Factors affecting the need of postoperative blood transfusion in elderly patients with intertrochanteric hip fracture

Myung-Rae Cho¹, Young-Jae Cho¹ and Suk-Kyoon Song¹
¹Daegu Catholic University Medical Center, Daegu, Korea

Abstract
Introduction: We investigated the risk factors that increased the frequency of blood transfusions in elderly patients with intertrochanteric hip fractures to determine blood transfusion risk before surgery and to take selective precautionary measures in the group at high risk for transfusion to ensure safe surgery.

Materials and methods: We retrospectively reviewed the electronic medical records of 203 patients who underwent surgical fixation of intertrochanteric hip fractures from January 2015 to December 2020. We hypothesized that patient sex, age, body mass index, preoperative hemoglobin, preoperative platelet count, glomerular filtration rate (GFR), preoperative albumin level, American Society of Anesthesiologist score, intraoperative blood loss, duration of surgery, method of anesthesia, and time from injury to surgery would affect the need for blood transfusion. Student’s t-test, Chi-squared test, and the one-way analysis of variance test were used to determine whether differences between variables in the transfusion and non-transfusion groups were significant.

Results: Unstable fractures (P = 0.002), general anesthesia (P = 0.028), lower preoperative hemoglobin levels (P < 0.001), and lower GFRs (P < 0.001) were identified as related to blood transfusions in univariate analysis. In multivariate logistic analysis, the need for allogeneic blood transfusion in unstable fractures was approximately 2.949 times higher than in stable fractures (P = 0.009). The risk in general anesthesia patients was about 2.953 times higher than in spinal anesthesia patients (P = 0.007). In addition, the need for allogeneic blood transfusion increased by about 1.293 times as preoperative hemoglobin levels decreased by 1 g/dL (P = 0.017) and increased by about 1.017 times as the GFR decreased by 1 mL/min/1.7 m² (P = 0.006).

Corresponding author:
Suk-Kyoon Song, Daegu Catholic University Medical Center, 42472 33, Duryugongwon-ro 17-gil, Nam-gu, Daegu, Korea.
Email: ryansong10@naver.com
Conclusion: Low preoperative hemoglobin levels, low GFRs, general anesthesia, and unstable fractures in elderly patients with intertrochanteric hip fractures increased the risk of blood transfusion.

Keywords
Hip, fracture, blood, transfusion, risk factor

Introduction

The incidence of intertrochanteric hip fractures in elderly people has increased annually recently due to extended life expectancy and the increased number of elderly patients with osteoporosis.\(^1\) Despite the advances in internal fixation devices and surgical techniques, intertrochanteric hip fractures are still associated with a high frequency of transfusions.\(^2\) Allogeneic blood transmission is essential for hemodynamic stability, but it can cause hematogenic infection, deep vein thrombosis, impairment in coagulation status, and immunosuppression after surgery, which may increase mortality and morbidity in patients with intertrochanteric hip fractures.\(^3\)–\(^6\) For this reason, surgeons are trying to reduce the frequency of allogeneic blood transfusions by treatment strategies such as autologous transfusion, erythropoietin, tranexamic acid, and iron supplementation before surgery.\(^7\)–\(^12\) As a result, the frequency of allogeneic transfusions after surgery has steadily decreased. However, these strategies are difficult to apply to all patients in terms of cost-effectiveness. Therefore, we conducted this study to evaluate the risk factors that increased the frequency of blood transfusions in patients with intertrochanteric hip fractures to determine the risk before surgery and to take selective precautionary measures in the high-risk transfusion group so that surgery can be performed safely.

Materials and methods

Patient population

We conducted a retrospective study of patients who underwent surgical fixation of their intertrochanteric fracture by a single surgeon in our hospital from January 2015 to December 2020. Of 335 patients who had surgery from 2015 to 2020, 203 patients were included in the study. Patients with multiple fractures, gastrointestinal bleeding, those taking antithrombotic agents, who had blood transfusions before and during surgery, and those who underwent surgery more than one week after injury were excluded (Figure 1).

Surgical techniques

Among 203 subjects, 44 subjects with stable fractures were managed with a dynamic hip screw (DHS) (4CIS CHS System®; Solco Inc., Pyeongtaek, Korea), and 159 subjects with unstable fractures were managed with a DHS with an additional trochanteric stabilization plate (TSP) (Figure 2). The type of hip fracture (stable/unstable) was documented based on a review of preoperative and postoperative radiographs. An unstable fracture was defined by satisfying the criteria of Gargan et al.\(^13\) (four-part fracture, medial cortical comminution, reverse obliquity, subtrochanteric extension, and large posterior trochanteric fragment). The direct lateral approach was used in all cases. A lag screw was inserted...
Figure 1. Flow chart of the patients.

