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Journal of Hematology & Thromboembolic Diseases

Research Article

Perioperative Blood Loss Factors Associated with Decreased Level of Postoperative Hemoglobin in Stable Femoral Pertrochanteric Fracture Groups Treated with Proximal Femoral Nail Antirotation (PFNA)

Filip Mazurczak*, Ignacy Eukasiewicz, Tomasz Pardała

Department of Medicine and Health Sciences, Andrzej Frycz Modrzewski Krakow University, Kraków, Poland

ABSTRACT

Aim: The purpose of this analysis was to compare simple Pertrochanteric Fractures (PTFs) AO31-A1.2 and PTFs with the detachment of lesser trochanter AO31-A1.3 along with the risk factors of perioperative blood loss in terms of their impact on postoperative level of hemoglobin.

Methods: This study analysed the clinical data of 334 unilateral, stable PTFs classified as AO31-A1.2 (205 cases) and AO31-A1.3 (129 cases) treated with Proximal Femoral Nail Antirotation (PFNA). First postoperative level of hemoglobin and hemoglobin drop (difference between first on admission to hospital and first postoperative hemoglobin levels) were chosen as the principal outcome. Analyzed patients were not transfused between hemoglobin measurements. Multivariate linear regression analysis was performed to study perioperative blood loss risk factors in patients undergoing surgery.

Results: Pertrochanteric fractures with the detachment of lesser trochanter (AO31-A1.3) are associated with both greater hemoglobin drop (p=0.011) and lower postoperative hemoglobin level (p=0.078). AO31-A1.3 type of fracture is also correlated with greater risk of postoperative blood transfusion (p=0.038). Female were associated with lower postoperative hemoglobin than men irrespective of the type of fracture (9.31 g/dl *vs.* 10.1 g/dl; p<0.0001). Multi linear regression analysis showed that age, gender, type of fracture, fracture gap displacement, preoperative level of hemoglobin and angle of the fracture gap significantly affect postoperative level of hemoglobin.

Conclusion: Despite being recognized as stable PTF with the detachment of lesser trochanter (AO31-A1.3) is burdened with greater risk of postoperative anemia and blood transfusion than simple PTF (AO31-A1.2). Fracture gap displacement and angle of fracture gap are useful predictors for lower level of postoperative hemoglobin.

Keywords: AO classification; Pertrochanteric fractures; Postoperative hemoglobin; Hemoglobin drop; Stable fractures

INTRODUCTION

As the elderly population is soaring, so is the number of fragility hip fractures, which has been estimated to reach 4.5 million by the year 2050 [1]. In the 65-and-older population group, PTFs comprise 42% of all hip fractures [2]. PTFs constitute also more than 75% of all extracapsular hip fractures [3]. Intracapsular fractures are known to cause less bleeding, mostly because the restricted area of articular capsule within blood can extravasate [4].

These fractures can be treated successfully either with intramedullary (Gamma nail, PFNA) or extramedullary (DHS) fixation. Recently developed low-invasive device PFNA poses lower risk of blood loss in comparison to the implementation of DHS and Gamma nail [5,6]. Regardless of surgical strategy, Hemoglobin Drop (HbD) during surgery is inevitable. Higher blood loss is associated with greater mortality and poorer functional recovery after hip surgery [7]. Additionally, higher blood loss is correlated with higher rate of allogenic blood transfusions, which may generate procedure-related complications such as infections and supplementary costs [8]. In regard of the fact the increased mortality among patients suffering from hip fractures, previous attempts have strived to establish the protocol for hip fracture management [9]. However, closer

Correspondence to: Filip Mazurczak, Department of Medicine and Health Sciences, Andrzej Frycz Modrzewski Krakow University, Kraków, Poland, E-mail: Mazurczak.filip@gamil.com

Received: 07-Oct-2022, Manuscript No. JHTD-22-19481; **Editor assigned:** 10-Oct-2022, Pre Qc No. JHTD-22-19481 (PQ); **Reviewed:** 24-Oct-2022, Qc No. JHTD-22-19481; **Revised:** 31-Oct-2022, Manuscript No. JHTD-22-19481 (R); **Published:** 07-Nov-2022, DOI:10.35248/2329-8790.22.10.504.

