Original Article • Journal of Southeast Asian Orthopaedics Vol 50 No 2 (2026) 99-108

Journal of Southeast Asian Orthopaedics
ISSN 2821-9848 (Print)
ISSN 2821-9864 (Online)
https://doi.org/10.56929/jseaortho-2026-0296 https://jseaortho.org

Optimal Hematocrit Level Associated with Blood Reservation for Surgery for Hip Fracture

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Purpose: To study the optimal hematocrit level associated with blood reservation for ~~high~~ hip fracture surgery.
Methods: We retrospectively studied the medical records of 56 patients with hip fractures who underwent surgery at our hospital between January and December 2022. Data were collected including hematocrit levels before and after surgery at 6, 48, and 72 h. Risk factors and hematocrit levels for blood transfusion were assessed using univariate, bivariate, and multivariate analyses and receiver operating characteristic (ROC) curves to determine the associated factors and optimal hematocrit level in patients with hip fractures.
Results: Fifty-six inpatient medical records showed a statistically significant difference in age, sex, and use of antiplatelet and/or anticoagulant drugs between the blood transfusion and non- transfusion groups. The group that received antiplatelet and/or anticoagulant drugs lost significantly more blood, 191.67 ± 172.67 ml, compared with 122.86 ± 75.49 ml in those who did not receive them. In the fractures at the intertrochanter of femur, the least intraoperative blood loss was statistically significant, at 110.00 ± 60.74 ml. Comparison with fractures at the neck and subtrochanteric of femur, the blood loss was 210.74 ± 126.06 ml and 1 liter, respectively. When divided into subgroups according to femoral neck fractures, the Garden 1 group had the least intraoperative blood loss, with statistical significance at 88.00 ± 52.63 ml. There was a linear relationship between estimated blood loss and body mass index (kg/m^2), time to operation (days), and operative time (minutes), with R = 0.724 and R^2 = 0.524. When analyzing the ROC, the optimal hematocrit level for blood reservation for hip fracture surgery was ≤34%. The sensitivity, specificity, and accuracy were 85.7 %, 60%, and 84.2 %, respectively.
Conclusions: The optimal hematocrit level in blood reservation planning is ≤34%, with accuracy of 84.2%.

Keywords: Hematocrit, Hip fracture, Blood loss, Hip surgery, Blood transfusion

Article history:
Received November 4, 2025 Revised: March 23, 2026
Accepted: May 10, 2026
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Although Thailand is considered a moderate-risk country for hip fractures[1,2], a study in the United States predicted that the number of hip fracture patients will increase by 1.3-fold after 2024[3]. Over the next 10 years, the number of patients, especially women, is expected to double. This indicates that Thailand will become a high-risk country for hip fractures within the next 10 years, similar to the United States. Furthermore, the median age reported for Switzerland by Michaëlsson et al.[4] is 75-79 years, consistent with the report for Jordan in the Middle East by Haddad et al.,[5] which is 76.27 ± 9.57 years. The trend of hip fracture age is increasing, as reported by Meye et al.,[6] which found that the baseline age range for hip fractures is 80-89 years. This increasing age imposes greater barriers to surgical procedures owing to underlying medical conditions and the patient's physical condition[7-9].

Owing to the increasing demand for blood to treat patients in Thailand, the National Blood Center and the National Blood Service need to increase their blood supply, with an average annual increase of 3.8%. In 2019, the national blood supply reached 2.7 million units. As a result, by 2020, the National Blood Center must accept blood donations to maintain a sufficient blood reserve of at least 3,400 units per day. Furthermore, the COVID-19 pandemic has affected Thailand's blood supply[10]. From March to May 2020, the number of blood donors at the National Blood Center decreased by 23%, the National Blood Service decreased by 27%, and the National Blood Service branches decreased by 57%. This has led to decreased blood reserves and shortages in some weeks. This is also a result of stricter screening for blood donations[11].

Ramadanov et al.[12] reported the effect of various hip surgeries on blood loss. This study showed high heterogeneity ($I^2 = 97\%$), which could not be accurately extrapolated to the general population. This has led to research on blood loss during hip fracture treatment in the Thai population for forecasting purposes. In the blood shortage situation after the COVID-19 pandemic, finding the appropriate hematocrit (Hct) level for each type of hip fracture surgery and planning appropriate blood reservation is needed for blood transfusion after hip fracture surgery. Studying this appropriate Hct level was the aim of the present study.