Figure 2. Radiographic hip images.
Plain radiographs obtained at our emergency department show a stable intertrochanteric fracture (A) and dynamic hip screw (DHS) taken the day after surgery (B) and unstable intertrochanteric fracture (C) and DHS with an additional trochanteric stabilization plate (TSP) taken the day after surgery (D).
in the center of the femoral head, if possible, or was inserted on the posteroinferior side of
the femoral head under C-arm fluoroscopic guidance in the anteroposterior and lateral
views. Additional wiring was applied at the surgeon’s discretion.

**Blood transfusion analysis**

We hypothesized that patient sex, age, body mass index (BMI), preoperative hemoglobin,
preoperative platelet count, GFR, preoperative albumin level, American Society of
Anesthesiologist (ASA) score, intraoperative blood loss, duration of surgery, method of anes-
thesia, and time from injury to surgery would affect the need for blood transfusion. These
factors were collected from the electronic medical records, and fracture type (stable/unstable)
was determined before surgery using a picture archiving and communication system. We
counted blood transfusions within three days of surgery. Patients received allogeneic concen-
trated red blood cell transfusions when their hemoglobin level was less than 8 g/dL or they
had symptoms of anemia such as dizziness, chest pain, tachycardia, and persistent hypoten-
sion within three days of surgery.14–16 In all patients, thromboembolic prophylaxis was deliv-
ered through a pneumatic pump throughout the hospitalization period.

**Statistical analysis**

All analyses were performed with IBM SPSS version 19.0 software (SPSS Inc., Chicago, IL,
USA) for windows. We used the Student’s t-test for continuous variables and the Chi-squared
test for categorical variables. The one-way analysis of variance test was used for categorical vari-
ables when more than two categories were used to determine whether the difference between
variables in the transfusion and non-transfusion groups was significant. A P-value of less than
or equal to 0.05 was considered to indicate statistical significance. A logistic regression analysis
was used to assess the relative contributions of patient factors to the frequency of transfusion.

**Ethical statement**

This trial was conducted with approval from the Institutional Review Board (IRB) of
Daegu Catholic University Medical Center (approval number: CR-21-020) and con-
ducted in accordance with local ethical guidelines. A Waiver of Documentation of
Consent was granted by the IRB because this was a retrospective study based on
medical records and the data obtained were protected in secured storage. This study
also has no possibility of benefitting or harming the involved patients.

**Results**

**Demographic characteristics**

Patient basic characteristics, including transfusion rates, are presented in Table 1. The
average age of the patients was 78.9 years old, with a total of 156 women (mean, 80.7
years old) and 47 men (mean, 74.5 years old). The mean preoperative hemoglobin
level was 10.8 g/dL, the preoperative platelet count was 208,000/µL, the albumin level
was 3.8 g/dL, and the GFR was 73.4 mL/min/1.7 m². Thirty-nine patients had general anesthesia and 164 had spinal anesthesia. There were 44 stable fractures (21.7%) and 159 unstable fractures (78.3%). The mean intraoperative blood loss volume was 143.2 mL. The mean duration of surgery was 60.3 min and the time from injury to surgery was 97.9 h. Ninety-three subjects (45.8%) had blood transfusions after surgery.

### Univariate analysis

Unstable fractures \((P = 0.002)\), general anesthesia \((P = 0.028)\), lower preoperative hemoglobin levels \((P < 0.001)\), and lower GFRs \((P < 0.001)\) were identified as related to blood transfusions in univariate analysis.

Age \((P = 0.447)\), sex \((P = 0.109)\), BMI \((P = 0.323)\), preoperative platelet count \((P = 0.906)\), preoperative albumin level \((P = 0.905)\), ASA score \((P = 0.090)\), intraoperative blood loss \((P = 0.378)\), duration of surgery \((P = 0.093)\), and time from injury to surgery \((P = 0.206)\) were not statistically significant.