Citation: Mazurczak F, Eukasiewicz I, Pardała T (2022) Perioperative Blood Loss Factors Associated with Decreased Level of Postoperative Hemoglobin in Stable Femoral Pertrochanteric Fracture Groups Treated with Proximal Femoral Nail Antirotation (PFNA). J Hematol Thrombo Dis.10:504.

investigation of the phenomenon of HbD as the vital factor affecting overall mortality was neglected in the trials. In recent years a few risk factors (sex, type of fracture, hemoglobin on admission, the use of anticoagulants, longer duration of surgery) have been correlated with an increased need for perioperative blood transfusions [10,11]. The correlation between type of fracture and blood transfusion was further expanded into presurgical blood transfusion promptness due to greater HbD in unstable fracture group [12]. However, no detailed data indicates the impact of the particular type of fracture regarding Modified AO/OTA 2018 classification was provided. Forasmuch as hemoglobin upon admission and HbD may elevate the risk of mortality and morbidity in patients undergoing the surgery for PTFs, it is essential to predict and prevent postoperative anemia. Therefore, this study was focused on the comparison between simple PTFs AO31-A1.2 and PTFs with the detachment of lesser trochanter AO31-A1.3 along with the risk factors of perioperative blood loss in terms of their impact on postoperative hemoglobin.

MATERIALS AND METHODS

Study population and design

All patients with unilateral PTFs included in this retrospective analysis were treated with PFNA between May 2015 and March 2021. All patients gave informed consent to participate in the study. Inclusion criteria enclosed the presence of unilateral, stable PTFs classified as AO31-A1.2 or AO31-A1.3, PFNA augmentation, blood parameters inspected preoperatively and postoperatively. Exclusion criteria were as follows: bilateral fractures, multiple trauma, different nailing technique, other types of proximal femur fractures, patients transfused before first postoperative blood examination, patients with missing data (Figure 1). In accordance with both the inclusion and exclusion criteria, 334 of the initial 575 patients suffering from proximal femur fractures treated with PFNA were examined at the Department of Traumatology and Orthopaedics.

Pursuant to the medical history, all patients were admitted to the hospital ward on the day of the injury. After a thorough medical inspection patients were subsequently qualified for the surgery. PTFs are known to be of a substantial risk of bleeding, especially among patients with ongoing anticoagulant treatment. Thus, all patients on blood thinners had their therapy withdrawn in line with preoperative anticoagulation management guidelines [13]. Standardized surgery protocol required three doses of intravenous second-generation cephalosporin antibiotic prophylaxis, along with omission of low-molecular-weight heparin thromboprophylaxis on the day of surgery, if introduced preoperatively.

All surgeries were performed under fluoroscopic guidance by two orthopedic surgeons, one of whom was always a senior surgeon. Surgical technique was convergent with manufacturer's directions. Fracture reduction was achieved through a longitudinal traction on a traction table. No drains were introduced. No antifibrinolytic drugs were used.

Data collection

The patients' characteristics were obtained through an electronic medical record system. The following variables were extracted: age, sex, occurrence of blood transfusions, admission to surgery time, operative time, Hb level on admission, first Hb level after surgery. The operative time was measured from the time of skin incision to skin closure. Hemoglobin on admission (Hb0) was the first level of Hb recorded on admission to the hospital, while hemoglobin after surgery (Hb1) was the first level of Hb recorded immediately after the surgery (Figure 2). HbD was calculated by subtracting the level of Hb0 from Hb1.

The preoperative anteroposterior and lateral radiographs of proximal femur fracture were evaluated independently by two of the authors twice. Apart from the allocation of fracture regarding AO classification, angle of fracture gap and the presence of fracture gap displacement were assessed. Angle of the fracture gap was defined by the line connecting lateral and medial split of the cortex and the line perpendicular to anatomic axis of the femur (Figure 3). Fracture gap displacement was defined as any gap visible to the naked eye on AP or lateral radiograph. In case of any discrepancies, a third expert was consulted to reach consensus. No masking was used.