METHODS

This was a retrospective study of 56 inpatients with hip fractures who underwent various surgeries at our hospital between January and December 2022. Data were collected including day, month, and year of admission, sex, age, body mass index (BMI), underlying diseases, anticoagulants, fracture type, time to operation, anesthesia during surgery, type of surgery, operative time, intraoperative blood loss, and Hct level before and after surgery at 6, 48, and 72 h. Transfusion requirements were assessed by experienced orthopedic surgeons. The number of transfusion units and complications from surgery and transfusion were evaluated. Patients were divided into two groups: those requiring transfusion and those not receiving transfusion. Transfusion criteria were based on cardiac risk factors, the patient's hip surgery history, and Hct level <30%. Orthopedic surgeons made the decision after receiving Hct level results at 6, 24, 48, and 72 hours postoperatively, using the standing order for Fracture Liaison Service (FLS) according to guidelines for blood transfusion when Hct is less than 30%. However, in healthy patients, a study by Carson et al.[13] of 2,016 patients showed no difference in walking ability and mortality rates within the first 60 days. The postoperative period with hidden blood loss after surgery was in the first 2 days[14]. The research period was approximately 6 months, from January 19 to June 19, 2025. The assessment of intraoperative blood loss and calculation of blood loss were done using the following blood loss calculation method. The formula for calculating the total blood volume (TBV) of Nadler's equation[15] was based on the variables of height (H:M), weight (W:Kg), and sex. The calculation formula for males = $(0.3669 \times H^3) + (0.03219 \times W) + 0.6041$ and for females = $(0.3561 \times H^3) + (0.03308 \times W) + 0.1833$. Total blood loss (TBL) was calculated using Gross's formula[16]: TBL = Total blood volume (TBV) × (Hctpre - Hctpost) / Hctave, based on the variable TBV of Nadler's equation, blood concentration before and after surgery (Hctpre - Hctpost), and average Hct level (Hctave). We performed comparison of two variables with Student's t-test and data of more than two variables with analysis of variance (ANOVA). Risk factors and blood concentration values for blood transfusion were assessed using statistical analysis programs with univariate, bivariate, and multivariate analyses and receiver operating characteristic (ROC) curves to identify the associated factors and optimal Hct level in patients with hip fractures.

RESULTS

Demographic data showed that older age had a greater effect on blood transfusion. The mean age of the blood transfusion group was 80.37 ± 7.45 years, while the mean age of the non-blood transfusion group was significantly younger at 73.57 ± 7.99 years. Females had a 3.6-fold higher odds ratio than males. Lower weight was statistically significant in the blood transfusion group, at 53.29 ± 8.80 kg versus 58.71 ± 9.19 kg in the non-transfusion group. The number of patients who received antiplatelet and/or anticoagulant drugs in the blood transfusion group was significantly higher at 4.96-fold than in the non-transfusion group. The preoperative Hct level was significantly lower, 33.51 ± 3.26% in the blood transfusion group and 38.72 ± 4.24% in the non-blood transfusion group. The blood transfusion group had significantly more complications than the non-blood transfusion group, with a 6.44-fold higher odds ratio. The most significant difference was observed in the incidence of anemia due to blood loss. Other characteristic data, underlying diseases, fracture location, fracture classification, fracture side, time to operation, operative time, and type of surgery were not significantly different between the groups.

Table 1 Demographic data.