### Multivariate logistic analysis

The need for allogeneic transfusion was significantly associated with unstable fractures in the multivariate logistic analysis and the risk was approximately 2.949 times higher than in patients with stable fractures \((P = 0.009)\). In general anesthesia patients, the transfusion risk was about 2.953 times higher than in spinal anesthesia patients \((P = 0.007)\). The need for allogeneic transfusion was increased by about 1.293 times for preoperative

### Table 1. Basic characteristics of all participants.

| Variable                  | N = 203 |
|---------------------------|---------|
| Age (years)               | 78.9 ± 7.7 |
| Body Mass Index (m/kg²)   | 21.4 ± 3.1 |
| Sex (F/M)                 | 156/47  |
| Preoperative hemoglobin (g/dL) | 10.8 ± 1.6 |
| Preoperative platelet (k) | 208 ± 91 |
| Preoperative albumin      | 3.8 ± 0.8 |
| GFR (mL/min/1.7m²)        | 73.4 ± 27.8 |
| Anesthesia                |         |
| General                   | 39 (19.2%) |
| Spinal                    | 164 (80.8%) |
| Fracture type             |         |
| Stable                    | 44 (21.7%) |
| Unstable                  | 159 (78.3%) |
| intraoperative blood loss (ml) | 143.2 ± 18.9 |
| duration of surgery (minutes) | 60.3 ± 15.8 |
| time from injury to operation (hours) | 97.9 ± 26.8 |
| Transfusion rate (%)      | 93 (45.8%) |

Abbreviation: N = number, F = female, M = male, GFR = glomerular filtration rate.
hemoglobin decreases of 1 g/dL ($P = 0.017$) and increased by about 1.017 times for GFR decreases of 1 mL/min/1.7m$^2$ ($P = 0.006$) (Table 2).

**Table 2.** Multiple variables logistic regression analysis between transfusion group and non-transfusion group.

| Variable                        | Adjusted OR (95% CI)         | P value |
|---------------------------------|------------------------------|---------|
| unstable fractures              | 2.949 (1.312/6.623)          | 0.009*  |
| general anesthesia              | 2.953 (1.347/6.478)          | 0.007*  |
| preoperative hemoglobin (g/dl)  | 1.293 (1.048/1.596)          | 0.017*  |
| GFR (ml/min/1.7m$^2$)           | 1.017 (1.005/1.029)          | 0.006*  |

Abbreviation: OR = odds ratio, CI = confidence interval, GFR = glomerular filtration rate.

*P value less than or equal to 0.05 was considered to indicate statistical significance.

Discussion

In elderly patients with intertrochanteric fractures, complications such as cardiovascular and pulmonary complications, infections, bleeding, and thrombosis can lead to death. In particular, perioperative anemia caused by bleeding from these fractures is a common complication and is highly associated with mortality,17,18 so surgeons want to address anemia with blood transfusions. Several studies have reported that the frequency of peri-operative allogeneic blood transfusions in patients with senile hip fractures was 30 to 70%.19,20 In elderly patients with intertrochanteric fractures, many factors can affect blood transfusion frequency, and not many studies have systematically studied the risk factors for blood transfusion. Therefore, we conducted this study to predict high-risk patients by retrospectively evaluating the blood transfusion risk of patients after osteosynthesis using a DHS in elderly patients with intertrochanteric fractures.

In our study, among numerous factors, preoperative hemoglobin levels, GFRs, anesthesia methods, and fracture types (stable/unstable) were shown to be associated with the frequency of transfusion.

Several studies have already shown that the lower the preoperative hemoglobin level, the higher the frequency of transfusions.21–23 Our study found statistically significant differences in preoperative hemoglobin levels in patients receiving postoperative blood transfusions (10.36 ± 1.51 g/dL) and in patients without blood transfusions (11.26 ± 1.53 g/dL) ($P < 0.001$). In multivariate logistic analysis, the risk of transfusion increased by about 29% when the preoperative hemoglobin level decreased by 1 g/dL ($P = 0.017$).

The study also found that the lower the GFR level, the higher the frequency of transfusions. Lejus et al.24 found that moderate-to-severe renal impairment (GFR < 60) was 2.35 times higher in patients with frequent transfusions when calculated using the Modification of Diet in Renal Disease (MDRD) equation.25 In our study, as GFR decreased by 1 mL/min/1.7 m$^2$, the need for allogeneic transfusion increased by about 1.017 times ($P = 0.017$). This was associated with an increased risk of bleeding by hemostatic abnormalities due to platelet dysfunction, the impaired release of tissue plasminogen activator (tPA), increased plasminogen activator inhibitor-1, elevated fibrinogen and D-dimer, and increased TF/Factor VIIa ratios in patients with chronic renal impairment.26
In orthopedic surgery, it is generally reported that regional anesthesia can reduce the requirement for blood transfusion compared to general anesthesia. A comparative study of hip fracture patients by Fields et al. recently reported that regional anesthesia could reduce the frequency of transfusions compared to general anesthesia, suggesting that regional anesthesia is advantageous in older patients with hip fractures. Regional anesthesia is considered to lower regional arterial and venous flow pressure, causing less bleeding and thus, requiring less transfused blood. In this study, the risk of transfusion in general anesthesia patients was about 2.953 times higher than in spinal anesthesia patients, which was statistically significant ($P = 0.007$). In general, anesthesia methods in surgery for elderly patients with hip fractures are mostly determined by the patient’s co-morbidities, surgeon preferences, and the ability of anesthesiologists. However, based on this study, spinal anesthesia was considered to have a significant advantage in reducing the frequency of transfusions.