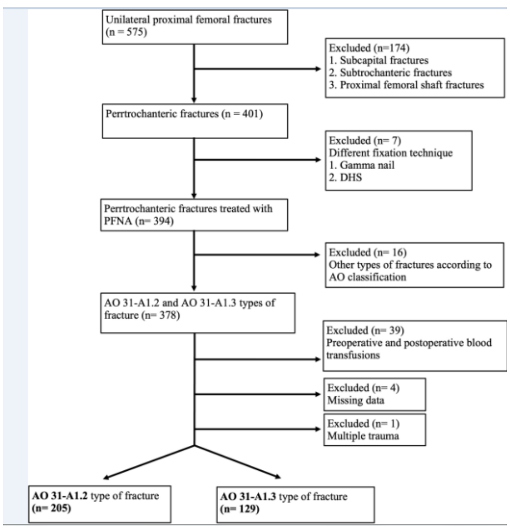

Figure 1: Flow-chart of the fracture selection.

Figure 2: Timeline of medical data and medical activities between admission and discharge from hospital.

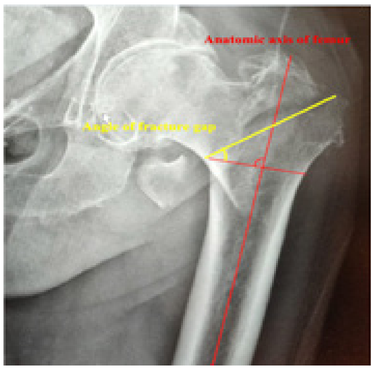

Figure 3: X-ray presenting the way of angle of fracture gap measurement.
Note: Red line: Anatomic axis of femur; Yellow line: Angel of fracture gap.

Statistical analysis

Continuous variables were presented as mean and standard deviation or median and interquartile range. The Shapiro-Wilk test was used to verify the normal distribution of continuous variables. The Mann-Whitney U-test was performed to compare two groups in case of large departures from normal distribution of continuous variables. The Student's t-test were used to compare two groups for normally distributed variables. The Levene's test was applied to assess the homogeneity of variances. The qualitative variables were presented as the number and corresponding percentages. The Fisher's exact test or the chi-squared test was used to compare qualitative variables between the two groups. The predictor of hemoglobin levels after operation was assessed by the multivariable linear regression model. The coefficient of determination for the resulted model was close to 53%. The Durbin-Watson test was used to detect autocorrelation. The significance level for the two-sided tests was assumed to be below 0.05. The package R [14] and Statistica 12.5 software ® (StatSoft Inc., Tulsa, Oklahoma, United States) were used to conduct the analyses.

RESULTS

A total of 334 patients meeting all inclusion criteria were analyzed. Out of the initial 575 patients, we excluded 190 patients recognized with different types of fracture, 7 patients with unlike fixation technique, 39 patients transfused preoperatively or perioperatively, 4 patients with missing data and 1 patient with multiple trauma. Eventually, according to AO classification 205 patients with AO31-A1.2 type of fracture and 129 patients with AO31-A2.1 type of fracture were identified (Figure 1).

The investigated group comprised 247 women (73,9%) and 87 men (26,1%), with median age of 84. The median operative time is 45 minutes. The mean preoperative and postoperative Hb levels for all fractures were 12 g/dl and 9.52 g/dl, respectively. The median interval between admission to hospital and surgery was 10.3 hours, while the median interval between surgery and Hb1 measurement was 14.6 hours.

PTFs with the detachment of lesser trochanter (AO31-A1.3) were associated with both greater HbD (p=0.011) and lower postoperative hemoglobin level (p=0.078) (Figure 4). Those fractures pose also greater risk of postoperative blood transfusion (p=0.038). The presence of the fracture gap displacement was noticed more frequently in the AO31-A1.3 group (p<0.0001) as well as the greater angle of gap fracture (p<0.0001). Patients' characteristic in the reference to type of fracture is shown in Table 1.

On the grounds that the gender of patients was not far from reaching statistical significance (p=0.15), one has decided to formulate similar characteristics, but with regard to the sex of patients (Table 2). As presented, females in the study were significantly older than men (85 *vs.* 80 years; p<0.0001). Both blood transfusion risk (42.9% *vs.* 24.1%; p=0.002) and HbD (2.6 g/dl *vs.* 1.9 g/dl; p<0.0001) were noticibly greater, while the level of postoperative hemoglobin (9.31 g/dl *vs.* 10.1 g/dl; p<0.0001) was considerably lower in women's group compared to men's group (Figure 5).