Characteristics	$\bar{x}$ (95%CI) / n (%)	Non-blood transfusion (n=21) / ($\bar{x}$ ± SD)	%	Blood transfusion (n=35) / ($\bar{x}$ ± SD)	%	p-value
Age	77.82 (75.60 - 80.04)	73.57 ± 7.99		80.37 ± 7.45		<0.01*
Sex						
Male	17 (30.4)	10	48	7	20	0.03*
Female	39 (69.6)	11	52	28	80	
Body weight	55.32 (52.84 - 57.80)	58.71 ± 9.19		53.29 ± 8.80		0.04*
Height	158.02 (156.31 - 159.72)	160.05 ± 5.99		156.80 ± 6.35		0.06*
BMI	22.12 (21.25 - 22.98)	22.95 ± 3.63		21.62 ± 2.90		0.16
Underlying diseases						
DM	15 (11.4)	4	19	11	31	0.31
HT	42 (31.8)	15	71	27	77	0.63
CKD	9 (6.8)	3	14	6	17	0.78
Hypokalemia	8 (6.1)	5	24	3	9	0.12
Hyponatremia	9 (6.8)	2	10	7	20	0.30
Hypomagnesimia	11 (8.3)	4	19	7	20	0.93
Dyslipidemia	12 (9.1)	6	29	6	17	0.31
BPH	5 (3.8)	3	14	2	6	0.28
Anemia	4 (3.0)	0	0	4	11	0.11
Old CVA	10 (7.6)	2	10	8	23	0.21
Gout	3 (2.3)	1	5	2	6	0.88
Osteoporosis	4 (3.0)	1	5	3	9	0.59
Antiplatlet or Anticoagulant	14 (25.0)	2	10	12	34	0.04*
ASA	12 (21.4)	1	5	11	31	
Clopidogrel (Plavix)	1 (1.8)	0	0	1	3	
Enoxaparin	1 (1.8)	1	5	0	0	

Table 1 Demographic data. (Cont.)

Characteristics	**$\bar{x}$ (95%CI) / n (%)**	**Non-blood transfusion (n=21) / ($\bar{x}$ ± SD)**	**%**	**Blood transfusion (n=35) / ($\bar{x}$ ± SD)**	**%**	**p-value**
Types of fracture femur						
Intertrochanter	28 (50.0)	11	52	17	49	0.73
Neck	27 (48.2)	10	48	17	49	
Subtrochanter	1 (1.8)	0	0	1	3	
Classifications						
Evan 1	22 (39.3)	7	33	15	43	0.56
Evan 2	6 (10.7)	4	19	2	6	
Garden 1	5 (8.9)	1	5	4	11	
Garden 3	3 (5.4)	1	5	2	6	
Garden 4	19 (33.9)	8	38	11	31	
Russel Taylor 1A	1 (1.8)	0	0	1	3	
Stability						
Impact valgus	5 (8.9)	1	5	4	11	0.93
Stable	16 (28.6)	6	29	10	29	
Complete displacement	3 (5.4)	1	5	2	6	
Total displacement	19 (33.9)	8	38	11	31	
Unstable	13 (23.2)	5	24	8	23	
Side						
Right	17 (30.4)	7	33	10	29	0.27
Left	37 (66.1)	12	57	25	71	
Time to operation (days)	8.05 (6.26 - 9.84)	7.31 ± 6.97		8.50 ± 6.55		0.53
Types of operation						
Multiple screw fixation	2 (3.6)	1	5	1	3	0.53
Dynamic hip screw	1 (1.8)	1	5	0	0	
Cephalomedullary nail	28 (50.0)	10	48	18	51	
Bipolar hip prosthesis	25 (44.6)	9	43	16	46	
Operative Time (Minute)	49 (44 -55)	50 ± 18		49 ± 21		0.84
Hct %	35.35 (34.24-36.46)	38.72 ± 4.24		33.51 ± 3.26		<0.01*
Complications		9	43	29	83	<0.01*
Anemia due to acute blood loss	22 (39.3)	0	0	22	63	<0.01*
Bed sore	11 (19.6)	3	14	8	23	0.43
Constipation	5 (8.9)	4	19	1	3	0.06
UTI	10 (17.9)	3	14	7	20	0.59
Pneumonia	2 (3.6)	0	0	2	6	0.27
Delirium	5 (8.9)	1	5	4	11	0.40
AKI	3 (5.4)	0	0	3	9	0.17
Nerve injury	3 (5.4)	2	10	1	3	0.28

* Statistically significant at $p < 0.05$

Table 2 Comparison of factors associated with blood loss.