There were several limitations to this study. First, the results could be affected by excluding the group of patients who received blood transfusions before and during surgery. In our study, we wanted to determine the frequency of postoperative blood transfusions, and it was not expected to have a significant impact because few patients received blood transfusions before and during surgery. Second, the transfusion risk was higher in patients with unstable fractures than in those with stable fractures. It was unclear whether the fracture type influenced it or whether the treatment methods (DHS versus DHS with a TSP) affected it. However, since fixing with a DHS and TSP is a currently established rationale for unstable fractures, it can be concluded that the risk differed depending on the fracture type. Third, although proximal femoral nails have been more widely used in the treatment of unstable intertrochanteric fractures, DHSs and TSPs were used in this study. The surgeon in this study still advocates for the DHS fixation method, which has many advantages. Also, the DHS fixation method is familiar to the operator, which he uses for most intertrochanteric fractures.

This study found that low preoperative hemoglobin levels, low GFRs, general anesthesia, and unstable fractures in elderly patients with intertrochanteric fractures increased the risk of blood transfusion. In conclusion, our study evaluated the risk factors that affected the blood transfusion rate of patients with intertrochanteric hip fractures, which can enable the use of selective, preoperative precautionary measures for patients with these risk factors.

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD
Suk-Kyoon Song https://orcid.org/0000-0002-3241-5820
References