Multiple linear regression analysis was conducted with the level of postoperative hemoglobin as the dependent variable and perioperative blood loss factors as the independent variables (Table 3). The results indicated that age, gender, type of fracture, preoperative hemoglobin level and angle of fracture gap had affected the postoperative level of hemoglobin (p<0.05). AO31-A1.2 types of fracture presented with 0.33 g/dl lower Hb1 than AO31-A1.3 type holding other predictors constant. The level of postoperative hemoglobin was 0.54 g/dl lower for women whereas others factors were held constant. The presence of fracture dislocation lowered the level of Hb1 by 0.74 g/dl while other independent variables remained unchanged. One unit (1 g/dl) of preoperative hemoglobin (Hb0) developed increase in postoperative level of Hb1 by 0.63 g/dl with others parameters constant. All the changes have been found to be statistically significant.

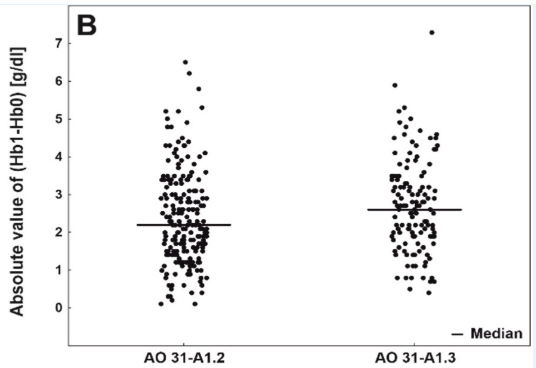

Figure 4: Absolute Hemoglobin Drop (HD) comparison between AO 31-A1.2 and AO 31-A1.3 types of fracture.

Table 1: Patient's characteristic in the reference to type of fracture.

	Overall	AO 31-A1.2	AO 31-A1.3	p-value
	(N=334)	(N=205)	(N=129)	
Age				
Median (Q1, Q3)	84 (77-88)	84 (77-89)	84 (78-88)	0.67
Gender				
Women	247 (74.0%)	146 (71.2%)	101 (78.3%)	0.15
Men	87 (26.0%)	59 (28.8%)	28 (21.7%)	
Blood transfusion				
No	207 (62.0%)	136 (66.3%)	71 (55.0%)	0.038
Yes, post-Hb1	127 (38.0%)	69 (33.7%)	58 (45.0%)	
Duration of surgery (min)				
Median (Q1-Q3)	45 (35-60)	45 (35-60)	45 (35-60)	0.35
Fracture gap displacement				
No	33 (9.9%)	32 (15.6%)	1 (0.8%)	<0.0001
Yes	301 (90.1%)	173 (84.4%)	128 (99.2%)	
Hb0 (g/dl)				
Mean (SD)	12.0 (1.66)	12.0 (1.61)	12.0 (1.75)	0.92
Hb1 (g/dl)				
Mean (SD)	9.52 (1.64)	9.64 (1.69)	9.32 (1.55)	0.078
HbD=|Hb1-Hb0| (g/dl)				
Median (Q1-Q3)	2.3 (1.6-3.3)	2.2 (1.5-3.1)	2.6 (1.9-3.4)	0.011
Angle of the fracture (°)				
Median (Q1-Q3)	52 (44-58)	49 (40-56)	55 (50-60)	<0.0001
Time from admission to surgery (h)				
Median (Q1-Q3)	10.3 (3.8-25.6)	10.3 (4.3-28.1)	9.5 (3.6-22)	0.76
Time from Hb0 to surgery				
Median (Q1-Q3)	9.4 (3.9-21.4)	9.8 (4.1-24.8)	8.6 (3.7-17.4)	0.5
Time from surgery to Hb1				
Median (Q1-Q3)	14.6 (9.9-19.7)	15.1 (10.3-20.7)	13.5 (9.4-18.6)	0.056

Table 2: Patients' characteristic in the reference to gender.