Factors	n	EBL ($\bar{x}$ ± SD)	p-value	TBL ($\bar{x}$ ± SD)	p-value
Sex					
Male	17	169.41 ± 133.58	0.875	692.81 ± 788.46	0.64
Female	39	176.67 ± 167.02		783.87 ± 606.64	
Antiplatelet Anticoag					
Yes	14	191.67 ± 172.67	0.045*	752.77 ± 688.63	0.943
No	42	122.86 ± 75.49		766.58 ± 593.84	
Types of fracture					
Intertrochanter	28	110.00 ± 60.74	<0.01*	764.59 ± 699.41	0.953
Neck	27	210.74 ± 126.06		740.61 ± 643.85	
Subtrochanteric	1	1000		943.5	
Classifications					
Intertrochanter					
Evan 1	22	108.18 ± 63.97	0.743	715.61 ± 604.49	0.621
Evan 2	6	116.67 ± 51.64		944.22 ± 1028.37	
Neck					
Garden 1	5	88.00 ± 52.63	0.032*	720.17 ± 819.17	0.696
Garden 3	3	183.33 ± 104.08		442.57 ± 250.58	
Garden 4	19	247.37 ± 124.13		793.05 ± 651.81	
Subtrochanteric					
Russell-Taylor 1A	1	1000		943.5	
Stability					
Neck					
Impact valgus	5	88.00 ± 52.63	0.032*	720.17 ± 819.17	0.696
Complete non-displacement	3	183.33 ± 104.08		442.57 ± 250.58	
Total displacement	19	247.37 ± 124.13		793.05 ± 651.81	
Intertrochanter					
Stable	16	167.50 ± 231.59	0.331	677.96 ± 554.94	0.451
Unstable	13	107.69 ± 53.41		884.99 ± 832.25	
Types of operation					
Bipolar prosthesis	25	224.80 ± 120.07	0.115	780.07 ± 651.62	0.266
Cephalomeullary nail	28	143.93 ± 178.04		732.21 ± 667.54	
Dynamic hip screw	1	50		50	
Multiple screw	2	35.00 ± 21.21		247.45 ± 249.38	

* Statistically significant at $p < 0.05$. EBL: estimated blood loss.

Factors associated with blood loss were compared using Nadler's equation[15] to calculate TBV and Gross's formula[16] to calculating TBL. The study found that intraoperative blood loss (estimated blood loss, EBL) was significantly higher with antiplatelet and/or anticoagulant therapy at 191.67 ± 172.67 ml when compared without antiplatelet and/or anticoagulant therapy, the EBL was significantly lower with 122.86 ± 75.49 ml. The intertrochanter of femur fractures showed the least statistically significant intraoperative blood loss (EBL) at 110.00 ± 60.74 ml when compared with neck and subtrochanteric of femur fractures at 210.74 ± 126.06 ml and 1 liter, respectively. When divided into subgroups according to femoral neck fractures, Garden 1 showed the least statistically significant intraoperative blood loss (EBL) at 88.00 ± 52.63 ml when compared with the femoral neck fracture group. However, when comparing the TBL, there was no statistically significant difference in all factors that affected blood loss.

Factors associated with blood loss were compared by assessing the assessment of hidden blood loss (HBL) and the number of units of blood transfused. The calculation of HBL was based on the formula: HBL = TBL - EBL. The study found that sex, antiplatelet and/or anticoagulant use, fracture location, fracture classification, and type of operations were not significantly different when HBL was compared with the number of units of blood transfusion.

Table 3 Comparison of factors associated with hidden blood loss and blood transfusion.

Factors	n	HBL ($\bar{x}$ ± SD)	*p*-value	Unit ($\bar{x}$ ± SD)	p-value
Sex					
Male	17	523.40 ± 793.09	0.67	1.86 ± 0.69	0.79
Female	39	607.20 ± 616.42		1.76 ± 0.91	
Antiplatelet Anticoag					
Yes	14	561.11 ± 703.78	0.66	1.78 ± 0.80	0.70
No	42	643.72 ± 568.88		1.83 ± 1.03	
Types of fracture					
Intertrochanter	28	654.59 ± 681.17	0.50	1.83 ± 0.86	0.30
Neck	27	529.87 ± 663.02		1.65 ± 0.86	
Subtrochanter	1	-56.51		3	
Classifications					
Intertrochanter					
Evan 1	22	607.43 ± 581.54	0.63	1.93 ± 0.88	0.54
Evan 2	6	827.55 ± 1019.57		1.50 ± 0.71	
Neck					
Garden 1	5	632.17 ± 802.75	0.75	1.50 ± 0.58	0.89
Garden 3	3	259.24 ± 212.64		1.50 ± 0.71	
Garden 4	19	545.68 ± 686.57		1.73 ± 1.01	
Subtrochanter					
Russell-Taylor 1A	1	-56.51		3	
Stability					
Neck					
Impact valgus	5	632.17 ± 802.75	0.75	1.50 ± 0.58	0.89
Complete non-displacement	3	259.24 ± 212.64		1.50 ± 0.71	
Total displacement	19	545.68 ± 686.57		1.73 ± 1.01	
Intertrochanter					
Stable	16	510.46 ± 559.41	0.32	2.10 ± 0.88	0.42
Unstable	13	777.29 ± 806.81		1.75 ± 0.89	
Types of operation					
Bipolar prosthesis	25	555.27 ± 681.26	0.27	1.69 ± 0.87	0.50
Cephalomeullary nail	28	588.28 ± 655.40		1.94 ± 0.87	
Dynamic hip screw	1	50		0	
Multiple screw	2	212.45 ± 270.59		1	