1. Lee Y-K, Kim JW, Lee MH, et al. Trend in the age-adjusted incidence of hip fractures in South Korea: systematic review. Clin Orthop Surg 2017; 9: 420.
2. Foss NB and Kehlet H. Hidden blood loss after surgery for hip fracture. J Bone Joint Surg Br 2006; 88: 1053–1059.
3. Carson J, Altman D, Duff A, et al. Risk of bacterial infection associated with allogeneic blood transfusion among patients undergoing hip fracture repair. Transfusion 1999; 39: 694–700.
4. Nielsen H. Detrimental effects of perioperative blood transfusion. Br J Surg 1995; 82: 582–587.
5. Hill GE, Frawley WH, Griffith KE, et al. Allogeneic blood transfusion increases the risk of postoperative bacterial infection: a meta-analysis. J Trauma 2003; 54: 908–914.
6. Koval KJ, Rosenberg AD, Zuckerman JD, et al. Does blood transfusion increase the risk of infection after hip fracture? J Orthop Trauma 1997; 11: 260–265.
7. Vassallo R, Goldman M, Germain M, et al. Preoperative autologous blood donation: waning indications in an era of improved blood safety. Transfus Med Rev 2015; 29: 268–275.
8. Goodnough LT and Merkel K. Parenteral iron and recombinant human erythropoietin therapy to stimulate erythropoiesis in patients undergoing repair of hip fracture. Hematology 1996; 1: 163–166.
9. Mohib Y, Rashid RH, Ali M, et al. Does tranexamic acid reduce blood transfusion following surgery for inter-trochanteric fracture? A randomized control trial. J Pak Med Assoc 2015; 65: S17.
10. Gausden EB, Garner MR, Warner SJ, et al. Tranexamic acid in hip fracture patients: a protocol for a randomised, placebo controlled trial on the efficacy of tranexamic acid in reducing blood loss in hip fracture patients. BMJ Open 2016; 6: e010676.
11. Yoon B-H, Lee BS, Won H, et al. Preoperative iron supplementation and restrictive transfusion strategy in hip fracture surgery. Clin Orthop Surgery 2019; 11: 265.
12. Carson JL, Stanworth SJ, Roubinian N, et al. Transfusion thresholds and other strategies for guiding allogeneic red blood cell transfusion. Cochrane Database Syst Rev 2016; 10: CD002042.
13. Gargan M, Gundle R and Simpson A. How effective are osteotomies for unstable intertrochanteric fractures? J Bone Joint Surg Br 1994; 76: 789–792.
14. Carson JL, Sieber F, Cook DR, et al. Liberal versus restrictive blood transfusion strategy: 3-year survival and cause of death results from the FOCUS randomised controlled trial. Lancet 2015; 385: 1183–1189.
15. Carson JL, Terrin ML, Noveck H, et al. Liberal or restrictive transfusion in high-risk patients after hip surgery. N Engl J Med 2011; 365: 2453–2462.
16. Nuttall GA, Brost BC, Connis RT, et al. Practice guidelines for perioperative blood transfusion and adjuvant therapies: an updated report by the American society of anesthesiologists task force on perioperative blood transfusion and adjuvant therapies. Anesthesiology 2006; 105: 198–208.
17. Gregersen M, Borris LC and Damsgaard EM. Postoperative blood transfusion strategy in frail, anemic elderly patients with hip fracture: the TRIFE randomized controlled trial. Acta Orthop 2015; 86: 363–372.
18. Zhang L, Yin P, Lv H, et al. Anemia on admission is an independent predictor of long-term mortality in hip fracture population: a prospective study with 2-year follow-up. Medicine (Baltimore) 2016; 95: e2469.
19. Johnston P, Wynn-Jones H, Chakravarty D, et al. Is perioperative blood transfusion a risk factor for mortality or infection after hip fracture? J Orthop Trauma 2006; 20: 675–679.
20. Foss NB, Kristensen MT, Jensen PS, et al. The effects of liberal versus restrictive transfusion thresholds on ambulation after hip fracture surgery. *Transfusion* 2009; 49: 227–234.
21. Desai SJ, Wood KS, Marsh J, et al. Factors affecting transfusion requirement after hip fracture: can we reduce the need for blood? *Can J Surg* 2014; 57: 342.
22. Adunsky A, Lichtenstein A, Mizrahi E, et al. Blood transfusion requirements in elderly hip fracture patients. *Arch Gerontol Geriatr* 2003; 36: 75–81.
23. Dillon MF, Collins D, Rice J, et al. Preoperative characteristics identify patients with hip fractures at risk of transfusion. *Clin Orthop Relat Res* 2005; 439: 201–206.
24. Lejus C, Desdoits A, Lambert C, et al. Preoperative moderate renal impairment is an independent risk factor of transfusion in elderly patients undergoing hip fracture surgery and receiving low-molecular-weight heparin for thromboprophylaxis. *J Clin Anesth* 2012; 24: 378–384.
25. Kopple JD. National kidney foundation K/DOQI clinical practice guidelines for nutrition in chronic renal failure. *Am J Kidney Dis* 2001; 37: S66–S70.
26. Jalal DI, Chonchol M and Targher G. Disorders of hemostasis associated with chronic kidney disease. Paper presented at: Seminars in thrombosis and hemostasis 2010.
27. Rashiq S and Finegan BA. The effect of spinal anesthesia on blood transfusion rate in total joint arthroplasty. *Can J Surg* 2006; 49: 391.
28. Hu S, Zhang Z-Y, Hua Y-Q, et al. A comparison of regional and general anaesthesia for total replacement of the hip or knee: a meta-analysis. *J Bone Joint Surg Br* 2009; 91: 935–942.
29. Pugely AJ, Martin CT, Gao Y, et al. Differences in short-term complications between spinal and general anesthesia for primary total knee arthroplasty. *J Bone Joint Surg Am* 2013; 95: 193–199.
30. Fields AC, Dieterich JD, Buterbaugh K, et al. Short-term complications in hip fracture surgery using spinal versus general anaesthesia. *Injury* 2015; 46: 719–723.

**Author biographies**

**Myung-Rae Cho** is Professor Orthopaedics at Daegu Catholic University. He received his MD from Kyungpook National University, school of medicine and received his master’s degree and PhD in Orthopedics from Kyungpook National University. He has published widely on Arthroplasty, Hip and Pelvic fracture.

**Young-Jae Cho** is resident at Daegu Catholic University. He received his MD from Chonbuk National University School of Medicine.

**Suk-Kyoon Song** is an Assistant Professor of Orthopaedics at Daegu Catholic University. He received his MD from Daegu Catholic University, school of medicine and received his master’s degree in medicine from Kyungpook National University, school of medicine, and undergoing PhD in Orthopedics from Daegu Catholic University. He has published widely on Arthroplasty, Hip and Pelvic fracture, Osteoporosis and Sarcopenia.