	Overall (N=334)	Women (N=247)	Men (N=87)	p-value
Age				
Median (Q1, Q3)	84 (77-88)	85 (79-89)	80 (67-87)	<0.0001
Type of fracture				
AO 31-A1.2	205 (61.4%)	146 (59.1%)	59 (67.8%)	0.15
AO 31-A1.3	129 (38.6%)	101 (40.9%)	28 (32.2%)	
Blood transfusion				
No	207 (62.0%)	141 (57.1%)	66 (75.9%)	0.002
Yes, post-Hb1	127 (38.0%)	106 (42.9%)	21 (24.1%)	
Duration of surgery (min)				
Median (Q1-Q3)	45 (35, 60)	45 (35, 60)	45 (35-60)	0.92
Fracture gap displacement				
No	33 (9.9%)	24 (9.7%)	9 (10.3%)	0.87
Yes	301 (90.1%)	223 (90.3%)	78 (89.7%)	
Hb0 (g/dl)				
Mean (SD)	12.0 (1.66)	11.9 (1.65)	12.1 (1.69)	0.54
Hb1 (g/dl)				
Mean (SD)	9.52 (1.64)	9.31 (1.62)	10.1 (1.59)	0.0001
HbD=|Hb1-Hb0| (g/dl)				
Median (Q1-Q3)	2.3 (1.6-3.3)	2.6 (1.7-3.4)	1.9 (1.3-2.8)	<0.0001
Angle of the fracture (°)				
Median (Q1-Q3)	52 (44-58)	52 (44-59)	52 (44-58)	0.64
Time from admission to surgery (h)				
Median (Q1-Q3)	10.3 (3.8-25.6)	9.5 (3.6-22.1)	15.1 (4.5-43.3)	0.032
Time from Hb0 to surgery				
Median (Q1-Q3)	9.4 (3.9-21.4)	8.6 (3.7-19.9)	12.1 (4.3-31.2)	0.098
Time from surgery to Hb1				
Median (Q1-Q3)	14.6 (9.9-19.7)	14.7 (9.6-19.9)	14.2 (10.2-19.5)	0.6

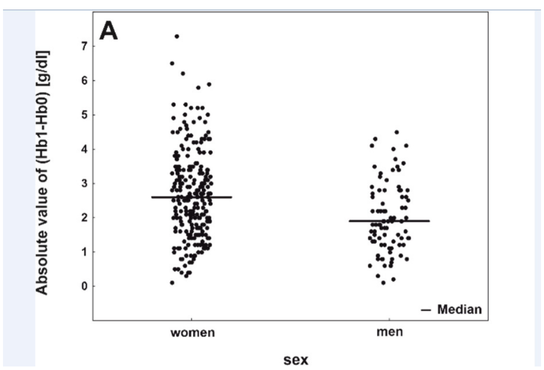

Figure 5: Absolute Hemoglobin Drop (HD) comparison in reference to the sex of patients.

Table 3: Multivariable linear regression model.

Parameter	Regression coefficient	p-value
Age (years)	-0.02	0.007
Gender (men)	0.54	0.0003
Duration of surgery (min)	0.0003	0.9
Type of fracture (AO 31-A1.3)	-0.33	0.016
Fracture gap Displacement (yes)	-0.74	0.0006
Hb0 (g/dl)	0.63	<0.0001
Angle of the fracture (°)	0.02	0.0009

DISCUSSION

The results of the present study has confirmed greater HbD (median 2,6 *vs.* 2,2 g/dl, p=0.011) and the higher percentage of postoperative blood transfusions (p=0.038) in PTFs with the detachment of lesser trochanter (AO31-A1.3) than in simple PTFs (AO31-A1.2). Both types of investigated PTFs (AO31-A1.2, AO31-A1.3) are generally considered stable [2].

Additionally, the analysis has demonstrated other statistically significant factors affecting the level of postoperative hemoglobin in those groups. Aforementioned factors are as follows: age of patients, gender of patients, type of fracture, admission Hb level, angle of the fracture gap and fracture gap displacement. With such preponderance of elderly patients suffering from those PTFs (58% of all unilateral femoral fractures at our faculty), patients are put under a very serious threat of limitation of disability and death. The peril of 30-day mortality due to intertrochanteric fracture surgery exceeds 7% of the initial population [3]. Thus, regarding the AO classification of PTFs, it is of paramount importance to foresee and prevent plausible blood loss originating from different types of pertrochanetric fractures. As it is commonly known that unstable PTFs lead to more blood loss than the stable PTFs [15], little is known about the factual perioperative blood loss differences within the stable fracture group [16].