Table 4 Bivariate analysis of the relationship of continuous factors with blood loss.

Pearson correlation						
	Age	**BMI**	**Time to Op**	**Op time**	**EBL**	**TBL**
Age (years)	1	-0.086	-0.176	-0.124	-0.094	0.011
BMI (kg/m^2)	-0.086	1	0.055	-0.106	0.296*	0.335*
Time to operation (day)	-0.176	0.055	1	0.293*	0.364*	0.038
Operative time (Minute)	-0.124	-0.106	0.293*	1	0.616*	0.027
EBL (cc)	-0.094	0.296*	0.364*	0.616*	1	0.066
TBL (cc)	0.011	0.335*	0.038	0.027	0.066	1

* Statistically significant, $p < 0.05$

The equation shows a linear relationship between estimated intraoperative blood loss

$$EBL=194.595-13.951(BMI)+7.751(TTOP)+0.075(OPT)$$

where EBL = estimated blood loss (ml)
BMI = body mass index (kg/m^2)
TTOP = time to operation (days)
OPT = operative time (minutes)
with $R = 0.724$ and $R^2 = 0.524$

The results in Table 4 show that the time to surgery and operative time were directly proportional to the amount of blood loss during surgery, whereas BMI was inversely proportional to the amount of blood loss during surgery, as shown in the equation above.

The results of the study were as follows: when the sensitivity was 85.7% and the specificity was 60%, the appropriate Hct level for preserving blood for hip fracture surgery was less than 34%, with an accurate area under the curve (AUC) of 84.2% when the sensitivity was 77.8% and a specificity of 60%. The appropriate age for reserving blood for hip fracture surgery was >75 years, with an accurate AUC of 75.9%, sensitivity of 68.2%, and specificity of 60%. The appropriate weight for preserving blood for hip fracture surgery was less than 53 kg, with an accurate AUC of 68.0%.

Table 5 Analysis of the relationship between sensitivity and specificity of the appropriate factors for donation (ROC).

Receiver Operating Characteristic (ROC)					
Factors	**Cut point**	**Sensitivity (%)**	**Specificity (%)**	**AUC (%)**	**p-value**
Hct (%)	< 34	85.7	60	84.2	<0.01
Age (years)	> 75	77.8	60	75.9	<0.01
Body weight (kg)	< 53	68.2	60	68.0	0.025

DISCUSSION

The reported blood loss during the surgical treatment of patients with hip fracture varies among different populations[12,17-19]. Wang et al.[20] reported factors associated with blood loss, such as sex, age[7], underlying diseases, antiplatelet and/or anticoagulant use, fracture site, time to operation, and operative time. Guo et al.[21] reported factors including BMI, thrombosis, and blood transfusion. The study found that factors affecting blood transfusion included sex, age, antiplatelet and/or anticoagulant use, and blood transfusion, whereas factors affecting intraoperative blood loss were BMI, waiting time, and operative duration. However, when calculating the TBL, there were no statistically significant differences. Although the numbers were not statistically significant, there were clinical differences in the need for blood transfusion to ensure adequate postoperative oxygenation[13].

This study conducted a multi-logistic regression analysis and found that sex, side, fracture site, and fracture group were not significantly different, because of the small study population. Furthermore, the amount of intraoperative blood loss was predicted using a multilinear regression analysis, which showed a linear relationship. With a correlation coefficient (R) of 0.724 and an accurate prediction probability (R^2) of 52.4%, the equation was as follows:

EBL=194.595-13.951(BMI)+7.751(TTOP)+0.075(OPT)

