
75–84	204 (37.0)
≥85	243 (44.1)
Female	449 (81.5)
White race	505 (91.6)
Use of long-term care services	
Nursing home	66 (11.9)
Paid helper in home	196 (35.6)
Neither of the above	289 (52.4)
Prefracture locomotion	
Independent or used device	275 (49.9)
Used personal assistance	276 (50.1)
Dementia	137 (24.9)
Type of fracture	
Femoral neck	270 (49.0)
Intertrochanteric	274 (49.7)
Subtrochanteric	7 (1.3)
Type of procedure	
Open reduction and internal fixation	355 (64.6)
Hemiarthroplasty	163 (29.6)
Closed reduction	21 (3.8)
Other	11 (1.9)
RAND comorbidity score	2.3 ± 2.2
APACHE score	2.7 ± 2.2

TABLE 2

Hemoglobin on Admission and Clinical Outcomes

Hemoglobin (g/dL)	No. (%)	Death (n = 21) (%)	Readmission (n = 93) (%)	Mobility Score (n = 459)	Length of Stay (days) (n = 549)
<9.0	16 (2.9)	3 (18.8)	6 (37.5)	4.8	16.4
9.0–9.9	26 (4.7)	2 (7.7)	6 (23.1)	5.8	7.8
10.0–10.9	67 (12.2)	4 (6.0)	11 (16.4)	7.0	9.5
11.0–11.9	113 (20.5)	4 (3.5)	23 (20.4)	5.9	8.3
≥12.0	328 (59.5)	8 (2.4)	47 (14.3)	6.8	8.2
P value		0.001	0.02	0.04	0.02

The initial hemoglobin was missing for one patient. P values for dichotomous outcomes are for a test for trend, and for the mobility score the Wilcoxon rank sum test.

TABLE 3

Associations Among Hemoglobin Measurements and Clinical Outcomes

	Death (n = 548)	Readmission (n = 548)	Mobility Score (n = 457)	Length of Stay (n = 548)
Hemoglobin value				
Admission	OR (95% CI)	OR (95% CI)	β coefficient (95% CI)	β coefficient (95% CI)
Unadjusted	0.72 (0.56–0.93)[‡]	0.86 (0.75–0.98)[§]	0.26 (0.053–0.48)[§]	–0.42 (–0.73–0.09)[‡]
Adjusted*	0.69 (0.49–0.95)[§]	0.86 (0.73–1.00)[§]	0.05 (–0.15–0.25)	–0.40 (–0.71–0.10)[¶]
Lowest Preoperative				
Unadjusted	0.69 (0.55–0.88)[‡]	0.85 (0.75–0.96)[‡]	0.36 (0.13–0.58)[‡]	–0.84 (–1.14–0.55)[¶]
Adjusted*	0.65 (0.48–0.89)[‡]	0.86 (0.74–1.00)[§]	0.05 (–0.15–0.24)	–0.76 (–1.04–0.47)[¶]
Lowest Postoperative				
Unadjusted	0.94 (0.70–1.26)	0.85 (0.73–0.99)[§]	0.36 (0.13–0.58)[‡]	–0.97 (–1.31–0.63)[¶]
Adjusted [†]	1.29 (0.86–1.94)	0.78 (0.64–0.95)[‡]	0.15 (–0.09–0.38)	–0.76 (–1.68–0.35)[¶]

Odds ratios are per 1 g/dL change in hemoglobin.

Bolded OR and CI are significant at the $P < 0.05$ level.

Two patients were excluded from the multivariable models because of missing data regarding relevant covariates.

* Adjusted for prefracture characteristics (mobility, age, gender, nursing home resident, dementia, and paid help at home), clinical status on admission (RAND comorbidity index, APACHE score), discharge status (DNR, active clinical issues and new impairments on discharge) and blood transfusion. The c statistic for the mortality model c = 0.85 and readmission c = 0.68. The R^2 was 0.35 for the mobility model and 0.16 for length of stay.

[‡] Adjusted for prefracture characteristics (mobility, age, gender, nursing home resident, dementia, and paid help at home), clinical status on admission (RAND comorbidity index, APACHE score), discharge status (DNR, active clinical issues and new impairments on discharge), and postoperative blood transfusion. The c statistic for the mortality model c = 0.85 and readmissions c = 0.68. The R^2 was 0.36 for the mobility model and 0.16 for length of stay.

[‡] $P < 0.01$;

[§] $P < 0.05$;

[¶] $P < 0.001$.

OR, odds ratio; CI, confidence intervals.