There are a few factors that have an impact on total blood loss after PTFs management. The use of PFNA is associated with the least blood loss compared to DHS, Gamma Nail or InterTan [4,17]. Secondly, the extension and severity of trauma, which is limited in our study to patients with unilateral PTFs. Thirdly, a vast meta-analysis concluded that patients on OACs (Oral Anticoagulants) experience increased surgical blood loss compared to those not anticoagulated [18,19]. In order to downsize that effect, any case of ongoing anticoagulant remedy was withdrawn before surgery and patients awaited surgical intervention according to preoperative anticoagulation management guidelines [13]. Worth highlighting is the fact that the majority of the patients were initially free from anticoagulants and the remedy did not influence the time between admission to the hospital and surgery between groups significantly (p=0.76).

Furthermore, authors hypothesized that primary dislocation of cortex would intensify loss of blood because of the fracture-induced disruption of the network of both cortical and medullary vessels. Fracture gap displacement caused by avulsion mechanism of iliopsoas muscle was significantly more often observed in AO31-A1.3 fractures (99.2% *vs.* 84,4%, p<0.0001), which were followed by greater HbD. The results confirmed this hypothesis, so that displaced fractures had on average 0.74 g/dl lower postoperative hemoglobin than the intact ones. Despite such a huge dissimilarity in the level of postoperative hemoglobin, there is still a paucity of research examining the impact of primar cortex dislocation on perioperative loss of hemoglobin.

All fractures were classified independently by two of the authors in line with the 2018 edition of the AO/OTA classification [20]. In the context of previous studies, this classification retains a similar interobserver reliability for subgroup classification, but is characterized with reduced interobserver reliability for group categorization in comparison to previous classification from 1990 [21-23]. To minimize the bias, the group assignment was performed twice and in case of any discrepancies a third expert was consulted.

Hidden blood loss comprises the major part of total perioperative blood loss [24], so just the sole measurement of visible blood loss may be considered inadequate. In order to depict comprehensive blood loss, the researchers have decided to make use of hemoglobin, as the fluctuation of the level of hemoglobin is known to be of greater predictive value for anemia assessment than the level of Hct [25].

The level of preoperative hemoglobin did not differ between the groups (12.0 g/dl *vs.* 12.0 g/dl, p=0.92). The findings are in line with Haidong Cui et al. preoperative level of hemoglobin, which was 11.82 g/dl in the stable group [12]. On the other hand, admission Hb may differ between population groups and the initial level was 1g/dl lower within the stable group presented by Luo Xiangping et al. [26].

As the exact level of postoperative hemoglobin varied on the verge of statistical significance (p=0.078), authors introduced another parameter of interest-HbD. From the results, it is clear that despite similar time from admission to surgery and longer time from surgery to postoperative hemoglobin measurement (15.1 hours *vs.* 13.5 hours, p=0.056), AO 31-A1.2 simple PTFs lost 0.4 g/dl less blood than fractures with the detachment of lesser trochanter (p=0.011).

Much attention has been drawn to divergence between blood loss in stable and unstable PTFs groups. Previous studies have documented considerably more bleeding associated with AO31-A2.2-AO31-A3.3 types, which are generally considered unstable [10,24,26,27]. This research, unlike others, reveals intra-stable-group disproportions in terms of surgery-associated. As a consequence, AO31-A1.3 fractures are more often expected to be transfused postoperatively (45% *vs.* 33,7%, p=0.038). This finding was observed regardless of the fact that both types of fractures are considered stable. Our observation is in consonance with Torres et al. statement that each type of fracture should be analyzed individually to anticipate potential perioperative blood loss [28].

Another promising finding was that females are more prone to suffer from greater perioperative blood loss. Attainable reports are incoherent with the explanation of the influence of gender on total blood loss. Jiqi Wang et al. found women are associated with blood transfusion [29], on the other hand Junfei Guo et al. and Xiangping Luo et al. indicated that men as the risk factor for blood transfusion [26,30]. In our study, a possible explanation of gender influence may be provided with respect to the primal age and group size differences.

Measurement of the angle of gap fracture was possible, as the medial point of secant line was largely oriented towards the base of lesser trochanter. The bigger the angle of fracture, the lower postoperative level of hemoglobin. Researchers deem that this correlation is the result of simultaneous increase in cross-sectional area and angle of fracture. Fractures with the lateral fracture line placed more proximally were susceptible to greater blood loss.