To reduce the risk of intraoperative blood loss (EBL), which may affect blood transfusion, three factors must be considered: BMI, TTOP, and OPT. This information is provided to surgeons for consideration in the treatment of hip fractures. According to a study by Pincus et al.[22] on time to operation for hip fracture surgery, surgery should be performed within the first 24 h to minimize mortality. However, if there are equipment, operating room, or patient conditions that necessitate a postponement, surgery should be performed within 48 hours[23]. Surgery within 48 hours can reduce blood loss by approximately 123 milliliters and blood transfusions by 1.6 times[24]. This study found the average waiting time for surgery to be 7.9 (6.13-9.69) days, a period longer than normal owing to the COVID-19 pandemic. This suggests a long waiting time for surgery, with a continuous linear relationship even after surgery within 48 h. After a fracture, bleeding at the fracture site can continue for at least 48 h[14]. If surgery is not performed, it may lead to further blood loss, lowering the preoperative Hct level, and increasing the chances of blood transfusion after surgery. All predictive factors for blood transfusion and loss were identified.

The primary objective of this study was to determine the optimal Hct level for the treatment of patients with hip fractures and to reserve appropriate blood transfusions. There have been no previous studies on optimal Hct levels. Instead, blood loss data from international textbooks were used to estimate blood reservation calculations. However, reports on blood loss are based on international data that differ among populations. Ramadanov et al.[12] reported the effects of various hip surgeries on blood loss. This study showed high heterogeneity (I^2 = 97%), which could not be accurately extrapolated to the general population. The primary differences include: The mean age in this study was 77.74 (75.60-80.04) years, which is similar to the report by Michaëlsson et al.[4] The mean age reported in the Swiss population was 75-79 years, and in the Middle East (Jordan) by Haddad et al.[5] was 76.27 ± 9.57 years. However, the overall mean age in the study by Ramadanov et al.[12] was 79 years. The proportion of men and women in this study was 29.82%, while that in the Ramadanov et al.[12] study was 24%, illustrating the intraoperative heterogeneity between the hospital study and previous studies. Furthermore, this study provided data on the optimal Hct level for preoperative blood reservation, which was less than 34%, with a sensitivity of 85.7%, specificity of 60%, accuracy of 84.2 %, and the highest level of validity. Age >75 years and weight <53 kg were significant risk factors. One limitation of this study was the small population size; therefore, the results cannot be applied to fractures of the subtrochanteric femur.

According to data on the ratio of blood units reserved to blood transfusions, the cross-match transfusion ratio (C:T ratio) for male orthopedic surgery patients at our hospital from April to May 2025 was 2.35-2.65, which is higher than the hospital's overall average of 2.00. A previous study by Carson et al.[13] found that the transfusion ratio for hip surgery patients in the restricted group was 61%, with transfusions performed when the blood concentration was less than 21%[14], whereas that in the unrestricted group was 97%, with transfusions performed when the blood concentration was less than 30%. This study found that 61% of the blood was transfused when the blood concentration was less than 30%[25]. Therefore, the results of the above study can be applied clinically to ensure adequate blood allocation and maximize the effectiveness of hip fracture treatment. Currently, our hospital's blood reservation method utilizes cross-matching and type and screening to maximize the benefits of limited blood transfusions. Type-and-screening is used in cases where hip fracture patients are not at risk for transfusion, similar to gynecological studies[26], and can also reduce costs[27]. The mean of blood units needed was 1.8 ± 0.87 units from 35 patients. Therefore, if blood is required, at least 2 units should be reserved.

CONCLUSIONS

The optimal Hct level for blood reservation planning was ≤34% with an accuracy of 84.2%. The findings of this study are important for orthopedic surgeons when making decisions regarding blood reservation. Patient age >75 years and weight <53 kg were statistically significant risk factors.