Duration of the surgery bore no correlation with the postoperative level of hemoglobin, which is consistent with other studies and diminishes the influence of surgeon bias [27].

The most significant advantage of our study is that the studied population with a total of 334 patients identified with either AO31-A1.2 or AO31-A1.3 type of fracture was much more sizeable than so far studied. Population was not age-restricted, so there is a good applicability of the results to the entire population of patients suffering from those fractures. Additionally, researchers have not identified any prior research investigating differences in blood loss between stable intertrochanteric fractures.

However, our study has several limitations. Firstly, the retrospective character of this study precludes randomization of patients. Secondly, authors restricted the number of parameters investigated in this study to relatively small extent. Moreover, the time from admission Hb (Hb0) measurement to the surgery and then the time from the surgery to following Hb (Hb1) measurement may differ between orthopedic wards, so that presented results should be adopted respectively with caution. On top of that, researchers did not follow patients post hospitalization.

CONCLUSION

In conclusion, the finding suggests that simple pertrochanteric fracture (AO31-A1.2) treated with PFNA is burdened with lower perioperative blood loss than the pertrochanteric fracture with the detachment of lesser trochanter (AO31-A1.3). Fracture gap displacement and angle of fracture gap are useful predictors for lower level of postoperative hemoglobin. Main factors affecting postoperative level of hemoglobin are: Age, sex, type of fracture, fracture gap displacement, angle of fracture gap and preoperative level of hemoglobin. As those fractures represent the most common types of PTFs, more attention should be paid to the intra-stable group perioperative blood loss differences. We believe that presented results will assist surgeons in predicting postoperative anemia.

REFERENCES

1. PD U. World population prospects: The 2006 revision, population database. 2006.
2. Adeyemi A, Delhougne G. Incidence and economic burden of intertrochanteric fracture: A medicare claims database analysis. JB JS Open Access. 2019;4(1).
3. Mattisson L, Bojan A, Enocson A. Epidemiology, treatment and mortality of trochanteric and subtrochanteric hip fractures: Data from the Swedish fracture register. BMC Musculoskelet Disord. 2018;19(1):1-8.
4. Harper KD, Navo P, Ramsey F, Jallow S, Rehman S. "Hidden" preoperative blood loss with extracapsular versus intracapsular hip fractures: What is the difference? Geriatr Orthop Surg Rehabil. 2017;8(4):202-207.
5. Ma KL, Wang X, Luan FJ, Xu HT, Fang Y, Min J, et al. Proximal femoral nails antirotation, Gamma nails, and dynamic hip screws for fixation of intertrochanteric fractures of femur: A meta-analysis. Orthop Traumatol Surg Res. 2014;100(8):859-866.
6. Zhang K, Zhang S, Yang J, Dong W, Wang S, Cheng Y, et al. Proximal femoral nail *vs.* dynamic hip screw in treatment of intertrochanteric fractures: A meta-analysis. Med Sci Monit. 2014;20:1628-1633.
7. Arshi A, Lai WC, Iglesias BC, McPherson EJ, Zeegen EN, Stavrakis AI, et al. Blood transfusion rates and predictors following geriatric hip fracture surgery. Hip Int. 2021;31(2):272-279.
8. Newman ET, Watters TS, Lewis JS, Jennings JM, Wellman SS, Attarian DE, et al. Impact of perioperative allogeneic and autologous blood transfusion on acute wound infection following total knee and total hip arthroplasty. J Bone Joint Surg Am. 2014;96(4):279-284.
9. HIP ATTACK Investigators. Accelerated surgery versus standard care in hip fracture (HIP ATTACK): An international, randomised, controlled trial. Lancet. 2020;395(10225):698-708.
10. Dai CQ, Wang LH, Zhu YQ, Xu GH, Shan JB, Huang WC, et al. Risk factors of perioperative blood transfusion in elderly patients with femoral intertrochanteric fracture. Medicine. 2020;99(15).
11. Cheng WJ, Ding GZ, Gong YH. Analysis of risk factors of perioperative blood transfusion in the treatment of femoral intertrochanteric fracture with proximal femoral nail antirotation. Zhongguo Gu Shang. 2021;34(8):755-758.
12. Lin PH, Chien JT, Hung JP, Hong CK, Tsai TY, Yang CC. Unstable intertrochanteric fractures are associated with a greater hemoglobin drop during the perioperative period: A retrospective case control study. BMC Musculoskelet Disord. 2020;21(1):1-7.
13. Hornor MA, Duane TM, Ehlers AP, Jensen EH, Brown PS, Pohl D, et al. American college of surgeons' guidelines for the perioperative management of antithrombotic medication. J Am Coll Surg. 2018;227(5):521-36e1.
14. Belova A, Mills D, Hall R, Juliana AS, Crimmins A, Barker C, et al. Impacts of increasing temperature on the future incidence of West Nile neuroinvasive disease in the United States. Am J Clim Change. 2017;6(01):166.
15. Baird RP, O'Brien P, Cruickshank D. Comparison of stable and unstable pertrochanteric femur fractures managed with 2-and 4-hole side plates. Can J Surg. 2014;57(5):327.
16. Phruetthiphat OA, Tutaworn T, Plumarom Y, Punyaratabandhu T, Chaichankul C. Proximal femoral nail anti-rotation with cement augmentation reduces the prevalence of mechanical failure for unstable type intertrochanteric fracture in elderly patient: A preliminary study. J Clin Case Stu. 2019;4(3).