REFERENCES

1. Kanis JA, Oden A, McCloskey EV, et al. A systematic review of hip fracture incidence and probability of fracture worldwide. Osteoporos Int 2012;23:2239-56.
2. Shoji A, Gao Z, Arai K, et al. 30-year trends of hip and vertebral fracture incidence in Japan: a systematic review and meta-analysis. J Bone Miner Metab 2022;40:327-36.
3. Brown CA, Starr AZ, Nunley JA. Analysis of past secular trends of hip fractures and predicted number in the future 2010–2050. J Orthop Trauma 2012;26:117-22.
4. Michaëlsson K, Baron JA, Byberg L, et al. Declining hip fracture burden in Sweden 1998–2019 and consequences for projections through 2050. Sci Rep 2024;14:706.
5. Haddad BI, Hamdan M, Alshrouf MA, et al. Preoperative hemoglobin levels and mortality outcomes after hip fracture patients. BMC Surg 2023;23:266.
6. Meyer AC, Ek S, Drefahl S, et al. Trends in hip fracture incidence, recurrence, and survival by education and comorbidity: a Swedish register-based study. Epidemiology 2021;32:425-33.
7. Hamel MB, Henderson WG, Khuri SF, et al. Surgical outcomes for patients aged 80 and older: morbidity and mortality from major noncardiac surgery. J Am Geriatr Soc 2005;53: 424-9.
8. Finlayson E, Birkmeyer JD. Operative mortality with elective surgery in older adults. Eff Clin Pract 2001;4:172-7.
9. Fowler A, Abbott TEF, Prowle J, et al. Age of patients undergoing surgery. Br J Surg 2019;106: 1012-8.
10. Centre TRCNB. Thailand Blood Service Action Plan 2022–2027: Thai Red Cross; 2022. 11 p.
11. Hematology TTSo. Blood Donation in the COVID-19 Era. n.d. Available from: https://tsh.or.th/Knowledge/Details/70.
12. Ramadanov N, Jóźwiak K, Hauptmann M, et al. Cannulated screws versus dynamic hip screw versus hemiarthroplasty versus total hip arthroplasty in patients with displaced and non-displaced femoral neck fractures: a systematic review and frequentist netw ork meta-analysis of 5703 patients. J Orthop Surg Res 2023;18:625.
13. Carson JL, Terrin ML, Noveck H, et al. Liberal or restrictive transfusion in high-risk patients after hip surgery. N Engl J Med 2011;365:2453-62.
14. Tian S, Li H, Liu M, et al. Dynamic analysis of perioperative hidden blood loss in intertrochanteric fractures. Clin Appl Thromb Hemost 2019;25:1076029618823279.
15. Nadler SB, Hidalgo JH, Bloch T. Prediction of blood volume in normal human adults. Surgery 1962;51:224-32.
16. Gross JB. Estimating allowable blood loss: corrected for dilution. Anesthesiology 1983;58: 277-80.
17. Cui H, Chen K, Lv S, et al. An analysis of perioperative hidden blood loss in femoral intertrochanteric fractures: bone density is an important influencing factor. BMC Musculoskelet Disord 2021;22:6.
18. Yu W, Zhang X, Wu R, et al. The visible and hidden blood loss of Asia proximal femoral nail anti-rotation and dynamic hip screw in the treatment of intertrochanteric fractures of

elderly high-risk patients: a retrospective comparative study with a minimum 3 years of follow-up. BMC Musculoskelet Disord 2016;17: 269.

19. Yu X, Zhang H, Zhang X, et al. Effects of the ratios of marrow cavity diameter to intramedullary nail diameter from different layers on blood loss during perioperative period for femoral intertrochanteric fractures. Medicine (Baltimore) 2019;98:e16936.

20. Wang T, Guo J, Hou Z. Risk factors for perioperative hidden blood loss after intertrochanteric fracture surgery in Chinese patients: a meta-analysis. Geriatr Orthop Surg Rehabil 2022;13:21514593221083816.

21. 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;16:475-86.

22. Pincus D, Ravi B, Wasserstein D, et al. Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. JAMA 2017;318:1994-2003.

23. Rader JC. Timing of surgery in elderly hip fracture patients. Vilniaus universitetas.; 2024.

24. Su S, Zhang Y, Wang R, et al. Early surgery within 48 h was associated with reduced perioperative blood loss and red blood cell transfusion requirements in older patients with hip fracture: a retrospective study. Eur Geriatr Med 2023;14:1241-8.

25. Schneider M, Schäfer N, Potthoff AL, et al. Perioperative red blood cell transfusion is associated with poor functional outcome and overall survival in patients with newly diagnosed glioblastoma. Neurosurg Rev 2022; 45:1327-33.

26. Ness PM, Rosche ME, Barrasso C, et al. The efficacy of type and screen to reduce unnecessary cross matches for obstetric patients. Am J Obstet Gynecol 1981;140:661-4.

27. Arthi R, Soundharya V, Suresh Kumar I, et al. Impact of type and screen method on turnaround time and man-hour utilization compared to conventional Coomb's crossmatch: A cross-sectional analytical study. Cureus 2024; 16:e69564.