17. Yang X, Wu Q, Wang X. Investigation of perioperative hidden blood loss of unstable intertrochanteric fracture in the elderly treated with different intramedullary fixations. Injury. 2017;48(8):1848-1852.

18. Xu Y, You D, Krzyzaniak H, Ponich B, Ronksley P, Skeith L, et al. Effect of oral anticoagulants on hemostatic and thromboembolic complications in hip fracture: A systematic review and meta analysis. J Thromb Haemost. 2020;18(10):2566-2581.

19. Akaoka Y, Yamazaki H, Kodaira H, Kato H. Risk factors for the effect of anticoagulant and antiplatelet agents on perioperative blood loss following proximal femoral fractures. Medicine. 2016;95(27).

20. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and dislocation classification compendium-2018. J Orthop Trauma. 2018;32:S1-S170.

21. Pervez H, Parker MJ, Pryor GA, Lutchman L, Chirodian N. Classification of trochanteric fracture of the proximal femur: A study of the reliability of current systems. Injury. 2002;33(8):713-715.

22. Schipper IB, Steyerberg EW, Castelein RM, Vugt AB. Reliability of the AO/ASIF classification for pertrochanteric femoral fractures. Acta Orthop Scand. 2001;72(1):36-41.

23. Chan G, Hughes K, Barakat A, Edres K, da Assuncao R, Page P, et al. Inter-and intra-observer reliability of the new AO/OTA classification of proximal femur fractures. Injury. 2021;52(6):1434-1437.

24. Cui H, Chen K, Lv S, Yuan C, Wang Y. An analysis of perioperative hidden blood loss in femoral intertrochanteric fractures: Bone density is an important influencing factor. BMC Musculoskelet Disord. 2021;22(1):1-6.

25. Quintó L, Aponte JJ, Menéndez C, Sacarlal J, Aide P, Espasa M, et al. Relationship between haemoglobin and haematocrit in the definition of anaemia. Trop Med Int Health. 2006;11(8):1295-12302.

26. Luo X, He S, Li Z, Li Q. Quantification and influencing factors of perioperative hidden blood loss during intramedullary fixation for intertrochanteric fractures in the elderly. Arch Orthop Trauma Surg. 2020;140(10):1339-1348.

27. Tüzün HY, Bilekli AB, Er en Ö. The factors that affect blood loss in intertrochanteric fractures treated with proximal femoral nail in the elderly. Eur J Trauma Emerg Surg. 2022;48(3):1879-1884.

28. Torres A, Laffosse J, Molinier F, Tricoire J, Chiron P, Puget J. Statistical analysis of the factors that increase perioperative bleeding in trochanteric fractures. Rev Esp Cir Ortop Traumatol. 2012;56(1):11-16.

29. Wang J, Zhao Y, Jiang B, Huang X. Development of a nomogram to predict postoperative transfusion in the elderly after intramedullary nail fixation of femoral intertrochanteric fractures. Clin Interv Aging. 2021;16:1-7.

30. Guo J, Zhang Y, Hou Z. Intramedullary fixation does not cause a large amount of hidden blood loss in elderly patients with intertrochanteric fractures. Clin Interv Aging. 2021;16:475-486.